2019 EAA Founder's Innovation Prize Entry
High-efficiency, Stall Proof Airfoil

ABSTRACT

According to the Federal Aviation Administration, loss of control, mainly stalls, account for most General Aviation accidents. Experimental amateur-built (E-AB) aircraft represent nearly 10 percent of the U.S. general aviation fleet, but these aircraft accounted for approximately 15 percent of the total-and 21 percent of the fatal-U.S. general aviation (GA) accidents in 2011. During the fiscal year 2016, experimental aircraft were involved in 49 fatal accidents. In addition, the EAA estimates that roughly two-thirds (32) of those accidents were accounted for by E-AB aircraft.

The submitted technology provides for an airfoil configuration wherein air flow is directly induced across the top, and parallel to, lifting surface of the airfoil. Lift is generated at 90° to air flow, but also the air stream will simultaneously induce a force approximately parallel to the chord of the wing. The lift is generated without regard to the angle-of-attack nor the configuration of the leading-edge; it will be generated even when ice has formed upon the leading-edge. As such, it is essentially stall proof.

To induce this air flow, pressurized air is generated within the central body of the aircraft, (This example uses engine driven turbine compressors), and is routed through tubular couplings to a pressurized header near the leading edge of each wing, where periodically located partitioning bulkheads capture a portion of the pressurized air flow and divert it into a flow normalizing chamber associated with the particular partitioning bulkhead. Each flow normalizing chamber has a slotted port through which the escaping air will be blown in a flattened flow pattern across and parallel to the lifting surface of the airfoil.

The above noted tubular couplings consist of rotating bearing and seals, such that each wing can be independently rotated about the axis of the tubular coupling and pressurized header. The angle-of-attack of both wings can be adjusted in coordination to either provide greater lift, or greater forward motion. The angle-of-attack of the wings can be adjusted and controlled differentially to function as do ailerons in standard aircraft wings.

For take-off, the wings are set at a highly negative angle-of-attack, where most of the lift generated will be consumed by accelerating the forward motion of the aircraft, while the force vectors created by the air escaping through the slotted ports will keep the aircraft securely in contact with the ground. As soon as sufficient speed has been obtained to insure the operation of the control surfaces on the empennage, the angle-of-attack of both wings can be increased, allowing the aircraft to climb, increasing its elevation and moving away from the ground.

During flight, the angle-of-attack of the wings and the power being delivered to compressors combine to control the climb/descend rate as well as the airspeed. Pitch is primarily controlled by the elevators located on the empennage; yaw by the rudder (also on the empennage). Aircraft roll is controlled by differential angle-of-attack of the two wings. As with standard aircraft wings, the forward motion of the aircraft, inducing airflow over the leading edge and across the lifting surface, provides lift, in addition to that produced by the air flowing through the slotted ports.

SUMMARY OF THE TECHNOLOGY

This technology provides for an airfoil configuration wherein air flow is directly induced across the top, and parallel to, lifting surface of the airfoil. Lift is generated at 90° to air flow and the air stream will simultaneously induce a force approximately parallel to the chord of the wing. This lift is generated without regard to the angle-of-attack nor the configuration of the leading-edge; it will be generated even when ice has formed upon the leading-edge. As such, it is essentially stall proof.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 – A cross-section of the fundamental wing configuration.

FIG. 2 – An exploded cross-section of the fundamental wing configuration.

FIG. 3 – An exploded isometric of the fundamental wing configuration.

FIG. 4 – A full wing assembly with control mechanism for setting and maintaining the Angle-of-Attack (AoA) of each wing.

FIG. 5 – A side view of the root edge of a wing, showing the various force vectors interacting with the wing, and flow arrows of air movement when the aircraft is in forward motion.

FIG. 6 – An enlarged isometric view of the full wing assembly showing the input pivot tubes with control mechanisms to individually controlling the AoA (pitch) of each wing.

FIG. 7 – An enlarged isometric view of the full wing assembly showing the counter-rotating turbine compressors used to provide pressurized air to each wing.

FIG. 8 – An elevation and isometric views of an aircraft with AoA configured for takeoff.

FIG. 9 – An elevation and isometric views of an aircraft with AoA configured for flight.

DETAILED DESCRIPTION OF THE SUBMITTED TECHNOLOGY

In the drawings labeled Fig. 1, Fig. 2, Fig. 3 and Fig. 4, unique views of the structure of a wing based upon this technology are presented.

The various components illustrated in Fig. 1, Fig. 2, Fig. 3 and Fig. 4 are all arranged about a centerline (0125) of and formed by a Pressurized Header (0115) and the Pivot Feed Tube (0110). Said Pressurized Header (0115) comprises various other components when assembled together and are not noted in the exploded views of Fig. 2 & Fig. 3, where the Centering Line of Various Component Centerlines (0127) is shown to assist the viewer in understanding how the various components would be fitted together.

This quasi-rectangular, fixed-wing type airfoil consists of a Pivot Feed Tube (0110) providing compressed, pressurized air to a Pressurized Header (0115), said Pressurized Header (0115) being formed by the cooperating elements of a Rib Enclosing Skin (0150) encasing multiple Ribs (0140), attached to multiple Partitioning Bulkheads (0130) which define a series of Flow Normalizing Chambers (0134) contained within a Leading Edge/Spar (0120). To provide for enhanced structural strength, said Partitioning Bulkheads (0130) can be arranged to align with the airfoil Ribs (0140), but said alignment is not required for the effective operation of the airfoil.

The Rib Enclosing Skin (0150) entirely encloses the multiple Ribs (0140), the top of which forms the Lifting Surface (0154), and the front of which forms the Chamber Completion Skin (0156), which, cooperating with said Leading Edge/Spar (0120) and the Partitioning Bulkheads (0130) form the Flow Normalizing Chambers (0134).

Said Pressurized Header (0115) is provided with compressed air by a variety of technologies, including Internal Combustion Engine (ICE) driven turbine compressors.

Passing through the Pivot Feed Tube (0110), the pressurized air moves through the Pressurized Header (0115) along the Centerline (0127) of said Pressurized Header, where the air flow is periodically interrupted by a Partitioning Bulkhead (0130) which diverts a portion of the total air flow into a Flow Normalizing Chamber (0134) at 90°, that is ‘normal’, to the flow along the Centerline (0127), where the Flow Normalizing Chamber (0134) directs the flow around and over the Pressurized Header (0115) to the Pressurized Fluid Escape Port (0185) where it exits along the Fluid Flow Escape Path (0170) across and normal to the Lifting Surface (0154).

The air flow along the Fluid Flow Escape path (0170), being parallel to the Lifting Surface (0154), reduces the pressure sensed at the Lifting Surface (0154) due to the Bernoulli Effect creating induced Lift Vectors (0180) which operate to, i.e. at 90°, to the Lifting Surface (0154).

Figure 4 shows right-hand and left-hand airfoils that are mirror images of each other. Each airfoil has its own differential gear assembly (0410), which fix and maintain a Common Angle-of-Attack (CAoA), or Pitch Rotation of each wing about the Pivot Point Centerline (0125), and also provides for a Differential Angle-of-Attack (DAoA) between the two wing assemblies to set and maintain the roll of the aircraft. These Differential Gear Assemblies will be discussed in more detail in Figure 6.

Figure 5 is a conceptual side view of a wing showing the force vectors that will be generated at 0° pitch, at +30° pitch and at -60° pitch about the Pivot Point Centerline (0125). At 0° pitch, the air flow from the Pressurized Fluid Escape Port (0185) will generate two force vectors: a Thrust Vector Reaction (0510), and a Vector Summation (0520) of the induced lift vectors. These force vectors will combine to produce a Resultant Vector Sum (0530) which, at the 0° pitch angle of attack will force the wing forward horizontally and upwards vertically. By rotating the wing to a Positive Pitch (0504), however, a Resultant Vector (0546) can be produced that has only a vertical component. Alternatively, rotating the wing to a Negative Pitch (0548), the Resultant Vector (0556) can provide a number of combinations of trade-offs between lift and forward propulsion. While the aircraft is in forward motion, the wings will continue to produce the Resultant Vectors (0530, 0546 or 0556), which will combine with any lift generated by the Fluid Stream Flow (0560).

The Resultant Vectors (0530, 0546 & 0556) of Figure 5, viewed with regard to the differential rotations of the wings illustrated in Figure 4, show how the differential wing pitch can be utilized to control and maintain the roll orientation of the aircraft.

Figure 6 shows the wing assemblies coupled to the mechanical system used to fix and control the Common Angle-of-Attack (CAoA) of both wings in unison, and the Differential Angle-of-Attack (DAoA) of the wings differentially. The control assembly consists of roller bearing assemblies to support the left wing (0604), and the right wing assembly (0606). These roller bearing assemblies couple the lift forces generated by the wings to the airframe through the Pivot Tube Mount Assemblies (0610), while allowing the wing assembles to be rotated about the Roll Axis (0612) by the supported Pivot Tube Assembly (PTA) (0642 & 0644). Each Wing Assembly has its dedicated Differential Gear assembly (DGA) (0614 & 0616), which control the Angle-of-Attack of each wing.

A chain drive system (0620) in Figure 6 transfers rotational forces from a pilot controlled level system in the cockpit to the CAoA drive shaft (0624), which, coupled to the Input Annulus Gear (0632 & 0634) of both DGAs (0614 & 0616), which in turn, through the Planetary Gear Assemblies (PGA) (0626 & 0628) of each DGA, drives the wing's Output Annulus Gear (0636 & 0638) which, being directly coupled to each wing's PTA (0642 & 0644) allows the CAoA of both wings to be controlled simultaneously.

A DAoA Rack And Pinion System in Figure 6, is driven via a cable controlled by the wheel or joystick in the cockpit. The side-to-side motion of the DAoA Drive Rack (0650) induces opposite rotation of the PGAs (0626 & 0628) thereby adding to, or subtracting from the CAoA of each wing the Differential Angle-of-Attack.

Figure 7 shows both wings with their Angle-of-Attack control systems with Internal-Combustion-Engine driven, counter-rotating Turbine Compressors (0710 & 0712), each delivering compressed/pressurized air to the wing assemblies through the stationary Seal Tubes (0716 & 0718) and the Pivot Tube Assemblies (0642 & 0644). If the wings are constructed of temperature withstanding materials, these Turbine Compressors (0710 & 0712) could be replaced by one or more Fan-jet Engines.

Figure 8 shows a complete aircraft during takeoff, with the wings rotated to -60° negative pitch to produce a Resultant Vector (0710) with a major forward component, accelerating the aircraft down the runway, and a negative vertical component to hold the aircraft onto the runway. Once sufficient speed is reached to insure the proper operation of the control surfaces at the tail, the wings can be rotated to a more positive pitch to increase the vertical component of the Resultant Vector to allow the aircraft to climb away from the runway.

Figure 9 shows the aircraft while in flight, where combinations of engine power and wing pitch can be used to control the elevation and climb/descent of the aircraft. Simultaneously, the differential wing pitch will be used to control the roll of the aircraft, at the same time as the tail rudder controls the yaw, and the tail elevators control the aircraft pitch.

SELF-EVALUATION OF THIS SOLUTION

- Expected effectiveness in reducing fatal LOC accident rate: 5, Outstanding (Highly likely to reduce fatal LOC occurrence significantly in most scenarios) Since this solution produces lift without ragard to angle-of-attack nor condition of the wing's leading edge, it is essentially stall-proof thereby eliminating the source of most fatal LOC accidents.
- Expected ease of installation and implementation: 1 (Acceptable) The installation and implementation of this solution is complex and requires in-depth technical capability.
- Expected low cost: 1 (Acceptable) The cost to implement this solution will be a significant percentage of the average GA aircraft hull value.

SUMMATION

Most Experimental Amateur-built (EA-B) fatal in-flight loss of control accidents are caused by stalls. This submitted technology, by inducing lift producing airflow across the lifting surfaces of the wings without regard to the angle-of-attack of the wing, nor to the configuration (or distortion) of the leading edges of the wings, is essentially stall-proof and should significantly reduce the quantity of fatal in-flight loss of control accidents with EA-B aircraft.

FIG. 1

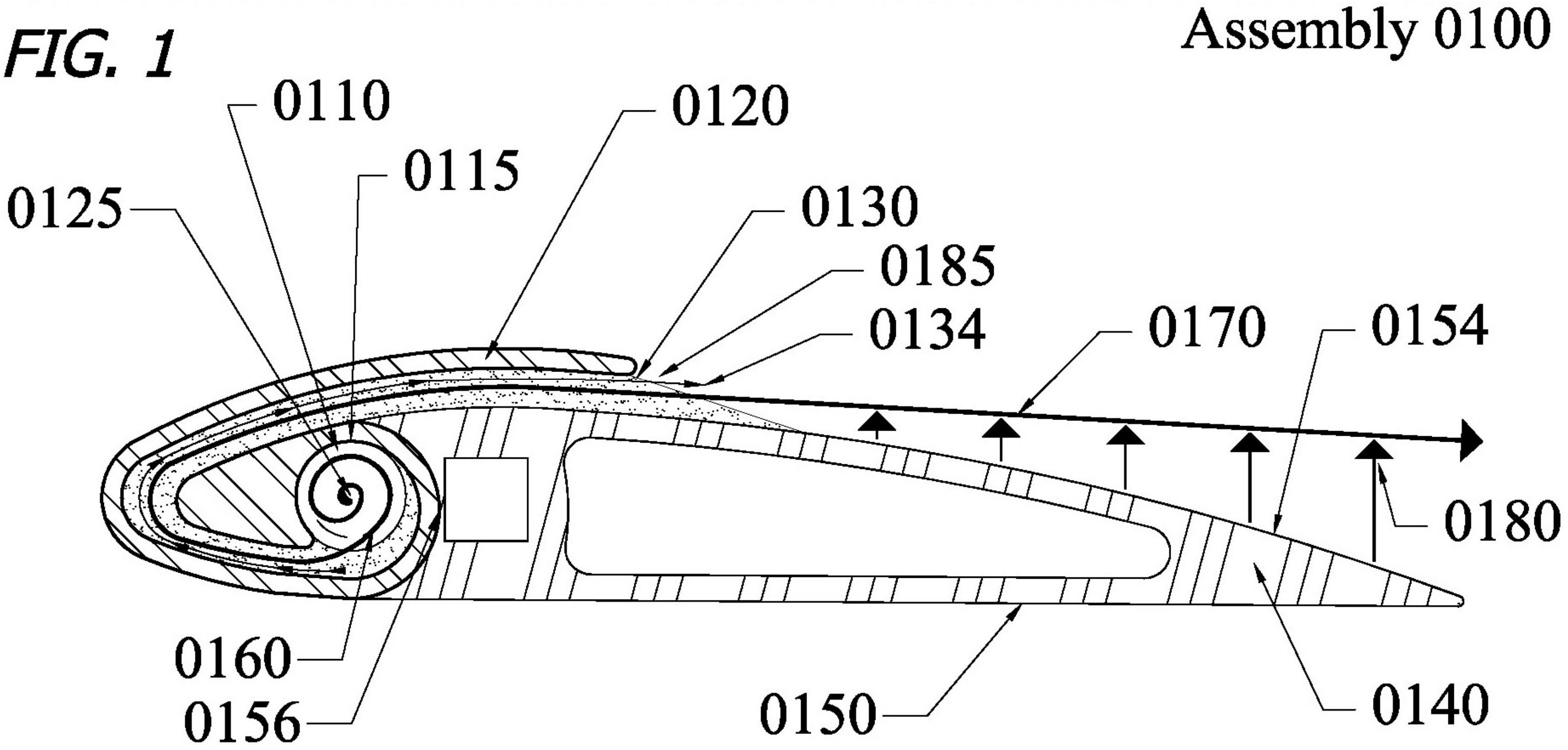
Assembly 0100
0110
0120
0115
0125
0130
0185
0134
0170
0154
0180
0160
0156
0150
0140

FIG. 2

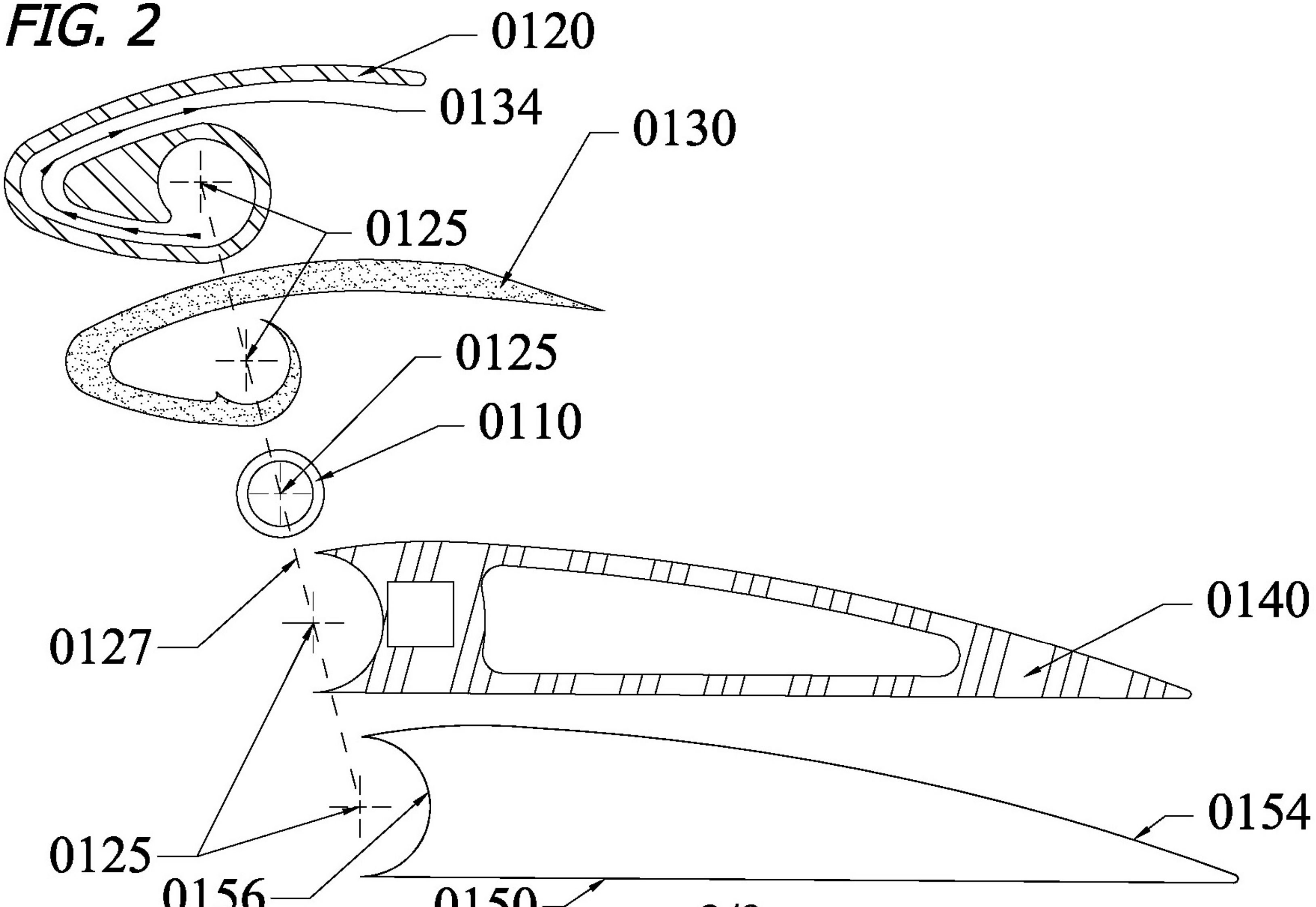

FIG. 3

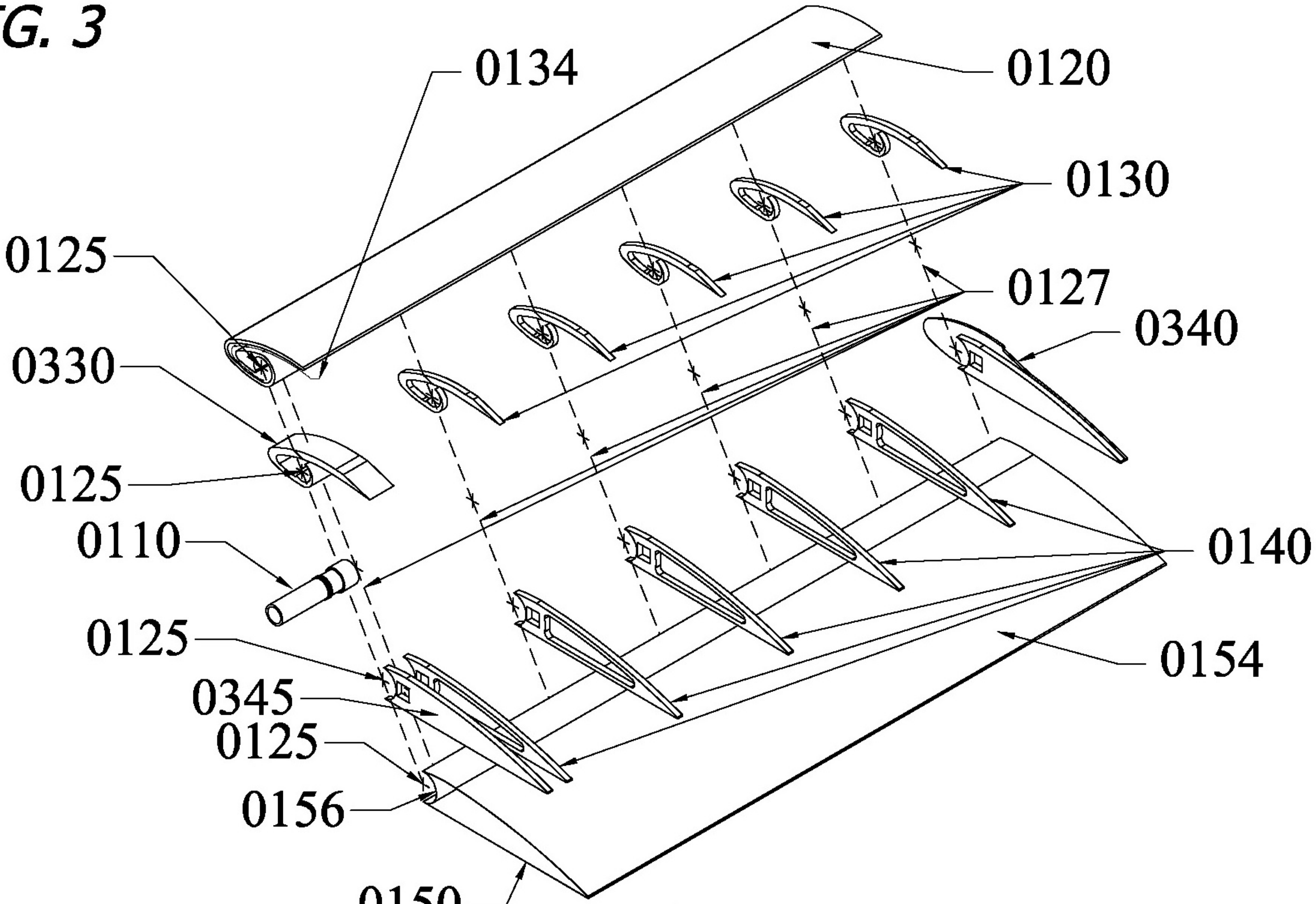
0134
0120
0130
0125
0127
0340
0330
0125
0110
0140
0125
0154
0345
0125
0156
0150

FIG. 4

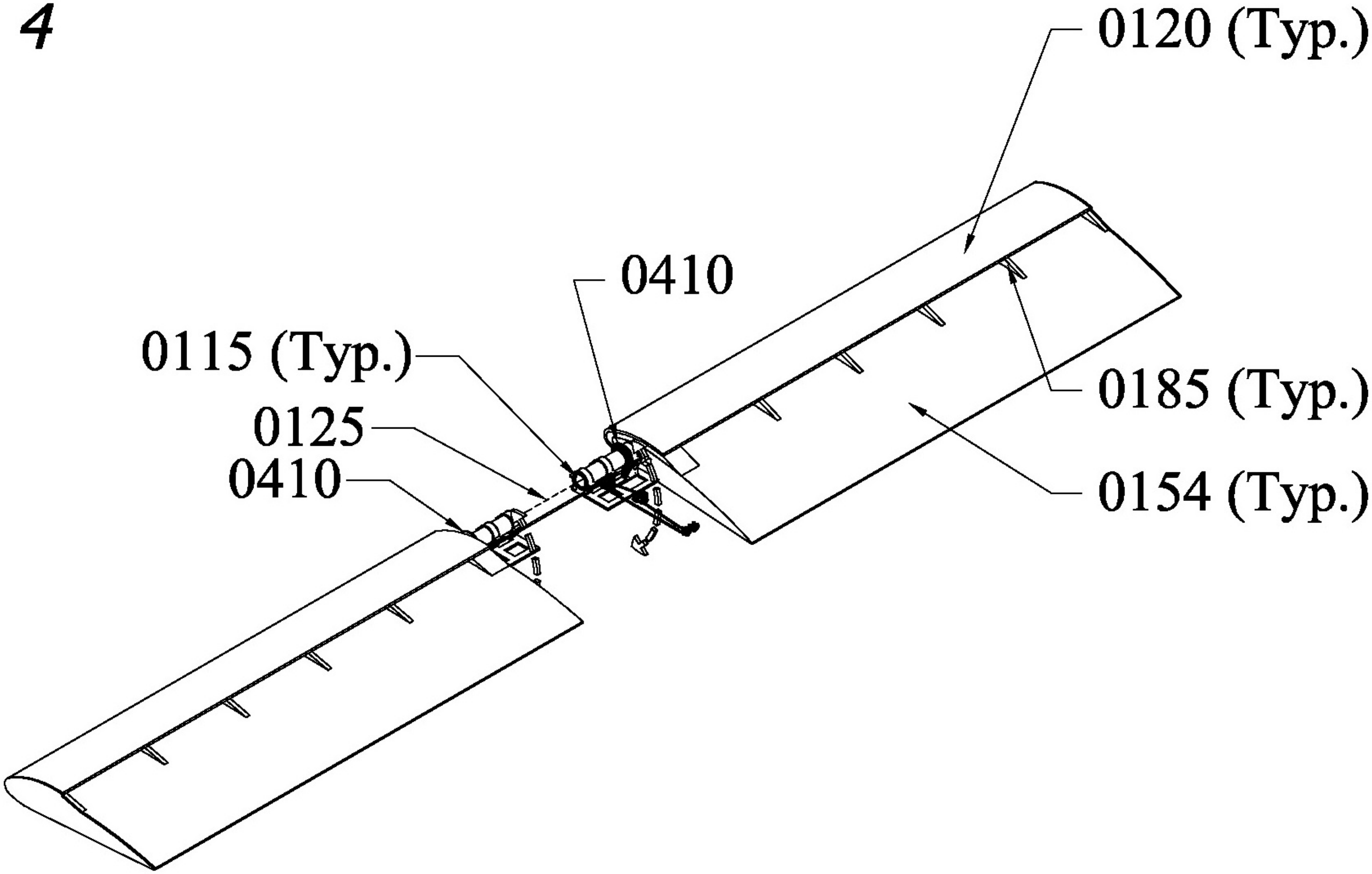

FIG. 5

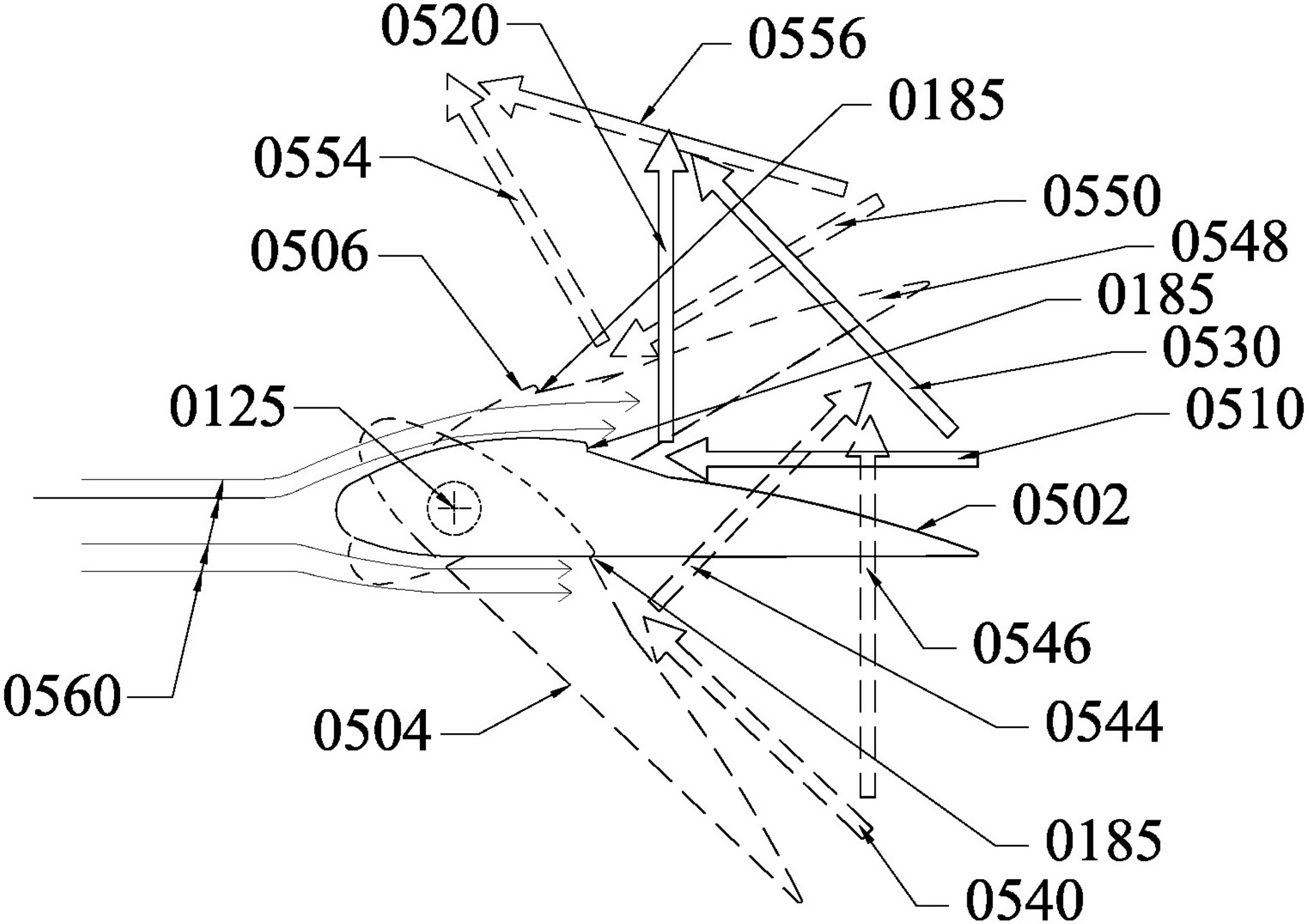
0520
0556
0185
0554
0550
0506
0548
0185
0530
0125
0510
0502
0546
0560
0544
0504
0185
0540

FIG. 6

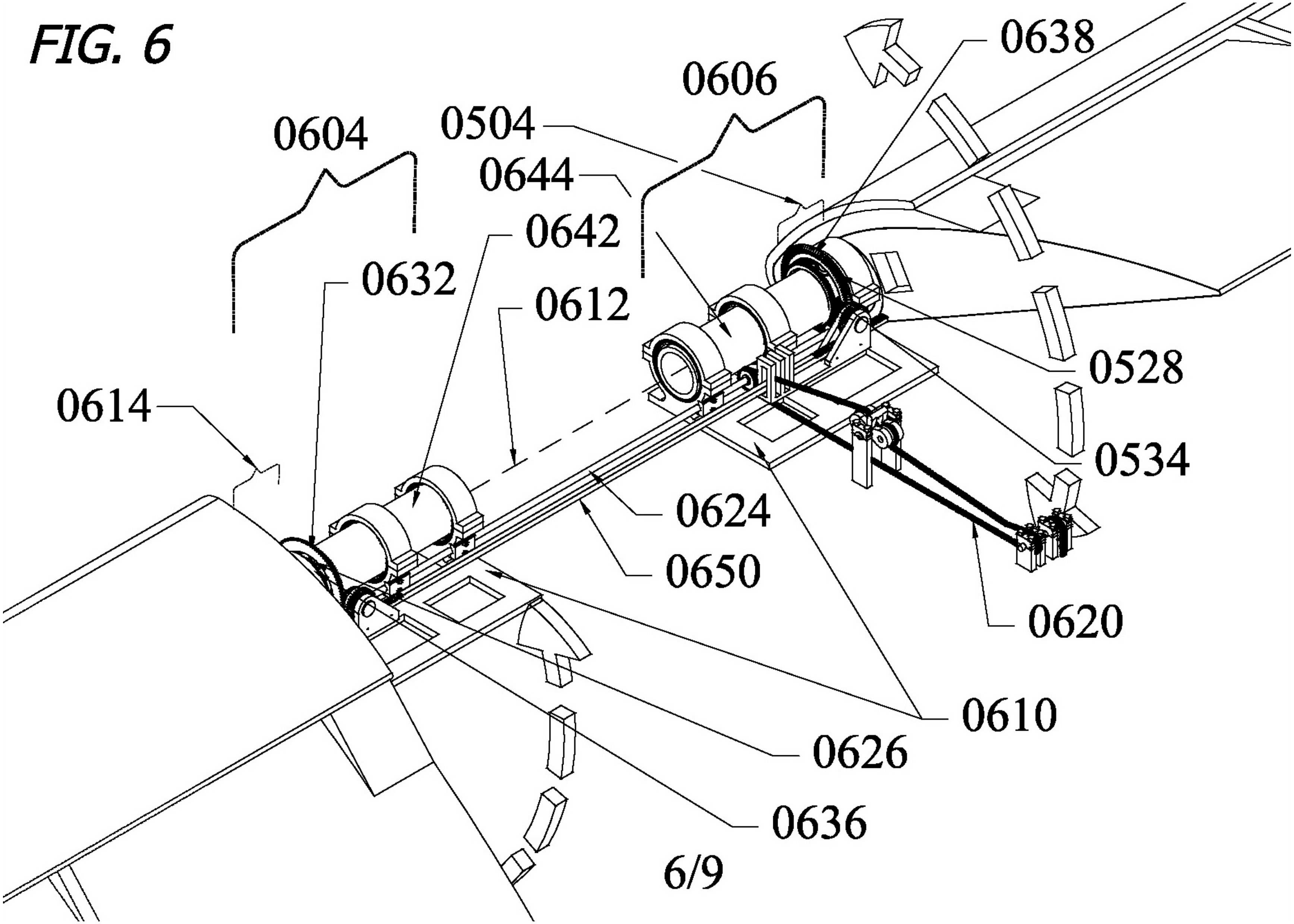
0638
0606
0604
0504
0644
0642
0632
0612
0614
0528
0534
0624
0650
0620
0610
0626
0636

FIG. 7

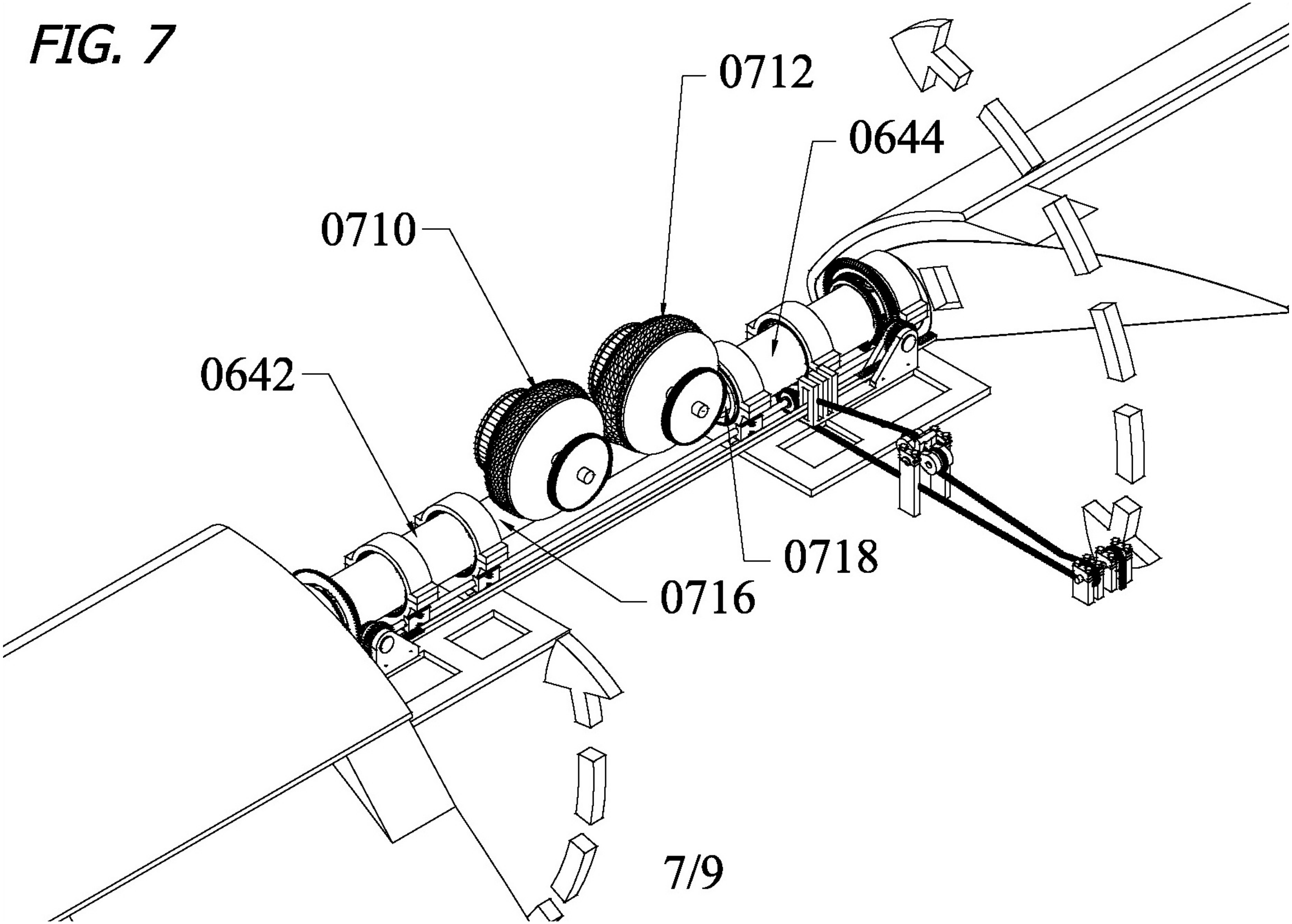

FIG. 8

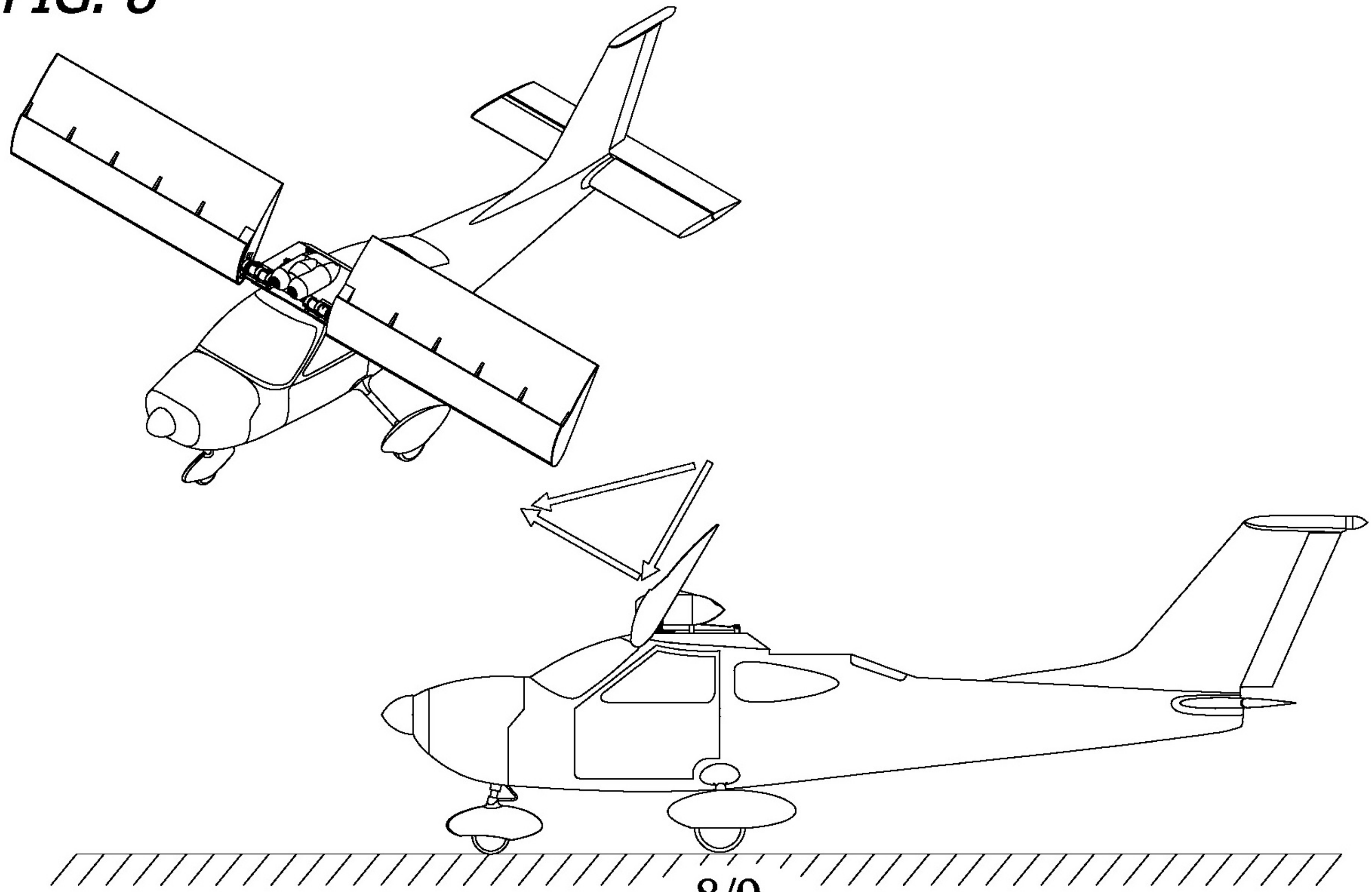

FIG. 9