(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(72) Inventors: GALLAGHER, Edward, J.; 26 Brookline
Drive, West Hartford, CT 06 107 (US). MONZON, Byron,
R.; 1 Debra Ct., Cromwell, CT 06416 (US). LIU, Ling; 43
Mallard Drive, Glastonbury, CT 06033 (US). LI, Linda,
S.; 10 Edgewood Court Ext., Middlefield, CT 06455 (US).
WHITLOW, Darryl; 149 Dove Lane, Middletown, CT
06457 (US). FORD, Barry, M.; 123 Greenview Terrace,
Middletown, CT 06457 (US).

(54) Title: GAS TURBINE ENGINE AIRFOIL

FIG.2A
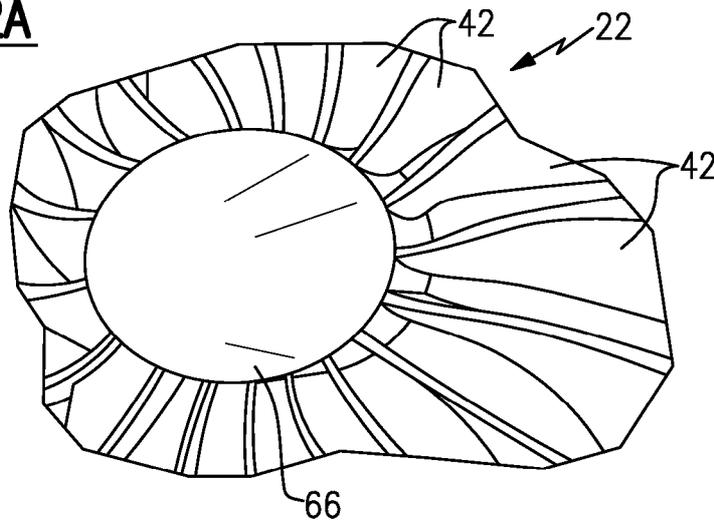
(57) Abstract: In one exemplary embodiment, an airfoil for a turbine engine includes pressure and suction sides extending in a radi-
al direction from a 0% span position at an inner flow path location to a 100% span position at an airfoil tip. The airfoil geometry cor-
responds to tangential leading and trailing edge curves and a tangential stacking offset curve. The airfoil extends from a root. A zero
tangential reference point corresponds to tangential center of the root. Y_{LE} corresponds to a tangential distance from a leading edge
to the reference point at a given span position. Y_{T_E} corresponds to a tangential distance from a trailing edge to the reference point at
a given span position. Y_d corresponds to a tangential stacking offset at a given span position. $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 40% span posi-
tion is about 1.5 and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 20% span position is about 2.

GAS TURBINE ENGINE AIRFOIL

CROSS-REFERENCE TO RELATED APPLICATION

[0001]   This application claims priority to United States Provisional Application No. 61/941,752 filed February 19, 2014.

BACKGROUND

[0002]   This disclosure relates generally to an airfoil for gas turbine engines, and more particularly to a fan or compressor blade and the relationship between tangential projection relative to span.

[0003]   A turbine engine such as a gas turbine engine typically includes a fan section, a compressor section, a combustor section and a turbine section. Air entering the compressor section is compressed and delivered into the combustor section where it is mixed with fuel and ignited to generate a high-speed exhaust gas flow. The high-speed exhaust gas flow expands through the turbine section to drive the compressor and the fan section. The compressor section typically includes low and high pressure compressors, and the turbine section includes low and high pressure turbines.

[0004]   The propulsive efficiency of a gas turbine engine depends on many different factors, such as the design of the engine and the resulting performance debits on the fan that propels the engine. As an example, the fan may rotate at a high rate of speed such that air passes over the fan airfoils at transonic or supersonic speeds. The fast-moving air creates flow discontinuities or shocks that result in irreversible propulsive losses. Additionally, physical interaction between the fan and the air causes downstream turbulence and further losses. Although some basic principles behind such losses are understood, identifying and changing appropriate design factors to reduce such losses for a given engine architecture has proven to be a complex and elusive task.

SUMMARY

[0005]   In one exemplary embodiment, an airfoil for a turbine engine includes pressure and suction sides extending in a radial direction from a 0% span position at an inner flow path location to a 100% span position at an airfoil tip. The airfoil geometry corresponds to tangential leading and trailing edge curves and a tangential stacking offset curve. The airfoil extends from a root. A zero tangential reference point corresponds to tangential center of the root. Y_{LE} corresponds to a tangential distance from a leading edge to the reference point at a given span position. Y_{TE} corresponds to a tangential distance from a trailing edge to the reference point at a given span position. Y_d corresponds to a tangential stacking offset at a given span position. $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 40% span position is about 1.5 and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 20% span position is about 2.

[0006]   In a further embodiment of the above airfoil, $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 100% span position is about 1.1 and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 90% span position is about 1.3.

[0007]   In a further embodiment of any of the above airfoils, $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 60% span position is about 1.8 and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 50% span position is about 0.75.

[0008]   In a further embodiment of any of the above airfoils, $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 100% span position is about 1 and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 90% span position is about 1.2.

[0009]   In a further embodiment of any of the above airfoils, $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 60% span position is about 1.3 and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 50% span position is about 1.4.

[0010]   In a further embodiment of any of the above airfoils, $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 100% span position is about 1.1 and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 90% span position is about 1.

[0011]   In a further embodiment of any of the above airfoils, $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 60% span position is about 1.4 and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 50% span position is about 1.2.

[0012]   In a further embodiment of any of the above airfoils, the airfoil is a fan blade for a gas turbine engine.

[0013]   In a further embodiment of any of the above airfoils, $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ has a tolerance of +/- 0.05.

[0014]   In one exemplary embodiment, a gas turbine engine includes a combustor section arranged between a compressor section and a turbine section. A fan section has an array of twenty-six or fewer fan blades. The fan section has a fan pressure ratio of less than

1.55. A geared architecture couples the fan section to the turbine section or the compressor section. The fan blades include an airfoil having pressure and suction sides. The airfoil extends in a radial direction from a 0% span position at an inner flow path location to a 100% span position at an airfoil tip. The airfoil geometry corresponds to tangential leading and trailing edge curves and a tangential stacking offset curve. The airfoil extends from a root. A zero tangential reference point corresponds to tangential center of the root. **YLE** corresponds to a tangential distance from a leading edge to the reference point at a given span position. **YTE** corresponds to a tangential distance from a trailing edge to the reference point at a given span position, Y_d corresponds to a tangential stacking offset at a given span position. **(YLE-**Y_d**)/(**Y_d**-YTE)** at 40% span position is about 1.5 and **(YLE-**Y_d**)/(**Y_d**-YTE)** at 20% span position is about 2.

[0015]   In a further embodiment of the above gas turbine engine, **(YLE-**Y_d**)/(**Y_d**-YTE)** has a tolerance of +/- 0.05.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]   The disclosure can be further understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0017]   Figure 1 schematically illustrates a gas turbine engine embodiment.

[0018]   Figure 2A is a perspective view of a portion of a fan section.

[0019]   Figure 2B is a schematic cross-sectional view of the fan section.

[0020]   Figure 2C is a cross-sectional view a fan blade taken along line 2C-2C in Figure 2B.

[0021]   Figure 3A is a schematic view of fan blade span positions.

[0022]   Figure 3B is a schematic view of a cross-section of a fan blade section at a particular span position and its tangential twist and chord parameters.

[0023]   Figure 4A illustrates a relationship between tangential leading edge position, tangential stacking offset position and tangential trailing edge position relative to span position for a set of first example airfoils.

[0024]   Figure 4B illustrates a relationship between tangential leading edge position, tangential stacking offset position and tangential trailing edge position relative to span position for a set of second example airfoils.

[0025]   Figure 4C illustrates a relationship between tangential leading edge position, tangential stacking offset position and tangential trailing edge position relative to span position for a set of third example airfoils.

[0026]   The embodiments, examples and alternatives of the preceding paragraphs, the claims, or the following description and drawings, including any of their various aspects or respective individual features, may be taken independently or in any combination. Features described in connection with one embodiment are applicable to all embodiments, unless such features are incompatible.

DETAILED DESCRIPTION

[0027]   Figure 1 schematically illustrates a gas turbine engine 20. The gas turbine engine 20 is disclosed herein as a two-spool turbofan that generally incorporates a fan section 22, a compressor section 24, a combustor section 26 and a turbine section 28. Alternative engines might include an augmenter section (not shown) among other systems or features. The fan section 22 drives air along a bypass flow path B in a bypass duct defined within a nacelle 15, while the compressor section 24 drives air along a core flow path C for compression and communication into the combustor section 26 then expansion through the turbine section 28. Although depicted as a two-spool turbofan gas turbine engine in the disclosed non-limiting embodiment, it should be understood that the concepts described herein are not limited to use with two-spool turbofans as the teachings may be applied to other types of turbine engines including three-spool architectures. That is, the disclosed airfoils may be used for engine configurations such as, for example, direct fan drives, or two- or three-spool engines with a speed change mechanism coupling the fan with a compressor or a turbine sections.

[0028]   The exemplary engine 20 generally includes a low speed spool 30 and a high speed spool 32 mounted for rotation about an engine central longitudinal axis X relative to an engine static structure 36 via several bearing systems 38. It should be understood that

various bearing systems 38 at various locations may alternatively or additionally be provided, and the location of bearing systems 38 may be varied as appropriate to the application.

[0029]   The low speed spool 30 generally includes an inner shaft 40 that interconnects a fan 42, a first (or low) pressure compressor 44 and a first (or low) pressure turbine 46. The inner shaft 40 is connected to the fan 42 through a speed change mechanism, which in exemplary gas turbine engine 20 is illustrated as a geared architecture 48 to drive the fan 42 at a lower speed than the low speed spool 30. The high speed spool 32 includes an outer shaft 50 that interconnects a second (or high) pressure compressor 52 and a second (or high) pressure turbine 54. A combustor 56 is arranged in exemplary gas turbine 20 between the high pressure compressor 52 and the high pressure turbine 54. A mid-turbine frame 57 of the engine static structure 36 is arranged generally between the high pressure turbine 54 and the low pressure turbine 46. The mid-turbine frame 57 further supports bearing systems 38 in the turbine section 28. The inner shaft 40 and the outer shaft 50 are concentric and rotate via bearing systems 38 about the engine central longitudinal axis X which is collinear with their longitudinal axes.

[0030]   The core airflow is compressed by the low pressure compressor 44 then the high pressure compressor 52, mixed and burned with fuel in the combustor 56, then expanded over the high pressure turbine 54 and low pressure turbine 46. The mid-turbine frame 57 includes airfoils 59 which are in the core airflow path C. The turbines 46, 54 rotationally drive the respective low speed spool 30 and high speed spool 32 in response to the expansion. It will be appreciated that each of the positions of the fan section 22, compressor section 24, combustor section 26, turbine section 28, and fan drive gear system 48 may be varied. For example, gear system 48 may be located aft of combustor section 26 or even aft of turbine section 28, and fan section 22 may be positioned forward or aft of the location of gear system 48.

[0031]   The engine 20 in one example is a high-bypass geared aircraft engine. In a further example, the engine 20 bypass ratio is greater than about six (6), with an example embodiment being greater than about ten (10), the geared architecture 48 is an epicyclic gear train, such as a planetary gear system or other gear system, with a gear reduction ratio of greater than about 2.3 and the low pressure turbine 46 has a pressure ratio that is greater than about five. In one disclosed embodiment, the engine 20 bypass ratio is greater than about ten

(10:1), the fan diameter is significantly larger than that of the low pressure compressor 44, and the low pressure turbine 46 has a pressure ratio that is greater than about five (5:1). Low pressure turbine 46 pressure ratio is pressure measured prior to inlet of low pressure turbine 46 as related to the pressure at the outlet of the low pressure turbine 46 prior to an exhaust nozzle. The geared architecture 48 may be an epicyclic gear train, such as a planetary gear system or other gear system, with a gear reduction ratio of greater than about 2.3:1. It should be understood, however, that the above parameters are only exemplary of one embodiment of a geared architecture engine and that the present invention is applicable to other gas turbine engines including direct drive turbofans.

[0032]   The example gas turbine engine includes the fan 42 that comprises in one non-limiting embodiment less than about twenty-six (26) fan blades. In another non-limiting embodiment, the fan section 22 includes less than about twenty (20) fan blades. Moreover, in one disclosed embodiment the low pressure turbine 46 includes no more than about six (6) turbine rotors schematically indicated at 34. In another non-limiting example embodiment the low pressure turbine 46 includes about three (3) turbine rotors. A ratio between the number of fan blades 42 and the number of low pressure turbine rotors is between about 3.3 and about 8.6. The example low pressure turbine 46 provides the driving power to rotate the fan section 22 and therefore the relationship between the number of turbine rotors 34 in the low pressure turbine 46 and the number of blades 42 in the fan section 22 disclose an example gas turbine engine 20 with increased power transfer efficiency.

[0033]   A significant amount of thrust is provided by the bypass flow B due to the high bypass ratio. The fan section 22 of the engine 20 is designed for a particular flight condition - typically cruise at about 0.8 Mach and about 35,000 feet. The flight condition of 0.8 Mach and 35,000 ft, with the engine at its best fuel consumption - also known as "bucket cruise Thrust Specific Fuel Consumption ('TSFC')" - is the industry standard parameter of lbm of fuel being burned divided by lbf of thrust the engine produces at that minimum point. "Low fan pressure ratio" is the pressure ratio across the fan blade alone, without a Fan Exit Guide Vane ("FEGV") system. The low fan pressure ratio as disclosed herein according to one non-limiting embodiment is less than about 1.55. In another non-limiting embodiment the low fan pressure ratio is less than about 1.45. In another non-limiting embodiment the low fan pressure ratio is from 1.1 to 1.45. "Low corrected fan tip speed" is the actual fan tip speed

in ft/sec divided by an industry standard temperature correction of $[(Tram \ °R) \ / \ (518.7$ $°R)]^{0.5}$. The "Low corrected fan tip speed" as disclosed herein according to one non-limiting embodiment is less than about 1200 ft / second.

[0034]   Referring to Figure 2A-2C, the fan blade 42 is supported by a fan hub 60 that is rotatable about the axis X. Each fan blade 42 includes an airfoil 64 extending in a radial span direction R from a root 62 to a tip 66. A 0% span position corresponds to a section of the airfoil 64 at the inner flow path (e.g., a platform), and a 100% span position corresponds to a section of the airfoil 64 at the tip 66.

[0035]   The root 62 is received in a correspondingly shaped slot in the fan hub 60. The airfoil 64 extends radially outward of the platform, which provides the inner flow path. The platform may be integral with the fan blade or separately secured to the fan hub, for example. A spinner 66 is supported relative to the fan hub 60 to provide an aerodynamic inner flow path into the fan section 22.

[0036]   The airfoil 64 has an exterior surface 76 providing a contour that extends from a leading edge 68 aftward in a chord-wise direction H to a trailing edge 70, as shown in Figure 2C. Pressure and suction sides 72, 74 join one another at the leading and trailing edges 68, 70 and are spaced apart from one another in an airfoil thickness direction T. An array of the fan blades 42 are positioned about the axis X in a circumferential or tangential direction Y. Any suitable number of fan blades may be used in a given application.

[0037]   The exterior surface 76 of the airfoil 64 generates lift based upon its geometry and directs flow along the core flow path C. The fan blade 42 may be constructed from a composite material, or an aluminum alloy or titanium alloy, or a combination of one or more of these. Abrasion-resistant coatings or other protective coatings may be applied to the fan blade 42.

[0038]   One characteristic of fan blade performance relates to the fan blade's tangential stacking offset and leading and trailing edge positions (Y direction) relative to a particular span position (R direction). Referring to Figure 3A, span positions a schematically illustrated from 0% to 100% in 10% increments. Each section at a given span position is provided by a conical cut that corresponds to the shape of the core flow path, as shown by the large dashed lines. In the case of a fan blade with an integral platform, the 0% span position corresponds to the radially innermost location where the airfoil meets the fillet joining the

airfoil to the platform. In the case of a fan blade without an integral platform, the 0% span position corresponds to the radially innermost location where the discrete platform meets the exterior surface of the airfoil. In addition to varying with span, tangential projection varies between a hot, running condition and a cold, static ("on the bench") condition.

[0039]   The Y_{CG} corresponds to the location of the center of gravity for a particular section at a given span location relative to a reference point 80 in the Y direction, as shown in Figure 3B. The center of gravity assumes a homogeneous material. The reference point 80 is the tangential center of the root, and Y_d corresponds to the circumferential distance from the reference point 80 to the center of gravity.

[0040]   A positive Y value corresponds to the opposite rotational direction as the hub's rotation, or toward the suction side of the airfoil. A negative Y value corresponds to the same rotational direction as the hub's rotation, or toward the pressure side of the airfoil.

[0041]   The tangential leading edge location is arranged at the leading edge 68 for a particular section at a given span location relative to the reference point 80 in the Y direction, as shown in Figure 3B. Y_{LE} corresponds to the circumferential distance from the reference point 80 to the tangential leading edge location at a given span location.

[0042]   The tangential trailing edge location is arranged at the trailing edge 70 for a particular section at a given span location relative to the reference point 80 in the Y direction. Y_{TE} corresponds to the circumferential distance from the reference point 80 to the tangential trailing edge location at a given span location.

[0043]   The changes in fan blade tangential projection at various span positions can be expressed using the differences Y_{LE}-Y_d and Y_d-Y_{TE}, which are tangential distances between the locations. These differences can be used to provide non-dimensional ratios indicative of desired airfoil characteristics.

[0044]   In one prior art airfoil, $(Y_{LE}$-$Y_d)/(Y_d$-$Y_{TE})$ at 100% span position is about 0.94 and $(Y_{LE}$-$Y_d)/(Y_d$-$Y_{TE})$ at 90% span position is about 1; $(Y_{LE}$-$Y_d)/(Y_d$-$Y_{TE})$ at 60% span position is about 1.16 and $(Y_{LE}$-$Y_d)/(Y_d$-$Y_{TE})$ at 50% span position is about 1.56; and $(Y_{LE}$-$Y_dV(Y_d$-$Y_{TE})$ at 40% span position is about 1.5 and $(Y_{LE}$-$Y_dV(Y_d$-$Y_{TE})$ at 20% span position is about 1.75.

[0045]   Example relationships between the tangential projection relative to the span position are shown in Figures 4A-4C for several example fan blades, each represented

by a curve. Only one curve in each graph is discussed for simplicity. The tangential trailing edge curve crosses the tangential stacking offset in the range of 4-10% span position. "About" used in relation to the $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ ratios means +/- 0.10 in one example, and +/- 0.05 in another example.

[0046]   Referring to Figure 4A, $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 100% span position is about 1.1 and $(Y_{LE}-Y_{CI})/(Y_{CI}-Y_{TE})$ at 90% span position is about 1.3; $(Y_{LE}-Y_{CI})/(Y_{CI}-Y_{TE})$ at 60% span position is about 1.8 and $(Y_{EE}-Y_d)/(Y_d-Y_{TE})$ at 50% span position is about 0.75; and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 40% span position is about 1.5 and $(Y_{EE}-Y_d)/(Y_d-Y_{TE})$ at 20% span position is about 2.

[0047]   Referring to Figure 4B, $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 100% span position is about 1 and $(Y_{LE}-Y_{CI})/(Y_{CI}-Y_{TE})$ at 90% span position is about 1.2; $(Y_{LE}-Y_{CI})/(Y_{CI}-Y_{TE})$ at 60% span position is about 1.3 and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 50% span position is about 1.4; and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 40% span position is about 1.5 and $(Y_{EE}-Y_d)/(Y_d-Y_{TE})$ at 20% span position is about 2.

[0048]   Referring to Figure 4C, $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 100% span position is about 1.1 and $(Y_{LE}-Y_{CI})/(Y_{CI}-Y_{TE})$ at 90% span position is about 1; $(Y_{LE}-Y_{CI})/(Y_{CI}-Y_{TE})$ at 60% span position is about 1.4 and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 50% span position is about 1.2; and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 40% span position is about 1.5 and $(Y_{EE}-Y_d)/(Y_d-Y_{TE})$ at 20% span position is about 2.

[0049]   The tangential leading and trailing edge positions and tangential stacking offsets in a hot, running condition along the span of the airfoils 64 relate to the contour of the airfoil and provide necessary fan operation in cruise at the lower, preferential speeds enabled by the geared architecture 48 in order to enhance aerodynamic functionality and thermal efficiency. As used herein, the hot, running condition is the condition during cruise of the gas turbine engine 20. For example, the tangential leading and trailing edge positions and tangential stacking offsets in the hot, running condition can be determined in a known manner using numerical analysis, such as finite element analysis.

[0050]   It should also be understood that although a particular component arrangement is disclosed in the illustrated embodiment, other arrangements will benefit herefrom. Although particular step sequences are shown, described, and claimed, it should be

understood that steps may be performed in any order, separated or combined unless otherwise indicated and will still benefit from the present invention.

[0051]   Although the different examples have specific components shown in the illustrations, embodiments of this invention are not limited to those particular combinations. It is possible to use some of the components or features from one of the examples in combination with features or components from another one of the examples.

[0052]   Although an example embodiment has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of the claims. For that reason, the following claims should be studied to determine their true scope and content.

CLAIMS

What is claimed is:

1.   An airfoil for a turbine engine comprising:

pressure and suction sides extending in a radial direction from a 0% span position at an inner flow path location to a 100% span position at an airfoil tip, wherein the airfoil geometry corresponds to tangential leading and trailing edge curves and a tangential stacking offset curve, wherein the airfoil extends from a root, and a zero tangential reference point corresponds to tangential center of the root, Y_{LE} corresponds to a tangential distance from a leading edge to the reference point at a given span position, Y_{TE} corresponds to a tangential distance from a trailing edge to the reference point at a given span position, Y_d corresponds to a tangential stacking offset at a given span position, wherein $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 40% span position is about 1.5 and $(Y_{LE}-Y_d)/(Y_d-Y_m)$ at 20% span position is about 2.

2.   The airfoil according to claim 1, wherein $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 100% span position is about 1.1 and $(Y_{LE}-Y_d)/(Y_d-Y_m)$ at 90% span position is about 1.3.

3.   The airfoil according to claim 2, wherein $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 60% span position is about 1.8 and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 50% span position is about 0.75.

4.   The airfoil according to claim 1, wherein $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 100% span position is about 1 and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 90% span position is about 1.2.

5.   The airfoil according to claim 4, wherein $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 60% span position is about 1.3 and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 50% span position is about 1.4.

6.   The airfoil according to claim 1, wherein $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 100% span position is about 1.1 and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 90% span position is about 1.

7.   The airfoil according to claim 6, wherein $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 60% span position is about 1.4 and $(Y_{LE}-Y_d)/(Y_d-Y_{TE})$ at 50% span position is about 1.2.

8.   The airfoil according to claim 1, wherein the airfoil is a fan blade for a gas turbine engine.

9.   The airfoil according to claim 1, wherein $(YLE-Y_d)/(Y_d-Y_{TE})$ has a tolerance of +/- 0.05.

10.   A gas turbine engine comprising:

a combustor section arranged between a compressor section and a turbine section;

a fan section having an array of twenty-six or fewer fan blades, wherein the fan section has a fan pressure ratio of less than 1.55;

a geared architecture coupling the fan section to the turbine section or the compressor section; and

wherein the fan blades include an airfoil having pressure and suction sides, the airfoil extends in a radial direction from a 0% span position at an inner flow path location to a 100% span position at an airfoil tip, wherein the airfoil geometry corresponds to tangential leading and trailing edge curves and a tangential stacking offset curve, wherein the airfoil extends from a root, and a zero tangential reference point corresponds to tangential center of the root, YLE corresponds to a tangential distance from a leading edge to the reference point at a given span position, YTE corresponds to a tangential distance from a trailing edge to the reference point at a given span position, Y_d corresponds to a tangential stacking offset at a given span position, wherein $(YLE-Yd)/(Yd-Ym)$ at 40% span position is about 1.5 and $(YLE-Yd)/(Yd-YTE)$ at 20% span position is about 2.

11.   The gas turbine engine according to claim 10, wherein $(YLE-Y_d)/(Y_d-YTE)$ has a tolerance of +/- 0.05.
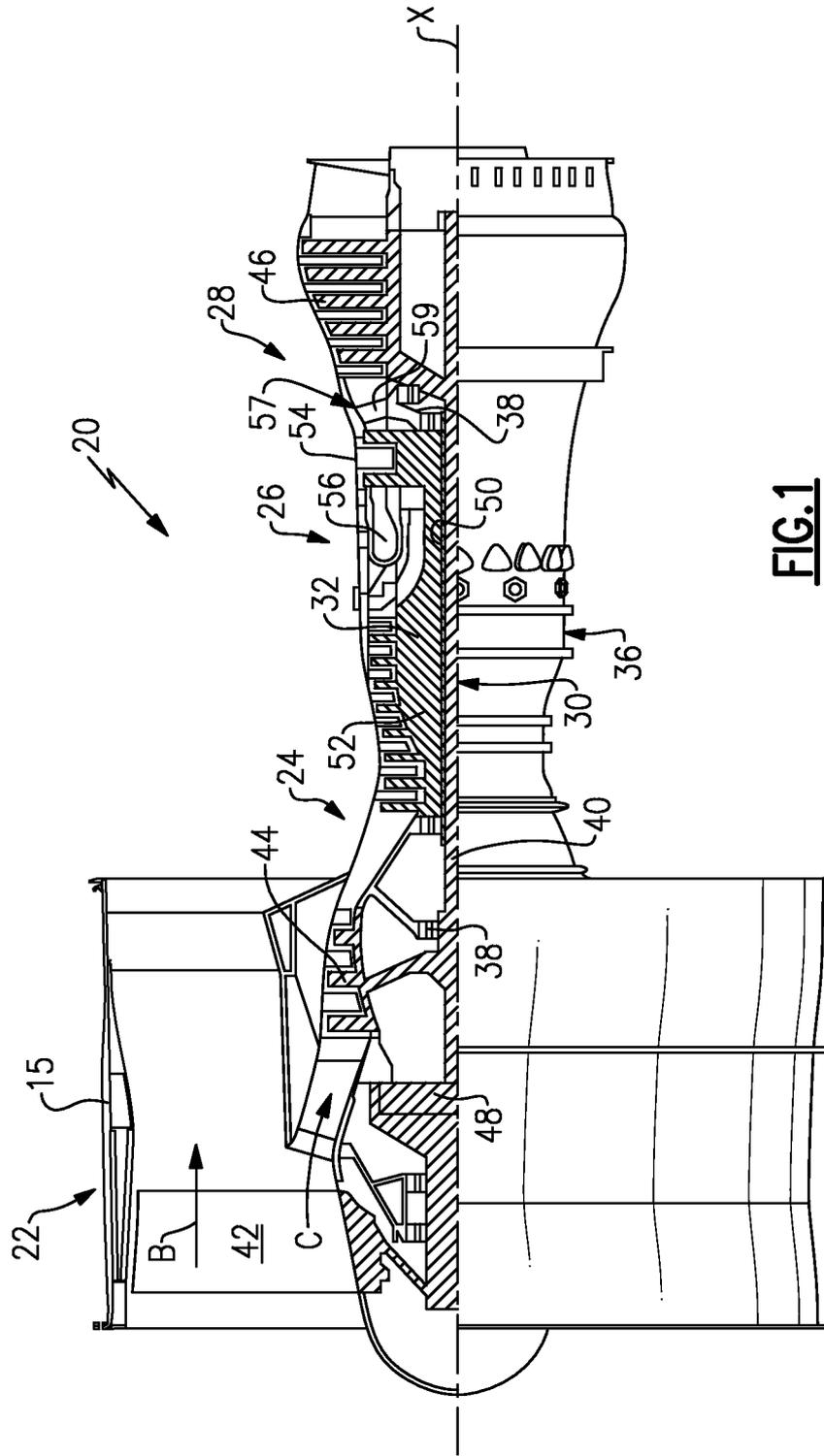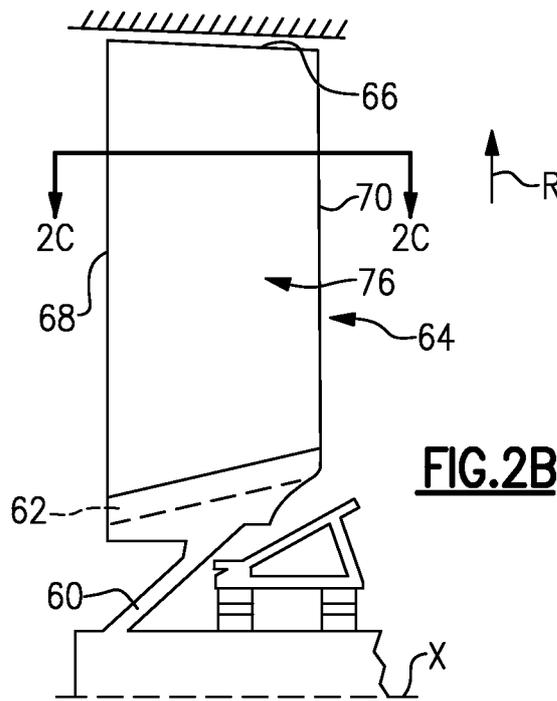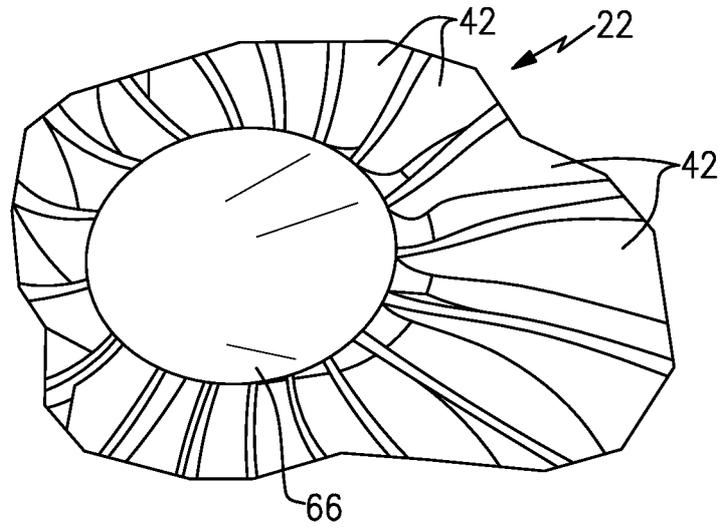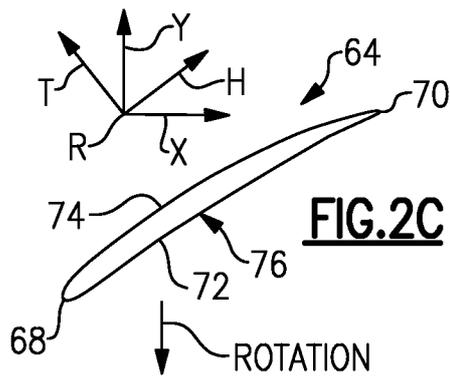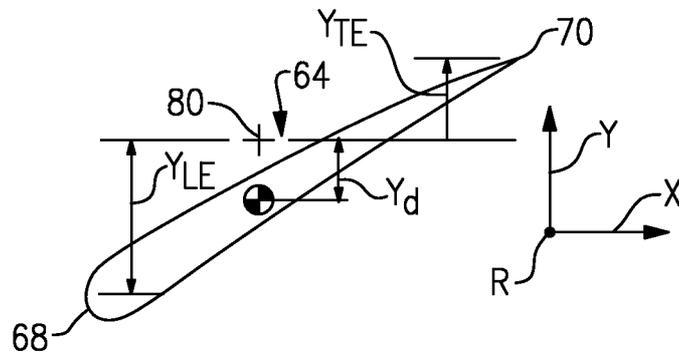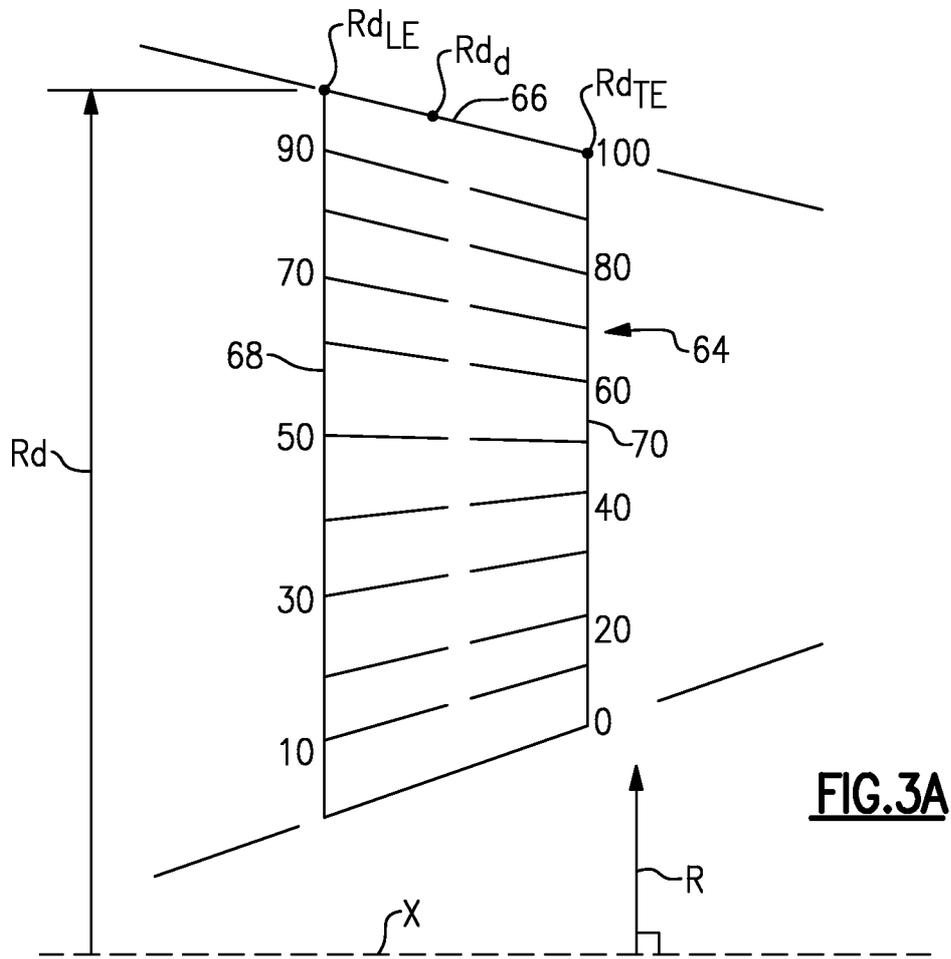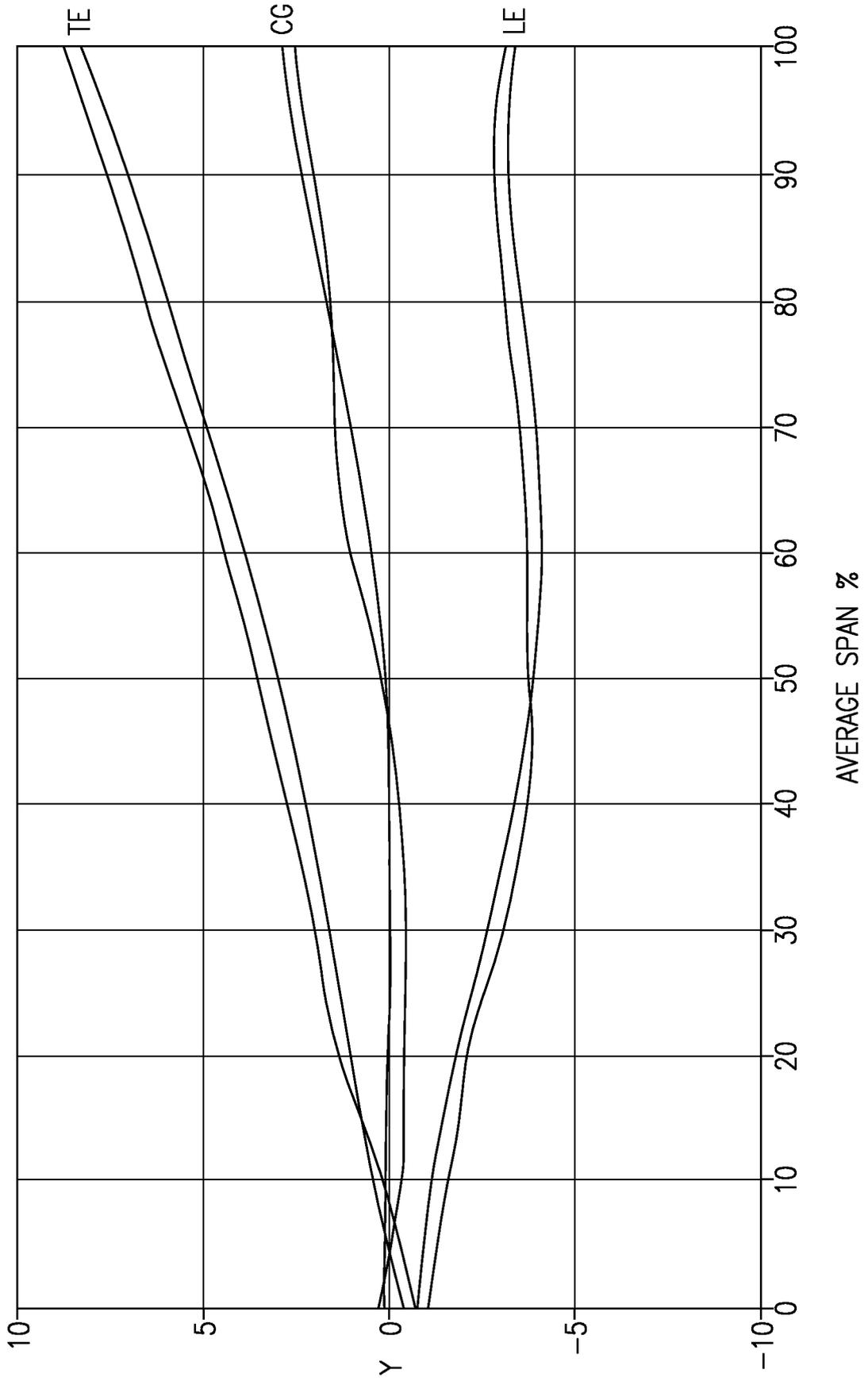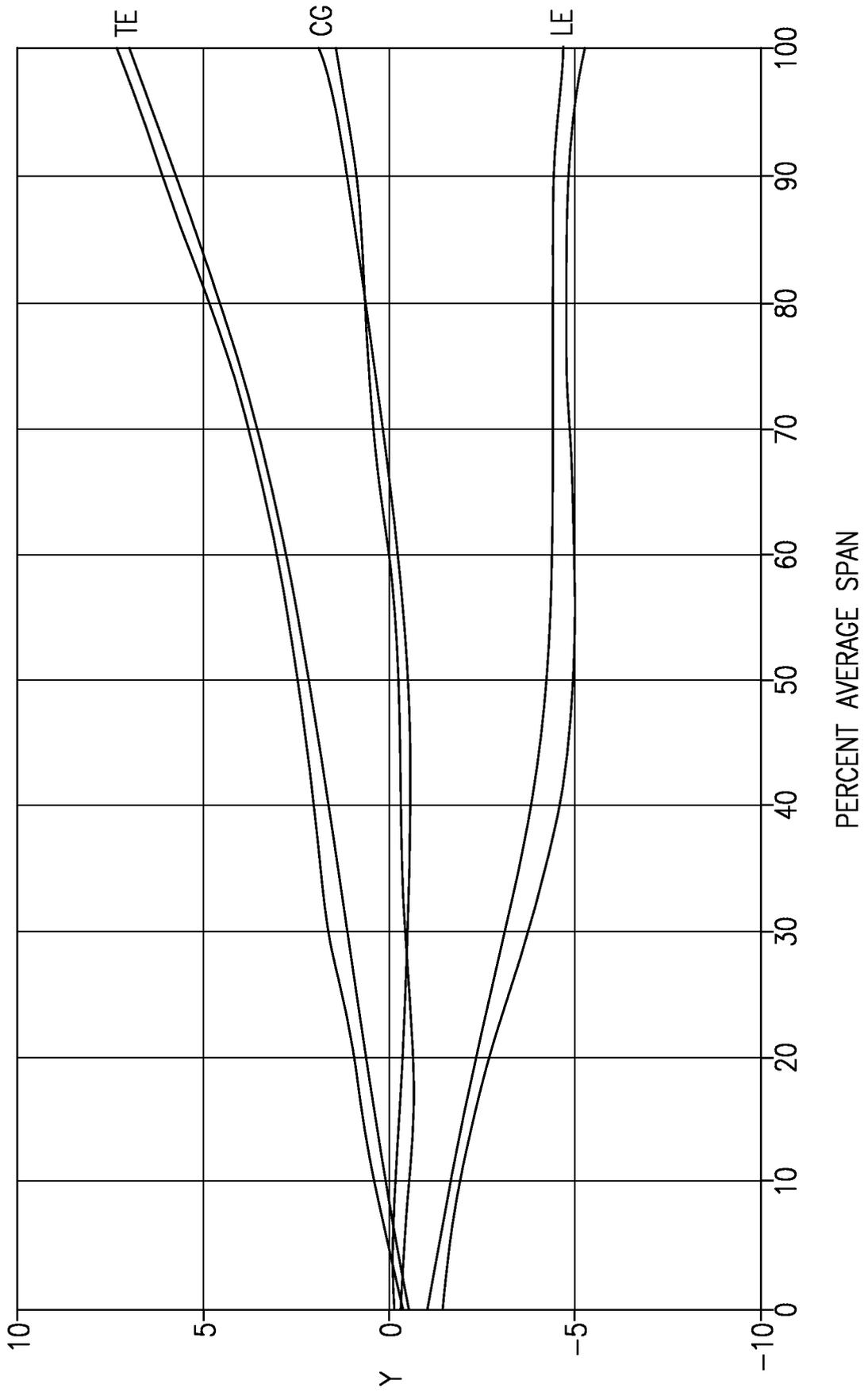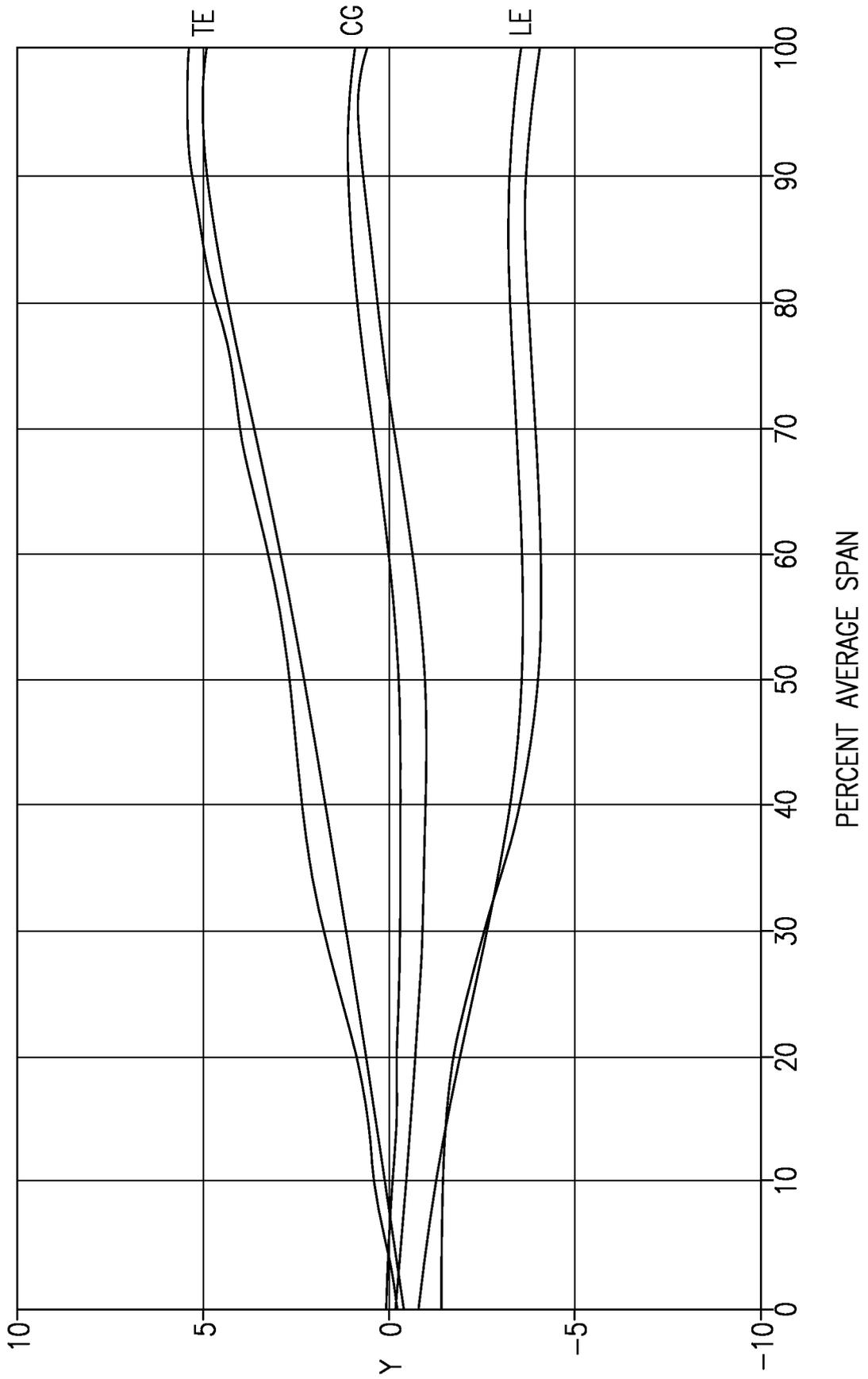
FIG.1

FIG.2A

FIG.2B

FIG.2C

3/6

FIG.3A

FIG.3B

FIG.4A

FIG.4B

FIG.4C

A.   CLASSIFICATION OF SUBJECT MATTER

F01D 5/14(2006.01)i, F02C 7/00(2006.01)i, F04D 29/38(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B.   FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01D 5/14; F02C 7/00; F04D 29/38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: airfoil, span, turbine

C.   DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2013-0259668 A1 (CHIHIRO MYOREN et al.) 03 October 2013 See figures 6-12B.	1-11
A	US 2010-0215503 A1 (MYOREN CHIHIRO et al.) 26 August 2010 See figures 5-16 .	1-11
A	US 2013-0224040 A1 (JOSEPH C. STRACCIA) 29 August 2013 See figures 5-8 .	1-11
A	US 2010-0054946 A1 (OROSA JOHN et al.) 04 March 2010 See figures 2-14 .	1-11
A	US 6331100 B1 (LIU ; HSIN-TUAN et al.) 18 December 2001 See figures 1-5 .	1-11

☐ Further documents are listed in the continuation of Box C.   ☒   See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 November 2014 (27.11.2014)	**27 November 2014 (27.11.2014)**

Name and mailing address of the ISA/KR	Authorized officer
International Application Division Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. +82-42-472-7140	LEE, Jung Hye Telephone No. +82-42-481-8437

Form PCT/ISA/210 (second sheet) (July 2009)

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013-0259668 Al	03/10/2013	CN103180617 A	26/06/2013
		EP 2631491 Al	28/08/2013
		JP 05-433793B2	05/03/2014
		WO 2012-053024 Al	26/04/2012
US 2010-0215503 Al	26/08/2010	EP 2226468 A2	08/09/2010
		JP 04-923073B2	25/04/2012
		JP 2010-196563A	09/09/2010
		US 8425185 B2	23/04/2013
US 2013-0224040 Al	29/08/2013	WO 2013-165527 A2	07/11/2013
		WO 2013-165527 A3	03/01/2014
		WO 2013-165527 A3	07/11/2013
US 2010-0054946 Al	04/03/2010	US 8147207 B2	03/04/2012
US 6331100 Bl	18/12/2001	CA 2326424 Al	06/06/2001
		CA 2326424 C	09/06/2009
		CN1299003 AO	13/06/2001
		CN1311144 CO	18/04/2007
		DE60039957 Dl	02/10/2008
		EP 1106836 A2	13/06/2001
		EP 1106836 A3	19/05/2004
		EP 1106836 Bl	20/08/2008
		JP 04-771585B2	14/09/2011
		JP 2001-193692A	17/07/2001
		KR 10-0827055 Bl	02/05/2008
		KR 20010062118A	07/07/2001
		PL196777 Bl	31/01/2008
		PL342227 Al	18/06/2001
		RU2228461 C2	10/05/2004