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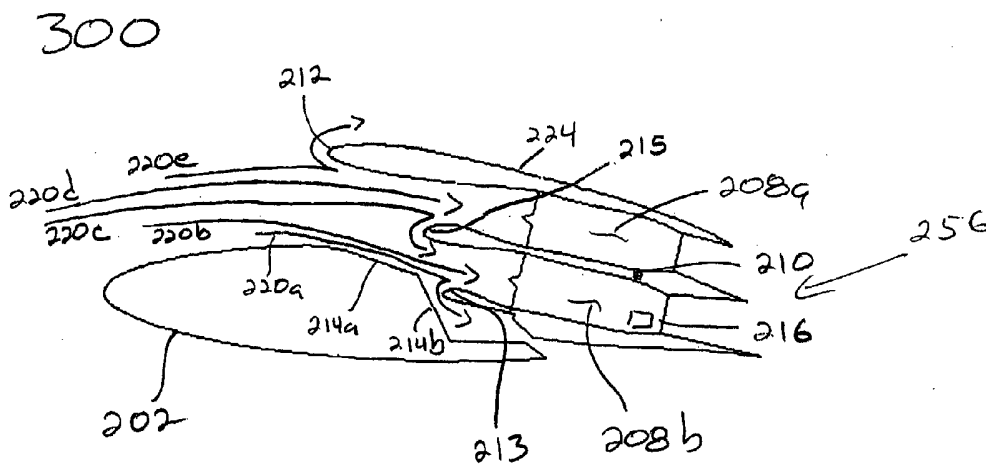
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(54) Title: VARIABLE ENGINE INLET FOR SHORT TAKE-OFF AND LANDING AND VERTICAL TAKE-OFF AND LANDING AIRCRAFT



(57) Abstract: A system and method for tilting an engine in a vertical take-off and landing/short take-off and landing aircraft (VTOL/STOL A/C) is provided comprising a main control system, an engine tilting mechanism, and an air flow volume detector, which is located in the engine. The system and method tilt the engine to maximize engine performance based on a variety of parameters including the air flow volume so that forward and horizontal speeds are maximized at the appropriate times, and also to reduce radar cross section and infra-red visibility.

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**VARIABLE ENGINE INLET FOR SHORT TAKE-OFF AND
LANDING AND VERTICAL TAKE-OFF AND LANDING
AIRCRAFT**

DOMESTIC PRIORITY

[0001] The present application claims priority under 35 U.S.C. § 119(e) to U.S. Provisional Patent Application Serial No. 60/637,761 filed December 22, 2004, the entire contents of which are expressly incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention:

[0002] The invention relates to short takeoff and landing (STOL) aircraft and vertical take-off and landing (VTOL) aircraft (STOL/VTOL A/C). More particularly, the invention relates to a system and method for tilting one or more engines in a suitably shaped area to maximize engine efficiency and minimize counter-detection observability.

Description of the Related Art:

[0003] FIGS. 1A-1C illustrate perspective views of several typical aircraft with tilt engine capabilities. The use of tilt engines in aircraft is well known to those of ordinary skill in the art. The principle benefit of a tilt engine is a shortened or vertical take-off capability. Vectoring the thrust allows the aircraft to provide a vertical component of thrust instead of, or complementary to, "conventional" horizontal thrust. Horizontal thrust pushes the aircraft forward, thereby moving air over the lifting surfaces of the aircraft, generating lift according to the well known principles of Bernoulli, and flight is thus achieved.

[0004] Aircraft with engines that can tilt seek to shorten their take-off distance, or eliminate it completely, by vectoring the thrust from the engine to a substantially totally or partially vertical orientation. Vertical thrust, as in a rocket or helicopter, lifts

the aircraft straight up, or shortens the take-off distance considerably. Following take-off, the tilt engine aircraft typically rotates the engines to a substantially horizontal position to push the aircraft forward, thereby moving air over the wings, as discussed above. The transition from vertical to horizontal flight must be done carefully, especially in non-rotating wing aircraft, because too fast a transition will leave the aircraft with an insufficient amount of air moving over the wings, and no lift will be generated, causing the aircraft will fall.

[0005] As is well known to those of ordinary skill in the art, to move an airplane through the air, a propulsion system is used to generate thrust. The amount of thrust an engine generates is important. The amount of fuel used to generate such thrust is sometimes more important, however, because the airplane has to lift and carry the fuel throughout the flight. Therefore, an efficiency factor, called thrust specific fuel consumption (TSFC), has been created to characterize an engine's fuel efficiency. Fuel consumption is the amount of fuel the engine burns each hour. By dividing the amount of fuel the engine burns per hour by the engine thrust, the specific fuel consumption is obtained. "Thrust" indicates the TSFC value pertains to gas turbine engines. In the case of TSFC, specific refers to "per pound (Newton) of thrust." There is a corresponding brake specific fuel consumption (BSFC) for engines that produce shaft power. Therefore, TSFC is the mass of fuel burned by an engine in one hour divided by the thrust that the engine produces. The units of TSFC are mass per time divided by force (in English units, pounds mass per hour per pound; in metric units, kilograms per hour per Newton).

[0006] TSFC is a ratio of the engine fuel mass flow rate, which can be expressed as " m_f ", to the amount of thrust " F " produced by burning the fuel:

$$\text{TSFC} = m_f \div F$$

[0007] There is an additional problem with substantially all STOL/VTOL aircraft known today. The engine power required to provide STOL/VTOL capabilities usually far exceeds that required to maintain a maximum flight speed of the aircraft. In addition, maintaining efficient engine operation at both high speeds and loitering speeds is problematic, especially with an engine that creates a large amount of thrust needed for

take-off configurations. Simply reducing the throttle settings on turbo jet aircraft does not increase the efficiency of the engine; at some point, reduced throttle settings increases the specific fuel consumption because fuel flow does not decrease proportionally. Therefore, reduced thrust, with near constant fuel consumption increases the TSFC of the engine at that operating parameter. This makes the conventional tilt engine aircraft expensive and inefficient to operate. The aircraft of FIG. 1A does not suffer from this problem as much as does its jet-powered counterparts, but neither does it enjoy the high dash speeds that the jet engines provide.

[0008] Another problem that all the aircraft shown in FIGS. 1A-1C exhibit is that of high observability. Observability is defined as the ability for the aircraft to be “observed” or detected by detection equipment. The detection equipment in this case refers to radar, which detects objects using the radio portion of the electromagnetic spectrum, and infra-red detectors, which uses the infra-red (IR) portion of the electromagnetic spectrum to detect objects. Generally, the larger an object is, the easier it will be to detect using radar. Detectability by radar can be lessened by designing the object to deflect electromagnetic energy in different directions (i.e., not back towards the radar receiver), use of non-reflective or low-reflective materials, or making the object smaller.

[0009] Infra-red detectors detect the object by the heat that the object emits. All objects emit heat (otherwise known as “blackbody” radiation). The heat generated by a body shows up in the infra-red portion of the electromagnetic portion. The main source of heat in an aircraft is the engines, and they are usually good heat generators. Turbo jet engines operate at very high temperatures (from about 1000° F to as much as 2700° F). Of course, the high temperature portions of the engines are covered with other components, which helps to hide the heat, and the cold atmosphere assists in reducing the heat of the engine. The engines still create enough heat, however, to be highly observable to infra-red detectors.

[0010] The aircraft illustrated in FIGS. 1A-1C are highly detectable in both a radar sense and an infra-red sense. The opposite of a high detectability is low detectability, and an aircraft that has low detectability can also be said to have low-observability, or “LO”. An aircraft that has LO is also said to be “stealthy”. The aircraft of FIGS. 1A-1C are not stealthy from a radar perspective, because their engines have a

large radar cross section (RCS) that adds to the RCS of the main fuselage of the aircraft. Radar cross section is a factor that relates the amount of power of the radio waves that an object reflects or scatters back in the direction of the radar to the power density of the radar's transmitted waves at the object's range. The radar cross section is dependent on the cross sectional area as seen by the radar, the object's reflectivity and its directivity. The cross sectional area, of course, is directly related to the size of the object. The aircraft of FIGS. 1A-1C also suffer from high infra-red signature, because their engines, which are a large source of heat as discussed above, are distanced away from the fuselage and are thus easy to observe from substantially all angles.

[0011] Therefore, a need exists for a STOL/VTOL A/C that maximizes engine efficiency at both high speed and loiter speeds and minimizes counter-detection observability.

SUMMARY OF THE INVENTION

[0012] An object of the present invention is to substantially solve at least the above problems and/or disadvantages and to provide at least the advantages described below. Accordingly, it is an object of the present invention to provide a STOL/VTOL A/C that maximizes engine efficiency and minimizes counter-detection observability.

[0013] It is an object of the present invention to provide a turbo jet or turbo fan powered STOL/VTOL A/C that tilts its main engines to provide all or part of its vertical thrust. According to an embodiment of the present invention, the STOL/VTOL A/C comprises a large well rounded air inlet area when producing vertical thrust while hovering. According to an embodiment of the invention, the STOL/VTOL A/C also comprises a substantially smaller air inlet area for forward flight. In addition, the shape of the air inlet area according to an embodiment of the present can be constrained for reasons of high speed flight, to minimize radar visibility and to decrease detectability by infra-red means.

[0014] Therefore, it is an object of the present invention to provide a STOL/VTOL A/C that comprises an engine with engine inlet lips and an airframe with specially shaped air intake opening to form an air inlet area. When the engine rotates to its nominally horizontal position for forward flight, the engine inlet lips enters the specially shaped air intake opening that corresponds to the well rounded engine inlet lips

to form the air inlet area. The exposed parts of the air inlet area are suitably shaped for high speed and/or low radar observability. The air inlet area is further shaped to maintain a substantially smooth airflow into the engine. With appropriate shaping of the air intake opening and the engine inlet lips, the engine assembly can be tilted a few degrees to adjust the size of the air inlet area to allow the proper amount of air to reach the engine for its current (or desired) operating condition. Performance of the STOL/VTOL A/C is maximized while spillage drag penalties are minimized.

[0015] According to another embodiment of the present invention, more than one engine is provided in the tilting nacelle. Multiple engines allow the use of both engines for high altitude or high speed flight, but one engine can be shut down to minimize fuel use during low speed loiter flight. The air inlet area can be designed so that as the nacelle is tilted substantially fully into the body of the airframe (at the air intake opening), the flow to the high speed engine is reduced and finally substantially fully cut off, while still providing the appropriate airflow to the operating low speed engine, thereby proving an efficient loiter capability.

[0016] According to a first aspect of the present invention, a vertical take-off and landing (VTOL) aircraft is provided comprising an engine tilting mechanism, wherein the engine tilting mechanism is configured to tilt a first engine to a first position substantially parallel to a fuselage of the VTOL aircraft to produce thrust for forward flight, and configured to tilt the first engine to a second position substantially perpendicular to the fuselage of the VTOL aircraft to produce thrust for hovering, a variable engine inlet mounted to the first engine, wherein the variable engine inlet is configured to provide a substantially smooth airflow into the first engine, and wherein the engine tilting mechanism is configured to tilt the first engine to the first position to align the variable engine inlet with an air intake opening of the fuselage of the VTOL aircraft, and an air volume detection circuit in communication with the engine tilting mechanism, wherein the air volume detection circuit is configured to detect a volume of air entering the first engine, wherein the air volume detection circuit is configured to determine the volume of air required by the first engine to maximize a current operating condition of the first engine, and wherein the air volume detection circuit is configured to send a tilt control signal to the engine tilting mechanism to tilt the variable engine inlet relative to the air intake opening to adjust a size of the air intake opening and alter the

volume of air entering the first engine to maximize the current operating condition of the first engine.

[0017] According to the first aspect of the present invention, the VTOL aircraft further comprises portions of the variable engine inlet exposed outside of the fuselage of the VTOL aircraft when the first engine is in the first position are configured for at least one of: i.) minimal drag during high speed forward flight; and ii.) minimal radar visibility during forward flight. The VTOL aircraft according to the first aspect of the present invention further comprises at least a second engine configured to be tilted with the first engine relative to the fuselage of the VTOL aircraft to produce the thrust for hovering, wherein the variable engine inlet is mounted to both the first and at least second engines, wherein the variable engine inlet is configured such that as the first and at least second engines are tilted to the first position, airflow to one of the first and at least second engines is reduced, and wherein the variable engine inlet is configured such that when the first and at least second engines are in the first position, airflow to the one of the first and at least second engines is cut off.

[0018] According to the first aspect of the present invention, the first engine of the VTOL aircraft is positioned above and substantially parallel to the at least second engine, and wherein the one of the first and at least second engines comprises the at least second engine, and the air intake opening is located within the fuselage of the VTOL aircraft. Further still, the first aspect of the present invention comprises a VTOL aircraft wherein the first engine comprises a turbo jet engine, or a turbo fan engine.

[0019] According to a second aspect of the present invention, a vertical take-off and landing (VTOL) aircraft is provided comprising a tilting nacelle, wherein the tilting nacelle includes a first engine, and at least a second engine, wherein the tilting nacelle is configured to be tilted relative to a fuselage of the VTOL aircraft for providing thrust for hovering. The VTOL aircraft further comprises an engine tilting mechanism, wherein the engine tilting mechanism is configured to tilt the tilting nacelle to a first position substantially parallel to the fuselage of the VTOL aircraft for providing thrust for forward flight, and configured to tilt the tilting nacelle to a second position substantially perpendicular with the fuselage of the VTOL aircraft for providing the thrust for hovering. The VTOL aircraft according to the second aspect still further comprises a variable engine inlet mounted to the tilting nacelle, wherein the variable engine inlet is

configured to provide a substantially smooth airflow into the tilting nacelle, and wherein the engine tilting mechanism is configured to tilt the tilting nacelle to the first position to align the variable engine inlet with an air intake opening of the fuselage of the VTOL aircraft. The second aspect of the present invention still further comprises an air volume detection circuit in communication with the engine tilting mechanism, wherein the air volume detection circuit is configured to detect a volume of air entering the tilting nacelle, wherein the air volume detection circuit is configured to determine the volume of air required by the first and at least second engines to maximize a current operating condition of the first and at least second engines, and wherein the air volume detection circuit is configured to send a tilt control signal to the engine tilting mechanism to tilt the variable engine inlet relative to the air intake opening to adjust a size of the air intake opening and alter the volume of air entering the tilting nacelle to maximize the current operating condition of the first and at least second engines.

[0020] In the VTOL aircraft according to the second aspect of the present invention, portions of the variable engine inlet exposed outside of the fuselage of the VTOL aircraft when the tilting nacelle is in the first position are configured for at least one of: i.) minimal drag during high speed forward flight; and ii.) minimal radar visibility during forward flight. The variable engine inlet is configured such that as the tilting nacelle is tilted to the first position, airflow to one of the first and at least second engines is reduced, and wherein the variable engine inlet is configured such that when the tilting nacelle is in the first position, airflow to the one of the first and at least second engines is cut off.

[0021] In the VTOL aircraft according to the second aspect, the first engine is positioned above and substantially parallel to the at least second engine within the tilting nacelle, and wherein the one of the first and at least second engines comprises the at least second engine. The air intake opening is located within the fuselage of the VTOL aircraft, and wherein each of the first and at least second engines comprises a turbo jet engine, or a turbo fan engine.

[0022] According to a third aspect of the present invention, a vertical take-off and landing (VTOL) aircraft is provided comprising means for tilting a first means for providing propulsion, wherein the tilting means is configured to tilt the first propulsion providing means to a first position substantially parallel to the fuselage of the VTOL

aircraft to produce thrust for forward flight, and configured to tilt the first propulsion providing means to a second position substantially perpendicular to the fuselage of the VTOL aircraft to produce thrust for hovering, a variable means for restricting airflow mounted to the first propulsion providing means, wherein the variable airflow restricting means is configured to provide a substantially smooth airflow into the first propulsion providing means, and wherein the tilting means is configured to tilt the first propulsion providing means to the first position to align the variable airflow restricting means with an air intake opening of the fuselage of the VTOL aircraft, and means for detecting air volume in communication with the tilting means, wherein the air volume detecting means is configured to detect a volume of air entering the first propulsion providing means, wherein the air volume detecting means is configured to determine the volume of air required by the first propulsion providing means to maximize a current operating condition of the first propulsion providing means. According to the third aspect of the present invention the air volume detecting means is configured to send a tilt control signal to the tilting means to tilt the variable airflow restricting means relative to the air intake opening to adjust a size of the air intake opening and alter the volume of air entering the first propulsion providing means to maximize the current operating condition of the first propulsion providing means.

[0023] According to the third aspect of the present invention, portions of the variable airflow restricting means exposed outside of the fuselage of the VTOL aircraft when the first propulsion providing means is in the first position are configured for at least one of: i.) minimal drag during high speed forward flight; and ii.) minimal radar visibility during forward flight. Still further according to the third aspect of the present invention, at least a second means for providing propulsion is configured to be tilted with the first propulsion providing means relative to the fuselage of the VTOL aircraft to produce the thrust for hovering, wherein the variable airflow restricting means is mounted to both the first and at least second propulsion providing means, wherein the variable airflow restricting means is configured such that as the first and at least second propulsion providing means are tilted to the first position, airflow to one of the first and at least second propulsion providing means is reduced, and wherein the variable airflow restricting means is configured such that when the first and at least second propulsion

providing means are in the first position, airflow to the one of the first and at least second propulsion providing means is cut off.

[0024] According to the third aspect of the present invention, the first propulsion providing means is positioned above and substantially parallel to the at least second propulsion providing means, and wherein the one of the first and at least second propulsion providing means comprises the at least second propulsion providing means. According to the third aspect of the present invention, the air intake opening is located within the fuselage of the VTOL aircraft, the first propulsion providing means comprises a turbo jet engine means, and the first propulsion providing means also comprises a turbo fan engine means.

[0025] According to a fourth aspect of the present invention, a vertical take-off and landing (VTOL) aircraft is provided comprising a tiltable means for enclosing, wherein the tiltable enclosing means is configured to enclose a first means for providing propulsion, at least a second means for providing propulsion, wherein the tiltable enclosing means is configured to be tilted relative to a fuselage of the VTOL aircraft for providing thrust for hovering. According to the fourth aspect of the present invention, the VTOL aircraft further comprises means for tilting the tiltable enclosing means, wherein the tilting means is configured to tilt the tiltable enclosing means to a first position substantially parallel to the fuselage of the VTOL aircraft for providing thrust for forward flight, and configured to tilt the tiltable enclosing means to a second position substantially perpendicular with the fuselage of the VTOL aircraft for providing the thrust for hovering, a variable means for restricting airflow mounted to the tiltable enclosing means, wherein the variable airflow restricting means is configured to provide a substantially smooth airflow into the tiltable enclosing means, and wherein the tilting means is configured to tilt the tiltable enclosing means to the first position to align the variable airflow restricting means with an air intake opening of the fuselage of the VTOL aircraft, and means for detecting air volume in communication with the tilting means, wherein the air volume detecting means is configured to detect a volume of air entering the tiltable enclosing means, and wherein the air volume detecting means is configured to determine the volume of air required by the first and at least second propulsion providing means to maximize a current operating condition of the first and at least second propulsion providing means, and wherein the air volume detecting means is

configured to send a tilt control signal to the tilting means to tilt the variable airflow restricting means relative to the air intake opening to adjust a size of the air intake opening and alter the volume of air entering the tiltable enclosing means to maximize the current operating condition of the first and at least second propulsion providing means.

[0026] According to the fourth aspect of the present invention, portions of the variable airflow restricting means exposed outside of the fuselage of the VTOL aircraft when the tiltable enclosing means is in the first position are configured for at least one of: i.) minimal drag during high speed forward flight; and ii.) minimal radar visibility during forward flight. Still further the variable airflow restricting means is configured such that as the tiltable enclosing means is tilted to the first position, airflow to one of the first and at least second propulsion providing means is reduced, and wherein the variable airflow restricting means is configured such that when the tiltable enclosing means is in the first position, airflow to the one of the first and at least second propulsion providing means is cut off.

[0027] According to the fourth aspect of the present invention, the first propulsion providing means is positioned above and substantially parallel to the at least second propulsion providing means within the tiltable enclosing means, and wherein the one of the first and at least second propulsion providing means comprises the at least second propulsion providing means.

[0028] Still further, in the fourth aspect of the present invention the air intake opening is located within the fuselage of the VTOL aircraft, and each of the first and at least second propulsion providing means comprises a turbo jet engine means. According to the fourth aspect of the present invention each of the first and at least second propulsion providing means comprises a turbo fan engine means.

[0029] According to a fifth aspect of the present invention, a method of regulating airflow to engines of a vertical take-off and landing (VTOL) aircraft is provided comprising the steps of a.) detecting a volume of air entering a first engine, wherein the first engine is configured to be tilted to a first position substantially parallel to a fuselage of the VTOL aircraft to produce thrust for forward flight, and configured to be tilted to a second position substantially perpendicular to the fuselage of the VTOL aircraft to produce the thrust for hovering, wherein a variable engine inlet is mounted to the first engine, wherein the variable engine inlet is configured to provide a substantially

smooth airflow into the first engine, and wherein in the first position, the variable engine inlet is substantially aligned with an air intake opening of the fuselage of the VTOL aircraft; b.) determining the volume of air required by the first engine to maximize a current operating condition of the first engine; and c.) tilting the variable engine inlet relative to the air intake opening to adjust a size of the air intake opening and alter the volume of air entering the first engine to maximize the current operating condition of the first engine.

[0030] According to the fifth aspect of the present invention, portions of the variable engine inlet exposed outside of the fuselage of the VTOL aircraft when the first engine is in the first position are configured for at least one of: i.) minimal drag during high speed forward flight; and ii.) minimal radar visibility during forward flight.

[0031] According to the fifth aspect of the present invention, the at least second engine is configured to be tilted with the first engine relative to the fuselage of the VTOL aircraft to produce the thrust for hovering, wherein the variable engine inlet is mounted to both the first and at least second engines, wherein the variable engine inlet is configured such that as the first and at least second engines are tilted to the first position, airflow to one of the first and at least second engines is reduced, and wherein the variable engine inlet is configured such that when the first and at least second engines are in the first position, airflow to the one of the first and at least second engines is cut off.

[0032] According to the fifth aspect of the present invention, the first engine is positioned above and substantially parallel to the at least second engine, and wherein the one of the first and at least second engines comprises the at least second engine. Further still, according to the fifth embodiment of the present invention, the air intake opening is located within the fuselage of the VTOL aircraft.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] The various objects, advantages and novel features of the present invention will be best understood by reference to the detailed description of the preferred embodiments that follows, when read in conjunction with the accompanying drawings, in which:

[0034] FIGS. 1A-1C illustrate perspective views of several typical aircraft with tilt engine capabilities.

- [0035]** FIGS. 2A-2D illustrate several side cross section views of a vertical take-off and landing (VTOL) or short-take-off and landing (STOL) aircraft (STOL/VTOL A/C) according to an embodiment of the present invention.
- [0036]** FIGS. 3A-3D illustrate several side views of a vertical take-off and landing (VTOL) or short-take-off and landing (STOL) aircraft (STOL/VTOL A/C) according to an embodiment of the present invention,
- [0037]** FIGS. 4A-4D illustrate vector representations of thrust from an engine in the VTOL/STOL A/C of FIG. 2.
- [0038]** FIGS. 5A-5D illustrate vector representation of thrust from a plurality of engines in the VTOL/STOL A/C 300 of FIG. 3.
- [0039]** FIGS. 6A-6L illustrate several front perspective views of engine inlet lips of engines used in the VTOL/STOL A/C according to an embodiment of the present invention.
- [0040]** FIGS 7A and 7B illustrate a side view of the engine inlet lips of the engine, the air intake opening and air inlet area of the VTOL/STOL A/C shown in FIGS. 2A-2C according to an embodiment of the present invention.
- [0041]** FIGS. 8A-8N illustrate a plurality of views of the VTOL/STOL A/C shown in FIGS. 3A-3C according to an embodiment of the present invention.
- [0042]** FIG. 9 illustrates a block diagram of an aircraft control system for controlling the VTOL/STOL A/C shown in FIGS. 2A-2D and 3A-3C according to an embodiment of the present invention.
- [0043]** FIGS. 10A and 10B illustrate a flow diagram of a method for tilting an engine in the VTOL/STOL A/C shown in FIGS. 2A-2D and 3A-3C to maximize an operating condition of the engine(s) according to an embodiment of the present invention.
- [0044]** FIG. 11 illustrates a front perspective view of the VTOL/STOL A/C shown in FIGS. 2A-2D according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

[045] According to various embodiments of the present invention, a short take-off and landing/vertical take-off and landing aircraft (STOL/VTOL A/C) is provided that

comprises a fuselage, tiltable engine, a plurality of fan engines, an engine tilt mechanism, an air volume detection circuit, and an air volume control circuit. The fuselage comprises an upper and lower air intake opening surface, and the engine comprises an upper and lower engine inlet lip. The tilt of the engine is controlled by the air volume control circuit according to one embodiment of the present invention, wherein an engine tilt signal is produced and sent to the engine tilt mechanism in order to maximize a current operating condition of the STOL/VTOL A/C. The air volume control circuit takes into account air flow as measured by the air volume detection circuit, which is located in the engine, when determining how much to tilt the engine to maximize its current operating condition. The engine's lower inlet lip is configured to interface with the upper and lower air intake opening surfaces to maximize the operating condition of the engine whether that is a low speed loiter condition, or a high speed dash condition. According to another exemplary embodiment of the present invention, a dual engine configuration is also provided. The engine in either the single or dual engine configuration is an internal combustion engine, and is preferably a turbo fan or a turbo jet engine. The engine can be tilted from a substantially vertical position with respect to the fuselage, to a substantially horizontal position in line with the nose-to-tail plane of the STOL/VTOL A/C.

[046] Several embodiments of the present invention will now be described in detail with reference to the accompanying drawings. In the drawings, the same or similar elements are denoted by the same reference numerals even though they are depicted in different drawings.

[047] FIGS. 2A-2D illustrate several side cross section views of a vertical take-off and landing/short take-off and landing aircraft (VTOL/STOL A/C) 200 according to an embodiment of the present invention. As shown in FIG. 2, the VTOL/STOL A/C 200 comprises a fuselage 202, air volume control circuit 204, main control system 206, an engine 208, and an engine tilt mechanism 210, among other components. Engine 208 comprises, among other components, an upper engine inlet lip (upper engine lip) 212, and a lower engine inlet lip (lower engine lip) 213, that are configured to interface with, as will be discussed in greater detail below, air intake opening (of the fuselage 202) 214.

[048] The embodiments of the present invention pertain to a system and method for increasing the operating efficiency of VTOL/STOL A/C 200 as discussed and described

herein. As one of ordinary skill in the art can appreciate, however, the embodiments of the present invention can and do apply to other types of aircraft including, but not limited to, unmanned aerial vehicles or UAVs. Unmanned aerial vehicles (UAVs) have substantially the same components as typical manned aerial vehicles but generally are much smaller than their human driven counterparts. It is well known by those of ordinary skill in the art, that a typical UAV is not simply a remotely controlled version of a human driven aircraft. The chief difference lies in the purpose of design. Typically, human drive aircraft are designed for particular missions, and include many design features that enable its operators to survive and perform their mission. For example, a human driven aircraft, to operate at significant lengths of time at or above about 14,000 feet above sea level, must be pressurized or contain air/oxygen supplies for the operators (operators can include pilot(s), flight engineers, navigators, radar/weapon systems officers, among others). This is not the case with UAVs. There is no absolute need for pressurization nor oxygen/air supplies. Another significant difference is that the flight envelope that the UAV performs in can be much more severe. A typical human can only withstand so many g-forces; this, again, is not the case with UAVs. The only constraint in that regard is the strength of the airframe and the ability of the internal components to withstand extreme forces of acceleration. By way of example, while a typical fighter aircraft can be designed to withstand many g-forces, the human body can only withstand about 10-12 for extended periods of time. Often times, aircraft will have built-in control systems that will not allow the aircraft to exceed the human tolerance level.

[049] The conventional UAV 100 has many of the same components as a conventional human powered aircraft. These include a fuselage, wings, vertical and horizontal stabilizers, landing gear, flight control surfaces, a propulsion system and avionics. Flight control surfaces include ailerons, flaps, elevators, and a rudder. Other types of UAVs can include canards. Avionics include communication systems, propulsion system monitoring equipment, and electronics that controls the flight control surfaces in response to pre-programmed commands and/or remotely received commands. Of course, UAVs are generally designed to perform one or more specific missions, so the UAVs will also include a payload that can include weapons and/or monitoring equipment. Monitoring equipment can include electronic monitoring systems (radar, electronic eavesdropping communications systems, among other types), video

surveillance systems, laser and/or infra-red surveillance systems, laser detections systems, and electronic communications jamming equipment. These are but a few very generalized types of payloads that UAVs can accommodate, and some UAVs can include one or more of these types of systems.

[050] As can be readily appreciated, UAVs have significant advantages over human crewed aircraft in many respects. First, they are generally smaller, less expensive and therefore more expendable than human driven aircraft. Because of their smaller size – sometimes many orders of magnitude smaller size - UAVs can operate from areas that ordinary human driven aircraft cannot. Because of their size, UAVs will be more difficult to detect, will have a much smaller turn radius, and therefore can be much more survivable in certain situations. With the current state of technology, UAVs can be remotely controlled from around the world (via satellite), and global positioning system tracking devices can pinpoint their locations within meters. UAVs can deliver some of the same ordinance that their well known human driven counterparts can, albeit on a smaller scale and quantity.

[051] FIG. 2A illustrates the situation when the VTOL/STOL A/C 200 is in a take-off or landing configuration. This can be before take-off, during take-off, or shortly after take-off. It is also possible for VTOL/STOL A/C 200 to achieve this configuration after it has been in forward flight at some altitude above the ground (hovering). For purposes of this discussion, we shall consider the scenario in which the VTOL/STOL A/C 200 is taking off from the ground or a launch vehicle. In the take-off configuration, engine 208 is substantially perpendicular to the fuselage 202. Therefore, the thrust from engine 208 is also substantially perpendicular to the fuselage 202. FIG. 4A illustrates the thrust vector from engine 208 in its lift-off configuration. In FIGS. 4A-4C, the vertical component of thrust is designated as T_V , the horizontal component of thrust is designated as T_H , and the total resultant thrust vector is designated as T_R . There is substantially no horizontal component of thrust, T_H , only a vertical component of thrust, T_V . The total resultant thrust vector, T_R , is also substantially perpendicular to the fuselage of the VTOL/STOL A/C 200. As a result, the thrust T_R pushes VTOL/STOL A/C 200 up from the ground (or a VTOL/STOL A/C 200 launch vehicle), in a substantially perpendicular manner.

[052] Also shown in FIG. 2A are air flow currents 220a-f. Airflow currents 220a-f represent the flow of air into engine 208 as it is generating its maximum thrust during take-off. Note that airflow currents 220c, d flow relatively straight into engine 208, but airflow currents 220b, e follow a more complex and therefore inefficient path into the engine 208. That the air follows this torturous path demonstrates the immense ingesting power the engine 208 creates as it is generating maximum take-off thrust. Air is being pulled from the sides of the engine 208 up and along nacelle 224, and then into the engine 208. Because of the complex and therefore inefficient path that air flow current 220b travels, lower engine lip 213 is designed to be substantially well rounded to allow the air to flow into the engine 208 substantially smoothly. Upper engine lip 212 is kept appropriately sharp, which is the preferred configuration for both high speed operation and LO (See FIG. 2C). Note that some airflow currents do not get ingested into the engine 208. Airflow currents 220a, f hit the nacelle 224 of engine 208, and go down (when the VTOL/STOL A/C 200 is taking-off). A plurality of stagnation points 222a, b occur or are created along the outer perimeter of nacelle 224 of engines 208a, b. Above the line of the plurality of stagnation point 222a, b, air flows into the engine 208; below the line of the plurality of stagnation point 222a, b, air flows downward along the nacelle 224. This line of stagnation points 222a, b is not constant, and at some point of operation, disappears altogether.

[053] In FIG. 2B, the engine 208 has tilted to approximately 45° with respect to the fuselage 202. The engine 208 tilts in response to commands given to engine tilt mechanism 210 from air volume control circuit 204. Air volume control circuit 204, in turn receives an air volume detection signal from air volume detection circuit 216. Engine tilt is performed by the engine tilt mechanism 210, which is controlled by signals received from a main control system 206 and the air volume detection circuit 216. The control of engine tilt is discussed in much greater detail below.

[054] FIG. 2B shows the configuration of engine 208 as the VTOL/STOL A/C 200 is transitioning from vertical flight – the take-off stage – to horizontal flight. As shown in FIG. 4B, the thrust from engine 208 is directed at approximately a 45° angle with respect to the fuselage 202. Because the thrust is now at a 45° angle with respect to the fuselage 202, there will be both a non-zero horizontal and a vertical component of thrust.

[055] Of course, as one of ordinary skill in the art can appreciate, the transition from a substantially vertical configuration to one on which the engine 208 is now at a 45° angle with respect to the fuselage does not occur instantaneously. In practice, according to an exemplary embodiment of the present invention, the tilting of engine 208 can occur no faster than a predetermined rate, otherwise lift will not be generated because no air is moving over the wings of the VTOL/STOL A/C 200. As the engine 208 moves from its substantially vertical configuration, the total thrust T_R transitions from substantially totally vertical (i.e., T_V is about 100%), to a continuously lower and lower percentage of total thrust T_R . Thus, the VTOL/STOL A/C 200 stops from substantially rising up into the air to moving slightly forward, and then more so as the horizontal component of thrust T_H increases. At the point that the engine is in the configuration as shown in FIG. 2B, the VTOL/STOL A/C 200 has as much vertical thrust as it does horizontal thrust. Thus, VTOL/STOL A/C 200 will now rise and move forward. This presumes, as one of ordinary skill in the art can appreciate, that all other flight control surface remains substantially unchanged. By appropriately altering certain flight surface configurations, the VTOL/STOL A/C 200 can, instead of rising because of the vertical thrust, actually descend. For example, VTOL/STOL A/C 200 can invert and the vertical component of thrust can then pushed VTOL/STOL A/C 200 downward.

[056] As discussed above, the plurality of airflow stagnation points 222a, b in FIG. 2B have moved in relation to where they were in FIG. 2A. Note that airflow currents 220c, d continue to flow relatively straight into engine 208, but airflow currents 222b, e follow a slightly less complex path into engine 208 than what was seen in FIG. 2A. Again, note that some airflow currents do not get ingested into the engine 208. Airflow currents 220a, f hit the nacelle 224 of engine 208, and go down along side nacelle 224. A plurality of new stagnation point 222a, b still occurs on both sides of nacelle 224 of engine 208, but now it is much closer to the upper and lower engine lips 212, 213 than before (in FIG. 2A). Above the stagnation point 222a, b, air flows into the engine 208; below the stagnation point 222a, b, air flows downward along the nacelle 224.

[057] In FIG. 2C, the engine 208 has tilted to between about 5° to about 10° above the fuselage 202. FIG. 2C shows the configuration of engine 208 as the VTOL/STOL A/C 200 has transitioned from the combination of vertical and horizontal flight shown in FIG. 2B, to substantially completely horizontal flight. This is a configuration for high thrust

at low to moderate speeds, and captures a large amount of airflow. As shown in FIG. 4C, the thrust from engine 208 is directed between about 5° to about 10° down from the nose-to-tail plane of fuselage 202. This creates a significant horizontal component of thrust T_H , and a substantially smaller component of vertical thrust, T_V . The resultant thrust, T_R substantially completely comprises the horizontal component T_H , and whatever vertical component there is, can easily be compensated for by trimming the VTOL/STOL A/C 200 using the trim tabs, as is well known to those of ordinary skill in the art of the present invention.

[058] In FIG. 2D, the engine 208 has tilted to about 0° above the nose-to-tail plane of fuselage 202. FIG. 2D shows the configuration of engine 208 as the VTOL/STOL A/C 200 is either in a moderate thrust mode in steady high speed flight, or a low thrust mode in low speed flight. This configuration has a substantially well shielded engine face for a substantially low radar observability. As shown in FIG. 4D, the thrust from engine 208 is directed at approximately a 0° angle with respect to the nose-to-tail plane of fuselage 202. Because the thrust is now at a 0° angle with respect to the nose-to-tail plane of fuselage 202, the thrust will be substantially horizontal, and the vertical component of thrust will be substantially non-existent. The total resultant thrust in this instance, T_R , is substantially the same as the horizontal thrust T_H . VTOL/STOL A/C 200 is moving forward, but at a greatly reduced rate than that as shown in FIG. 2C.

[059] The transition from lift-off to forward flight discussed above involved only a general description of engine 208 as it rotates from a substantially vertical position to a substantially horizontal one. There are times during forward flight, however, when the transition is much less dramatic in terms of relative position, but can greatly affect operation and performance of the VTOL/STOL A/C 200, i.e., from high speed to loiter. This is shown in FIGS. 2C and 2D. It is during the more subtle relative position difference that is now the focus of the discussion.

[060] The air inlet area 218 is defined as the combination of the upper and lower air intake opening surfaces 214a, b and the lower engine inlet lip 213. The air inlet area 218 is suitably shaped for efficient high speed engine performance, loiter capability, low radar observability and substantially reduced infra-red signature. The upper and lower air intake opening surfaces 214a, b that the lower engine inlet lip 213 retracts about, are shaped to maintain a substantially smooth airflow into engine 208 during both low speed

and high speed flight. With appropriate shaping, engine 208 can be tilted just a few degrees to adjust the size of the air inlet area 218. This allows a suitable amount of air to reach the engine 208 for its current or desired operating condition. Engine 208 performance is maximized while spillage drag penalties are minimized.

[061] Between high speed and loiter operations, the relative position of the engine 208 with the fuselage 202 will change, but only by a small amount. This is shown in greater detail in FIGS. 7A and 7B, which is discussed in greater detail below. However, that small amount of change in configuration (i.e., the tilt angle) produces large changes in operating conditions, and creates the unique advantages of the variable inlet according to an embodiment of the present invention.

[062] During high speed flight (FIG. 2C), engine 208 nests onto a lower air intake opening surface 214b so that the lower engine lip 213 is elevated a small amount with respect to the lower air intake opening surface 214b. In this configuration, the maximum amount of air enters engine 208. So much air enters engine 208 that some air spills out of engine 208, as shown by airflow currents 220c. This is the opposite condition of what occurs as shown in FIGS. 2A and 2B. Since engine 208 can only use so much air, some of the air attempting to enter will be forced out and around the upper engine lip 212 (airflow current 222c). Airflow currents 222a, b represent air that is accepted and used by engine 208, and it enters at relatively easily and from a substantially horizontal direction. Lower engine lip 213 is shaped considerably differently than that of upper engine lip 212. It is considerably blunter and larger, making it more difficult for air to escape from around it, and provides a larger area so that it can nest about upper and lower air intake opening surfaces 214a, b.

[063] During loiter flight (FIG. 2D), engine 208 nests below upper air intake opening surface 214b so that the lower engine lip 213 is substantially even with respect to the upper air intake opening surface 214a (i.e., lower engine lip 213 is against lower air intake opening surface 214b). In this configuration, a greatly reduced amount of air reaches engine 208. Since a much smaller amount of air is entering engine 208, there is substantially no air spillage out of engine 208, as shown by airflow current 220a. This represents a different operating condition from what is shown in FIG. 2C. Since engine 208 is using much less air, less fuel can be provided, thereby preserving substantially more of the TSFC value at which the engine operates during high speed mode. Recall

that a low TSFC value represents a highly efficient engine, and that gas turbine engines are more efficient at high speeds, generally. This unique combination of upper and lower engine lips 212, 213, and upper and lower air intake surfaces 214a, b create the variable air inlet area according to the various embodiments of the present invention. The VTOL/STOL A/C 200 can thereby operate efficiently over a wide range of airspeed and engine air flow requirements.

[064] Another advantage provided by the recessing engine 208 into and about the upper and lower air intake opening surfaces 214a, b is that engine 208 provides a substantially reduced cross sectional surface (i.e., lower RCS, as discussed above) to oncoming radio waves transmitted by a radar. Also, recessing engine 208 as described herein hides a substantially greater amount of heat generated by engine 208 by the fuselage that comprises upper and lower air intake opening surfaces 214a, b. This reduces the infra-red “signature” of engine 208 and subsequently VTOL/STOL A/C 200.

[065] FIG. 7A represents the loiter configuration. In FIG. 7A, engine 208 is recessed into and about upper and lower air intake opening surfaces 214a, b. The engine 208 is substantially horizontal with the fuselage 202. The upper engine lip 212 is at a height h_1 above the fuselage as shown. If the engine 208 has a width w , the area A_1 of air inlet area 218 is:

$$A_1 = w \times h_1$$

[066] The larger the area A_1 of the air inlet area, the greater the volume of air that engine 208 can receive. If the VTOL/STOL A/C 200 wants to operate in a high thrust mode, engine 208 is tilted via operation of tilt mechanism 210. Tilt mechanism 210 is a distance l from the air inlet opening 218. Therefore, small changes in tilt angle will cause large changes in the height of the upper engine lip 212 above the nose-to-tail plane of fuselage 202, as shown in FIG. 7B. The total height h_T is the total height of the upper engine lip 213 after a tilt angle has occurred because of tilt mechanism 210. The total height h_T is the combination h_1 and h_2 , wherein h_2 is the change in height because engine 208 is tilted. The change in height h_2 is calculated as follows (where Θ equals the tilt angle of engine):

$$h_2 = \sin \Theta \times l$$

[067] Therefore, the new area, A_2 is:

$$A_2 = (h_1 + h_2) \times w; \text{ or}$$

$$A_2 = (h_1 + \sin \Theta \times l) \times w$$

[068] By way of a non-limiting example, suppose h_1 is 6 inches, and w is 20 inches. Then A_1 is 120 in². If the engine 208 is about 8 feet in length, and the tilt mechanism is about 6 feet from the air inlet area 218, and the engine 208 is tilted only 5°, the new area, A_2 is ((6 in. + sin 5° x 72 in.) x 20 in), which equals 245.5 in². This is an increase of area of over 100%. Therefore, very small engine tilt angles will produce substantially significant changes in the volume of air that does or does not enter engine 208. Note that in FIGS. 2A and 2B, there is no discussion of the air inlet area 218. Since the air inlet area 218 is defined as the combination of the upper and lower engine lips 212, 213, and the upper and lower air intake opening surfaces 214a, b, such discussion is not necessary when engine 208 is so far away from the upper and lower air intake opening surfaces 214a, b, and the upper and lower engine lips 212, 213 have no discernable aerodynamic effect on the air entering engine 208.

[069] FIGS. 6A-6L illustrate several front perspective views of the upper, middle and lower engine inlet lips 212, 215, 213 of engines 208a, b used in VTOL/STOL A/C 300 according to an embodiment of the present invention. The perspective views of FIGS. 6A-6L illustrate the shapes and configuration of upper, middle and lower engine inlet lips 212, 215, 213 of engines 208a, b that can be used in UAV/VTOL A/C 300 according to an embodiment of the present invention.

[070] FIGS. 3A-3C illustrate several side views of an STOL/VTOL A/C 300 according to an embodiment of the present invention, and FIGS. 5A-5C illustrate a vector representation of the thrust from a plurality of engines 208a, b in the VTOL/STOL A/C 300 of FIGS. 3A-3C.

[071] STOL/VTOL A/C 300 differs from STOL/VTOL A/C 200 in one significant respect: STOL/VTOL A/C 300 has two engines, 208a, b, whereas STOL/VTOL A/C 200 has only one engine 208. The manner in which STOL/VTOL A/C 300 operates is

substantially similar to the operation of STOL/VTOL A/C 200 with a single engine. Through the unique combination of the upper and lower engine lips 212, 213 (in the cases of STOL/VTOL A/C 300, there is also a middle engine lip 215) and upper and lower air intake opening surfaces 214a, b, the STOL/VTOL A/C 200, 300 can operate with a high degree of efficiency (i.e., low TSFC) at both high and low speeds. The difference in the STOL/VTOL A/C 300 is that both a low and high speed engine are included in the airframe. However, STOL/VTOL A/C according to exemplary embodiments of the present invention can incorporate any suitable number of engines.

[072] FIGS. 3A-3C illustrate several side views of a vertical take-off and landing/short take-off and landing aircraft (VTOL/STOL A/C) 300 according to an embodiment of the present invention. As shown in FIG. 3A, the STOL/VTOL A/C 300 comprises a fuselage 202, air volume control circuit 204, main control system 206, an engine 208, and an engine tilt mechanism 210, and substantially the same components as STOL/VTOL A/C 200. Thus, a detailed description of those components will be omitted for the purpose of brevity. Because engine 208a, 208b are combined in one assembly, and therefore contain an additional component, engines 208a, b will be referred to in combination as engine assembly 256. Engine assembly 256 comprises, among other components, loiter or low speed engine (low speed engine) 208a, high speed and vertical flight engine 208b, upper engine inlet lip (upper engine lip) 212, middle engine inlet lip (middle engine lip 215) and lower engine inlet lip (lower engine lip) 213). In the case of STOL/VTOL A/C 300, the middle and lower engine lips 215, 213 are configured to interface with, as will be discussed in greater detail below, to air intake opening (of the fuselage 202) 214.

[073] FIG. 3A illustrates the situation when the VTOL/STOL A/C 300 is in a take-off or landing configuration. This can be before take-off, during take-off, or shortly after take-off. VTOL/STOL A/C 300 can also achieve this configuration after it has been in forward flight at some altitude above the ground (hovering). For purposes of this discussion, the scenario in which the VTOL/STOL A/C 300 is taking off from the ground or a launch vehicle will be considered. In the take-off configuration, engine assembly 256 is substantially perpendicular to the fuselage 202. Therefore, the thrust from both low speed and high speed engines 208a, b are also substantially perpendicular to the plane of the wings and the tail-to-nose plane of fuselage 202. FIG. 5A illustrates

the thrust vector from engines 208a, b in its lift-off configuration. In FIGS. 5A-5C, the vertical component of thrust from engine 208a is designated as T_{V1} and the vertical component of thrust from engine 208b is designated T_{V2} ; the horizontal component of thrust from engine 208a is designated as T_{H1} , and the horizontal component of thrust from engine 208b is designated as T_{H2} ; and the total resultant thrust vector is designated as T_R . There is substantially no horizontal component of thrust, T_{H1} , T_{H2} , only a vertical component of thrust from engines 208a, b T_{V1} , T_{V2} . The resultant thrust vector, T_R , is also substantially perpendicular to the nose-to-tail plane of fuselage 202 of VTOL/STOL A/C 300. As a result, the total resultant thrust T_R pushes VTOL/STOL A/C 300 up from the ground (or a VTOL/STOL A/C 300 launch vehicle), in a substantially perpendicular manner.

[074] Also shown in FIG. 3A are air flow currents 220a-f. Airflow currents 220a-f represent the flow of air into engines 208a, b as it is generating its maximum thrust during take-off. Note that airflow currents 220c, d flow relatively straight into engines 208a, b respectively, but airflow currents 222b, e follow a more complex, and therefore inefficient path into their respective engines 208a, b. That the air follows this complex path demonstrates the immense ingesting power engines 208a, b create as they generate maximum take-off thrust. Air is being pulled from the sides of engines 208a, b up and along both sides of nacelle 224, and then into engines 208a, b. Because of the complex and inefficient path that air flow current 222b travels, lower engine lip 213 is designed to be suitably well rounded to allow the air to flow into the engine 208 substantially smoothly. Upper engine lip 212 is kept appropriately sharp, which is the preferred configuration for both high speed operation and LO (See FIG. 3C). Note that some airflow currents do not enter into engines 208a, b. Airflow currents 220a, f hit the nacelle 224 of engines 208a, b, and go down (when the VTOL/STOL A/C 300 is taking-off). A plurality of stagnation points 222a, b occur or are created along the outer perimeter of nacelle 224 of engines 208a, b. Above the line of the plurality of stagnation point 222a, b, air flows into the engine 208; below the line of the plurality of stagnation point 222a, b, air flows downward along the nacelle 224. This line of stagnation points 222a, b is not constant, and at some point of operation, disappears altogether.

[075] In FIG. 3B, engines 208a, b have tilted to approximately 45° with respect to the nose-to-tail plane of fuselage 202. Engines 208a, b tilt in response to commands given to

engine tilt mechanism 210 from air volume control circuit 204. Air volume control circuit 204 in turn receives an air volume detection signal from air volume detection circuit 216. Engine tilt is performed by the engine tilt mechanism 210, which is controlled by signals received from a main control system 206 and the air volume detection circuit 216. The control of engine tilt is discussed in greater detail below.

[076] FIG. 3B shows the configuration of engines 208a, b as the VTOL/STOL A/C 300 is transitioning from vertical flight – the take-off stage – to horizontal flight. As shown in FIG. 5B, the total resultant thrust T_R from engines 208a, b is directed at approximately a 45° angle with respect to the fuselage 202. Because the thrust is now at a 45° angle with respect to the fuselage 202, there will be both a non-zero horizontal and a vertical component of thrust.

[077] Of course, as one of ordinary skill in the art can appreciate, the transition from a substantially vertical configuration to one in which the engine assembly 256, and consequently engines 208a, b are now at approximately a 45° angle with respect to the nose-to-tail plane of fuselage 202 does not occur instantaneously. In practice, according to an exemplary embodiment of the present invention, the tilting of engine assembly 256 and engines 208a, b can occur no faster than a suitable predetermined rate, otherwise lift will not be generated because no air is moving over the wings of the VTOL/STOL A/C 300. As engine assembly 256 and engines 208a, b moves from its substantially vertical configuration, the total thrust T_R transitions from substantially totally vertical (i.e., T_{V1} , T_{V2} is about 100%), to a continuously lower and lower percentage of total thrust T_R . Thus, the VTOL/STOL A/C 300 stops from substantially rising up into the air to moving slightly forward, and then more so as the horizontal component of thrust T_{H1} , T_{H2} , increases. At the point that engine assembly 256 and engines 208a, b are in the configuration as shown in FIG. 3B, VTOL/STOL A/C 300 has as much vertical thrust as it does horizontal thrust. Thus, VTOL/STOL A/C 300 will now rise and move forward. This presumes, as one of ordinary skill in the art can appreciate, that all other flight control surface remains substantially unchanged. By altering certain flight surface configurations, VTOL/STOL A/C 300 can, instead of rising because of the vertical thrust, actually descend. For example, VTOL/STOL A/C 300 could invert and the vertical component of thrust could be pushing the VTOL/STOL A/C 300 downward.

[078] As discussed above, the plurality of airflow stagnation points 222a, b in FIG. 3B have moved in relation to where they were in FIG. 3A. Note that airflow currents 220c, d continue to flow relatively straight into engine 208, but airflow currents 222b, e follow a slightly less complex path into engine 208 than what was seen in FIG. 3A. Again, note that some airflow currents do not enter into engines 208a, b. Airflow currents 220a, f hit the nacelle 224 of engine assembly 256 and engines 208a, b, and go down along side nacelle 224. A plurality of new stagnation points 222a, b still occurs on both sides of nacelle 224 of engine assembly 256 and engines 208a, b, but now it is much closer to the upper and lower engine lips 212, 213 than before (in FIG. 2A). Above the stagnation point 222a, b, air flows into the engine 208; below the stagnation point 222a, b, air flows downward along the nacelle 224.

[079] In FIG. 3C, engine assembly 256 and engines 208a, b have tilted to between about 5° to about 10° above the nose-to-tail plane of fuselage 202. FIG. 3C shows the configuration of engines 208a, b as the VTOL/STOL A/C 300 has transitioned from the combination of vertical and horizontal flight shown in FIG. 3B, to substantially completely horizontal flight. This is a high thrust configuration and provides maximum airflow to both engines. This would be appropriate for acceleration or performing tight maneuvers. As shown in FIG. 5C, the thrust from engines 208a, b is directed between about 5° to about 10° down from the fuselage 202. This creates a significant horizontal component of thrust from both engines T_{H1} , T_{H2} , and a substantially smaller component of vertical thrust from both engines, T_{V1} , T_{V2} . The resultant thrust, T_R , substantially completely comprises the horizontal component, and whatever vertical component there is can easily be compensated for by trimming the VTOL/STOL A/C 300 using the trim tabs, as is well known to those of ordinary skill in the art of the present invention.

[080] In FIG. 3D, engine assembly 256 and engines 208a, b have tilted to about 0° above the nose-to-tail plane of fuselage 202. FIG. 3D shows the configuration engines 208a, b as the VTOL/STOL A/C 300 has transitioned from substantially horizontal flight at high speed to substantially horizontal flight at low speed, or loiter. As shown in FIG. 5D, the thrust from engine 208a is directed at approximately a 0° angle with respect to the fuselage 202. Because the thrust is now at about a 0° angle with respect to the nose-to-tail plane of fuselage 202, the thrust will be substantially horizontal, and the vertical component of thrust will be substantially non-existent. The total resultant thrust in this

instance, T_R , is substantially the same as the horizontal thrust from the low speed engine T_{H1} . VTOL/STOL A/C 300 is moving forward, but at a greatly reduced rate than that as shown in FIG. 3C.

[081] In the low speed mode as shown in FIG. 3D, the second engine, or high speed engine 208b, is completely shut off, and, according to an exemplary embodiment of the present invention, ceases to operate. That is why there no horizontal component of velocity T_{H2} . T_{H1} is substantially smaller than T_{H2} , and this is represented in FIG. 5D. When the high speed engine is in this shut off condition, no air passes through it, and thus there is substantially no danger of damage due to, for example, wind induced rotation and wear resulting from lack of oil pressure. The mechanism for shutting down the high speed engine 208b, and why there is little or no airflow through it is discussed in greater detail below.

[082] The transition from lift-off to forward flight discussed above involved a general description of engine assembly 256 and engines 208a, b as it rotates from a substantially vertical position to a substantially horizontal one. There are times during forward flight, however, when the transition is much less dramatic in terms of relative position, but can greatly affect operation and performance of the VTOL/STOL A/C 300, i.e., from high speed to loiter. This is shown in FIGS. 3C and 3D. It is during the more subtle relative position difference that is now the focus of the discussion.

[083] The air inlet area 218 is defined as the combination of the upper and lower air intake opening surfaces 214a, b and the middle and lower engine inlet lips 215, 213. The air inlet area 218 is suitably shaped for efficient high speed engine performance, loiter capability, low radar observability and substantially reduced infra-red signature. The upper and lower air intake opening surfaces 214a, b that the middle and lower engine inlet lips 215, 213 retract about, are shaped to maintain a substantially smooth airflow into engines 208a, b during high speed and low speed flight. With appropriate shaping, engine assembly 256 can be tilted a few degrees to adjust the size of the air inlet area 218 and position the engines 208a, b for the desired performance. This allows an appropriate amount of air to reach engines 208a, b for their current or desired operating condition. Performance of each engine 208a, b is maximized while spillage drag penalties are minimized.

[084] Between high speed and loiter operations, the relative position of the engine assembly 256 and engines 208a, b with the fuselage 202 will change, although by a small amount. This principle was discussed in greater detail above in regard to engine 208 (the single engine embodiment), and applies to this exemplary embodiment as well, but differs in its application. A discussion of FIGS. 7A and 7B will not be repeated.

However, that small amount of change in configuration (i.e., the tilt angle) produces large changes in operating conditions, and creates the unique advantages of the variable inlet according to an embodiment of the present invention.

[085] During high speed flight (FIG. 3C), engine 208b partially nests onto a lower air intake opening surface 214b so that the lower engine lip 213 is substantially in line with upper air intake opening surface 214a. Low speed engine 208a, however, remains well above upper air intake opening surface 214a, and provides as much thrust as it possibly can. In this configuration, the maximum amount of air enters both low speed and high speed engines 208a, 208b. So much air enters low speed engine 208a that some air spills out of engine 208a, as shown by airflow currents 220c, e. This is the opposite condition of what occurs to engines 208a, b as shown in FIGS. 3A and 3B. Since low speed engine 208a can only use so much air (because it is operating within a regime it was not intended to operate), some of the air attempting to enter will be forced out and around the middle engine lip 215 (airflow current 222c). Airflow currents 222d represent air that is accepted and used by low speed engine 208a, and it enters relatively easily and from a substantially horizontal direction.

[086] Similar phenomena occur in regard to high speed engine 208b. So much air enters high speed engine 208b that some air spills out of engine 208b, as shown by airflow current 220a. This is the opposite condition of what occurs to engines 208a, b as shown in FIGS. 3A and 3B. Since high speed engine 208b can only use so much air, some of the air attempting to enter will be forced out and around the lower engine lip 213 (airflow current 222a). Airflow currents 222b represent air that is accepted and used by high speed engine 208b, and it enters at relatively easily and from a substantially horizontal direction.

[087] Middle and lower engine lips 215, 213 are shaped considerably differently than that of upper engine lip 212. They are considerably blunter and larger, making it more difficult for air to escape from around it (though not impossible, as FIG. 3C

demonstrates), and provides a larger area so that it can nest about upper and lower air intake opening surfaces 214a, b.

[088] During loiter flight, FIG. 3D, high speed engine 208b nests substantially completely below upper air intake opening surface 214b so that the middle engine lip 215 is substantially even with respect to the upper air intake opening surface 214a (i.e., both middle and lower engine lip 215, 213 is against lower air intake opening surface 214b). In this configuration, substantially no air reaches high speed engine 208b. VTOL/STOL A/C 300 flies at its loiter speed, which is defined as the speed that gives maximum flight endurance. It may also be desirable to fly slowly to improve the performance of the aircraft sensors, for example, to look at or monitor events on the ground. Only low speed engine 208a is operating, and it is operating within its design parameters. Therefore, low speed engine 208a is operating efficiently, with a low TSFC. Since a much smaller amount of air is entering low speed engine 208a, there is substantially no air spillage out of low speed engine 208a, as shown by airflow currents 220a, b. This is a different operating condition as what is shown in FIG. 3C.

[089] The unique combination of upper, middle and lower engine lips 212, 215, 213, and upper and lower air intake surfaces 214a, b create the variable air inlet area 218 according to another embodiment of the present invention. By using both a low speed engine 208a and a high speed engine 208b, VTOL/STOL A/C 300 can therefore operate extremely efficiently at both high speeds and loiter speeds, because at loiter speeds, the high speed engine 208b is shut off, and does not operate outside its design parameters. At high speeds, both low and high speed engines 208a, b operate, but at maximum efficiency. Retracting high speed engine 208b into the fuselage about upper and lower air intake surfaces 214a, b prevents damage to high speed engine 208b since its engine parts substantially cease to move, and substantially little or no friction is generated. Gas turbine engines only generate lubricating oil pressure when their components (fans, turbines compressors) are moving, and oil lubricates the internal components (i.e., bearings). Both low speed and high speed engines 208a, b operate at their lowest TSFC value for a greater period of time because of the two engine configurations and the ability to retract high speed engine 208b and shut it off during loiter speed operations, as described herein according to an embodiment of the present invention.

[090] Another advantage provided by the recessing engines 208a, b into and about the upper and lower air intake opening surfaces 214a, b is that recessing engines 208a, b substantially reduce their cross sectional surface (i.e., lower RCS, as discussed above) to oncoming radio waves transmitted by a radar. Also, recessing engines 208a, b hide a substantially greater amount of heat generated by engine 208 by the fuselage that comprises upper and lower air intake opening surfaces 214a, b. This reduces the infra-red "signature" of engine 208 and subsequently VTOL/STOL A/C 200.

[091] FIG. 9 illustrates a block diagram of an aircraft control system 500 for controlling VTOL/STOL A/C 200, 300 shown in FIGS. 2A-2D and 3A-3C according to an embodiment of the present invention. For purposes of discussion of FIG. 9, reference shall only be made to VTOL/STOL A/C 200, though, as one of ordinary skill in the art can appreciate, aircraft control system 500 applies to VTOL/STOL A/C 300 as well. Main control system 206 communicates with all of the other components of aircraft control system 400 via main communication bus 226. Main control system 206 acquires information from, and provides instructions and information to landing gear/lights system 232, weapons systems controller 234, flight data accumulator 238, air volume control system 204, propulsion control system 242, navigation control system 244, flight surface control system 248, and detection/protection system 252. Main control system 206 also communicates with communications system 228, that receives and transmits information via first communication antenna 228. Main control system 206 receives navigation data from navigation control system 244, which receives global position data via navigation antenna 246. Weapons system controller 234 controls weapon system 236a-n, and flight data accumulator receives flight data from an air speed instrumentation system, an altimeter, vertical speed instrumentation, rate of turn instrumentation, gyroscopic data, and engine data. Propulsion control system controls and monitors a plurality of engines 208a-n. Flight surface control system 248 controls and receives status information from flight control surfaces such as ailerons, flaps, elevators, rudder, and trim tabs, among other types of flight control surfaces. Detection and protection system 252 can monitor and control a radar system, electronic counter measures system, chaff and flare protection system, infra-red detection system and camera/video systems, depending on what is carried on the VTOL/STOL A/C 200. A

complete and detailed discussion of any of these systems is beyond the scope of this document, and as such, for purpose of brevity, shall be omitted.

[092] As discussed above, engine 208 can tilt to maximize a current operating condition of the engine according to an embodiment of the present invention. The current operating condition of engine 208 is maintained and updated by a main control system 206. Main control system 206 monitors the current airspeed of the VTOL/STOL A/C 200, the current flight attitude (i.e., bank left, bank right, climb, descent, acceleration, deceleration), the desired flight attitude (i.e., bank left, bank right, climb, descend, accelerate, decelerate), the desired airspeed, the current action the UAV/VTOL A/C 200 is taking (weapons delivery, electronic countermeasures, among others), the desired action the VTOL/STOL A/C 200 is to take, current environmental conditions (air temperature, density, altitude, among others), fuel flow and fuel capacity, weight, external payloads, status of electrical and hydraulic systems, and various other factors. These factors can be categorized into two main categories: current state of the VTOL/STOL A/C 200, and the desired state of the VTOL/STOL A/C 200.

[093] According to an exemplary embodiment of the present invention, the air volume control circuit 204 processes pertinent information and generates a nacelle tilt angle signal that controls the tilt of engine 208. Of course, as one of ordinary skill in the present invention can appreciate, the main control system 206 can perform all the same calculations as the air volume control circuit 204.

[094] To maximize the current operating condition of the engine 208, the main control system 206 first determines whether a change to the current operating condition of the engine 208 is warranted based on the desired state of the VTOL/STOL A/C 200. The main control system 206 acquires a current reading from the air volume detection circuit 216 that is located in the engine 208, as well as the current airspeed, altitude and temperature. The current and desired airspeed, air temperature and altitude information is then forwarded to the air volume control circuit. The air volume control system 204 generates throttle settings based on the current and desired airspeed, altitude, and temperature. Based on the throttle settings, the air volume control circuit 204 determines a new airflow in cubic feet per minute (CFM).

[095] Based on the new airflow (X CFM), the air volume control circuit 204 determines a capture area (as discussed above). The capture area is the area defined by the upper

engine lips 212, two sides of engine nacelle 224, and the fuselage 202 in the immediate vicinity of the upper engine lip 212. From the air capture area, a nacelle tilt angle is generated. The engine tilt angle is then forwarded to the engine tilt mechanism 210. The engine tilt mechanism 210 tilts the engine 208 to the calculated nacelle tilt angle. The engine tilt mechanism 210 also provides an angle measurement feedback signal, which is reported back to the air volume control circuit 204, verifying that the correct tilt nacelle tilt angle has indeed been accomplished. The air volume detection circuit 216 measures the air flow volume through the engine 208, which is then reported back to main control system 206, which monitors the airspeed. Finally, the main control system 206 checks all the parameters described above, to see if the desired condition has been achieved. If it has not, then a correcting signal is sent to the air volume control circuit 204. If it has, then the main control system 206 and air volume control circuit continue to monitor the various aforementioned parameters until a change in the configuration of the VTOL/STOL A/C 200 is desired.

[096] FIGS. 10A and 10B illustrate a flow diagram of a method for tilting an engine in the VTOL/STOL A/C 200 shown in FIGS. 2A-2D and 3A-3C to maximize an operating condition of the engine(s) according to an embodiment of the present invention. As discussed above, the method for controlling the tilt of the engine 208 can be accomplished in the main control system 206, or in combination between the main control system 206 and the air volume control circuit 204. In step 402, the current state of the VTOL/STOL A/C 200 is obtained. This is a constant monitoring process performed by the main control system 206. According to an exemplary embodiment of the present invention, data is accumulated and sent back to a remotely located ground station, that monitors the status of the VTOL/STOL A/C 200. In step 404, a new desired state of the VTOL/STOL A/C 200 is obtained. The current state of the VTOL/STOL A/C 200 is compared to the desired state of the VTOL/STOL A/C 200 and the differences are noted. As noted above, method 400 can be used for both the single engine VTOL/STOL A/C 200 or the dual engine VTOL/STOL A/C 300 as shown in FIGS, 3A-3D. The method is substantially the same, except that method 400 would determine, in the case of the VTOL/STOL A/C 300, in step 404 whether one engine or both engine 8a, b would be needed for take-off. In addition, throughout method 400, wherever a determination about thrust is made, method 400 will determine whether to

use one or the other engine, or both engines. In step 406, method 400 determines a new throttle setting for engine 208 based on the current and desired airspeed, altitude and temperature. In step 408, a new airflow setting is determined based on the new throttle setting. In step 410, a new capture area is calculated, and from the new capture area, a nacelle tilt angle setting is determined in step 412. In step 414, method 400 forwards the nacelle tilt angle setting to the engine tilt mechanism 210. In step 416, the engine tilt mechanism tilts the engine 208 according to the nacelle tilt angle setting.

[097] Referring now to FIG. 10B, method 400 verifies whether engine 208 has been tilted to the correct angle. If engine 208 has not been tilted to the correct engine tilt angle (“No” path from decision step 418), method 400 proceeds through path B (back to FIG. 10A) and step 414, where the nacelle tilt angle signal is again transmitted to the engine tilt mechanism 210. Then, steps 416 and 418 are executed until the correct engine tilt angle is achieved. If, however, the engine tilt angle is verified to be correct (“Yes” path from decision step 418), the air flow volume is checked in decision step 420. Method 400 determines this by again acquiring a current air volume signal from the air volume detection circuit 216. If the air flow volume is not correct (“No” path from decision step 420), method 400 proceeds back to step 414 via path C (back to FIG. 10A), where the nacelle tilt angle signal is again transmitted to the tilt mechanism 210. Then, steps 416, 418 and 420 are repeated until the correct air flow volume is achieved. If, however, the correct air flow volume is achieved (“Yes” path from decision step 420), method 400 proceeds to step 402 via path C (again back to FIG. 10A). Step 402 acquires the current state of the VTOL/STOL A/C 200, and method 400 repeats.

[098] Any and all components of the aircraft control system 500, and any and all components thereof, including, but not limited to, main control system 206, and/or air volume control system 204 (among other components), can be any suitable type of electrical or electronic device capable of performing the functions for aircraft control system 500 and its components discussed herein. For example, the aircraft control system 500 can be comprised of hardware, software, firmware or any suitable combination thereof.

[099] Alternatively, the aircraft control system 500, and any and all components thereof, including, but not limited to, main control system 206, and/or air volume control system 204 (among other components), can be comprised of any suitable type of

processor, including any type of microprocessor, microcontroller, digital signal processor (DSP), application-specific integrated circuit (ASIC), programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), electrically-erasable programmable read-only memory (EEPROM), or the like. The aircraft control system 500, and any and all components thereof, including, but not limited to, main control system 206, and/or air volume control system 204 (among other components), can be connected to or include a memory, such as, for example, any type of computer memory or any other type of electronic storage medium, such as, for example, read-only memory (ROM), random access memory (RAM), cache memory, compact disc read-only memory (CDROM), electro-optical memory, magneto-optical memory, or the like. The processor and memory can be used, for example, to perform some or all of the functions of the aircraft control system 500, and any and all components thereof, including, but not limited to main control system 206, and/or air volume control system 204 (among other components), described herein. As will be appreciated based on the foregoing description, the memory can be programmed using conventional techniques known to those having ordinary skill in the art of computer programming. For example, the actual source code or object code of the computer program can be stored in the memory.

[0100] FIG. 11 illustrates a front perspective view of the VTOL/STOL A/C 200 shown in FIGS. 2A-2D according to an embodiment of the present invention. In this exemplary configuration, VTOL/STOL A/C 200 is shown as an unmanned aerial vehicle, with one engine 208. FIGS. 8A-8N illustrate a plurality of views of the VTOL/STOL A/C 300 shown in FIGS. 3A-3C according to an embodiment of the present invention. In FIGS. 8A-8N, VTOL/STOL A/C 300 is also shown as an unmanned aerial vehicle, but with a low speed engine 208a, and a high speed engine 208b.

[0101] The present invention has been described with reference to several exemplary embodiments. However, it will be readily apparent to those skilled in the art that it is possible to embody the invention in specific forms other than that of the exemplary embodiments described above. This may be done without departing from the spirit and scope of the invention. The exemplary embodiments are merely illustrative and should not be considered restrictive in any way. The scope of the invention is given by the appended claims, rather than the preceding description, and all variations and equivalents which fall within the range of the claims are intended to be embraced therein.

[0102] All United States patents and applications, foreign patents, and publications discussed above are hereby incorporated herein by reference in their entireties.

WHAT IS CLAIMED IS:

1. A vertical take-off and landing (VTOL) aircraft, comprising:

an engine tilting mechanism,

wherein the engine tilting mechanism is configured to tilt a first engine to a first position substantially parallel to a fuselage of the VTOL aircraft to produce thrust for forward flight, and configured to tilt the first engine to a second position substantially perpendicular to the fuselage of the VTOL aircraft to produce thrust for hovering;

a variable engine inlet mounted to the first engine,

wherein the variable engine inlet is configured to provide a substantially smooth airflow into the first engine, and

wherein the engine tilting mechanism is configured to tilt the first engine to the first position to align the variable engine inlet with an air intake opening of the fuselage of the VTOL aircraft; and

an air volume detection circuit in communication with the engine tilting mechanism,

wherein the air volume detection circuit is configured to detect a volume of air entering the first engine,

wherein the air volume detection circuit is configured to determine the volume of air required by the first engine to maximize a current operating condition of the first engine, and

wherein the air volume detection circuit is configured to send a tilt control signal to the engine tilting mechanism to tilt the variable engine inlet relative to the air intake opening to adjust a size of the air intake opening and alter the volume of air entering the first engine to maximize the current operating condition of the first engine.

2. The VTOL aircraft of claim 1, wherein portions of the variable engine inlet exposed outside of the fuselage of the VTOL aircraft when the first engine is in the first position are configured for at least one of: i.) minimal drag during high speed forward flight; and ii.) minimal radar visibility during forward flight.

3. The VTOL aircraft of claim 1, wherein at least a second engine is configured to be tilted with the first engine relative to the fuselage of the VTOL aircraft to produce the thrust for hovering,

wherein the variable engine inlet is mounted to both the first and at least second engines,

wherein the variable engine inlet is configured such that as the first and at least second engines are tilted to the first position, airflow to one of the first and at least second engines is reduced, and

wherein the variable engine inlet is configured such that when the first and at least second engines are in the first position, airflow to the one of the first and at least second engines is cut off.

4. The VTOL aircraft of claim 3, wherein the first engine is positioned above and substantially parallel to the at least second engine, and

wherein the one of the first and at least second engines comprises the at least second engine.

5. The VTOL aircraft of claim 1, wherein the air intake opening is located within the fuselage of the VTOL aircraft.

6. The VTOL aircraft of claim 1, wherein the first engine comprises a turbo jet engine.

7. The VTOL aircraft of claim 1, wherein the first engine comprises a turbo fan engine.

8. A vertical take-off and landing (VTOL) aircraft, comprising:

a tilting nacelle,

wherein the tilting nacelle includes:

a first engine; and

at least a second engine,

wherein the tilting nacelle is configured to be tilted relative to a fuselage of the VTOL aircraft for providing thrust for hovering;

an engine tilting mechanism,

wherein the engine tilting mechanism is configured to tilt the tilting nacelle to a first position substantially parallel to the fuselage of the VTOL aircraft for providing thrust for forward flight, and configured to tilt the tilting nacelle to a second position substantially perpendicular with the fuselage of the VTOL aircraft for providing the thrust for hovering;

a variable engine inlet mounted to the tilting nacelle,

wherein the variable engine inlet is configured to provide a substantially smooth airflow into the tilting nacelle, and

wherein the engine tilting mechanism is configured to tilt the tilting nacelle to the first position to align the variable engine inlet with an air intake opening of the fuselage of the VTOL aircraft; and

an air volume detection circuit in communication with the engine tilting mechanism,

wherein the air volume detection circuit is configured to detect a volume of air entering the tilting nacelle,

wherein the air volume detection circuit is configured to determine the volume of air required by the first and at least second engines to maximize a current operating condition of the first and at least second engines, and

wherein the air volume detection circuit is configured to send a tilt control signal to the engine tilting mechanism to tilt the variable engine inlet relative to the air intake opening to adjust a size of the air intake opening and alter the volume of air entering the tilting nacelle to maximize the current operating condition of the first and at least second engines.

9. The VTOL aircraft of claim 8, wherein portions of the variable engine inlet exposed outside of the fuselage of the VTOL aircraft when the tilting nacelle is in the first position are configured for at least one of: i.) minimal drag during high speed forward flight; and ii.) minimal radar visibility during forward flight.

10. The VTOL aircraft of claim 8, wherein the variable engine inlet is configured such that as the tilting nacelle is tilted to the first position, airflow to one of the first and at least second engines is reduced, and

wherein the variable engine inlet is configured such that when the tilting nacelle is in the first position, airflow to the one of the first and at least second engines is cut off.

11. The VTOL aircraft of claim 10, wherein the first engine is positioned above and substantially parallel to the at least second engine within the tilting nacelle, and

wherein the one of the first and at least second engines comprises the at least second engine.

12. The VTOL aircraft of claim 8, wherein the air intake opening is located within the fuselage of the VTOL aircraft.

13. The VTOL aircraft of claim 8, wherein each of the first and at least second engines comprises a turbo jet engine.

14. The VTOL aircraft of claim 8, wherein each of the first and at least second engines comprises a turbo fan engine.

15. A vertical take-off and landing (VTOL) aircraft, comprising:

means for tilting a first means for providing propulsion,

wherein the tilting means is configured to tilt the first propulsion providing means to a first position substantially parallel to the fuselage of the VTOL aircraft to produce thrust for forward flight, and configured to tilt the first propulsion providing means to a second position substantially perpendicular to the fuselage of the VTOL aircraft to produce thrust for hovering;

a variable means for restricting airflow mounted to the first propulsion providing means,

wherein the variable airflow restricting means is configured to provide a substantially smooth airflow into the first propulsion providing means, and

wherein the tilting means is configured to tilt the first propulsion providing means to the first position to align the variable airflow restricting means with an air intake opening of the fuselage of the VTOL aircraft; and

means for detecting air volume in communication with the tilting means,

wherein the air volume detecting means is configured to detect a volume of air entering the first propulsion providing means,

wherein the air volume detecting means is configured to determine the volume of air required by the first propulsion providing means to maximize a current operating condition of the first propulsion providing means, and

wherein the air volume detecting means is configured to send a tilt control signal to the tilting means to tilt the variable airflow restricting means relative to the air intake opening to adjust a size of the air intake opening and alter the volume of air entering the first propulsion providing means to maximize the current operating condition of the first propulsion providing means.

16. The VTOL aircraft of claim 15, wherein portions of the variable airflow restricting means exposed outside of the fuselage of the VTOL aircraft when the first propulsion providing means is in the first position are configured for at least one of: i.) minimal drag during high speed forward flight; and ii.) minimal radar visibility during forward flight.

17. The VTOL aircraft of claim 15, wherein at least a second means for providing propulsion is configured to be tilted with the first propulsion providing means relative to the fuselage of the VTOL aircraft to produce the thrust for hovering,

wherein the variable airflow restricting means is mounted to both the first and at least second propulsion providing means,

wherein the variable airflow restricting means is configured such that as the first and at least second propulsion providing means are tilted to the first position, airflow to one of the first and at least second propulsion providing means is reduced, and

wherein the variable airflow restricting means is configured such that when the first and at least second propulsion providing means are in the first position, airflow to the one of the first and at least second propulsion providing means is cut off.

18. The VTOL aircraft of claim 17, wherein the first propulsion providing means is positioned above and substantially parallel to the at least second propulsion providing means, and

wherein the one of the first and at least second propulsion providing means comprises the at least second propulsion providing means.

19. The VTOL aircraft of claim 15, wherein the air intake opening is located within the fuselage of the VTOL aircraft.

20. The VTOL aircraft of claim 15, wherein the first propulsion providing means comprises a turbo jet engine means.

21. The VTOL aircraft of claim 15, wherein the first propulsion providing means comprises a turbo fan engine means.

22. A vertical take-off and landing (VTOL) aircraft, comprising:

a tiltable means for enclosing,

wherein the tiltable enclosing means is configured to enclose:

a first means for providing propulsion;

at least a second means for providing propulsion,

wherein the tiltable enclosing means is configured to be tilted relative to a fuselage of the VTOL aircraft for providing thrust for hovering;

means for tilting the tiltable enclosing means,

wherein the tilting means is configured to tilt the tiltable enclosing means to a first position substantially parallel to the fuselage of the VTOL aircraft for providing thrust for forward flight, and configured to tilt the tiltable enclosing means to a second position substantially perpendicular with the fuselage of the VTOL aircraft for providing the thrust for hovering;

a variable means for restricting airflow mounted to the tiltable enclosing means,

wherein the variable airflow restricting means is configured to provide a substantially smooth airflow into the tiltable enclosing means, and

wherein the tilting means is configured to tilt the tiltable enclosing means to the first position to align the variable airflow restricting means with an air intake opening of the fuselage of the VTOL aircraft; and

means for detecting air volume in communication with the tilting means,

wherein the air volume detecting means is configured to detect a volume of air entering the tiltable enclosing means,

wherein the air volume detecting means is configured to determine the volume of air required by the first and at least second propulsion providing means to maximize a current operating condition of the first and at least second propulsion providing means, and

wherein the air volume detecting means is configured to send a tilt control signal to the tilting means to tilt the variable airflow restricting means relative to the air intake opening to adjust a size of the air intake opening and alter the volume of air entering the tiltable enclosing means to maximize the current operating condition of the first and at least second propulsion providing means.

23. The VTOL aircraft of claim 22, wherein portions of the variable airflow restricting means exposed outside of the fuselage of the VTOL aircraft when the tiltable enclosing means is in the first position are configured for at least one of: i.) minimal drag during high speed forward flight; and ii.) minimal radar visibility during forward flight.

24. The VTOL aircraft of claim 22, wherein the variable airflow restricting means is configured such that as the tiltable enclosing means is tilted to the first position, airflow to one of the first and at least second propulsion providing means is reduced, and

wherein the variable airflow restricting means is configured such that when the tiltable enclosing means is in the first position, airflow to the one of the first and at least second propulsion providing means is cut off.

25. The VTOL aircraft of claim 24, wherein the first propulsion providing means is positioned above and substantially parallel to the at least second propulsion providing means within the tiltable enclosing means, and

wherein the one of the first and at least second propulsion providing means comprises the at least second propulsion providing means.

26. The VTOL aircraft of claim 22, wherein the air intake opening is located within the fuselage of the VTOL aircraft.

27. The VTOL aircraft of claim 22, wherein each of the first and at least second propulsion providing means comprises a turbo jet engine means.

28. The VTOL aircraft of claim 22, wherein each of the first and at least second propulsion providing means comprises a turbo fan engine means.

29. A method of regulating airflow to engines of a vertical take-off and landing (VTOL) aircraft, comprising the steps of:

a.) detecting a volume of air entering a first engine,

wherein the first engine is configured to be tilted to a first position substantially parallel to a fuselage of the VTOL aircraft to produce thrust for forward flight, and configured to be tilted to a second position substantially perpendicular to the fuselage of the VTOL aircraft to produce the thrust for hovering,

wherein a variable engine inlet is mounted to the first engine,

wherein the variable engine inlet is configured to provide a substantially smooth airflow into the first engine, and

wherein in the first position, the variable engine inlet is substantially aligned with an air intake opening of the fuselage of the VTOL aircraft;

b.) determining the volume of air required by the first engine to maximize a current operating condition of the first engine; and

c.) tilting the variable engine inlet relative to the air intake opening to adjust a size of the air intake opening and alter the volume of air entering the first engine to maximize the current operating condition of the first engine.

30. The method of claim 29, wherein portions of the variable engine inlet exposed outside of the fuselage of the VTOL aircraft when the first engine is in the first position are configured for at least one of: i.) minimal drag during high speed forward flight; and ii.) minimal radar visibility during forward flight.

31. The method of claim 29, wherein at least second engine is configured to be tilted with the first engine relative to the fuselage of the VTOL aircraft to produce the thrust for hovering,

wherein the variable engine inlet is mounted to both the first and at least second engines,

wherein the variable engine inlet is configured such that as the first and at least second engines are tilted to the first position, airflow to one of the first and at least second engines is reduced, and

wherein the variable engine inlet is configured such that when the first and at least second engines are in the first position, airflow to the one of the first and at least second engines is cut off.

32. The method of claim 31, wherein the first engine is positioned above and substantially parallel to the at least second engine, and

wherein the one of the first and at least second engines comprises the at least second engine.

33. The method of claim 29, wherein the air intake opening is located within the fuselage of the VTOL aircraft.



↑
100a

FIG 1A

PRIOR ART



100b ↗

FIG. 1B

PRIOR ART

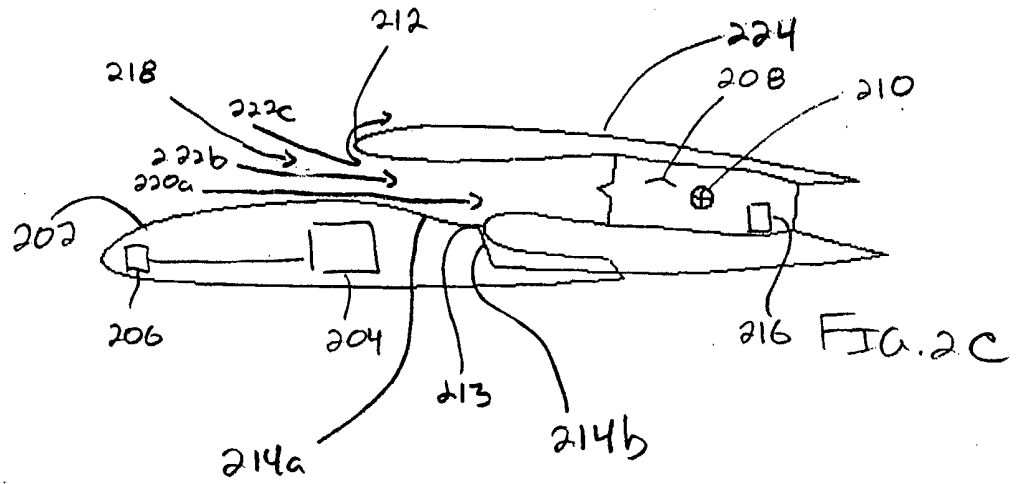


100C
↖

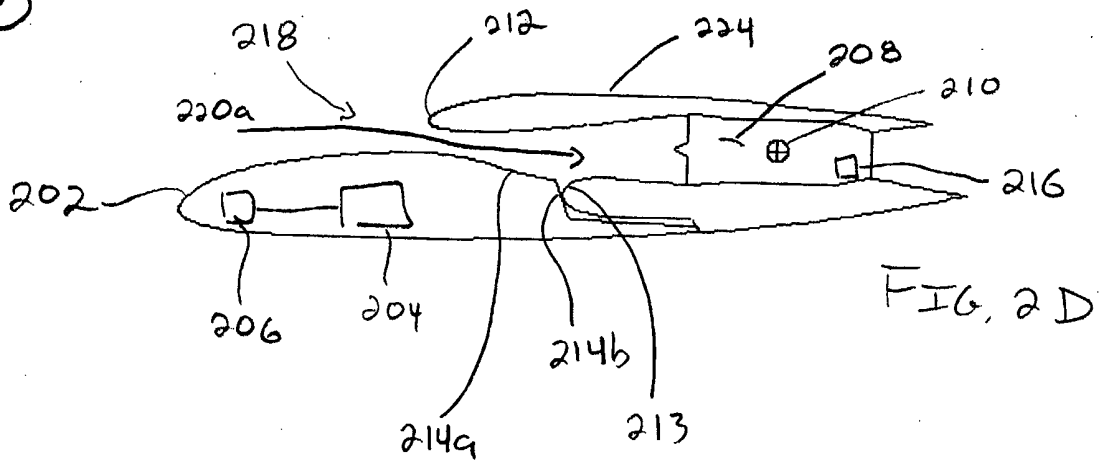
FIG. 1C

PRIOR ART

200



200



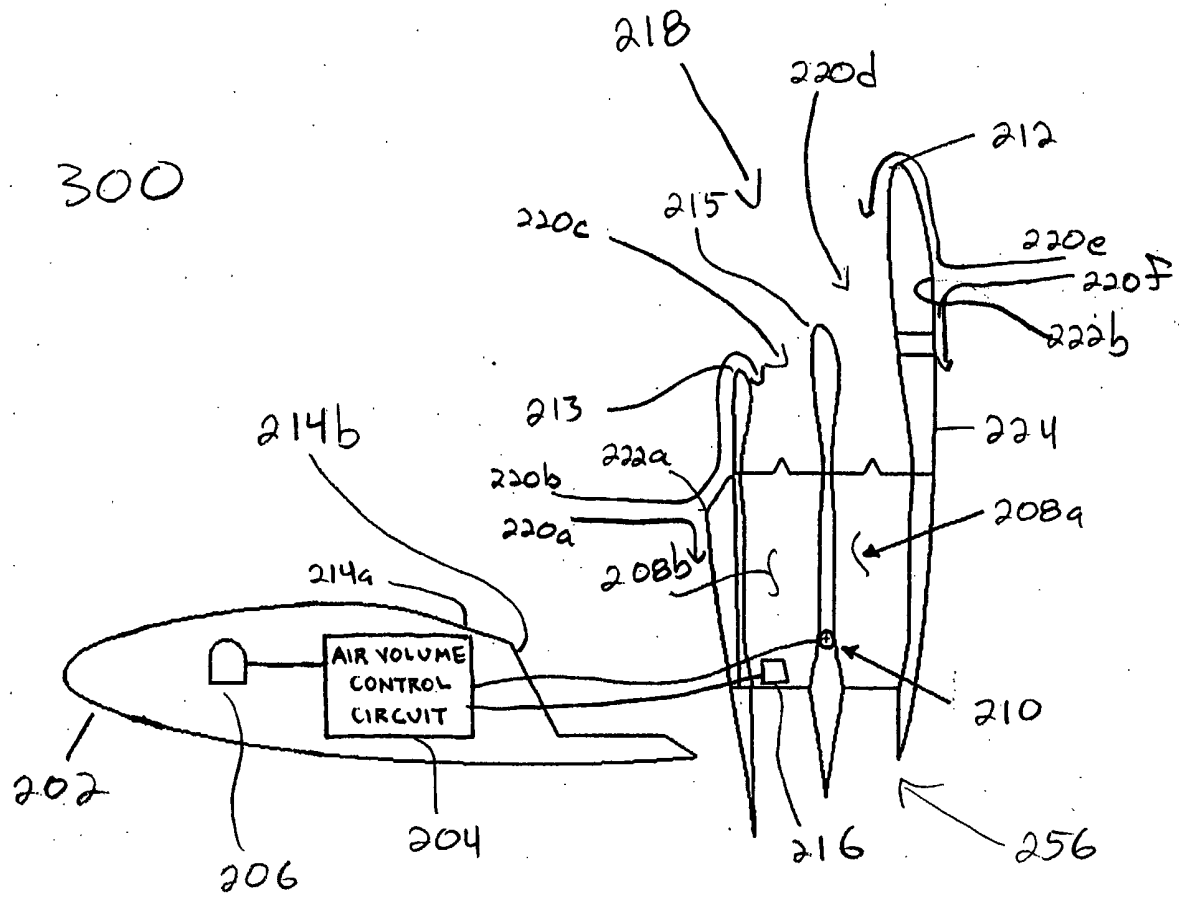


FIG. 3A

300

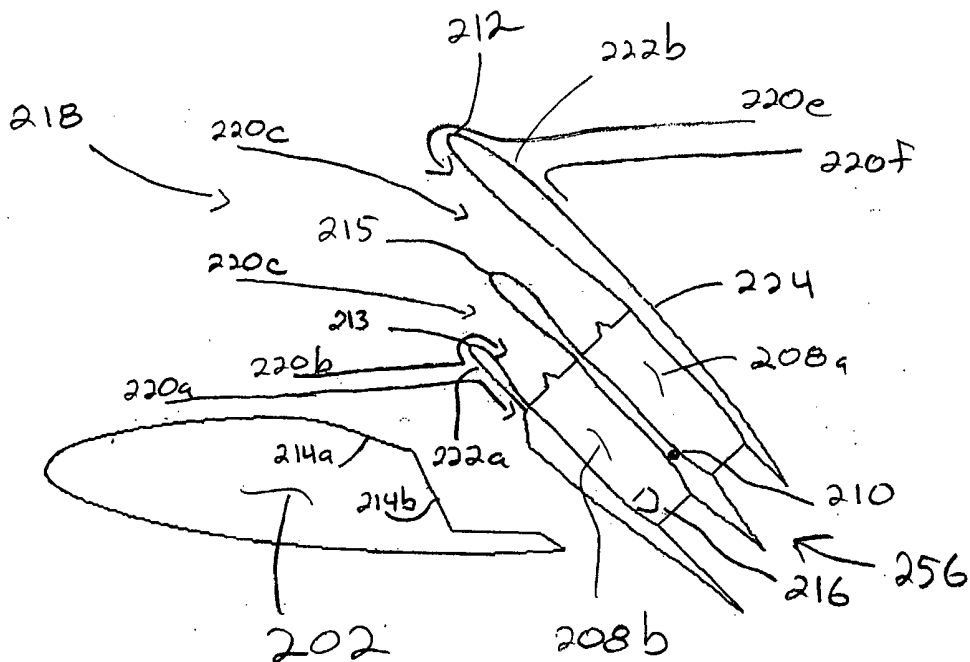
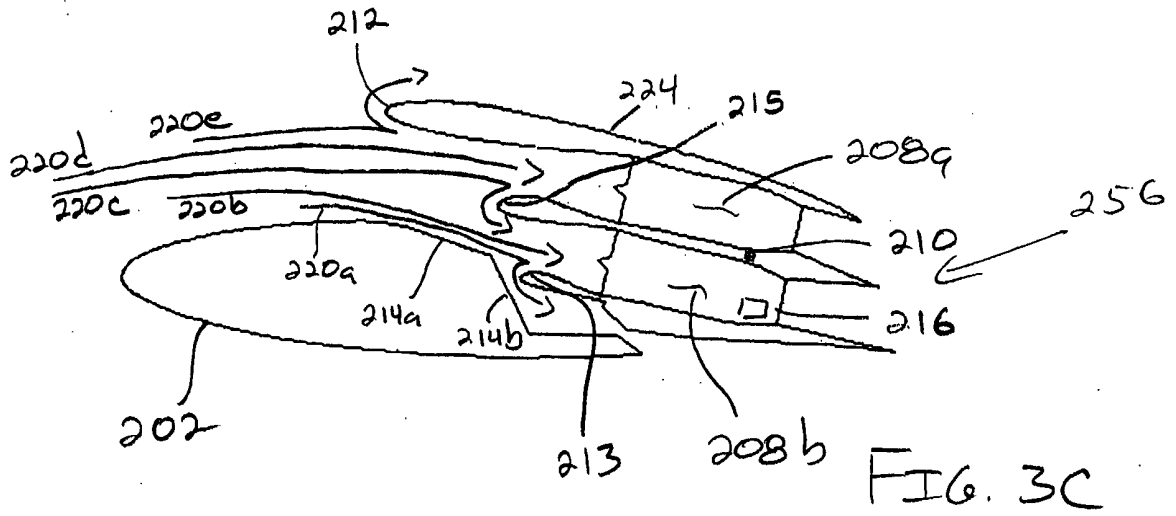


FIG. 3B

300



300

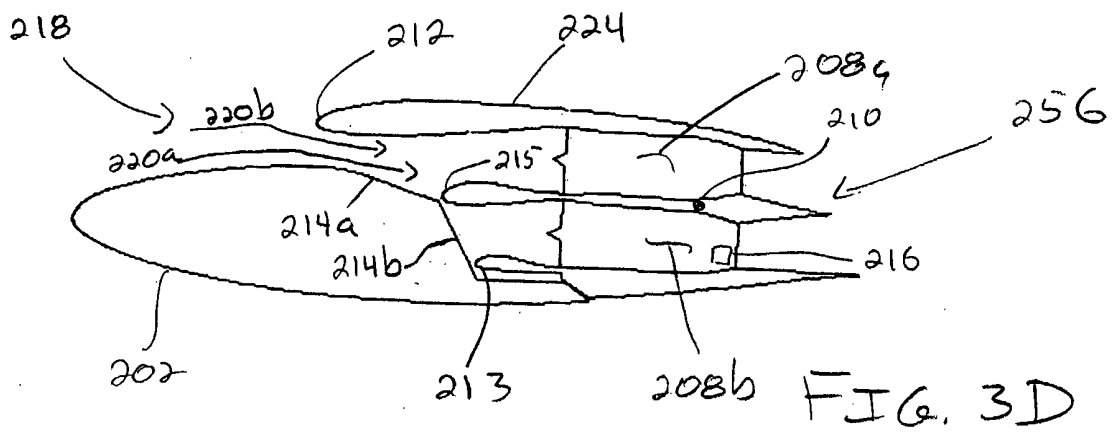


FIG. 4A

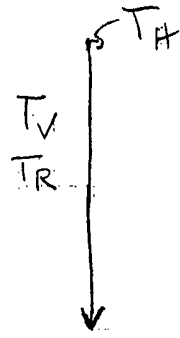


FIG. 4B

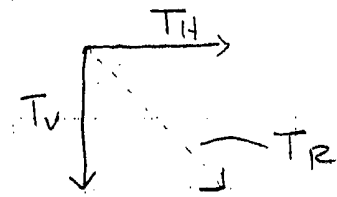


FIG. 4C

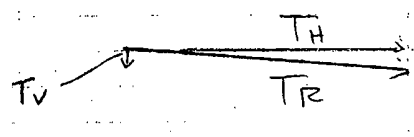
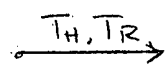
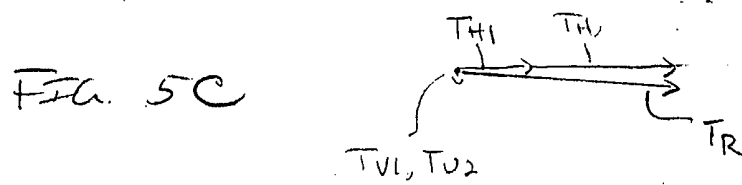
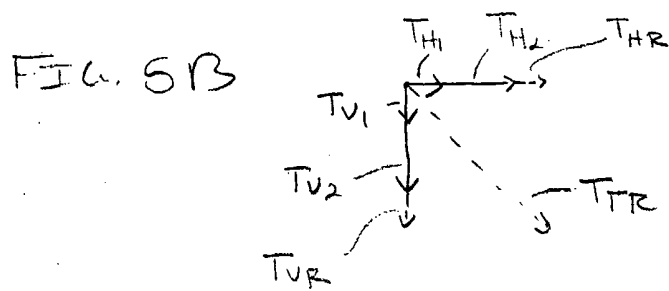
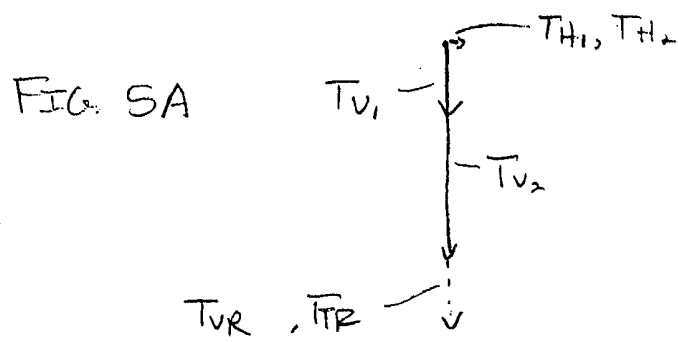
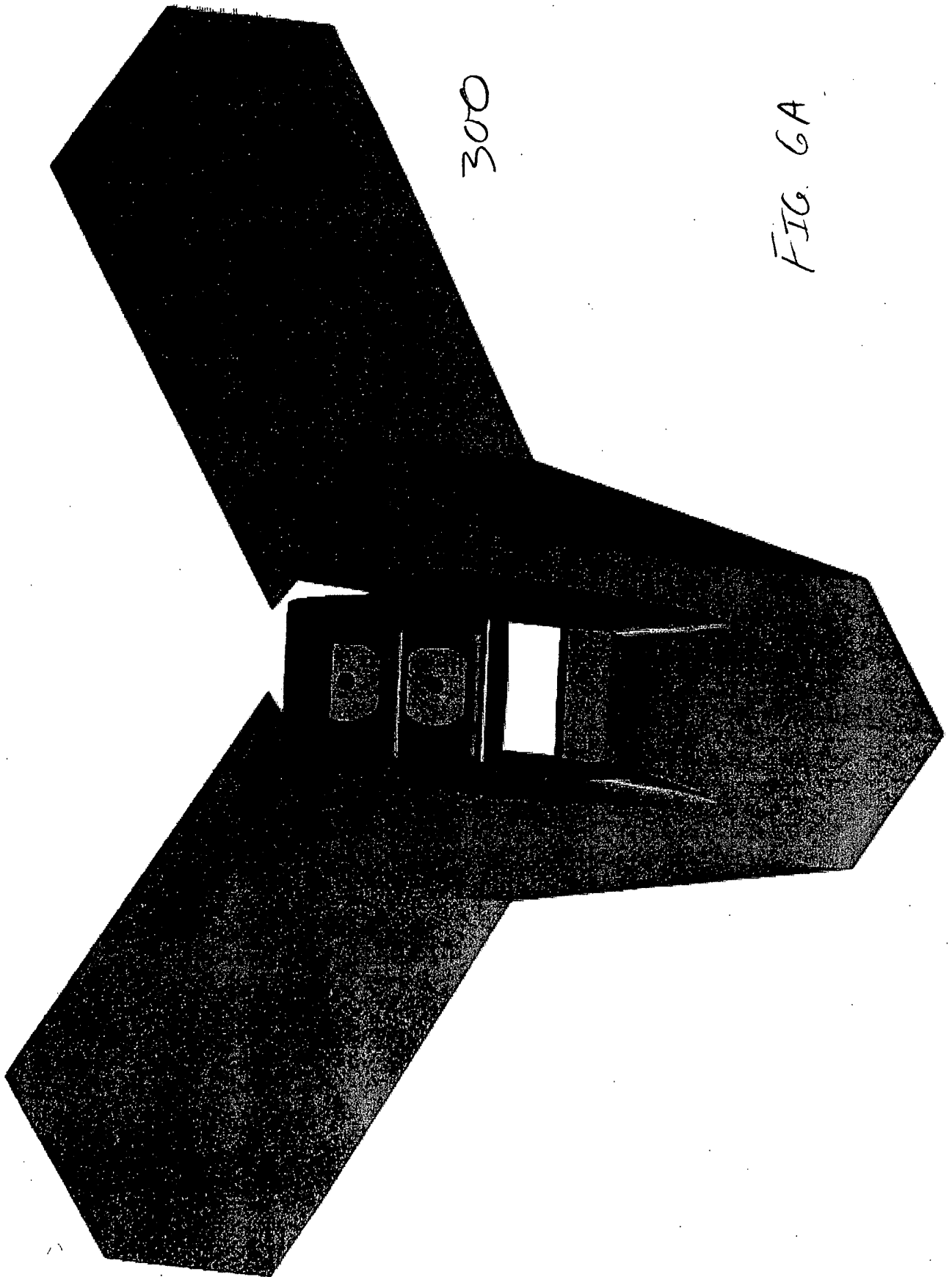


FIG. 4D

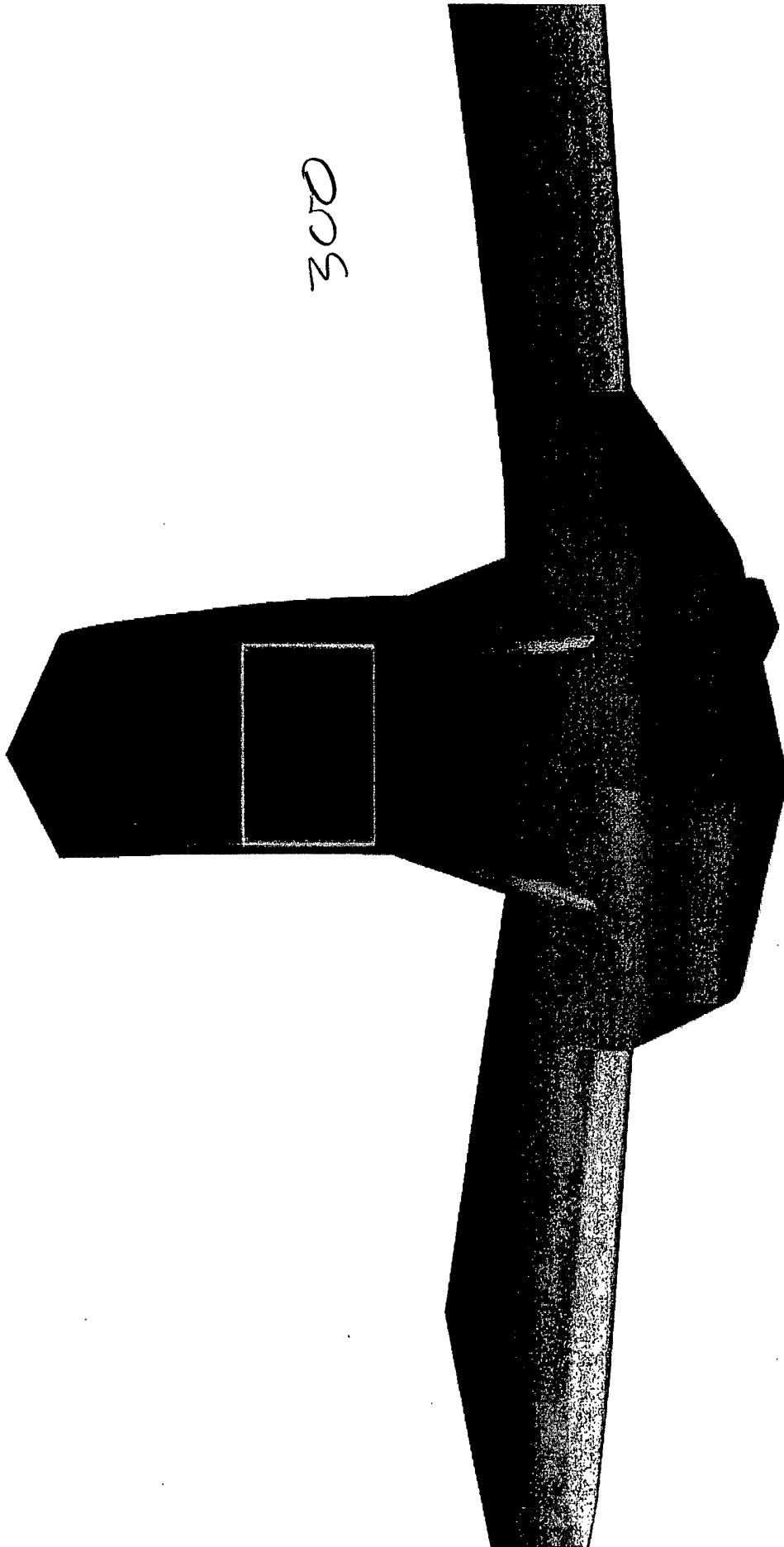






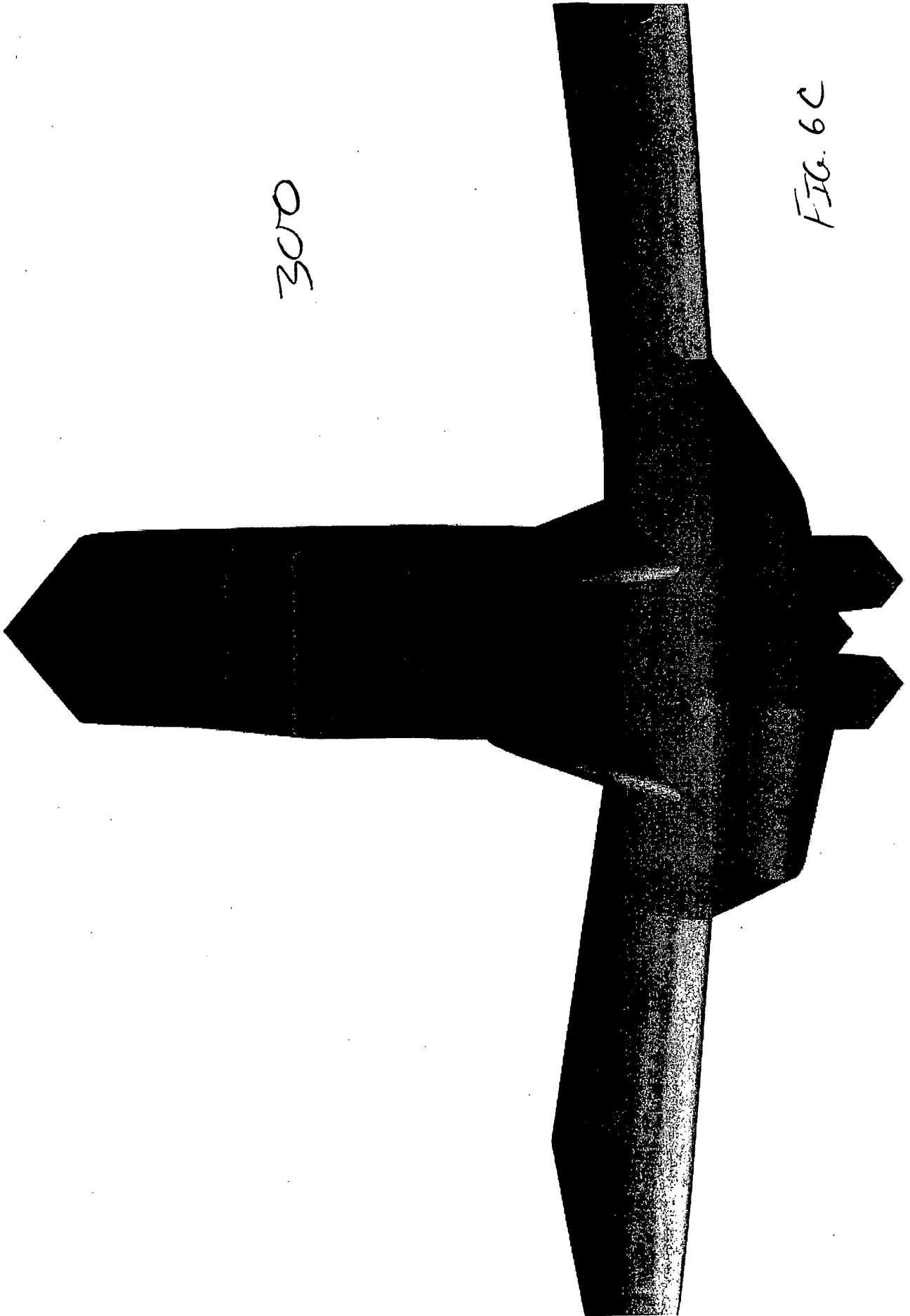
300

FIG. 6A



300

FIG. 6B



300

FIG. 6C

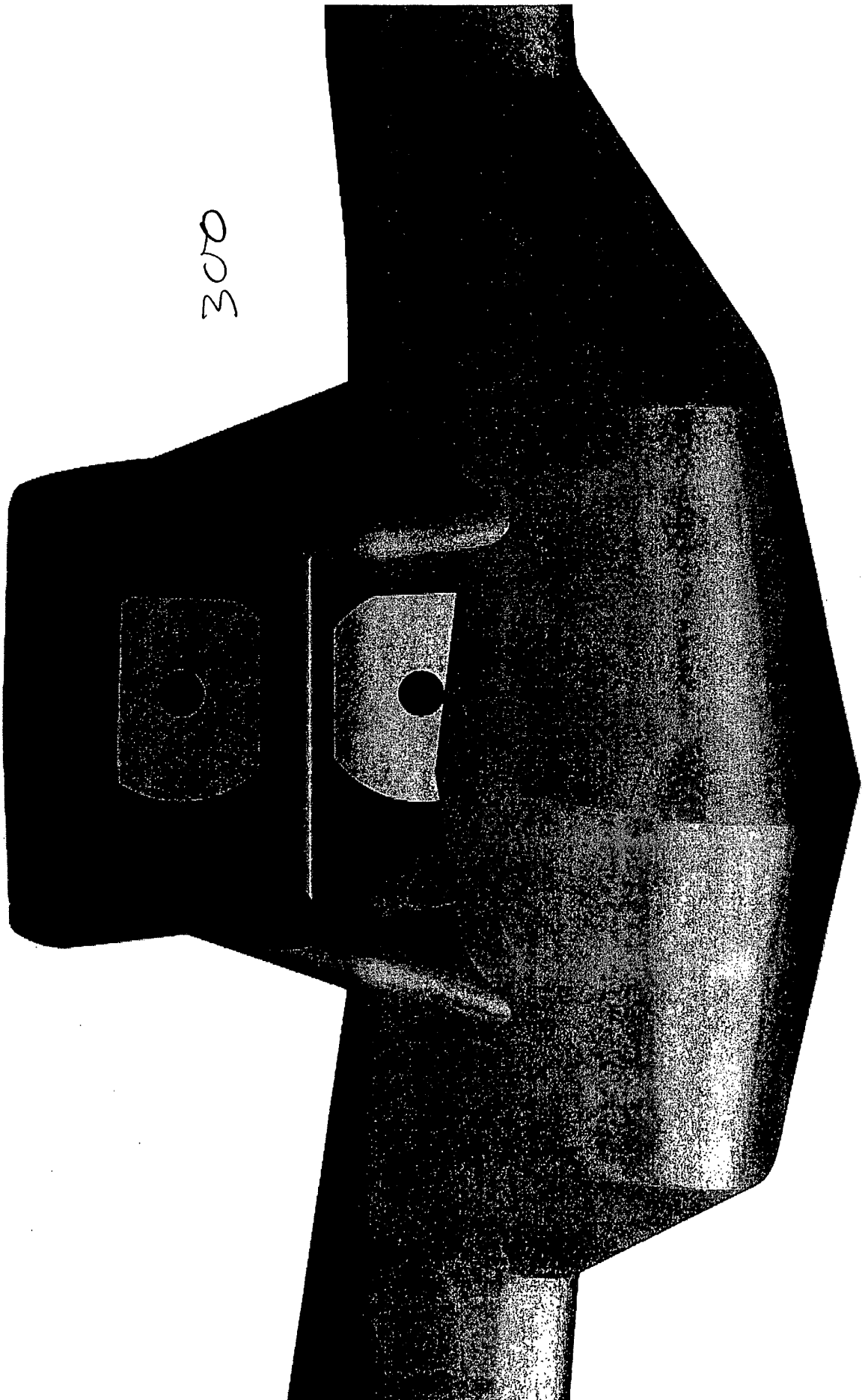
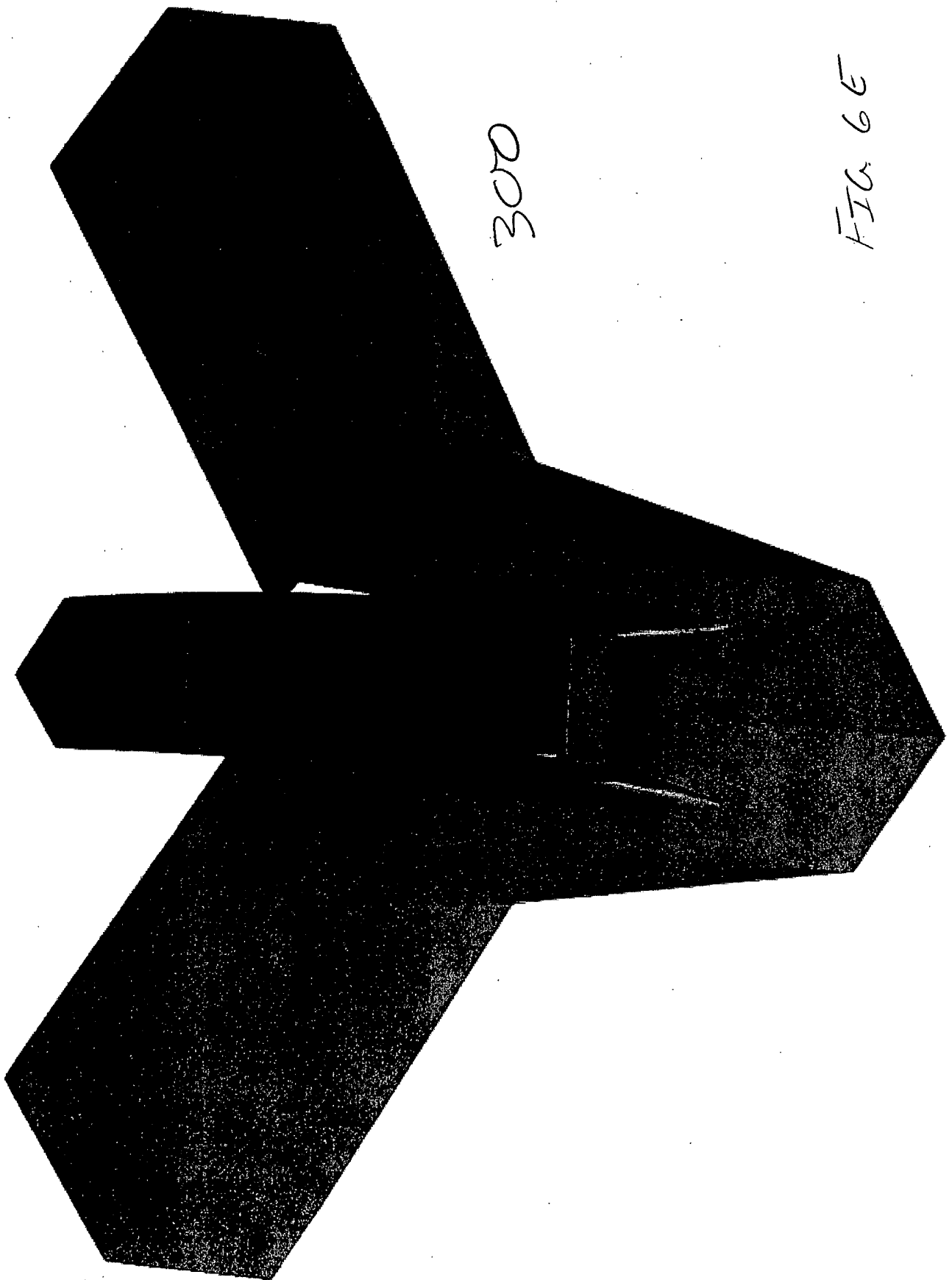
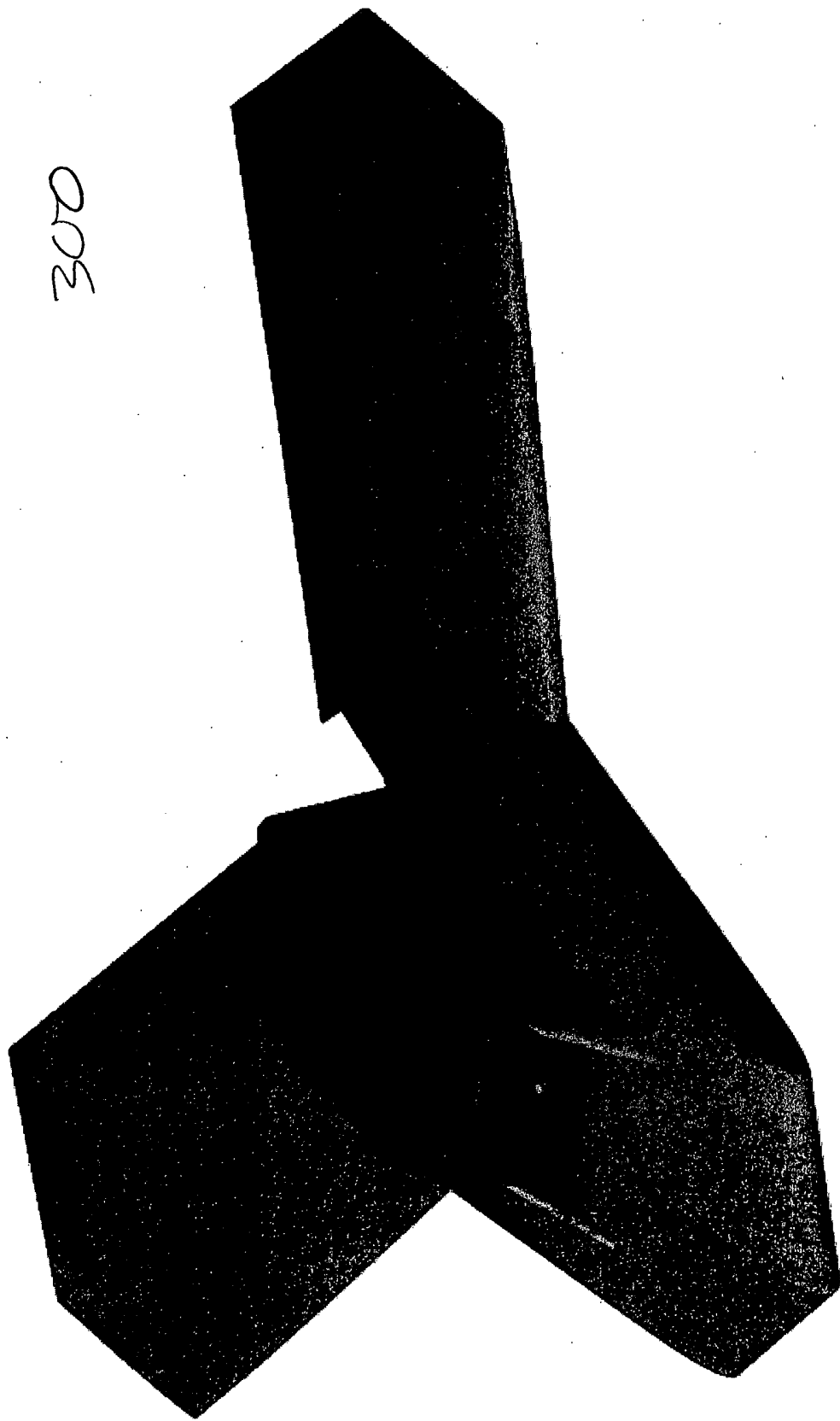


FIG. 6D



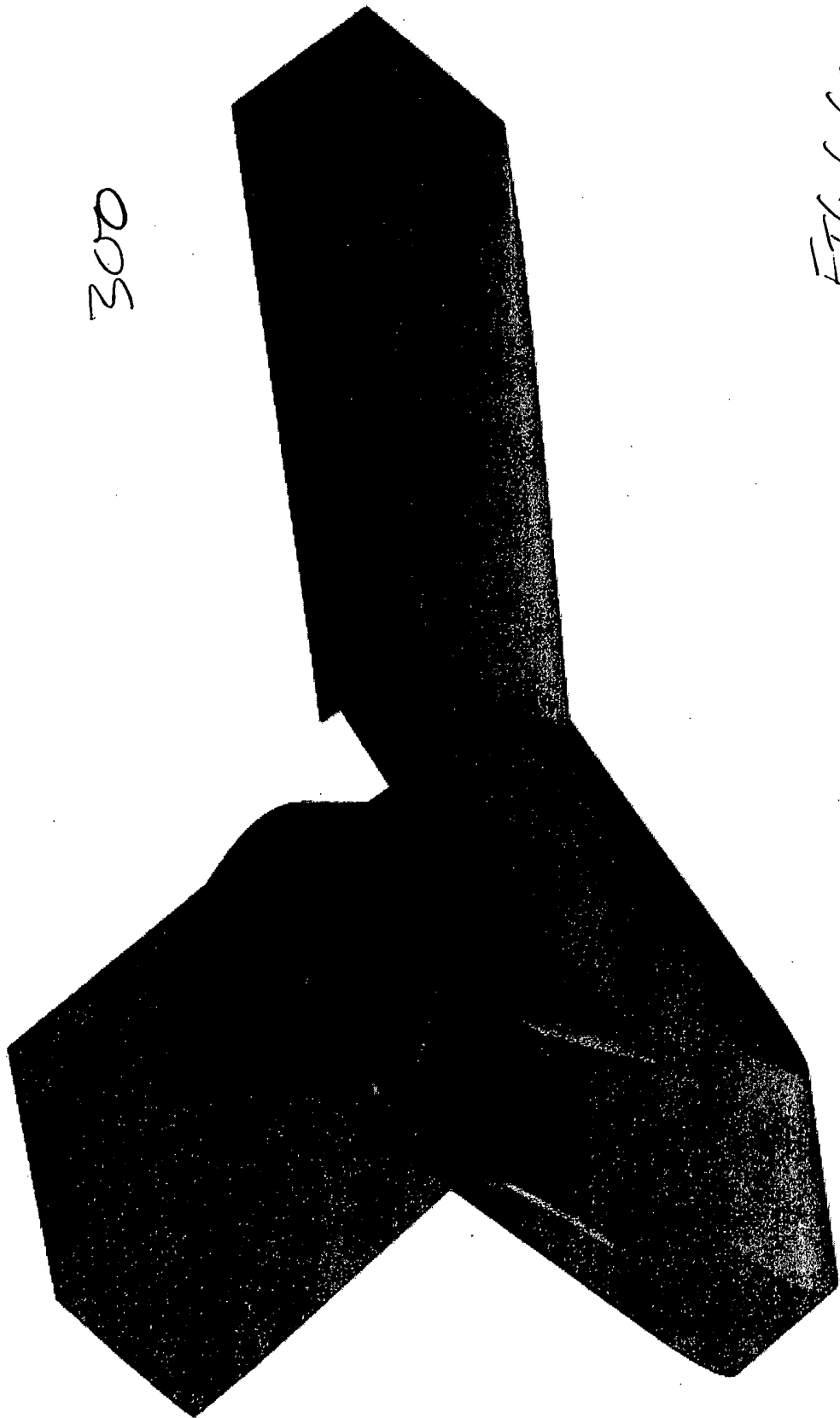
300

FIG. 6E



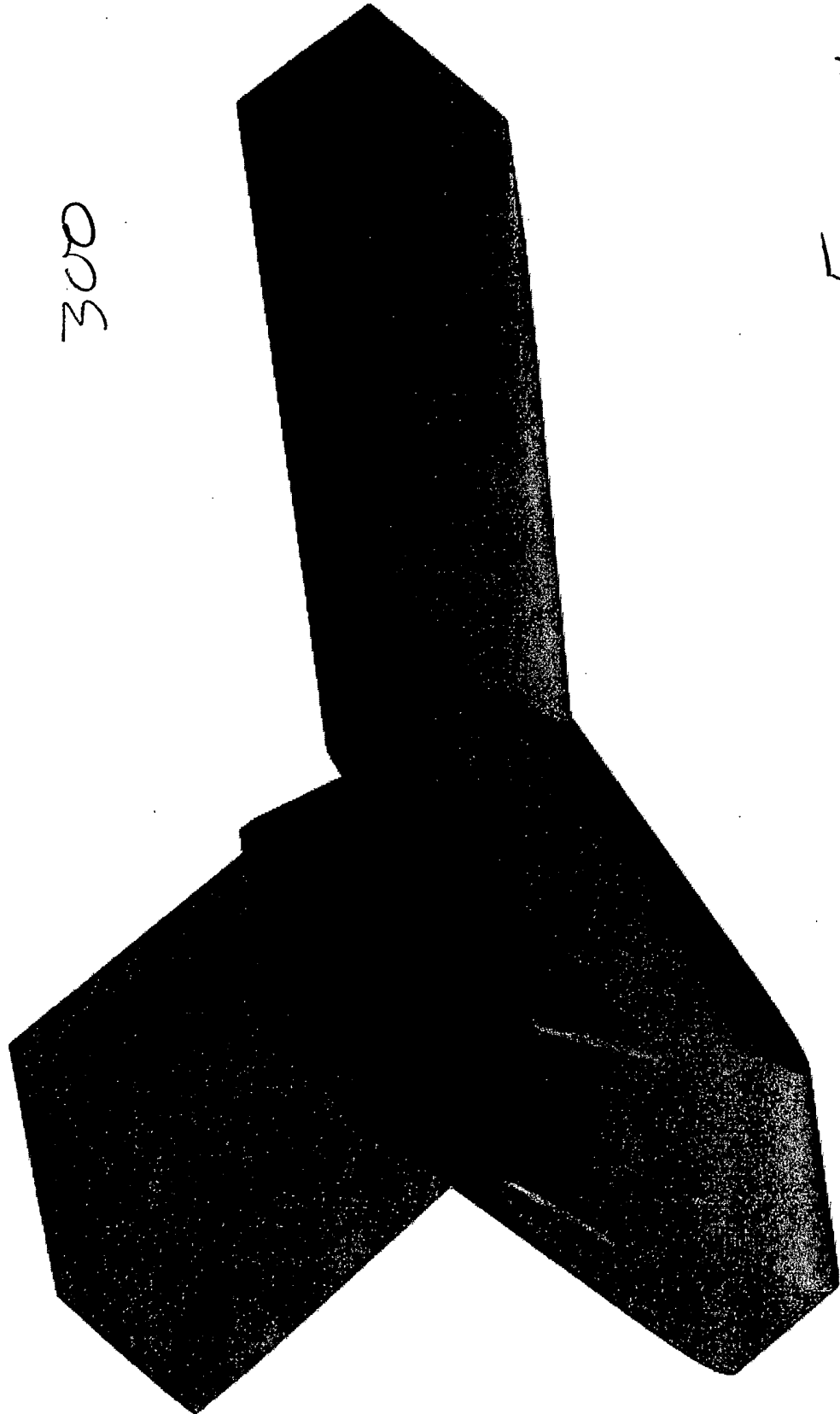
300

FIG. 6F



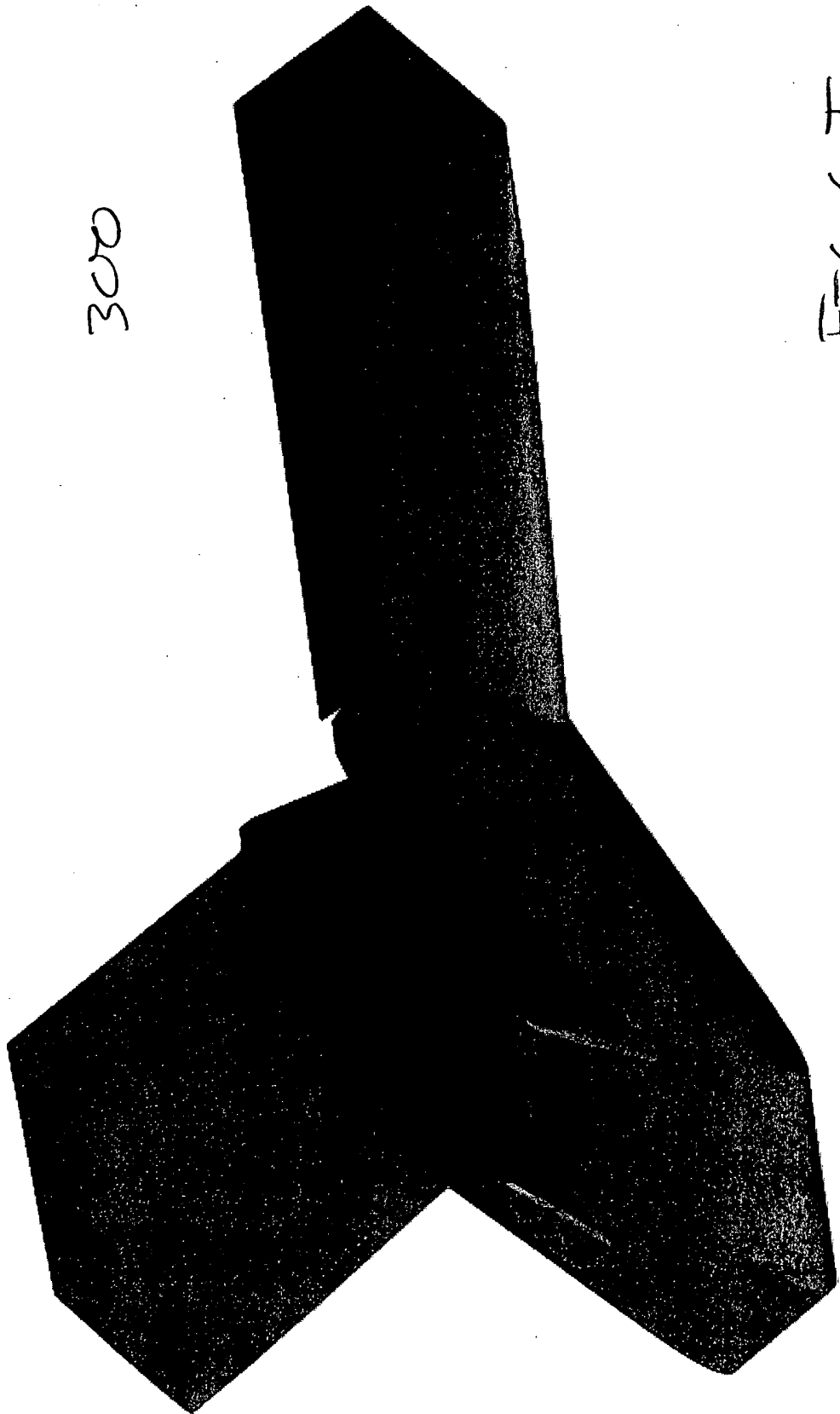
300

FIG. 6G



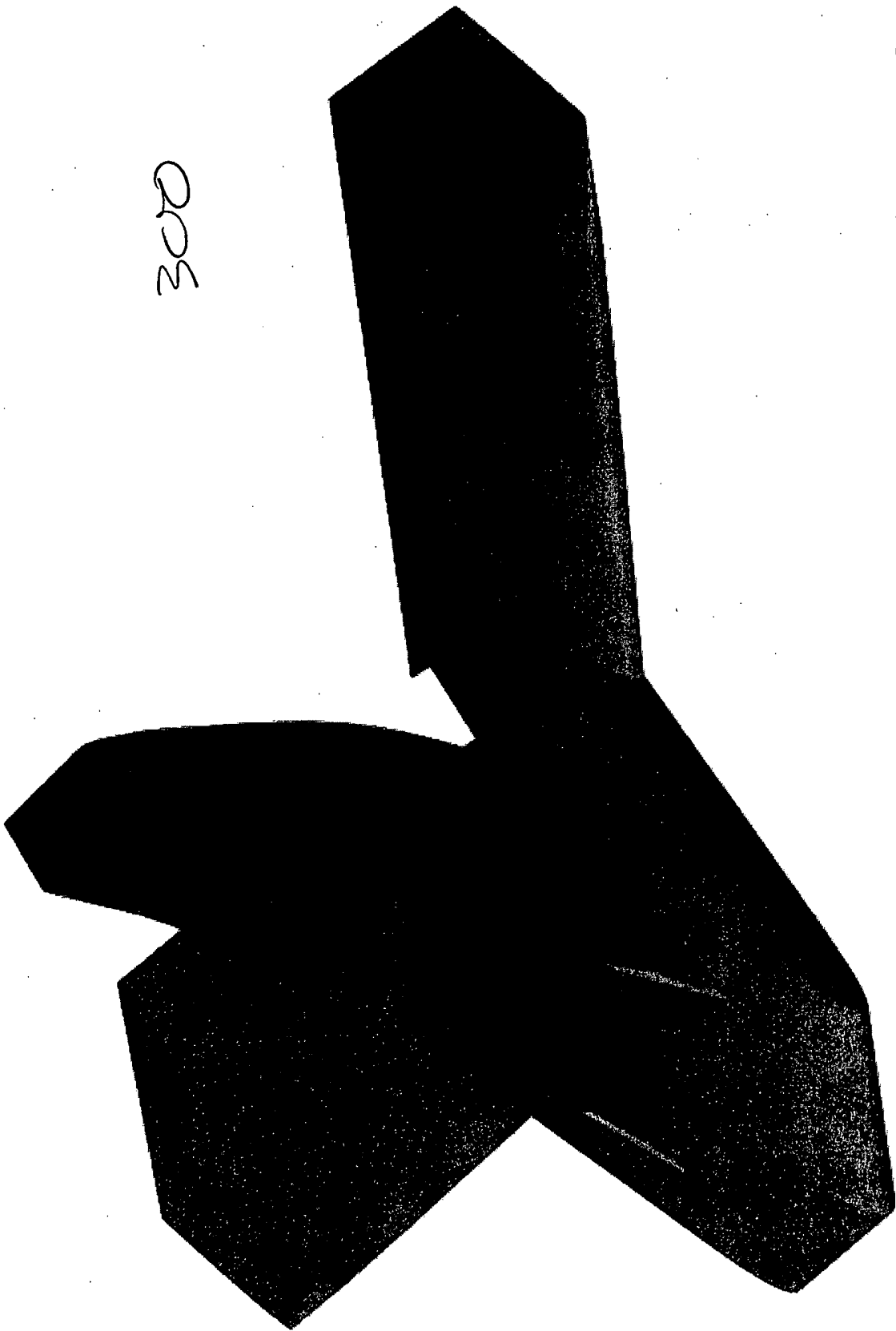
300

FIG. 6H



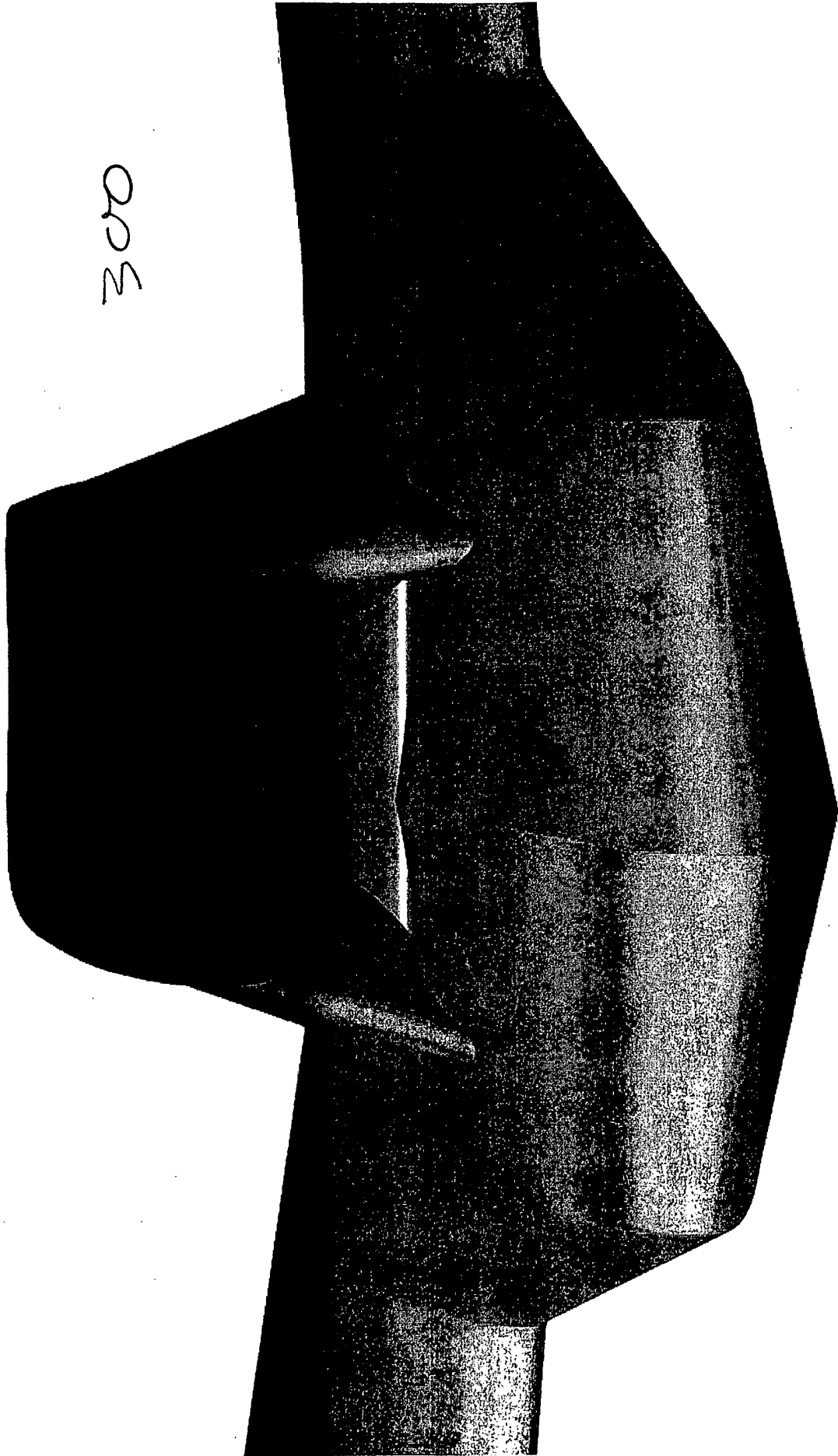
300

FIG. 6 I



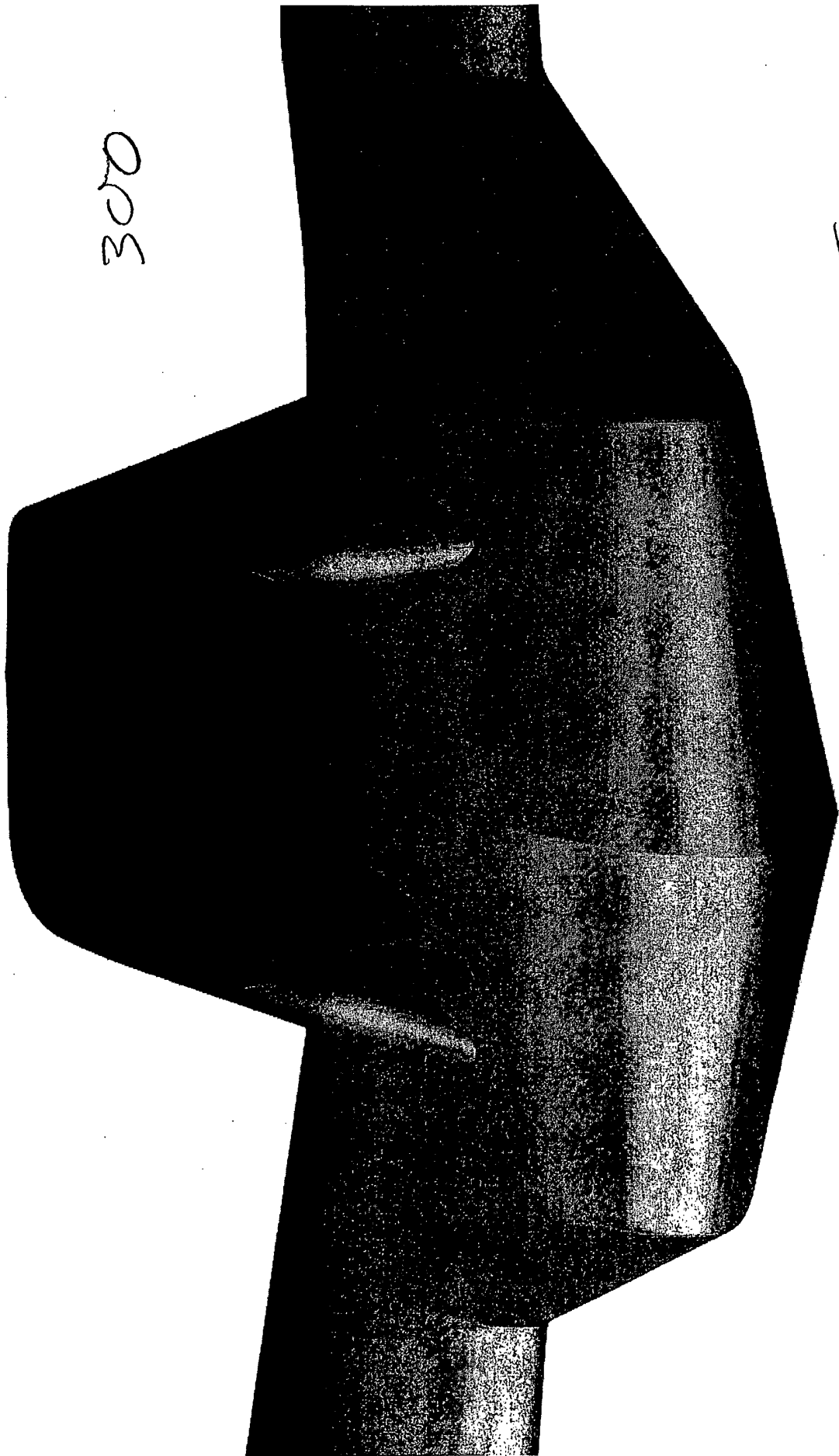
300

FIG. 65



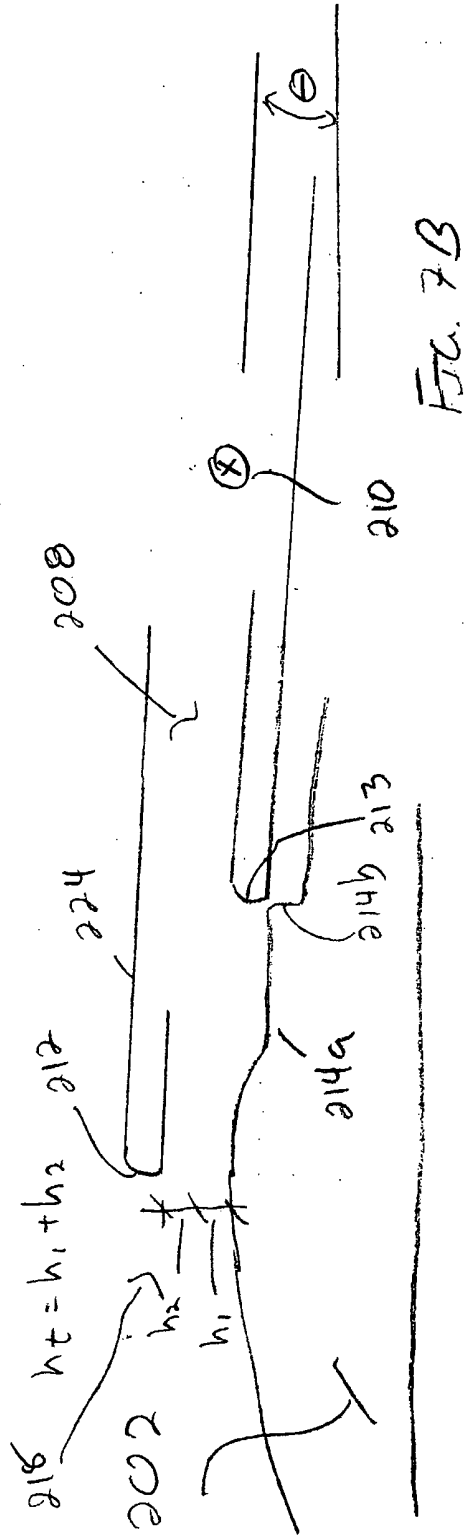
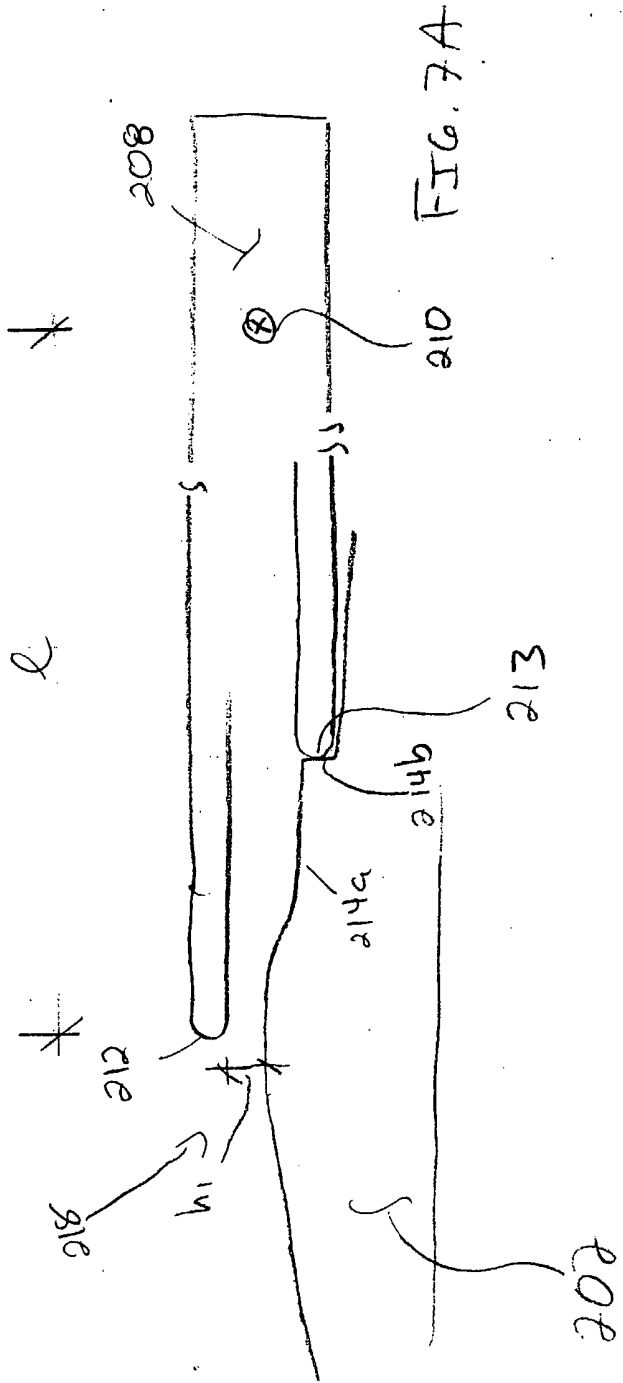
300

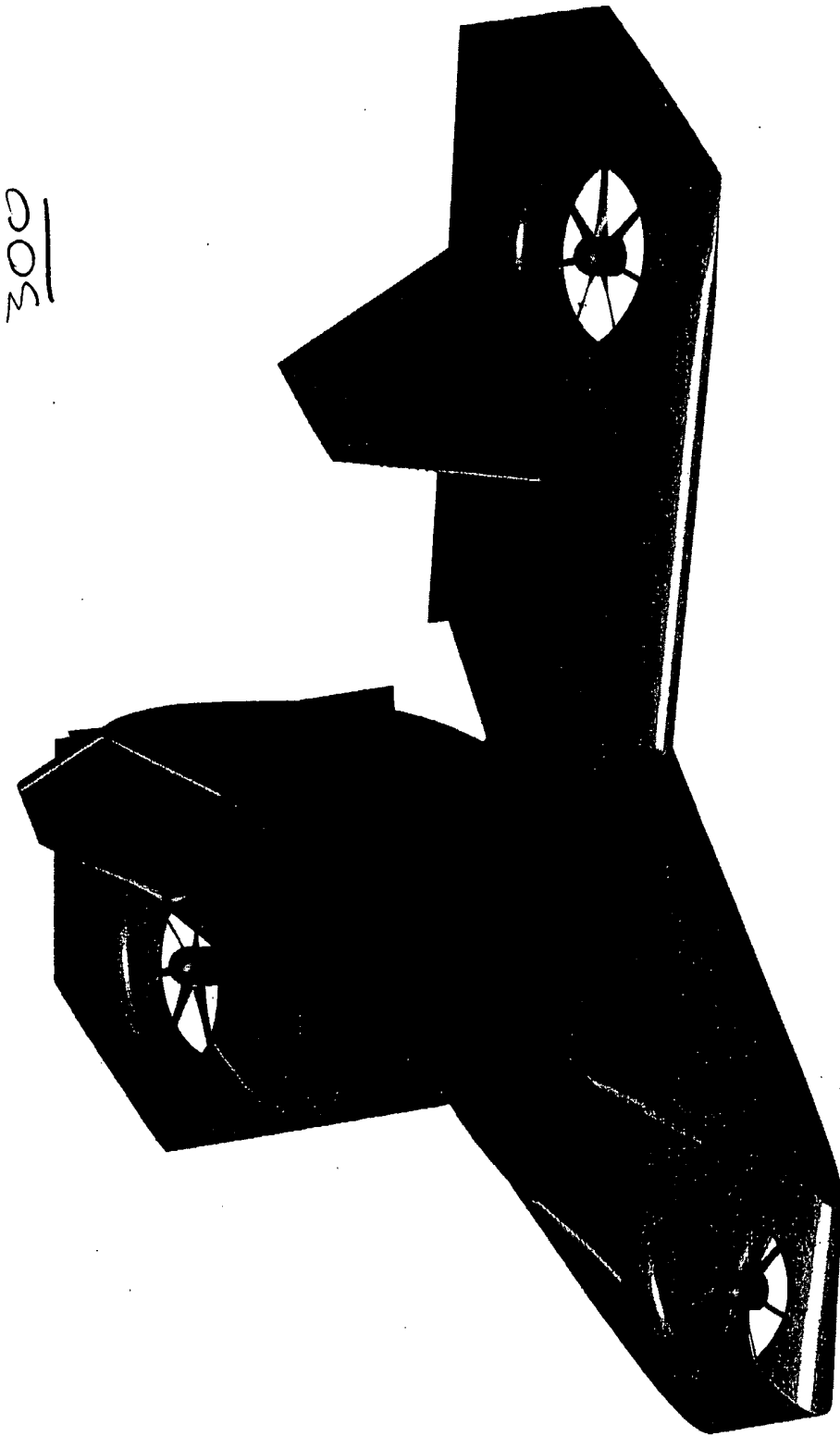
FIG. 6K



300

FIG. 6L





300

FIG. 8A

300

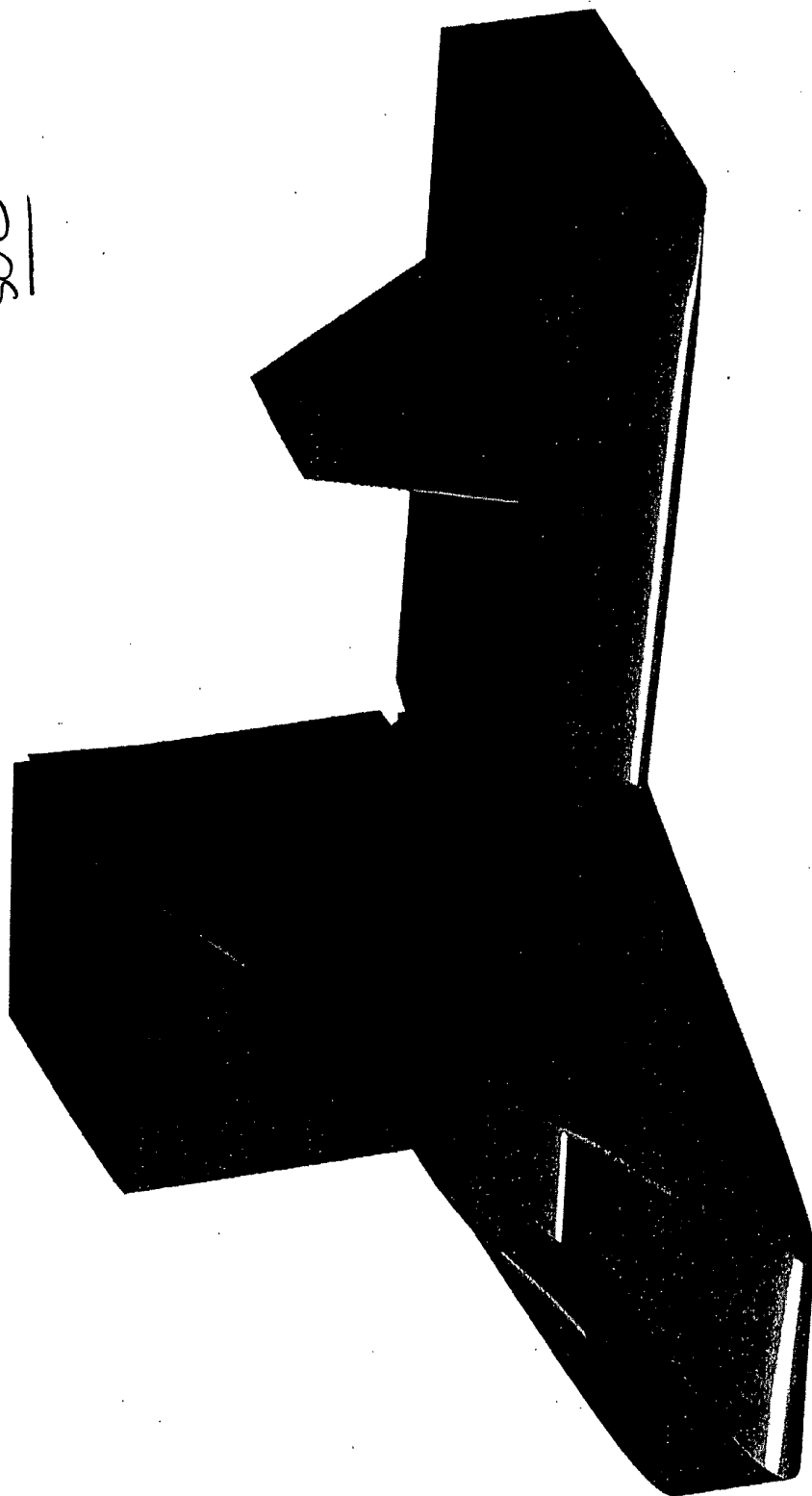
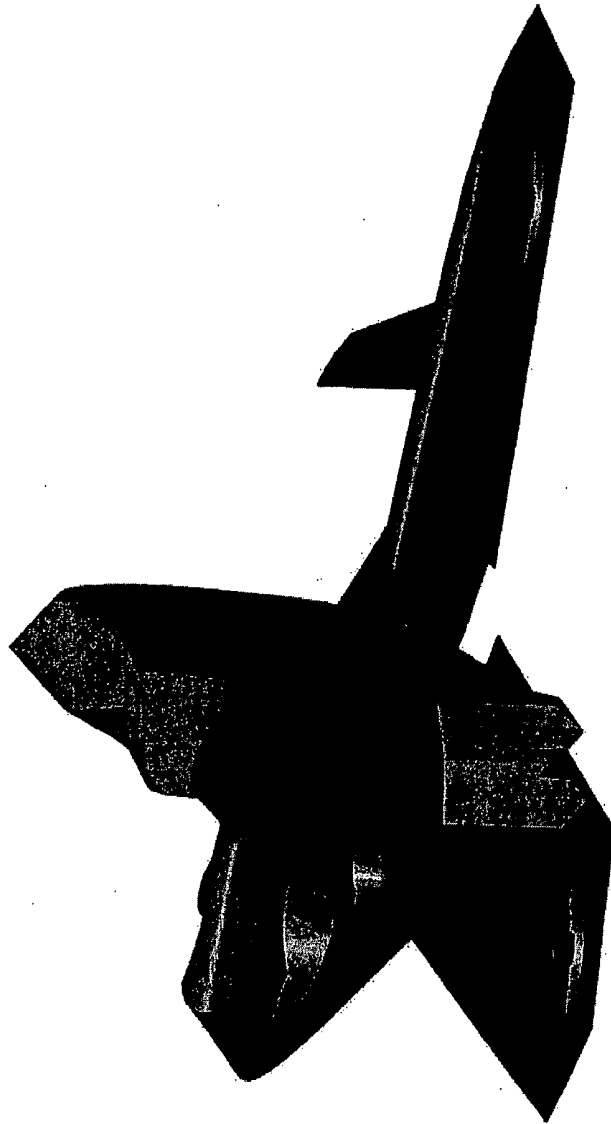


FIG. 8B

300

FIG. 8C



300

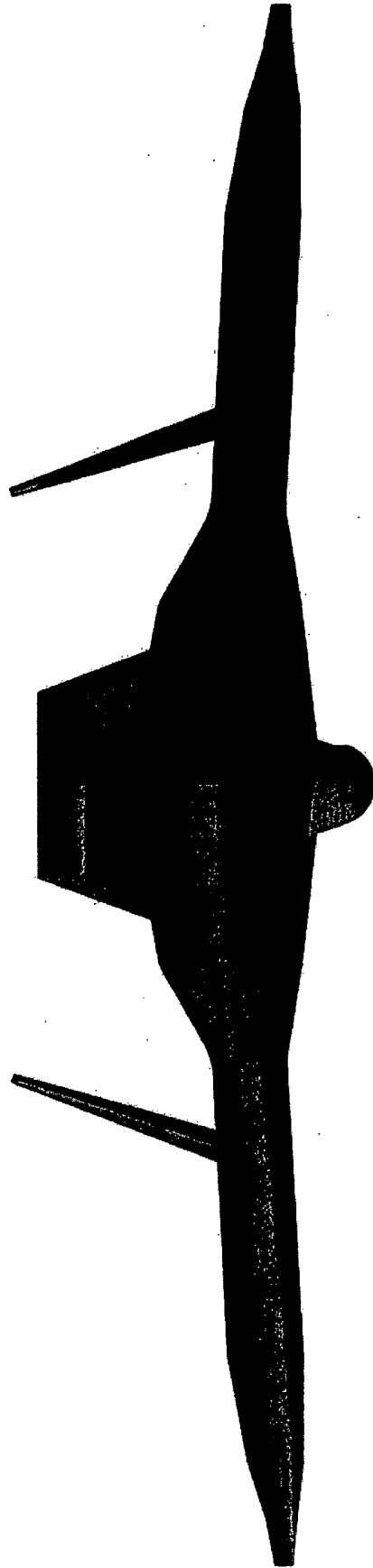


FIG. 8D

300



FIG. 8E

300

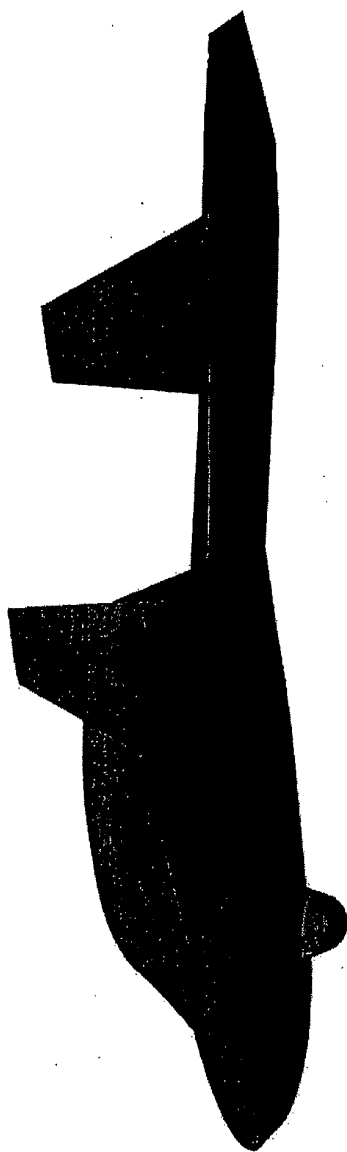


FIG. 8F

300

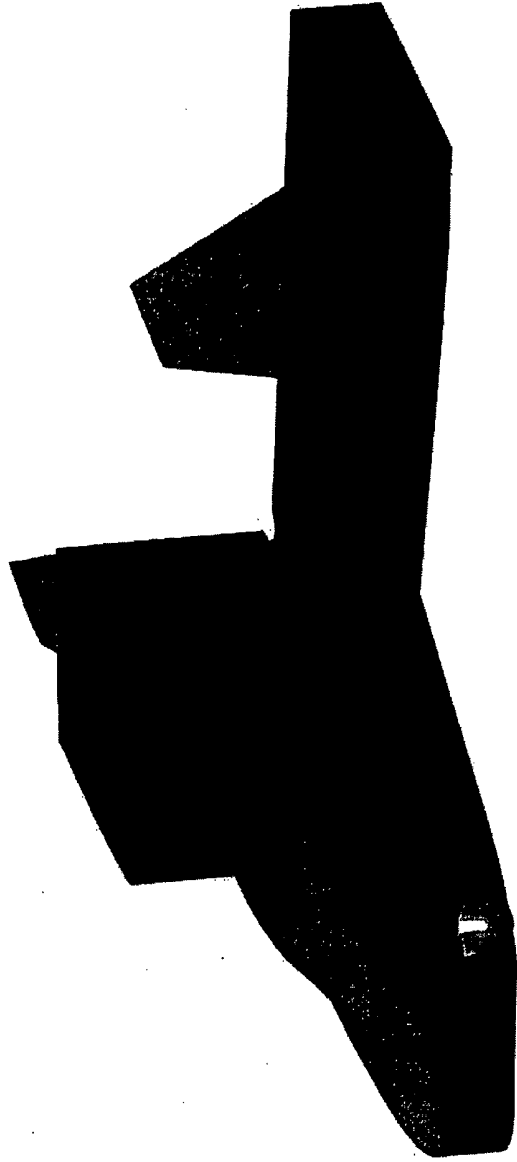


FIG. 86

300

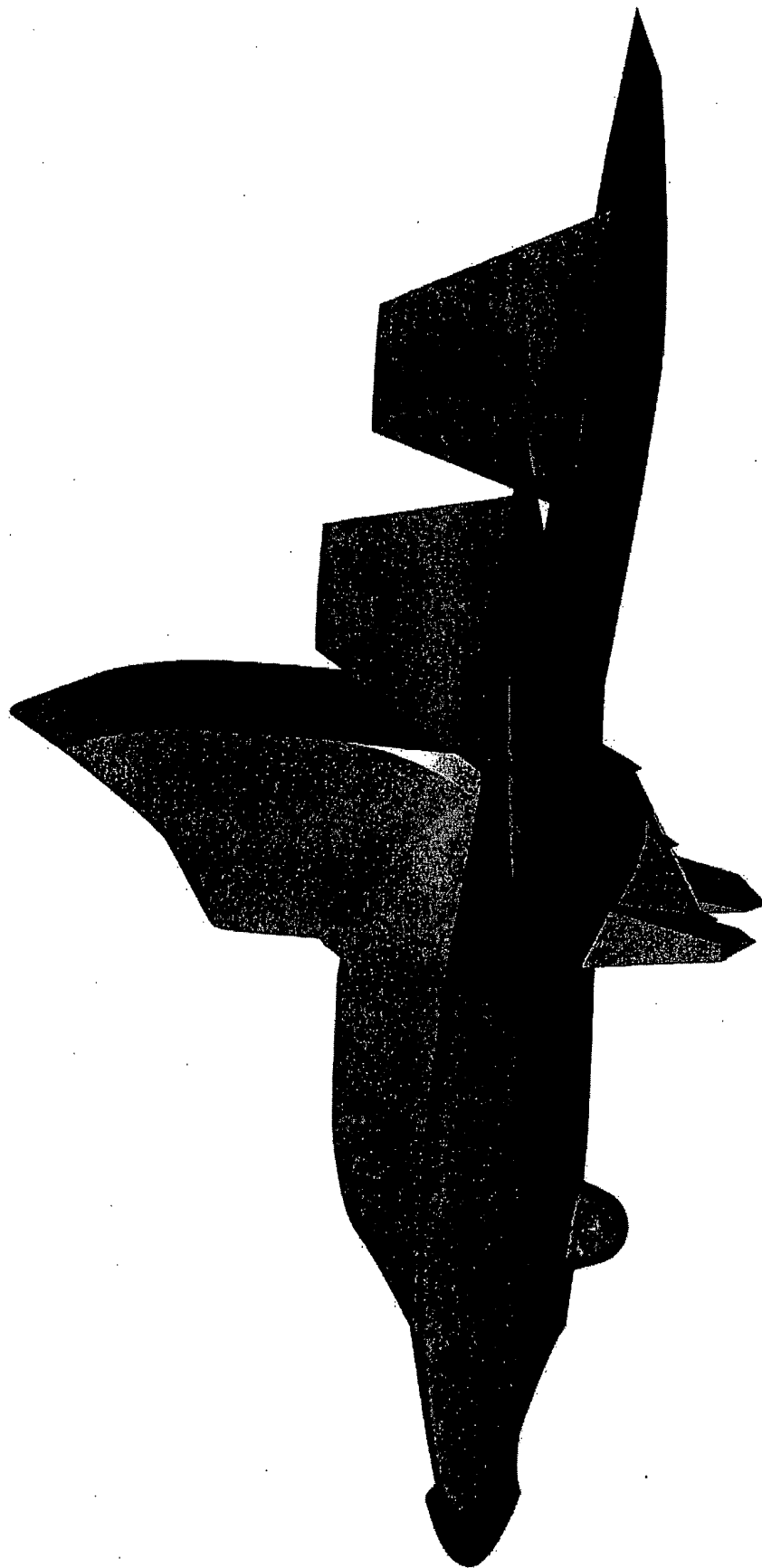
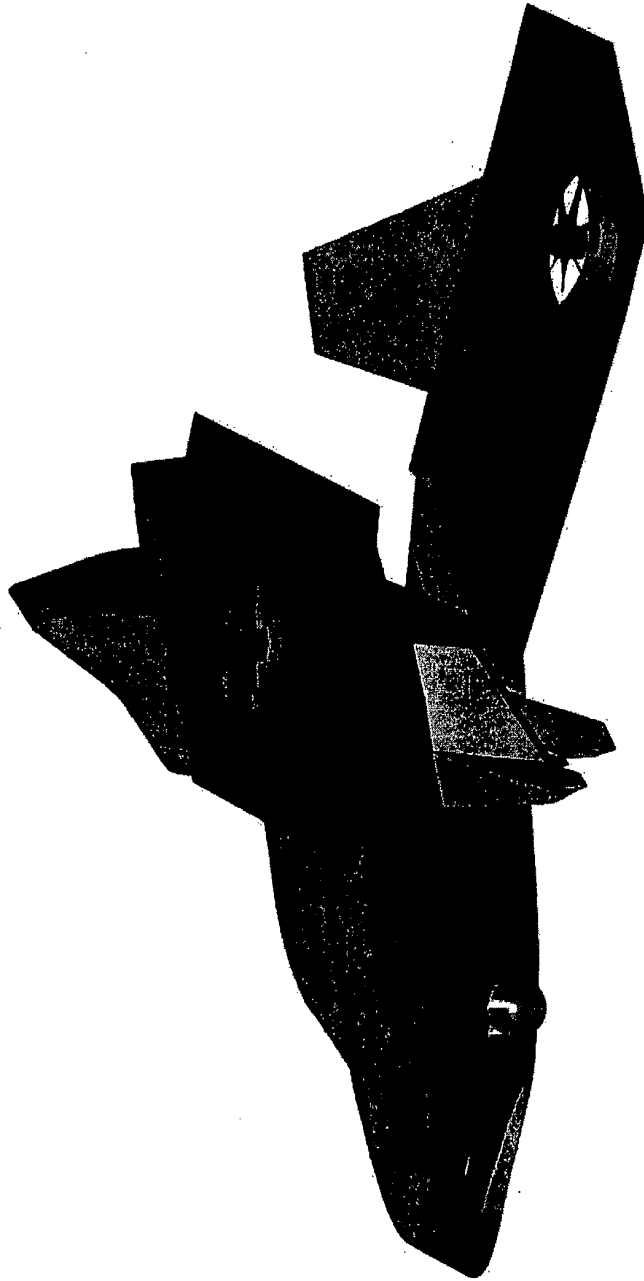


FIG. 8H

300

FIG. 8I



300

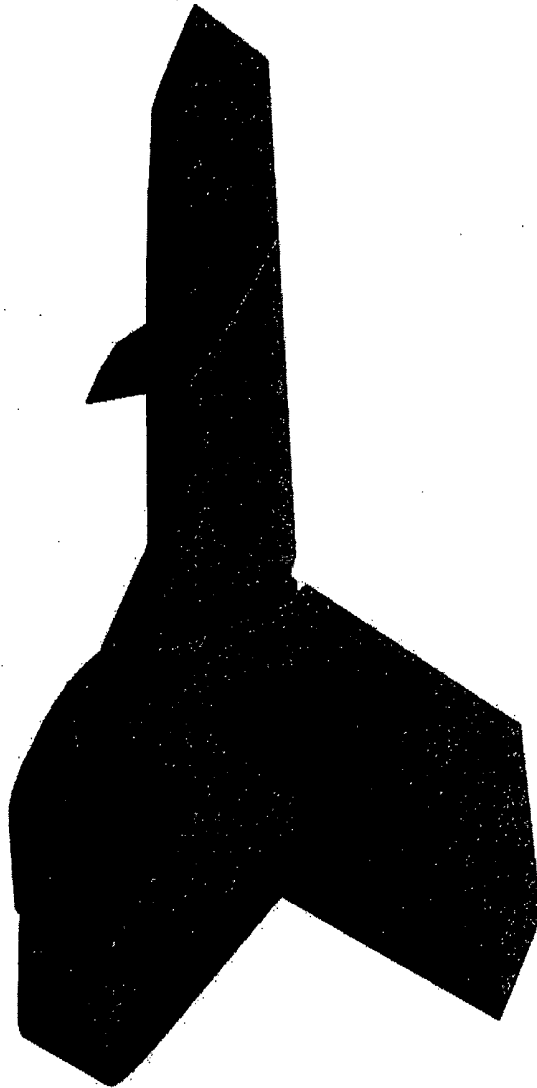


FIG. 8 J

300

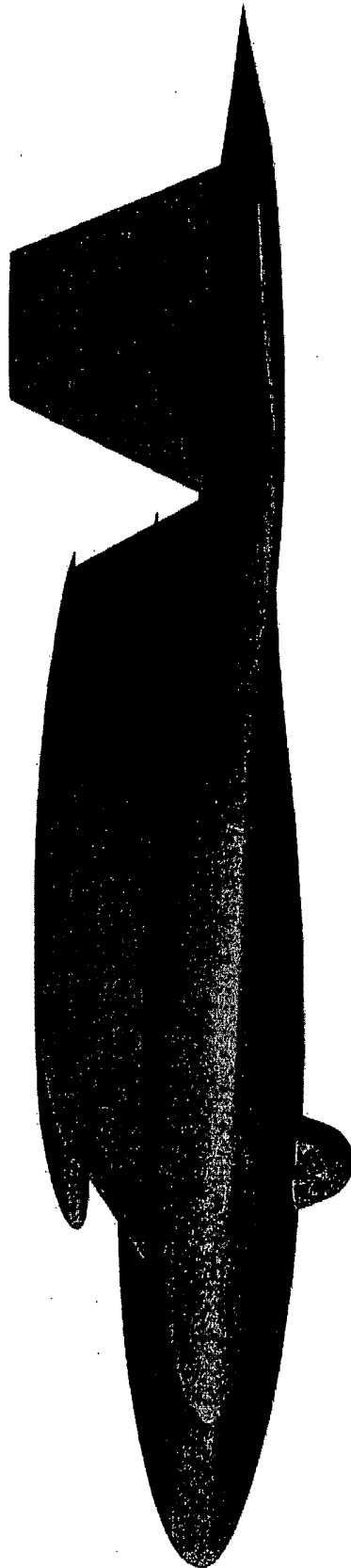


FIG. 8K

300

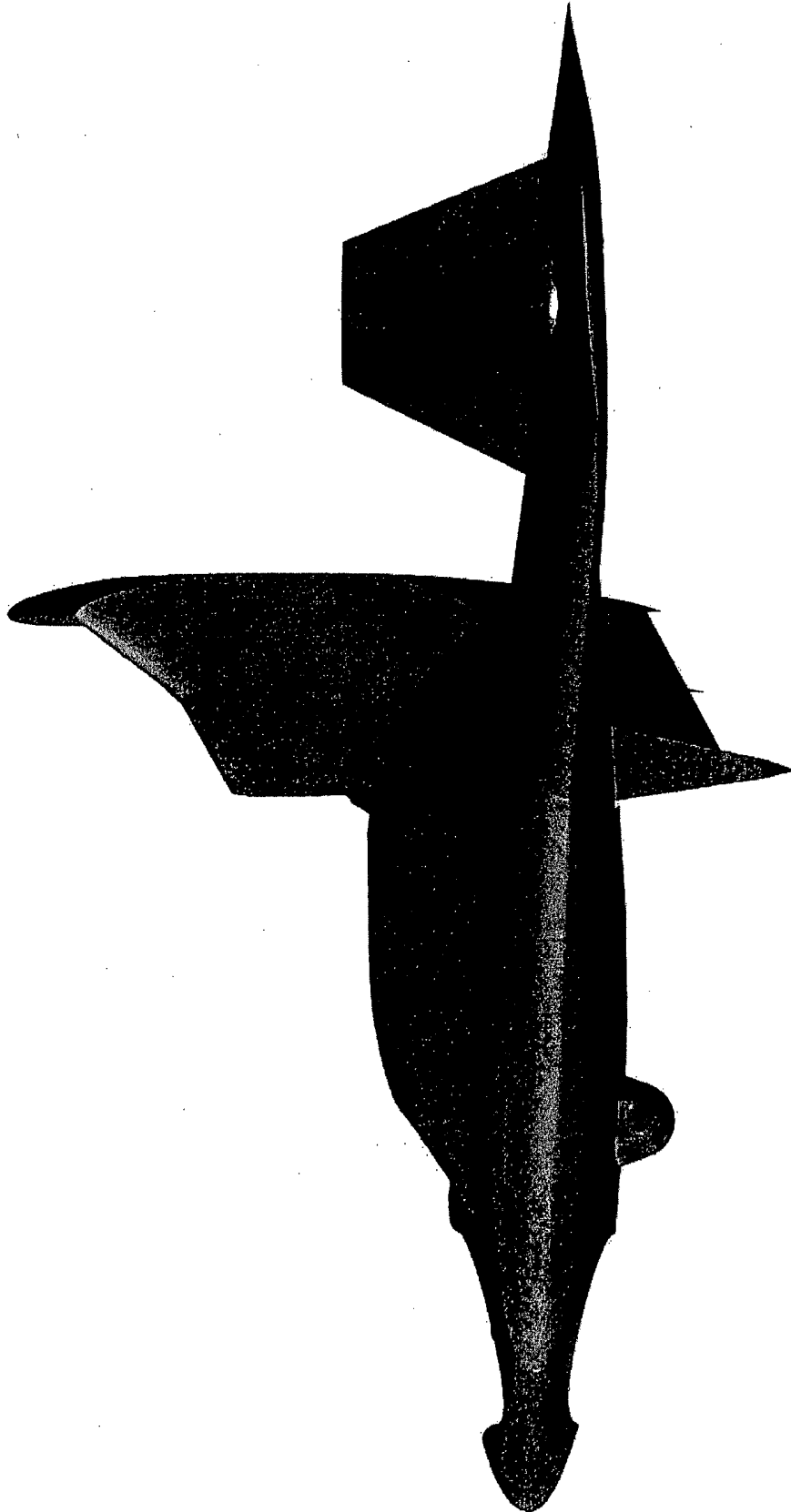
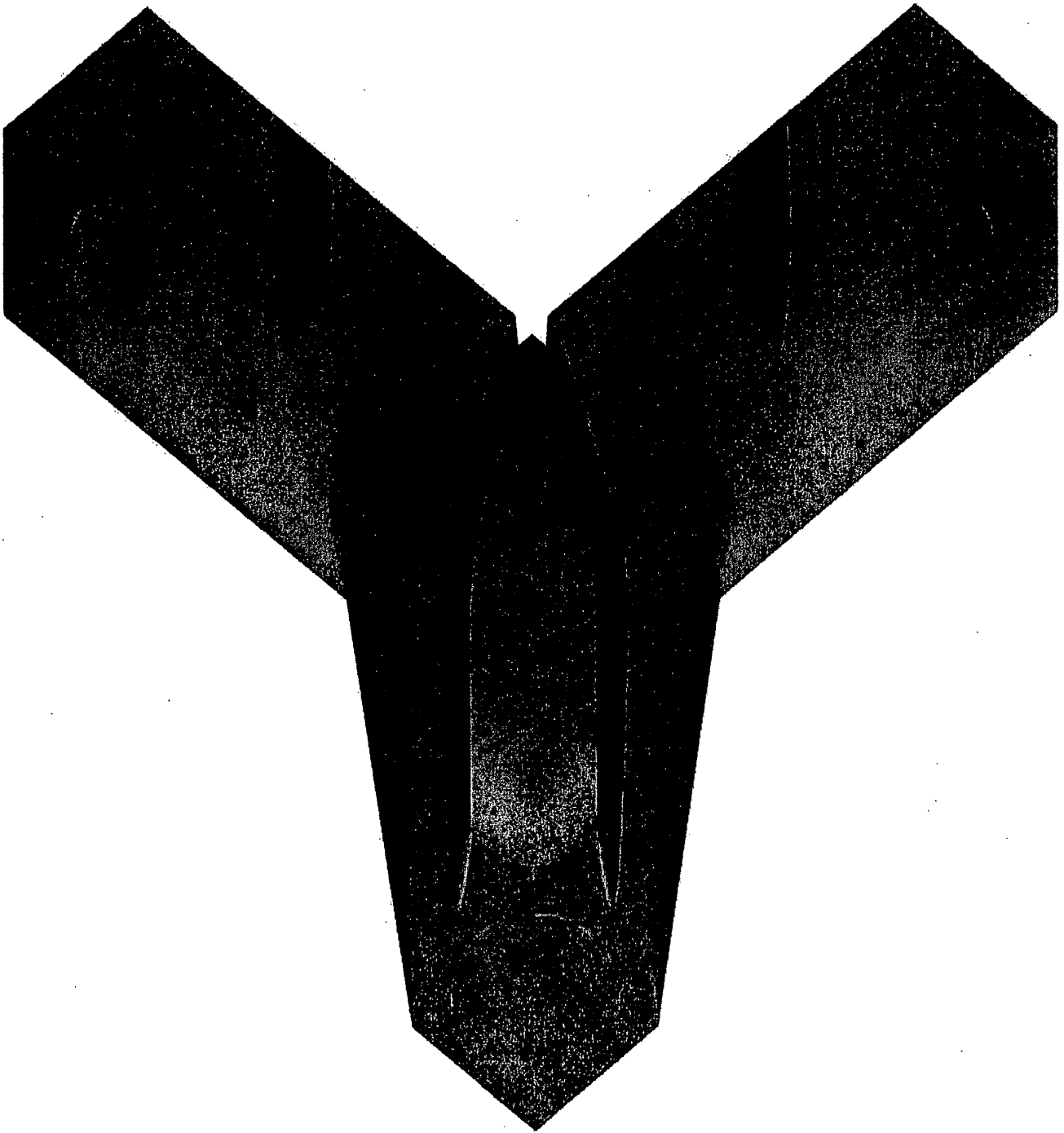
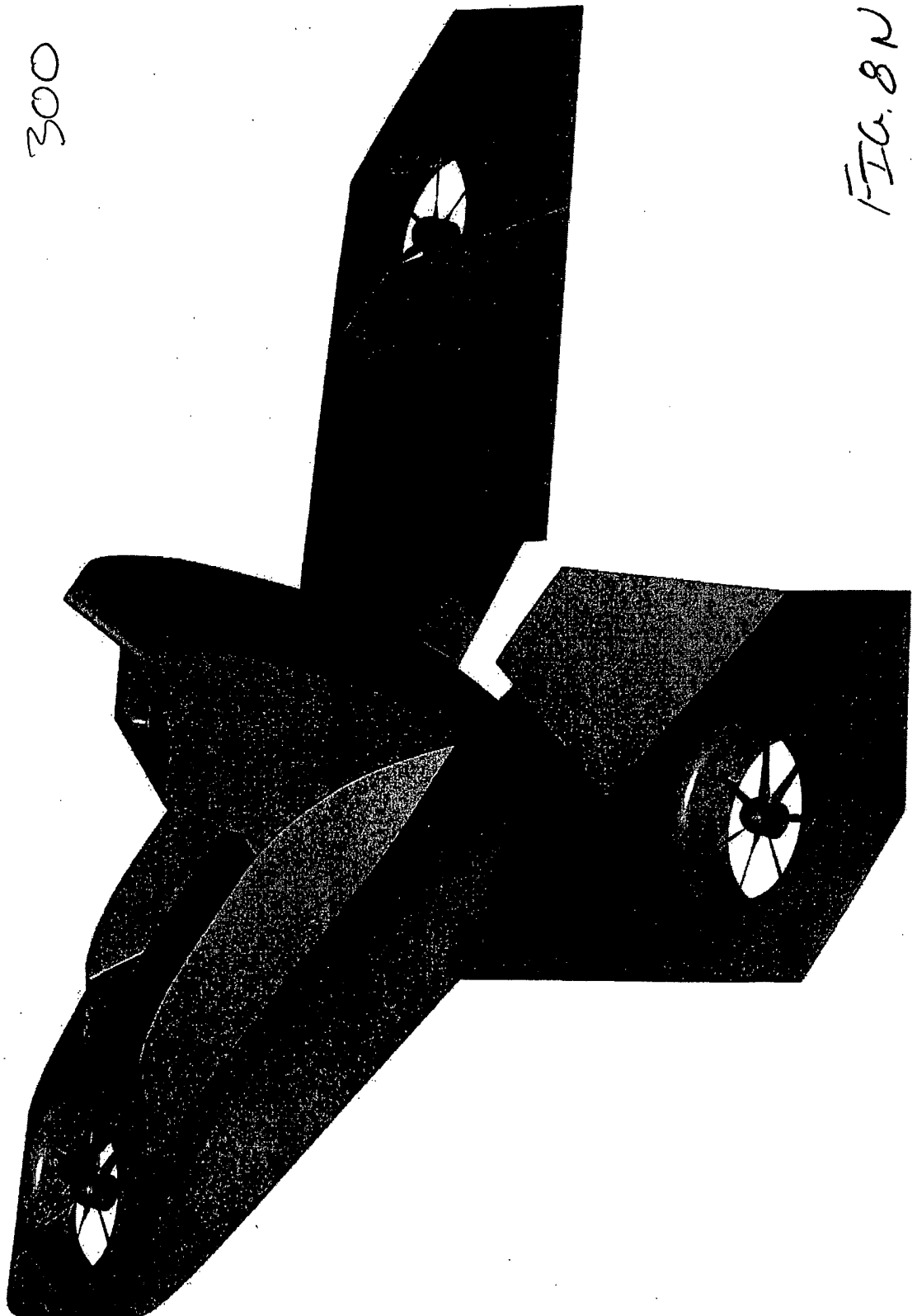


FIG. 8C

300

FIG. 8M





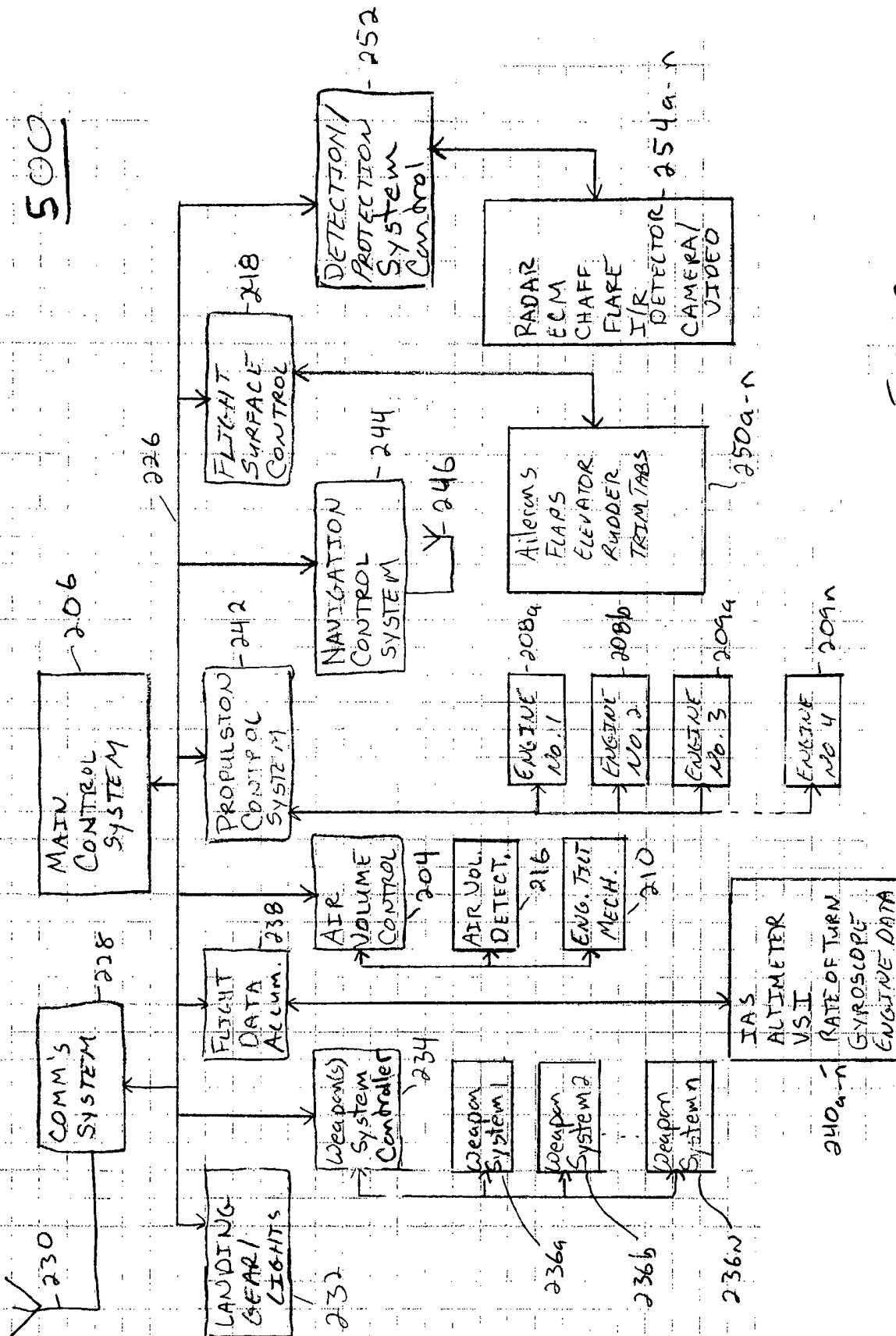


FIG. 9

400

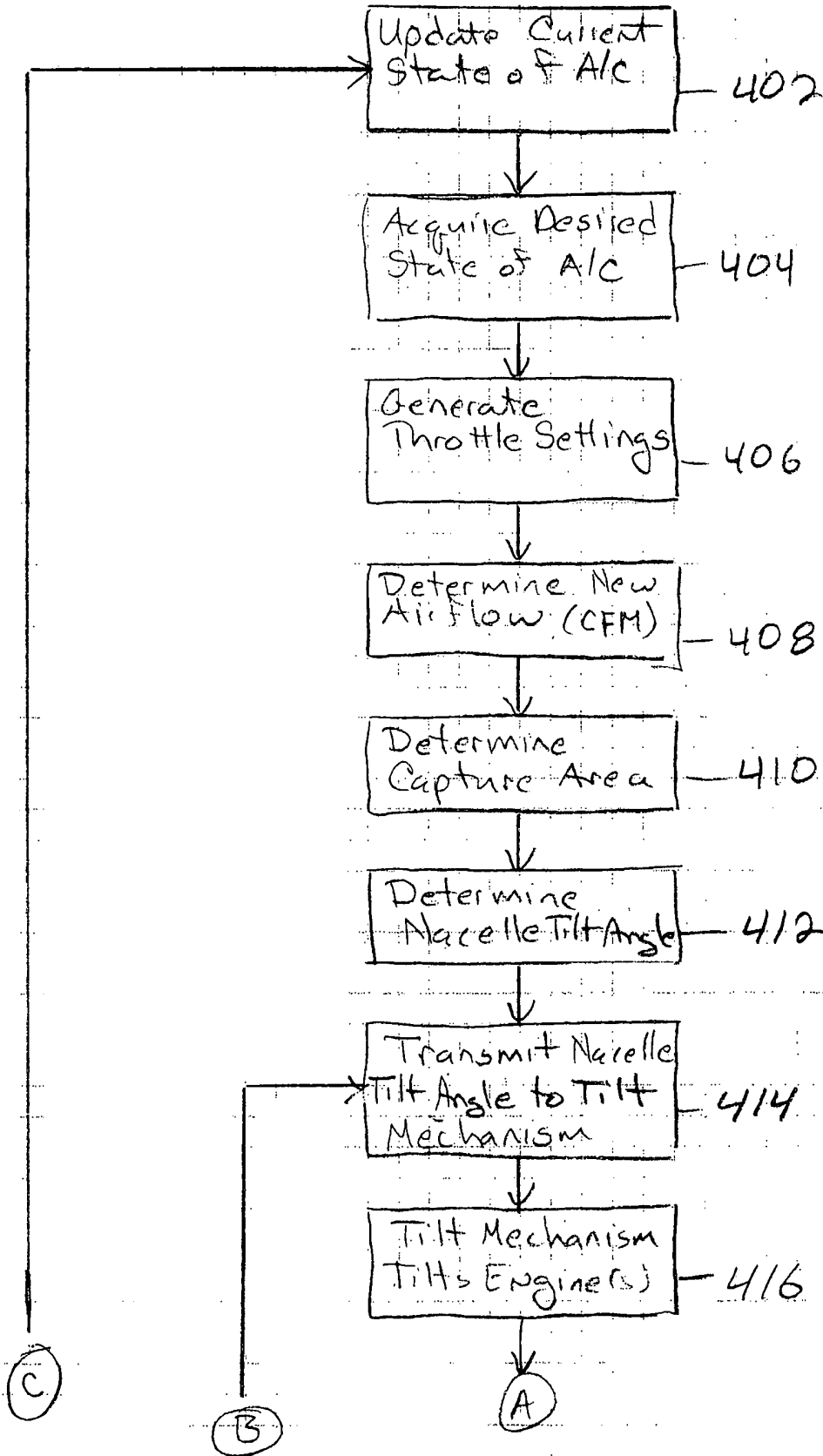


FIG. 10A

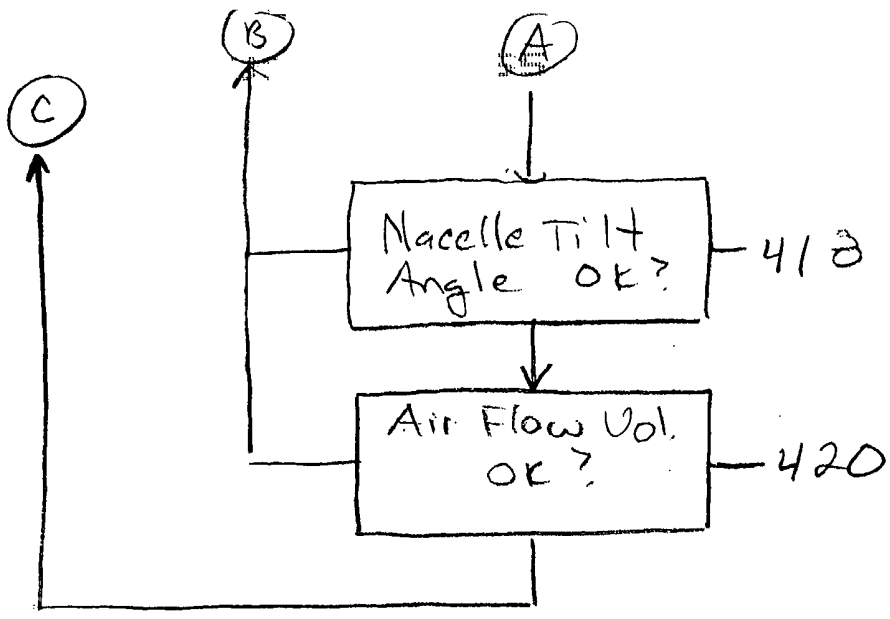


FIG 10B

200

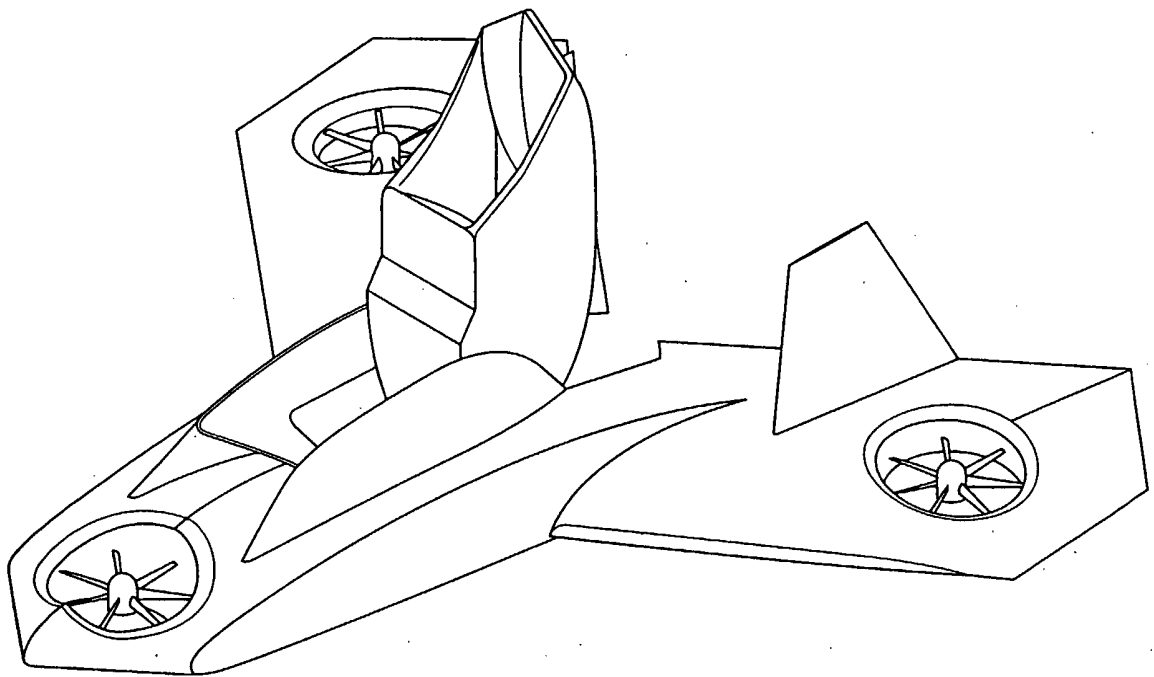


FIG. 11