



US 20250256838A1

(19) **United States**

(12) **Patent Application Publication**
Ullman et al.

(10) **Pub. No.: US 2025/0256838 A1**

(43) **Pub. Date: Aug. 14, 2025**

(54) **LEADING-EDGE DUCTED FAN THRUST
REDUCTION SYSTEM**

B64C 13/16 (2006.01)

B64C 21/00 (2023.01)

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

CPC *B64C 13/50* (2013.01); *B64C 7/02*
(2013.01); *B64C 13/04* (2013.01); *B64C 13/16*
(2013.01); *B64C 21/00* (2013.01)

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(57)

ABSTRACT

The present invention is a powered electric lift augmentation systems (ELAS's) to add drag while minimally reducing or enhancing the lift augmentation of an airplane. At least one ELAS is attached to an airfoil, and each ELAS comprises: a nacelle; and electric duct fan (EDF) housed within the nacelle; an optional pylon perpendicularly connected beneath the nacelle; an optional slat; and one or more drag elements, pivotably connected through a range of angles to airflow. Each drag element comprises a hinged plate, or a pair of opposing plates, connected to a pilot's control element able to rotate the plates to create a range of drag levels or to stow away. The drag elements are connected to the airfoil leading edge, the nacelle, pylon, or slat; and may further comprises holes. As ELAS assembly may comprise one or more ELAS systems attached to an airfoil (aerodynamic lifting element—ALE).

(21) Appl. No.: **19/034,465**

(22) Filed: **Jan. 22, 2025**

Related U.S. Application Data

(60) Provisional application No. 63/553,603, filed on Feb. 14, 2024.

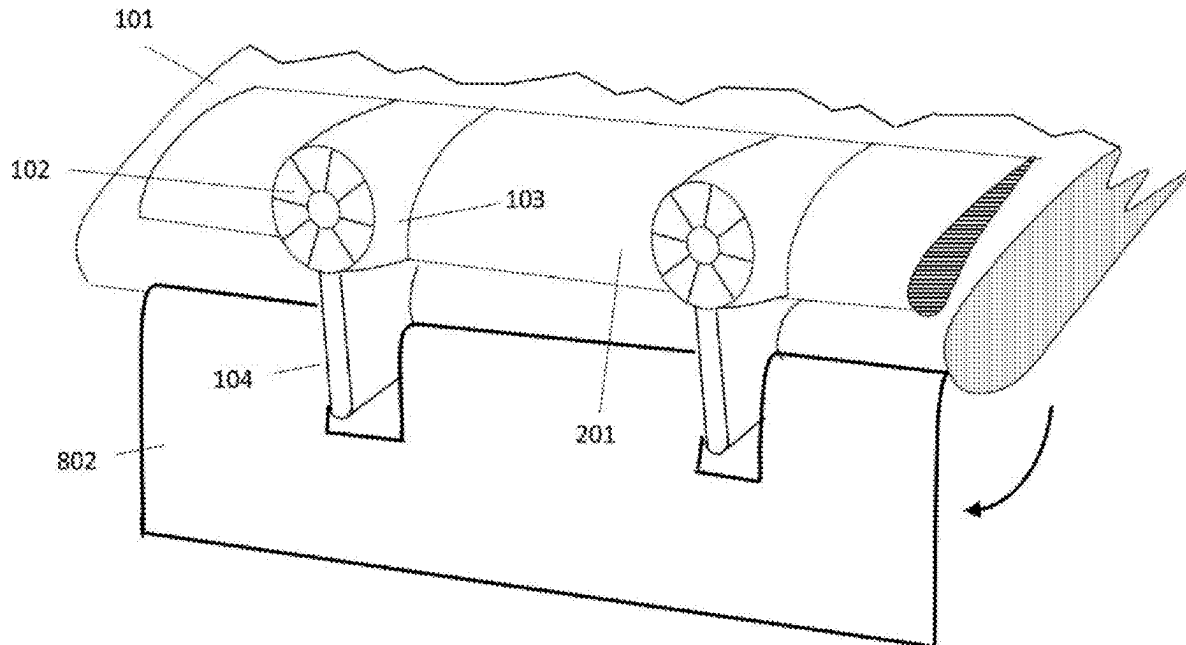
Publication Classification

(51) **Int. Cl.**

B64C 13/50 (2006.01)

B64C 7/02 (2006.01)

B64C 13/04 (2006.01)



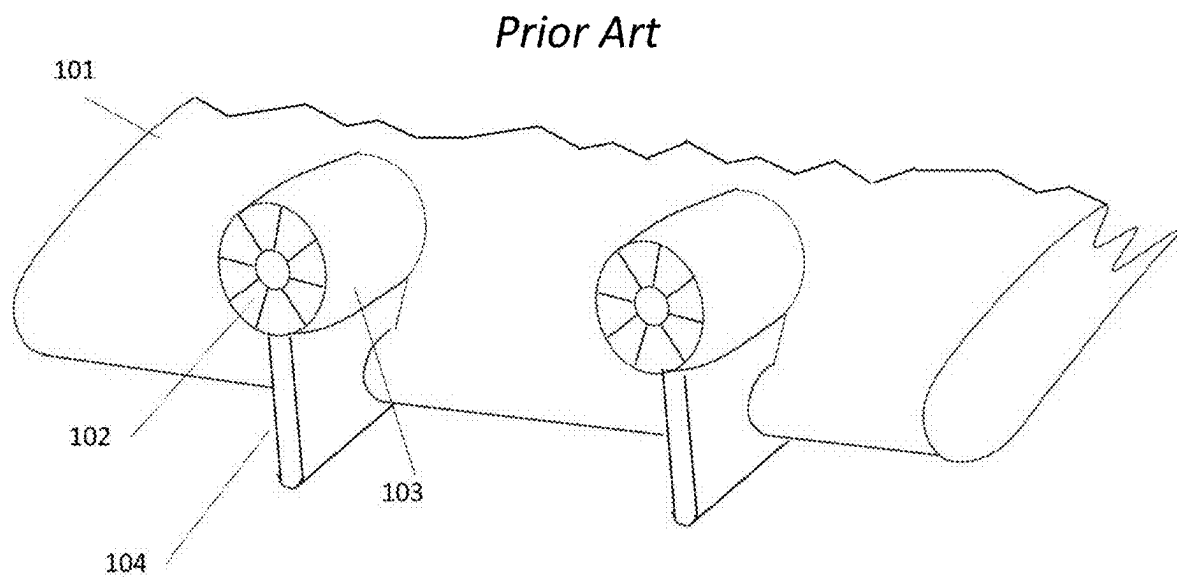


FIG. 1

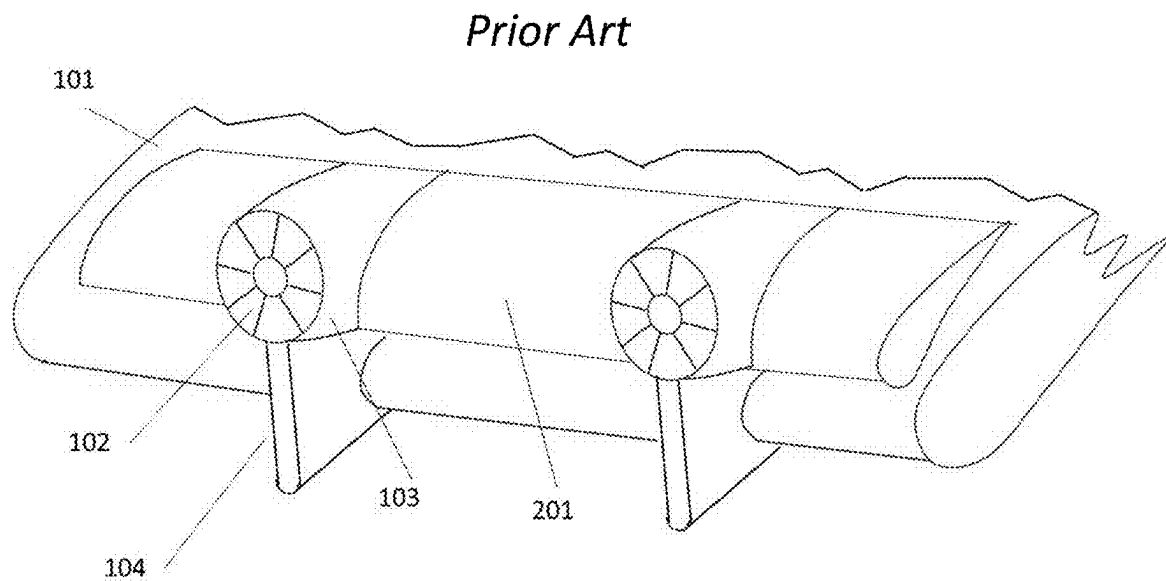


FIG. 2

Prior Art

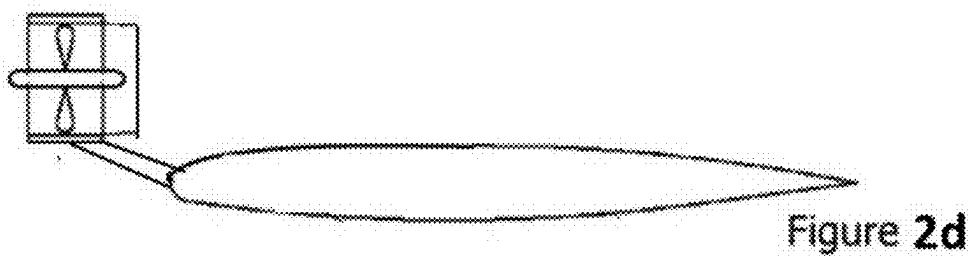
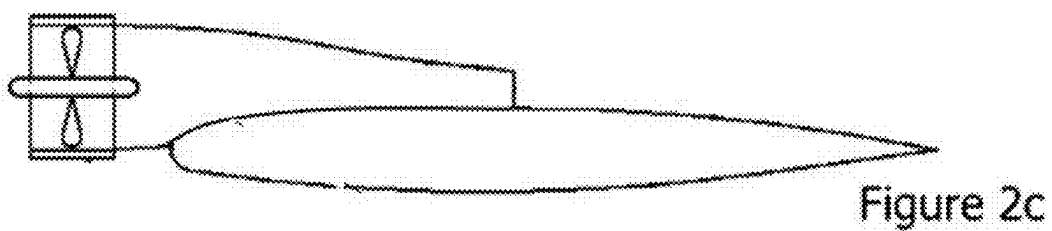
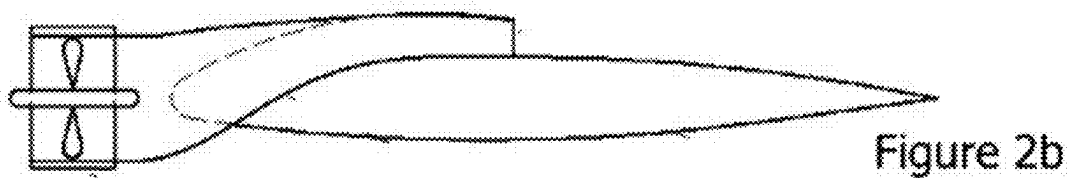
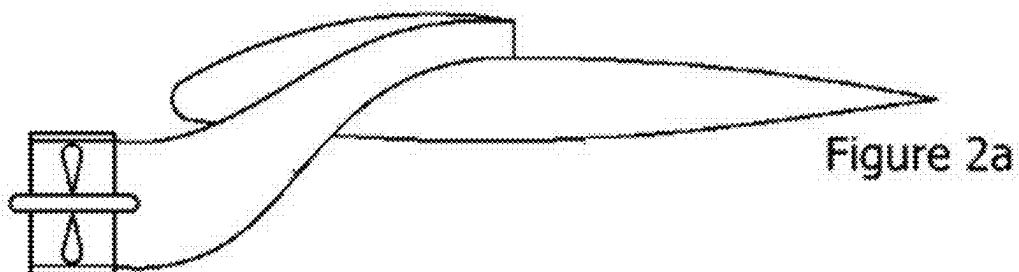


FIG. 3

Prior Art

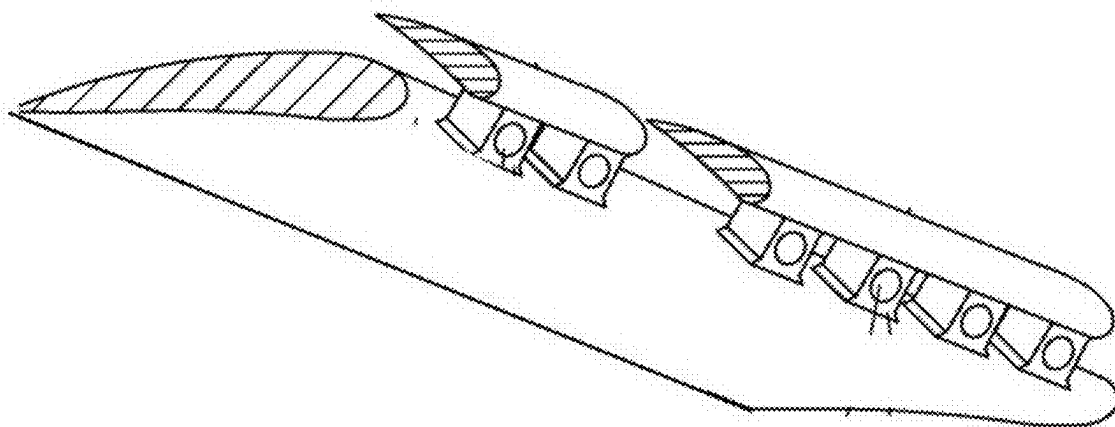


FIG. 4

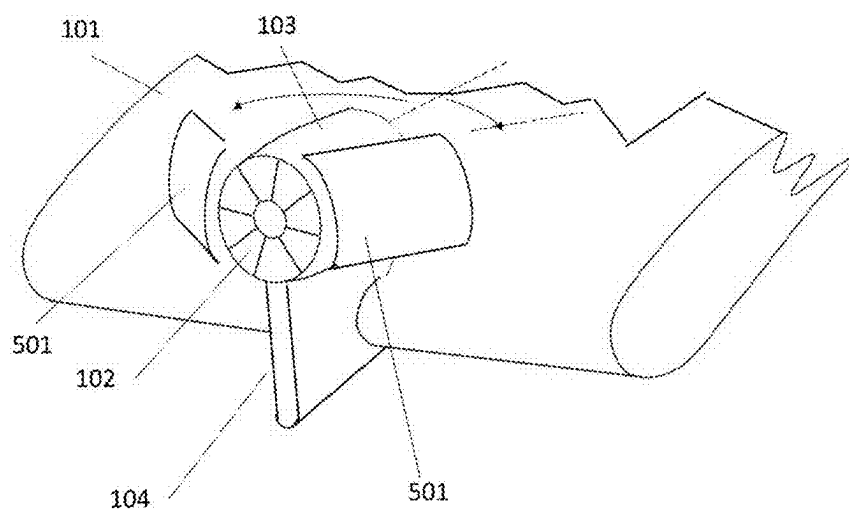


FIG. 5A

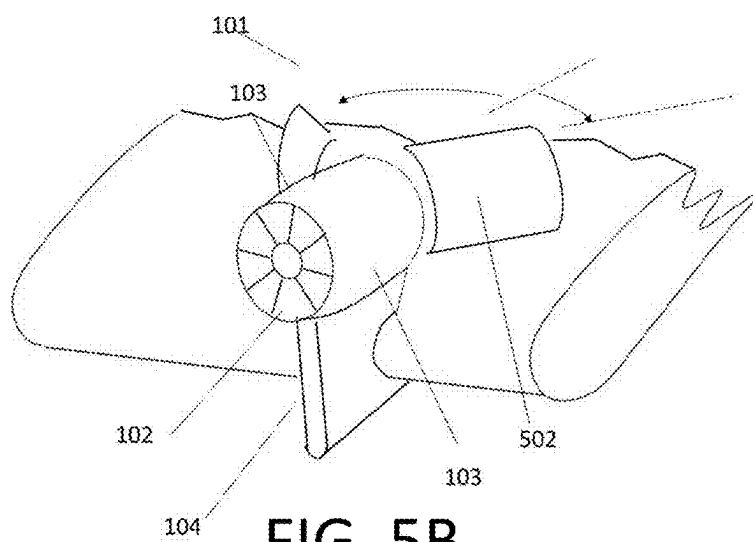


FIG. 5B

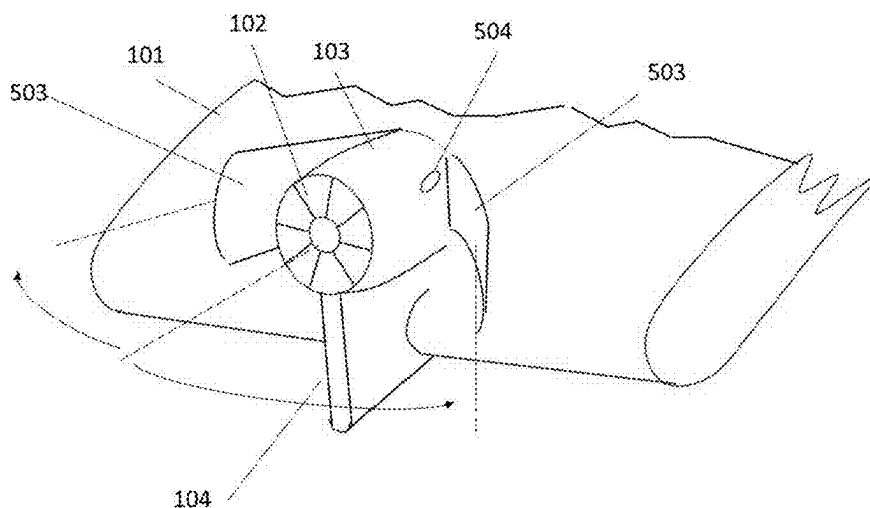


FIG. 5C

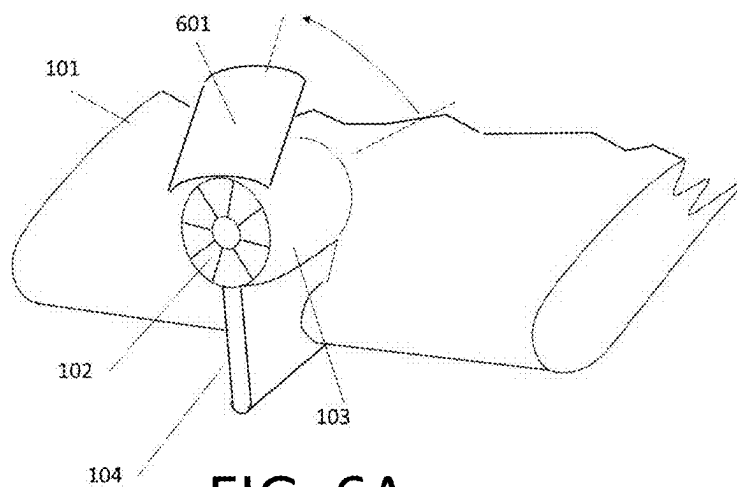


FIG. 6A

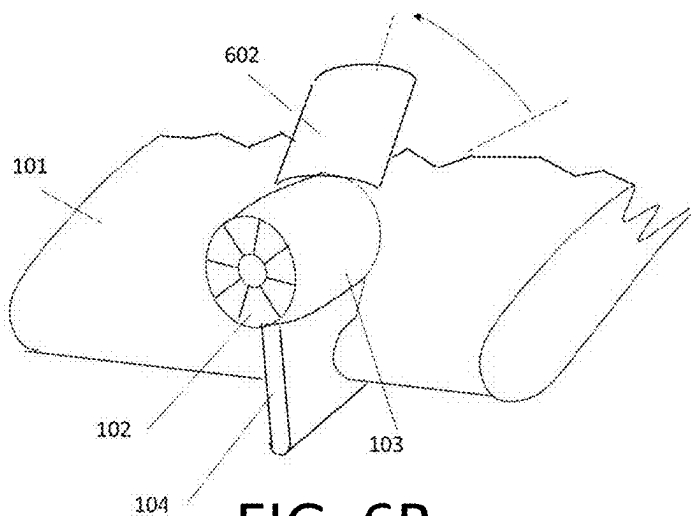


FIG. 6B

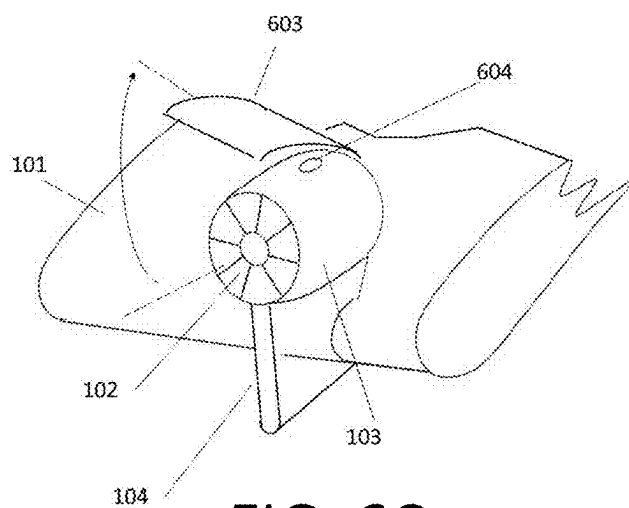


FIG. 6C

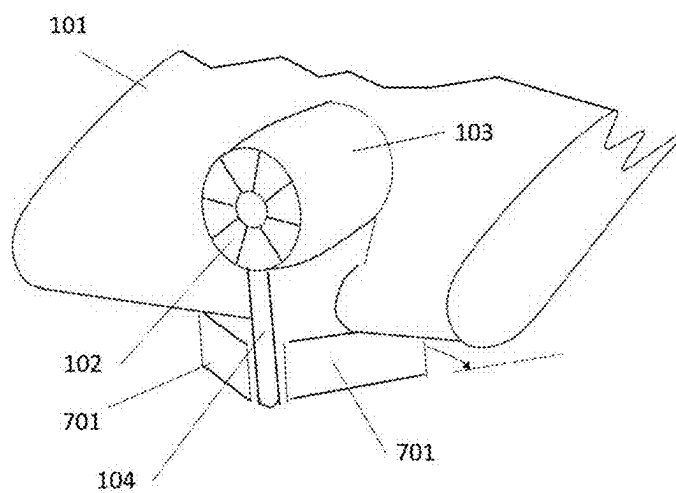


FIG. 7A

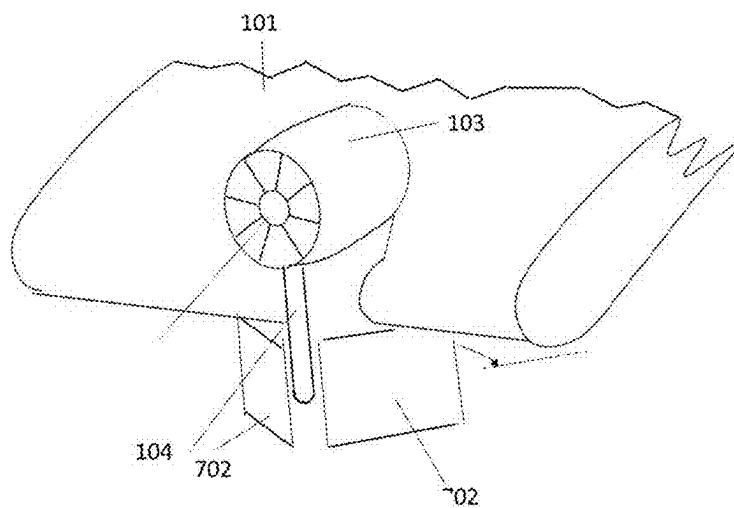
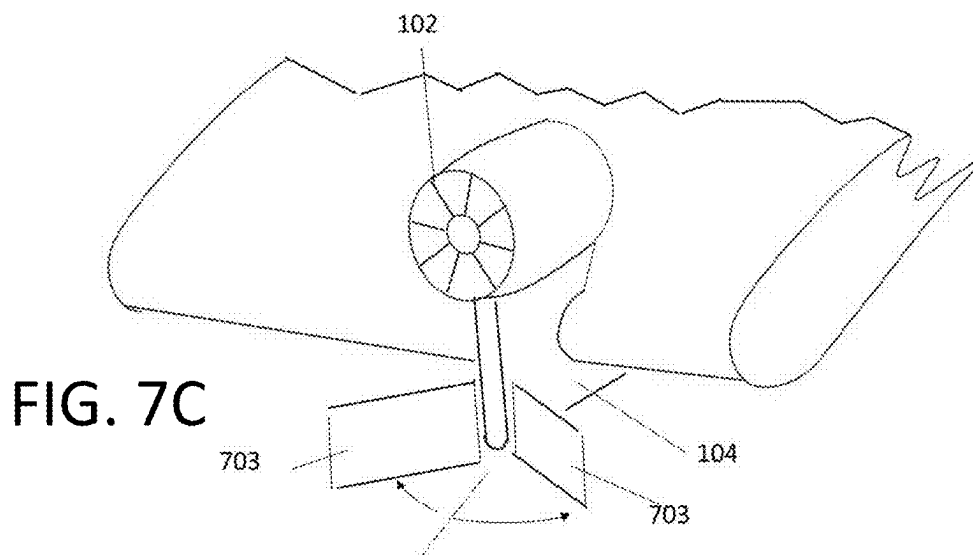


FIG. 7B



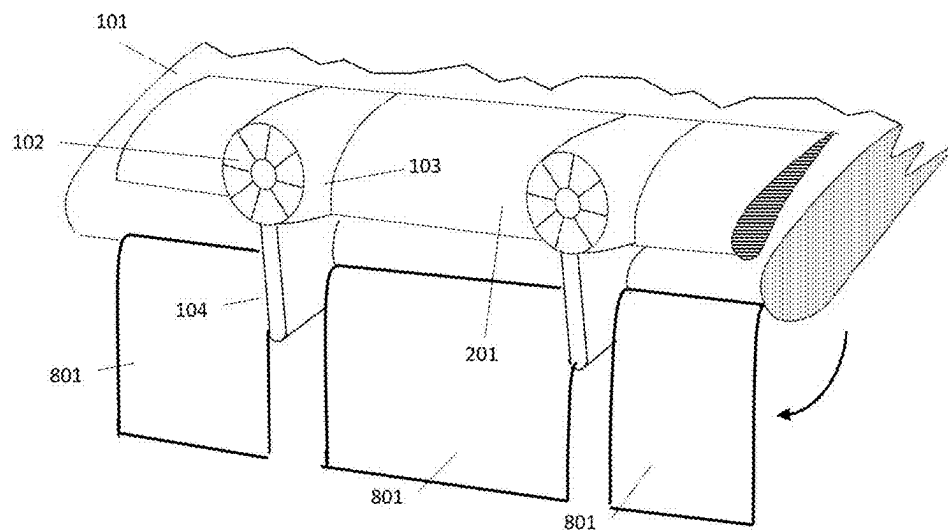


FIG. 8A

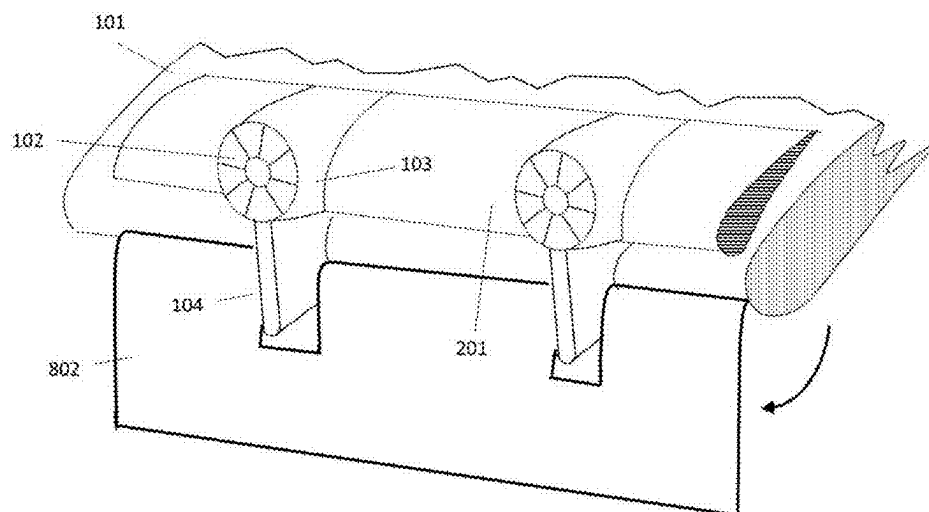


FIG. 8B

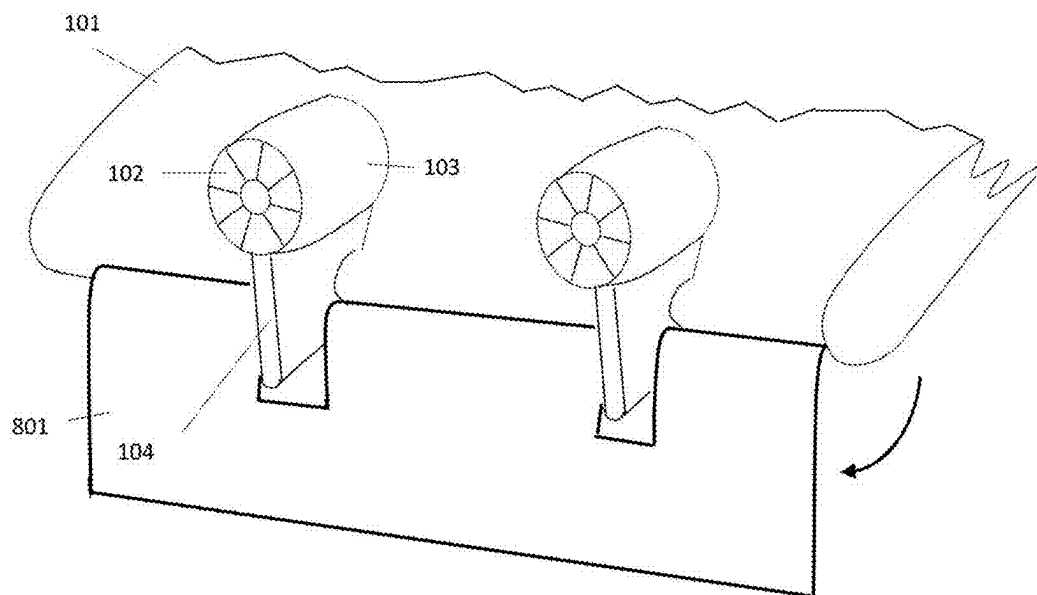
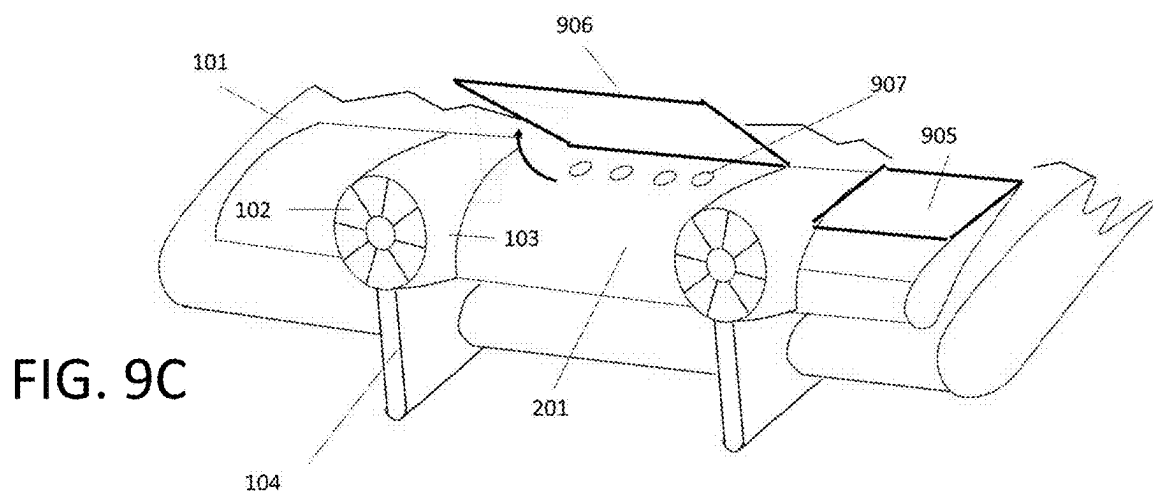
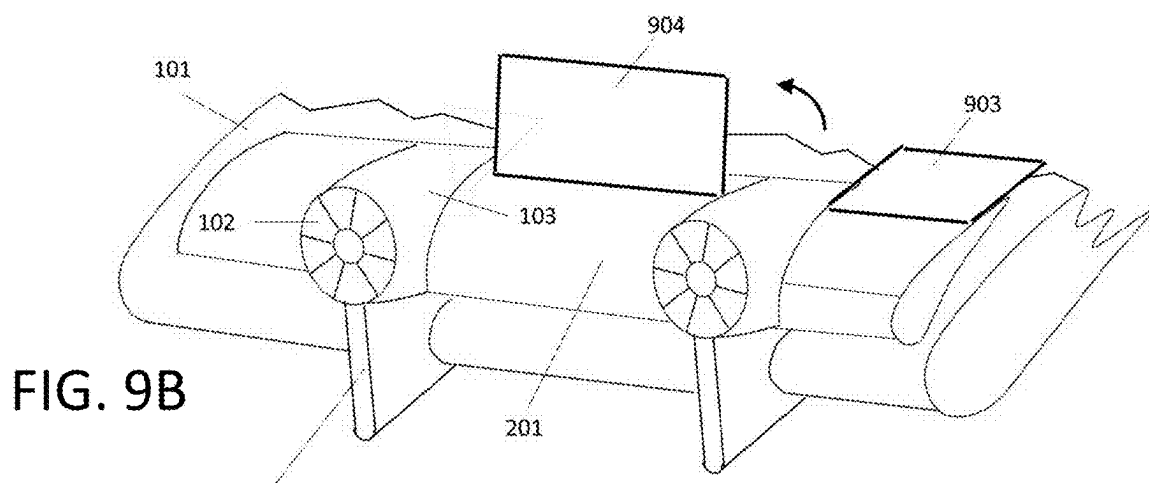
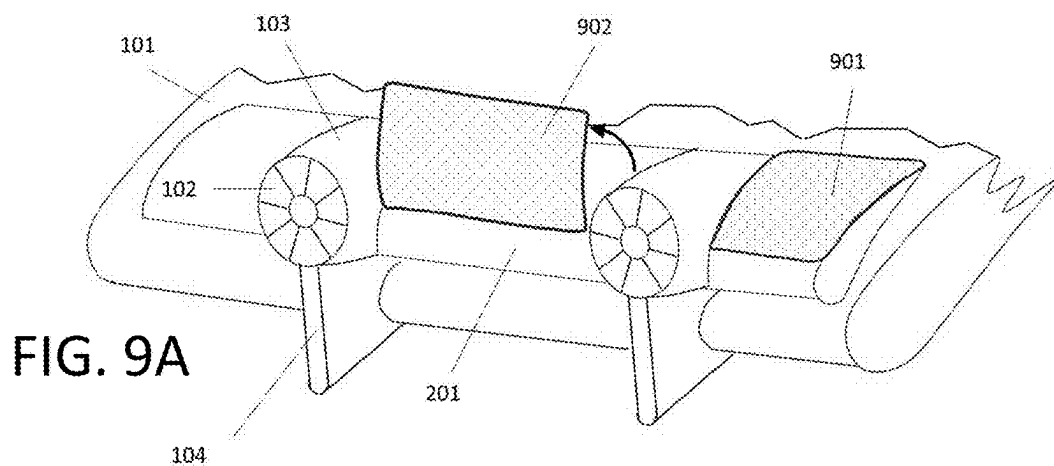


FIG. 8C



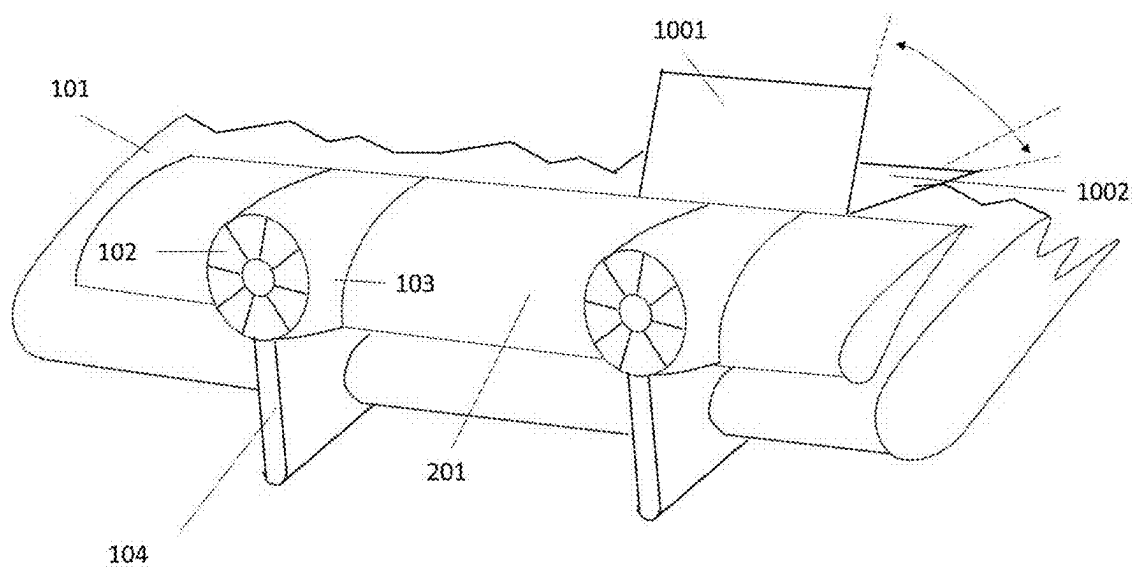


FIG. 10

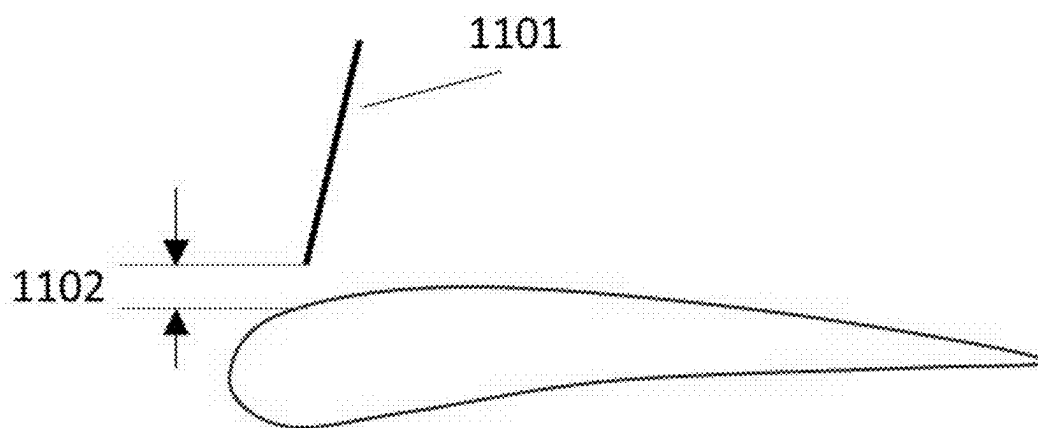


FIG. 11

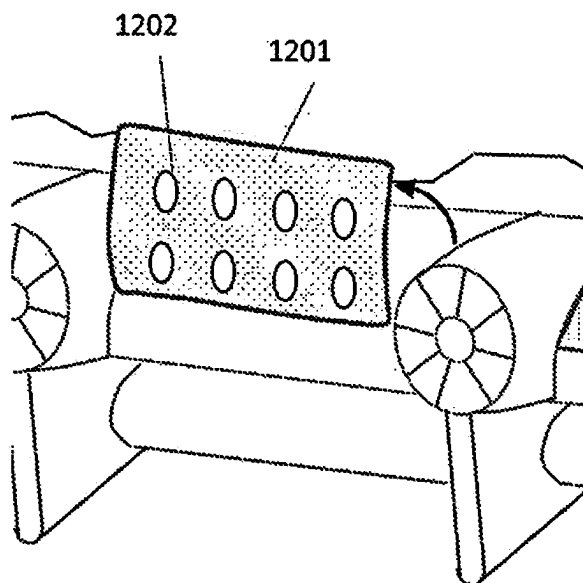
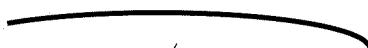


FIG. 12



1301

FIG. 13A



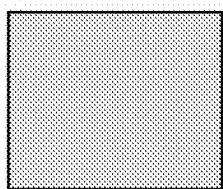
1302

FIG. 13B



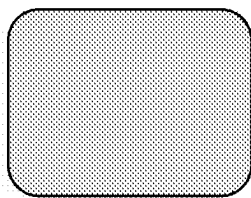
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FIG. 13C



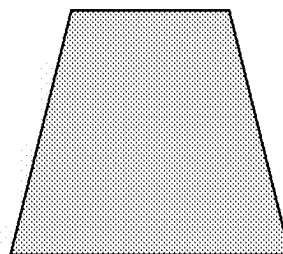
1401

FIG. 14A



1402

FIG. 14B



1403

FIG. 14C

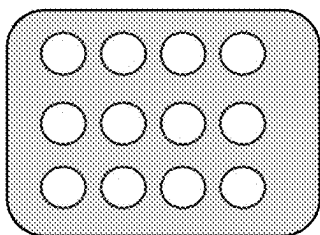


FIG. 15A

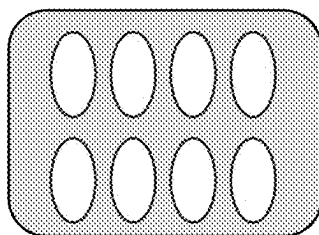


FIG. 15B

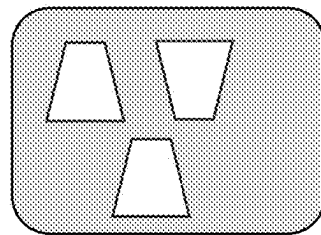


FIG. 15C

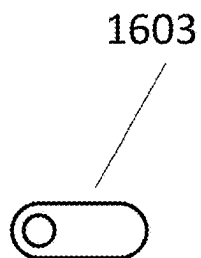


FIG. 16A

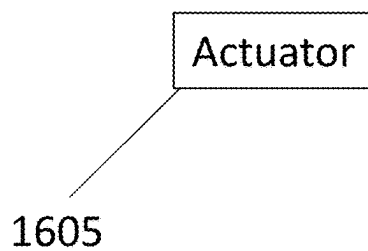


FIG. 16B

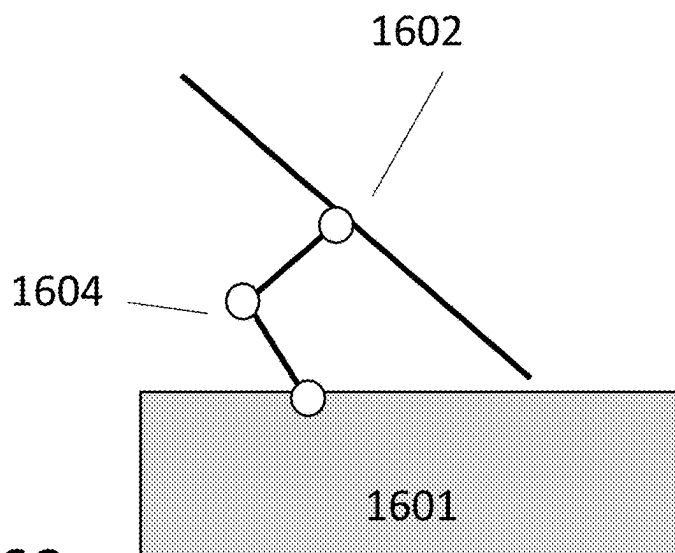


FIG. 16C

LEADING-EDGE DUCTED FAN THRUST REDUCTION SYSTEM

FIELD OF THE INVENTION

[0001] The present invention generally relates to airplane airfoil drag; and particularly to an apparatus and system on an airfoil, and a method of use, to increase the airplane lift while minimally adding unwanted thrust.

BACKGROUND OF THE INVENTION

[0002] There is a strong need to develop aircraft that can take off and land in short distances. Shortening these distances over the current capabilities requires higher lift at low speeds and improved low-speed control capabilities. Increasing lift can be obtained using a lift-augmentation system.

[0003] The prior art discloses two types of leading-edge ducted fan systems that can provide the needed lift augmentation at sub-sonic speeds:

[0004] U.S. Pat. No. 10,926,868 (aka 868), “Distributed Leading-Edge Lifting Surface Slat and Associated Electric Ducted Fans for Fixed Lifting Surface Aircraft,” Ullman, Horgan, and Homer, assigned to Cub Crafters, granted Feb. 3, 2021.

[0005] U.S. Pat. No. 10,099,793 (aka 793), “Distributed Electric Ducted Fan Wing,” Ullman and Homer, granted Oct. 16, 2018.

[0006] These two patents will hereafter be referred to as 868 and 793. Patent 793 discloses a ducted fan accelerating air over the top surface of lifting surfaces and providing lift augmentation. Patent 868 discloses a combination of ducted fan and slat system to accomplish the same.

[0007] These systems not only augment lift but produce thrust. While the air accelerated by the ducted fans produces lift by lowering the pressure on the lifting surface, there is also a thrust component. This thrust component is helpful on takeoff and climb out but is unwanted during other phases of the flight envelope, such as descent and landing.

[0008] There are many ways of increasing the drag on an aircraft, such as spoilers, flaps, speed brakes, belly flaps, parachutes, deflected panels, and the like. The concept here is to increase the drag with a system integrated into the ducted fan system described in either U.S. Pat. Nos. 10,099,793 or 10,926,868. This aims to reduce the unwanted thrust by increasing the drag while minimally affecting the lift augmentation. Integrated means that the thrust reduction system is physically part of the lift augmentation system described in the patents.

[0009] The desire for an integrated system is predicated on the thought that the systems envisioned in U.S. Pat. Nos. 10,926,868 and 10,099,793 might be add-ons to existing aircraft or be implemented with the desire to minimally affect the design of aircraft. Thus, providing a single package that augments the lift with a useful thrust component and is also controllable with the thrust reduced is desirable.

SUMMARY OF THE INVENTION

[0010] The various embodiments of the present invention comprise: a powered aerodynamic lift device, comprising: a) one or more electric lift augmentation systems (ELAS) distributed along a span of an aerodynamic surface near a leading edge of an aerodynamic lifting element (ALE—i.e. airfoil), each ELAS comprising: i) one nacelle positioned along

the leading edge of an aerodynamic lifting element; ii) an electric duct fan (EDF) housed within the nacelle, each EDF comprising a fan and a power source to operate the fan, wherein each EDF forces accelerated air through the fan; iii) one pylon (optional) positioned perpendicularly between the nacelle and the airfoil; and iv) one or more slats (optional); and b) one or more drag elements pivotably connected to the ELAS, and each drag element comprising a rotatable/hinged/pivotable plate connected to a control element able to rotate the plate to create a range of drag; and c) wherein the one or more ELAS's add drag while minimally reducing or even enhancing the lift augmentation of the powered aerodynamic lift device.

[0011] In an embodiment, one or more (e.g. a pair) of drag elements are pivotably connected to one or more EDFs (e.g. nacelle's outer curved surface), and face forward or backward. In an embodiment, one or more (e.g. a pair) of drag elements are pivotably connected to one or more pylons, which are connected between the nacelle and the airfoil, and the drag elements face forward or backward. In an embodiment, a slat is positioned above the leading edge of the aerodynamic lifting element, and the one or more drag elements are positioned on the slats, facing forward or backwards, on the leading or trailing edge of the slats.

[0012] In an embodiment, the ELAS's comprise a plurality of holes or gaps in the drag elements, slats, or nacelle.

[0013] In an embodiment, the assembly comprises one or more pylons extending perpendicular to an ALE leading edge, and the one or more drag elements, or the EDF and nacelle, are attached to the one or more pylons.

[0014] In an embodiment, the one or more drag elements comprise one or more shapes of: a planar flat plate; a curved flat plate shaped to fit over a nacelle when stowed; and an airfoil shape curved to fit over the ALE/airfoil when stowed. By way of non-limiting examples, the planar flat plates comprise: rectangular; rectangular with rounded corners; and rectangular while tapered moving aft.

[0015] In an embodiment, the one or more drag elements are rotatable from one or more positions that create drag to stowed positions that create no drag. For example, the one or more drag elements are connected on one end to the nacelle or slat or pylon, and the opposing end rotates against an airflow to create drag.

[0016] In an embodiment, the assemblies comprise an electrical circuit control system comprising a master control unit able to control the operation of the ELAS, the master control unit comprising: 1) a plurality of electronic speed controllers (ESCs) able to control the speed of the EDFs, 2) a plurality of pivot control units to position the drag elements; and 3) a plurality of actuators. For example, the master control unit further controls the modulation of energy supplied by a power source to the EDFs and drag elements, wherein the power source comprises one or more of: batteries, a fuel cell, an engine/generator or other electrical energy source.

[0017] In an embodiment, the assemblies comprise an actuator element coupled to each drag element, or to all drag elements connected to one nacelle, wherein the actuator element enables a pilot to control the rotation of the drag element. The actuator element further controls the modulation of energy supplied by a power source to the drag elements, wherein the power source comprises one or more of: batteries, a fuel cell, an engine/generator or other energy source comprising: pneumatically, hydraulically, or by using

the flowing air to provide actuation force. And/or the drag elements are controlled by the pilot, manually or automatically or some combination thereof.

[0018] In an embodiment, the assemblies further comprise a gap between the drag elements and a surface the drag element is attached to comprising: the ALE; the nacelle; or a slat.

[0019] In another embodiment, one or more drag elements are on the leading edge of the airfoil (e.g. FIGS. 8A-8C).

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] In the following drawings, all the deployable elements are called drag elements. They could also be called speed brakes, deflected panels, etc. The term “drag element” can be a single or multiple elements, as the drawings describe. Further, other elements, referred to as “flow elements,” direct the flow in concert with the drag elements.

[0021] FIG. 1 is an illustration of a prior art leading-edge lift augmentation system envisioned in 793.

[0022] FIG. 2 is an illustration of a prior art typical leading-edge lift augmentation system envisioned in 868.

[0023] FIG. 3 is an illustration of a prior art optional placement of the EDFs relative to the lifting surface as envisioned in U.S. Pat. No. 10,099,793, FIGS. 2A-2D.

[0024] FIG. 4 is an illustration of a prior art placement of EDFs with slats as envisioned in U.S. Pat. No. 10,926,868.

[0025] FIG. 5A is an illustration of a pair of opposing drag elements deployed in a generally spanwise direction from a nacelle, wherein the drag elements open/close rearward and are attached to the nacelle front surface.

[0026] FIG. 5B is an illustration of a pair of opposing drag elements deployed in a generally spanwise direction from a nacelle, wherein the drag elements open/close rearward and are attached to the nacelle back surface.

[0027] FIG. 5C is an illustration of a pair of opposing drag elements deployed in a generally spanwise direction from a nacelle, wherein the drag elements open/close forward and are attached to the nacelle back surface.

[0028] FIG. 6A is an illustration of one drag element deployed in a generally vertical direction from a nacelle, wherein the drag element opens/closes rearward and is attached to the nacelle front surface.

[0029] FIG. 6B is an illustration of one drag element deployed in a generally vertical direction from a nacelle, wherein the drag element opens/closes rearward and is attached to the nacelle back surface.

[0030] FIG. 6C is an illustration of one drag element deployed in a generally vertical direction from a nacelle, wherein the drag element opens/closes forward and is attached to the nacelle back surface.

[0031] FIG. 7A is an illustration of a pair drag elements deployed in a general spanwise direction from a pylon, wherein the drag element opens/closes rearward, are generally rectangular shaped and do not extend below the pylon.

[0032] FIG. 7B is an illustration of a pair drag elements deployed in a general spanwise direction from a pylon, wherein the drag element opens/closes rearward, and are generally square or rectangular shaped and extend below the pylon.

[0033] FIG. 7C is an illustration of a pair drag elements deployed in a general spanwise direction from a pylon, wherein the drag element opens/closes forward, and are generally square or rectangular shaped and may extend below the pylon.

[0034] FIG. 8A is an illustration of an ELAS with a slat and a plurality of drag elements deployed in a generally spanwise direction from a pylon or lifting surface (e.g. an ALE/airfoil leading edge).

[0035] FIG. 8B is an illustration of an ELAS with a slat and one drag element extending in a generally spanwise direction from a plurality of pylons or a lifting surface (e.g. an ALE/airfoil leading edge), wherein the exemplified drag element has rectangular shaped openings/cutouts to fit around two pylons.

[0036] FIG. 8C is an illustration of an ELAS without a slat, and one drag element extending in a generally spanwise direction from a plurality of pylons or a lifting surface (e.g. an ALE/airfoil leading edge), wherein the exemplified drag element has rectangular shaped openings/cutouts to fit around two pylons.

[0037] FIG. 9A is an illustration of drag elements deployed in a generally upward direction from near the slat's leading edge.

[0038] FIG. 9B is an illustration of drag elements deployed in a generally upward direction from the slats midsection.

[0039] FIG. 9C is an illustration of drag elements deployed in a generally upward direction from the slats trailing edge, wherein the drag elements open forward.

[0040] FIG. 10 is an illustration of drag elements deployed in a generally upward direction from the slats trailing edge, wherein the drag elements open rearward.

[0041] FIG. 11 is an illustration a gap between drag elements and surface/ELAS.

[0042] FIG. 12 is an illustration drag elements with holes.

[0043] FIG. 13A is an illustration of the cross section of drag element comprising a planar flat plates

[0044] FIG. 13B is an illustration of the cross section of a drag element comprising a flat plate that is curved to fit the surface (e.g. airfoil/ALE or slat) when stowed.

[0045] FIG. 13C is an illustration of the cross section of a drag element generally curved, airfoil shaped with one side to fit the surface (e.g. airfoil/ALE or slat) when stowed.

[0046] FIG. 14A is an illustration of the planform (top/ bottom plan view) of a rectangular drag element.

[0047] FIG. 14B is an illustration of the planform (top/ bottom plan view) of a rectangular with rounded corners drag element.

[0048] FIG. 14C is an illustration of the planform (top/ bottom plan view) of a rectangular but tapered moving aft drag element.

[0049] FIG. 15A is an illustration of a plurality of circular holes within a drag element.

[0050] FIG. 15B is an illustration of a plurality of oval holes within a drag element.

[0051] FIG. 15C is an illustration of a plurality of isosceles trapezoid holes within a drag element.

[0052] FIG. 16A is an illustration of a pilot actuated switch or automatic mechanism to rotate drag elements into position or stow away.

[0053] FIG. 16B is an illustration of a linkage, screw or other actuator for rotating the drag elements, or powered by the EDFs.

[0054] FIG. 16C is an illustration of a pneumatic, hydraulic, electric mechanism to control rotation of the drag elements.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Glossary of Terms

[0055] As used herein, the term “aerodynamic lifting element” or “ALE” refers to an airfoil.

[0056] As used herein, the term “lift augmentation” refers to the ratio of the lift generated by artificially accelerating the air over the upper aerodynamic surface of a lifting body (airfoil) to the lift generated without said acceleration.

[0057] As used herein, the term “electric lift augmentation system” or ELAS refers to an assembly comprising: an electric duct fan, housed within a nacelle, and an optional pylon, and an optional slat, wherein one or a pair of opposing drag elements are pivotably connected to the nacelle, pylon or slats.

[0058] As used herein, the term “EDF” refers to electric duct fan, which is housed within a nacelle.

[0059] As used herein, the term “nacelle” refers to a circular streamlined housing on the outside of an airfoil or ALE.

[0060] The basic concept is to add drag while minimally reducing or even enhancing the lift augmentation of the system. The systems patented in 868 and 793 both augment or enhance the lift on the surface of a body by increasing the velocity of the air over the convex surface of the body. For each doubling of the air velocity at a point, the lift is increased by a factor of four at that point, a square of the increase in velocity. The amount of augmentation at that point is thus four. The augmentation over a lifting surface is the sum of the local augmentations times the area acted on by each. The accelerated air also adds thrust, which in some scenarios such as descending and landing is unwanted.

[0061] A majority of the concepts apply to both systems with slats (868) and without slats (793). FIG. 1 shows a typical system developed in prior art patent 793. Here, a lifting surface **101** has attached a system comprising an electric ducted fan (EDF) **102** housed in a nacelle **103**. The EDF and nacelle are optionally held off the lifting surface by a pylon **104**. The EDF, nacelle and optional pylon is one configuration of the ELAS.

[0062] As shown in FIG. 2, the above system can also have slats **201**, bridging the gap between nacelles **103** or extending beyond them as is covered in prior art patent 868. The EDF, nacelle, optional pylon and optional slat is one configuration of ELAS.

[0063] FIG. 3 is from prior art **793**, FIGS. 2A-2D, and illustrate the possible relative position of the EDF normal to the lifting surface.

[0064] FIG. 4 is taken from prior art patent **868**, showing the spanwise distribution of nacelles.

[0065] FIG. 5A shows the electric ducted fan **102** housed in a nacelle **103** and with optional pylon **104** with extendable drag elements **501** flexibly attached or hinged to the nacelle **103** near the leading edge and opening to the rear, as shown. These can be stowed and streamlined into the shape of the nacelle when not deployed and then actuated into the airflow when needed, as shown. Drag elements **501** can be in pairs as shown or on just one side of nacelle **103**. The deployed position can be variable if needed and asymmetrical if in pairs.

[0066] FIG. 5B shows the electric ducted fan **102** housed in a nacelle **103** with extendable drag elements **502** flexibly attached or hinged to the nacelle **103** near the trailing edge

and opening to the rear as shown. As with **501**, they can be variably and asymmetrical deployed. The extendable drag elements can direct the EDF thrust from side to side as needed either when stowed or deployed by moving them asymmetrical. Drag elements **502** can be in pairs as shown or on just one side. The deployed position can be variable if needed and asymmetrical if in pairs.

[0067] FIG. 5C shows the electric ducted fan **102** housed in a nacelle **103** with extendable drag elements **503** flexibly attached or hinged to the nacelle **103** near the trailing edge and opening forward. When stowed these are flush with the nacelle. These can be stowed and streamlined into the shape of the nacelle when not deployed and then actuated into the airflow when needed, as shown. Drag elements **503** can be in pairs as shown or on just one side. The deployed position can be variable if needed and asymmetrical if in pairs. Optionally, the aft edge of the drag elements **503** may be designed to add airflow to the EDF **102** air stream. Holes or vents **504** in nacelle **103** can be added to add airflow to the EDF **102** air stream.

[0068] FIG. 6A shows the electric ducted fan **102** housed in a nacelle **103** with extendable drag element **601** flexibly attached or hinged to the nacelle **103** near the leading edge and opening to the rear, as shown. This can be stowed and streamlined into the shape of the nacelle when not deployed and then actuated into the airflow when needed, as shown. Drag elements **601** deployed position can be variable if needed.

[0069] FIG. 6B shows the electric ducted fan **102** housed in a nacelle **103** with extendable drag elements **602** flexibly attached or hinged to the nacelle **103** near the trailing edge and opening to the rear, as shown. As with **601**, it can be variably deployed. When stowed, the extendable drag element can vector the EDF **102** airflow. This may or may not occur in parallel with deployment for drag.

[0070] FIG. 6C shows the electric ducted fan **102** housed in a nacelle **103** with extendable drag elements **603** flexibly attached or hinged to the nacelle **103** near the trailing edge and opening forward. As with **601**, it can be variably deployed. The deployed position can be variable if needed. Optionally, the aft edge of the drag elements **603** may be designed to add airflow to the EDF **102** air stream. Holes or vents **604** in nacelle **103** can be added to add airflow to the EDF **102** air stream.

[0071] FIG. 7A shows the electric ducted fan **102** housed in a nacelle **103** with extendable drag element **701** flexibly attached or hinged to the pylon **104** anywhere along its chordwise dimension. Elements **701** can be stowed and streamlined into the shape of the pylon when not deployed and then actuated into the airflow when needed, as shown. Drag elements **701** deployed position can be variable if needed.

[0072] FIG. 7B is the same as FIG. 7A, but with the drag element **702**, a different shape relative to the pylon **104** may be used in some instantiations when no or minimal pylon exists.

[0073] FIG. 7C shows the electric ducted fan **102** with extendable drag elements **703** flexibly attached or hinged to the nacelle **103** near the leading edge and opening forward. As with **701**, it can be variably deployed. The deployed position can be variable if needed.

[0074] FIG. 8A shows drag elements **801** hinged or flexibly attached to the pylon **104**, or other fixed features of the ELAS system. In its non-extended position, this drag ele-

ment is faired into the lifting surface **101**. When deployed as shown, it both acts as a type of Kreuger flap providing drag but also directs the airflow into the slot between the slat **201** and the lifting surface **101** to be entrained in the flow created by the forward velocity of the vehicle enhanced by the airflow created by the EDFs **102**. Kreuger flaps are used on airliners to increase the lift on the wing during landing by adding effective camber to the airfoil. Here they are uniquely used to not only to increase the effective camber, but also direct additional air into the EDFs and under the slat, enhancing the lift augmentation.

[0075] FIG. 8B shows drag element **802** hinged or flexibly attached to either near the leading edge of the lifting surface **101**, the pylon **104**, or other fixed features of the system. This is a continuous version of drag elements **801**.

[0076] FIG. 8C is similar to FIGS. 8A and 8B, but there are no slats between the nacelles per patent 793, and the drag element **801** spanning multiple EDF **102**, nacelles **103**, and optionally pylon **104** structures is hinged or flexibly attached on the pylons **104** or flexibly attached or hinged to the lifting surface **101**.

[0077] FIG. 9A shows the electric ducted fan **102** housed in a nacelle **103** with extendable drag elements **901** flexibly attached or hinged to the slat **201** near the leading edge and opening to the rear as shown **902**. These can be stowed and streamlined into the shape of the nacelle when not deployed and then actuated into the airflow when needed, as shown.

[0078] FIG. 9B shows the electric ducted fan **102** housed in a nacelle **103** with extendable drag elements **903** flexibly attached or hinged to the slat **201** near the trailing edge and opening to the rear as shown **904**. These can be streamlined into the shape of the slat or extended behind it to guide the airflow when not deployed and then actuated to provide drag when needed, as shown.

[0079] FIG. 9C shows the electric ducted fan **102** housed in a nacelle **103** with extendable drag elements **905** flexibly attached or hinged to the slat **201** near the trailing edge and opening forward as shown **906**. These can be streamlined into slat **201** when not deployed **905** and then actuated to provide drag when needed, as shown, **906**. Holes or vents **907** in slat **201** can add airflow between the slat and the lifting surface **101**.

[0080] FIG. 10 shows the electric ducted fan **102** housed in a nacelle **103** with extendable drag elements **1001** and **1002** flexibly attached or hinged to the slat **201** near the trailing edge, with **1001** opening upwards away from the lifting surface **101** and **1002** opening toward the lifting surface. As shown, these can be streamlined when not deployed and then actuated to provide drag and flow control when needed. The motion of **1001** and **1002** need not be symmetrical. Further, they can be installed aft of the EDF **102** or between them as needed.

[0081] As shown in FIG. 11, all the drag and flow control elements **1101** shown in FIGS. 3-14 can be gapped **1102** from the surfaces. A gap is the space between the drag element and the lifting surface or other surface on which the drag element is attached. This gap allows air flow between the drag element and the surface on which it is mounted.

[0082] As shown in FIG. 12, all the drag and flow control elements **1201** shown in FIGS. 3-10 can have holes in their surfaces **1202** to allow flow. These holes may or may not be round as shown, may or may not be in a grid pattern as shown, and may vary in number as shown in FIG. 15.

[0083] All the drag and flow control elements shown in FIGS. 3-12 need not be rectangular and may assume other shapes in cross-section and planform as needed and shown in FIGS. 13A-13C and 14A-14C. As illustrated in FIGS. 13A-13C, cross sectional shapes include planar flat plates **1301**, flat plates curved to fit the surface when stowed, **1302** and airfoil shapes with one side to fit the surface when stowed, **1303**. Planform shapes include rectangular **1401** (FIG. 14A), rectangular with rounded corners **1402** (FIG. 14B), rectangular but tapered moving aft, **1403** (FIG. 14C),.

[0084] FIGS. 15A-15C illustrate a variety of types of holes in drag elements. They may or may not be round **1202** as shown in FIG. 12, and may or may not be in a grid pattern as shown, and may vary in number as shown in FIGS. 15A-15C.

[0085] FIGS. 16A-16C illustrates drag or flow control elements shown in FIGS. 3-12 that can be actuated electrically, pneumatically, hydraulically, or by using the flowing air to provide actuation force.

Method Of Use

[0086] The system uses the thrust of the EDFs to provide additional lift. However, in some conditions the lift is wanted, but the additional thrust is not.

[0087] The system described here is used when there is need for lift enhancement without the additional thrust provided by the EDFs, or when the drag needed is greater than the thrust provided by the EDFs. This is generally during descent for landing but could be applied during other situations where high lift is needed with no additional or reduced thrust. In these conditions the pilot can actuate the system or it can be automatically actuated.

[0088] The pilot activates the EDFs and positioning of the drag elements **501** using one or more of the control elements in FIG. 16. In an embodiment, each drag element **501** or pairs of drag elements on the same EDF, move simultaneously. In another embodiment, all drag elements **501** on the same air foil move simultaneously. In yet another embodiment, all drag elements **501** on all air foils move simultaneously.

Conclusion

[0089] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment(s), but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims, which scope is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures as permitted under the law.

[0090] Further, it should be understood that while the use of the word preferable, preferably, or preferred in the description above indicates that feature so described may be more desirable, it nonetheless may not be necessary and any embodiment lacking the same may be contemplated as within the scope of the invention, that scope being defined by the claims that follow.

[0091] In reading the claims it is intended that when words such as “a,” “an,” “at least one” and “at least a portion” are used, there is no intention to limit the claim to only one item unless specifically stated to the contrary in the claim. Fur-

ther, when the language “at least a portion” and/or “a portion” is used the item may include a portion and/or the entire item unless specifically stated to the contrary.

[0092] As used herein, the term “substantially” refers to a shape similar to the one stated. Trademarks are the property of their owners.

What is claimed is:

1. A powered aerodynamic lift device, comprising:
 - a) one or more electric lift augmentation systems (ELAS) distributed along a span of an aerodynamic lifting element, each ELAS comprising:
 - ii) one or more nacelles positioned along the leading edge of an aerodynamic lifting element;
 - ii) an electric duct fan (EDF) housed within each of the one or more nacelles, each EDF comprising a fan and a power source to operate the fan, wherein each EDF forces accelerated air through the fan;
 - b) one or more drag elements pivotably connected, and comprising a rotatable/hinged/pivotable plate connected to a control element able to rotate the plate to create a range of drag; and
 - c) wherein the one or more ELAS's increase an airplane lift while minimally adding unwanted thrust.
2. The powered aerodynamic lift device of claim 1, wherein the one or more drag elements are positioned on the nacelle, facing forward or backward.
3. The powered aerodynamic lift device of claim 1, wherein the ELAS further comprises a pylon positioned perpendicularly between the nacelle and the airfoil; and the one or more drag elements are positioned on the pylon, facing forward or backward.
4. The powered aerodynamic lift device of claim 1, wherein the ALE further comprises one or more slats, and the one or more drag elements are positioned on the one or more slats facing forward or backward.
5. The powered aerodynamic lift device of claim 1, further comprising a plurality of holes or vents in the drag elements, slats, or nacelle.
6. The powered aerodynamic lift device of claim 1, wherein the one or more drag elements comprise one or more shapes of: a planar flat plate; a curved flat plate shaped to fit over a nacelle when stowed; and an airfoil shape curved to fit over the ALE when stowed.
7. The powered aerodynamic lift device of claim 6, wherein the planar flat plates comprise:
 - rectangular; rectangular with rounded corners; and rectangular while tapered moving aft.

8. The powered aerodynamic lift device of claim 1, wherein the one or more drag elements are rotatable from one or more positions that create drag to stowed positions that create no drag.

9. The powered aerodynamic lift device of claim 1, further comprising an electrical circuit control system comprising a master control unit able to control the operation of the one or more drag elements, the master control unit comprising: 1) a plurality of electronic speed controllers (ESCs) able to control the speed of the EDFs, 2) a plurality of pivot control units to position the drag elements; and 3) a plurality of actuators.

10. The powered aerodynamic lift device of claim 9, wherein the master control unit further controls the modulation of energy supplied by a power source to the EDFs and drag elements, wherein the power source comprises one or more of: batteries, a fuel cell, an engine/generator or other electrical energy source.

11. The powered aerodynamic lift device of claim 1, further comprising an actuator element coupled to each drag element, or to all drag elements connected to one nacelle, or to all drag elements connected to the ALE, wherein the actuator element enables a pilot to control the rotation of the drag element(s).

12. The powered aerodynamic lift device of claim 11, wherein the actuator element further controls the modulation of energy supplied by a power source to the drag elements, wherein the power source comprises one or more of: batteries, a fuel cell, an engine/generator or other energy source comprising: pneumatically, hydraulically, or by using the flowing air to provide actuation force.

13. The powered aerodynamic lift device of claim 1, wherein the drag elements are controlled by the pilot, manually or automatically or some combination thereof.

14. The powered aerodynamic lift device of claim 1, further comprising a gap between the drag element and a surface the drag element is attached to comprising: the ALE; the nacelle; or a slat.

15. The powered aerodynamic lift device of claim 1, comprising one drag element per ELAS.

16. The powered aerodynamic lift device of claim 1, comprising a pair of opposing drag elements per ELAS.

17. A powered aerodynamic lift device of claim 1, wherein the one or more drag elements are pivotably connected to a leading edge of the ALE, and rotate the one or more plates to create a range of drag to increase an airplane lift while minimally adding unwanted thrust.

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