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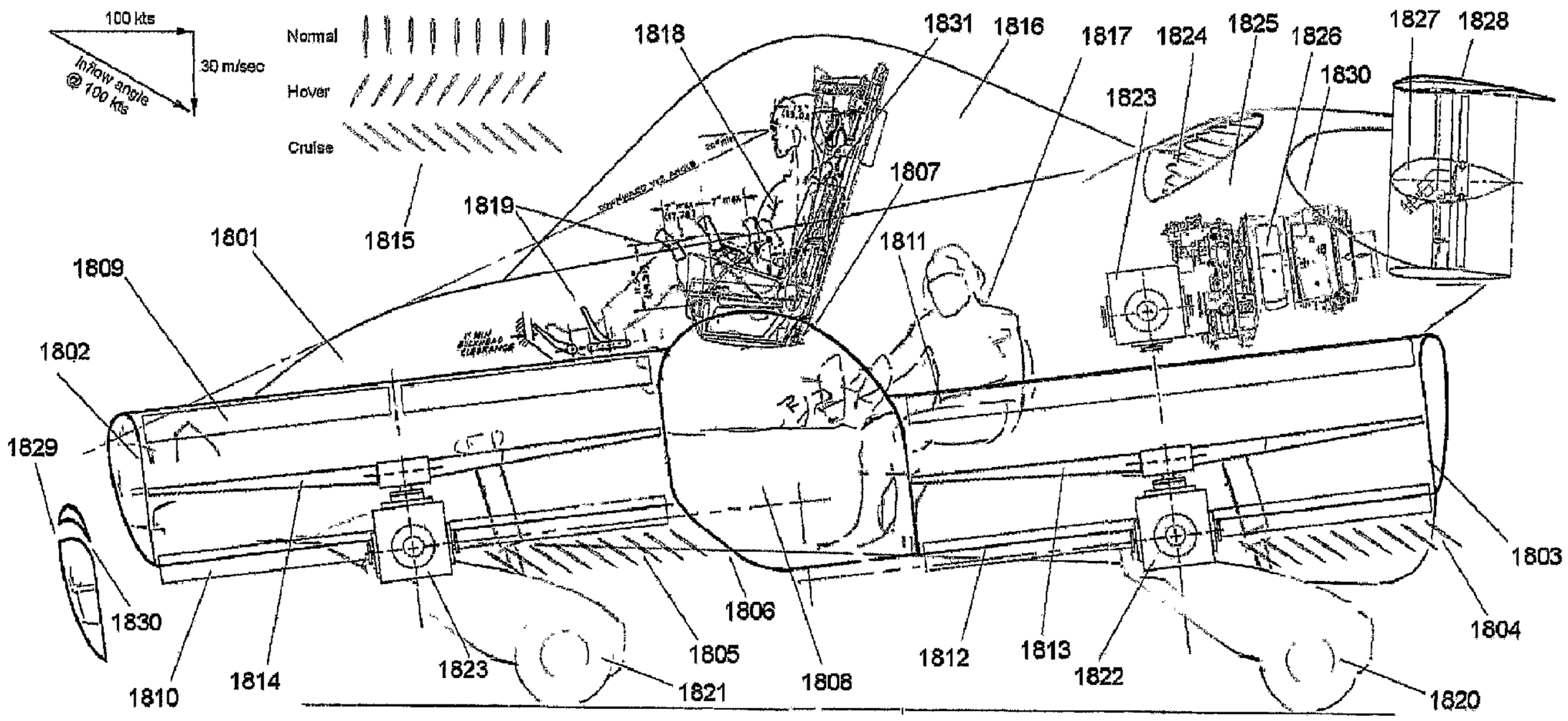

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A vehicle including a fuselage having a longitudinal axis and a transverse axis, two Ducted Fan lift-producing propellers carried by the fuselage on each side of the transverse axis, a pilot's compartment formed in the fuselage between the lift-producing propellers and substantially aligned with one side of the fuselage, a payload bay formed in the fuselage between the lift-producing propellers and opposite the pilot's compartment, and two pusher fans located at the rear of the vehicle. Many variations are described enabling the vehicle to be used not only as a VTOL vehicle, but also as a multi-function utility vehicle for performing many diverse functions including hovercraft and ATV functions. Also described is an Unmanned version of the vehicle. Also described are unique features applicable in any single or multiple ducted fans and VTOL vehicles.

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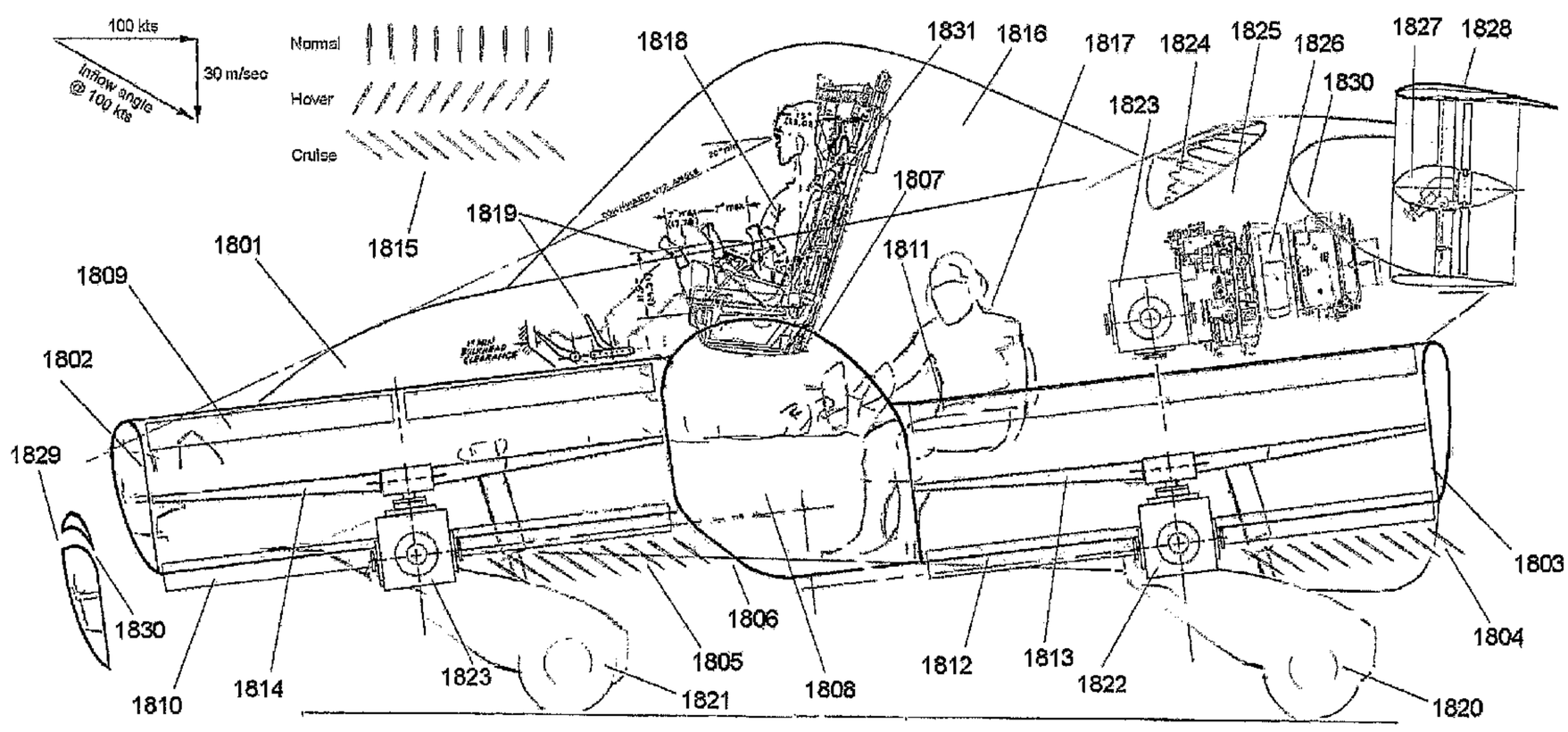

(57) Abstract: A vehicle including a fuselage having a longitudinal axis and a transverse axis, two Ducted Fan lift-producing propellers carried by the fuselage on each side of the transverse axis, a pilot's compartment formed in the fuselage between the lift-producing propellers and substantially aligned with one side of the fuselage, a payload bay formed in the fuselage between the lift-producing propellers and opposite the pilot's compartment, and two pusher fans located at the rear of the vehicle. Many variations are described enabling the vehicle to be used not only as a VTOL vehicle, but also as a multi-function utility vehicle for performing many diverse functions including hovercraft and ATV functions. Also described is an Unmanned version of the vehicle. Also described are unique features applicable in any single or multiple ducted fans and VTOL vehicles.

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Ducted fan VTOL vehicles.

FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to vehicles, and particularly to Vertical Take-Off and Landing (VTOL) vehicles having multi-function capabilities.

VTOL vehicles rely on direct thrust from propellers or rotors, directed downwardly, for obtaining lift necessary to support the vehicle in the air. Many different types of VTOL vehicles have been proposed where the weight of the vehicle in hover is carried directly by rotors or propellers, with the axis of rotation perpendicular to the ground. One well known vehicle of this type is the conventional helicopter which includes a large rotor mounted above the vehicle fuselage. Other types of vehicles rely on a multitude of propellers that are either exposed (e.g., unducted fans), or installed inside circular cavities, shrouds, ducts or other types of nacelle (e.g., ducted fans), where the flow of air takes place inside ducts. Some VTOL vehicles (such as the V-22) use propellers having their axes of rotation fully rotatable (up to 90 degrees or so) with respect to the body of the vehicle; these vehicles normally have the propeller axis perpendicular to the ground for vertical takeoff and landing, and then tilt the propeller axis forward for normal flight. Other vehicles use propellers having nearly horizontal axes, but include aerodynamic deflectors installed behind the propeller which deflect all or part of the flow downwardly to create direct upward lift.

A number of VTOL vehicles have been proposed in the past where two or four propellers, usually mounted inside ducts (i.e., ducted fans), were placed forwardly of, and rearwardly of, the main payload of the vehicle. One typical example is the Piasecki VZ-8 'Flying Jeep' which had two large ducts, with the pilots located to the sides of the vehicle, in the central area between the ducts. A similar configuration was used on the Chrysler VZ-6 and on the CityHawk flying car. Also the Bensen 'Flying Bench' uses a similar

arrangement. The Curtiss Wright VZ-7 and the Moller Skycar use four, instead of two, thrusters where two are located on each side (forward and rear) of the pilots and the payload, the latter being of fixed nature at the center of the vehicle, close to the vehicle's center of gravity.

The foregoing existing vehicles are generally designed for specific functions and are therefore not conveniently capable of performing a multiplicity of functions.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a vehicle of a relatively simple inexpensive construction and yet capable of performing a multiplicity of different functions.

According to the present invention, there is provided a vehicle, comprising: a fuselage having a longitudinal axis and a transverse axis; at least one lift-producing propeller carried by the fuselage on each side of the transverse axis; a pilot's compartment formed in the fuselage between the lift-producing propellers and substantially aligned with the longitudinal axis; and a pair of payload bays formed in the fuselage between the lift-producing propellers and on opposite sides of the pilot's compartment.

According to further features in the preferred embodiments of the invention described below, each of the payload bays includes a cover deployable to an open position providing access to the payload bay, and to a closed position covering the payload bay. In some described preferred embodiments, the cover of each of the payload bays is pivotally mounted to the fuselage along an axis parallel to the longitudinal axis of the fuselage at the bottom of the respective payload bay, such that when the cover is pivoted to the open position it also serves as a support for supporting the payload or a part thereof in the respective payload bay.

Various embodiments of the invention are described below, wherein the lift propellers are ducted or unducted fans, and wherein the fuselage carries a pair of the lift producing propellers on each side of the transverse axis, a vertical stabilizer at the rear end of the fuselage, or a horizontal stabilizer at the rear end of the fuselage.

Several preferred embodiments are also described below wherein the fuselage further carries a pair of pusher propellers at the rear end of the fuselage, on opposite sides of the longitudinal axis. In the described embodiments, the fuselage carries two engines, each for driving one of the lift-producing propellers and pusher propellers with the two

engines being mechanically coupled together in a common transmission. In one described preferred embodiment, the two engines are located in engine compartments in pylons formed in the fuselage on opposite sides of its longitudinal axis. In another described embodiment, the two engines are located in a common engine compartment aligned with the longitudinal axis of the fuselage and underlying the pilot's compartment.

One preferred embodiment is described wherein the vehicle is a vertical take-off and landing (VTOL) vehicle and includes a pair of stub wings each pivotally mounted under one of the payload bays to a retracted, stored position, and to an extended, deployed position for enhancing lift. Another embodiment is described wherein the vehicle includes a flexible skirt extending below the fuselage enabling the vehicle to be used as, or converted to, a hovercraft for movement over ground or water. A further embodiment is described wherein the vehicle includes large wheels attachable to the rear end of the fuselage for converting the vehicle to an all terrain vehicle (ATV).

As will be described more particularly below, a vehicle constructed in accordance with the foregoing features may be of a relatively simple and inexpensive construction capable of conveniently performing a host of different functions besides the normal functions of a VTOL vehicle. Thus, the foregoing features enable the vehicle to be constructed as a utility vehicle for a large array of tasks including serving as a weapons platform; transporting personnel, weapons, and/or cargo; evacuating medically wounded, etc., without requiring major changes in the basic structure of the vehicle when transferring from one task to another.

According to further features in the preferred embodiments of the invention described below an alternative vehicle arrangement is described wherein the vehicle is relatively small in size, having insufficient room for installing a cockpit in the middle of the vehicle and where the pilot's cockpit is therefore installed to one side of the vehicle, thereby creating a large, single payload bay in the remaining area between the two lift-producing propellers.

According to further features in the preferred embodiments of the invention described below an alternative vehicle arrangement is described wherein the vehicle does not feature any form of pilot's enclosure, for use in an unmanned role, piloted by suitable on-board electronic computers or being remotely controlled from the ground.

Further features and advantages of the invention will be apparent from the description below. Some of those describe unique features applicable in any single or multiple ducted fan and VTOL vehicles.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

Fig. 1 illustrates one form of VTOL vehicle constructed in accordance with present invention with two ducted fans;

Fig. 2 illustrates an alternative construction with four ducted fans;

Fig. 3 illustrates a construction similar to Fig. 1 with free propellers, i.e., unducted fans;

Fig. 4 illustrates a construction similar to Fig. 2 with free propellers;

Fig. 5 illustrates a construction similar to that of Fig. 1 but including two propellers, instead of a single propeller, mounted side-by-side in a single, oval shaped duct at each end of the vehicle;

Figs. 6a, 6b and 6c are side, top and rear views, respectively, illustrating another VTOL vehicle constructed in accordance with the present invention and including pusher propellers in addition to the lift-producing propellers;

Fig. 7 is a diagram illustrating the drive system in the vehicle of Figs. 6a – 6c;

Fig. 8 is a pictorial illustration of a vehicle constructed in accordance with Figs. 6a – 6c and 7;

Fig. 8a – 8d illustrate examples of various tasks and missions capable of being accomplished by the vehicle of Fig. 8;

Figs. 9a and 9b are side and top views, respectively, illustrating another VTOL vehicle constructed in accordance with the present invention;

Fig. 10 is a diagram illustrating the drive system in the vehicle of Figs. 9a and 9b;

Figs. 11a and 11b are side and top views, respectively, illustrating a VTOL vehicle constructed in accordance with any one of Figs. 6a – 10 but equipped with deployable stub wings, the wings being shown in these figures in their retracted stowed positions;

Fig. 11c and 11d are views corresponding to those of Figs. 11a and 11b but showing the stub wings in their deployed, extended positions;

Fig. 12 is a perspective rear view of a vehicle constructed in accordance with any one of Figs. 6a – 10 but equipped with a lower skirt for converting the vehicle to a hovercraft for movement over ground or water;

Fig. 13 is a perspective rear view of a vehicle constructed in accordance with any one of Figs. 6a – 10 but equipped with large wheels for converting the vehicle for ATV (all terrain vehicle) operation;

Figs. 14a-14e are a pictorial illustration of an alternative vehicle arrangement wherein the vehicle is relatively small in size, having the pilot's cockpit installed to one side of the vehicle. Various alternative payload possibilities are shown;

Fig. 15 is a pictorial illustration of a vehicle constructed typically in accordance with the configuration in Figs. 14a-14e but equipped with a lower skirt for converting the vehicle to a hovercraft for movement over ground or water;

Figs. 16a-16d show top views of the vehicle of Figs. 14a-14e with several payload arrangements;

Fig. 17 is a see-through front view of the vehicle of Fig. 16a showing various additional features and internal arrangement details of the vehicle;

Fig. 18 is a longitudinal cross-section of the vehicle of Figs. 16b showing various additional features and internal arrangement details of the vehicle;

Fig. 19 is a pictorial illustration of an Unmanned application of the vehicle having similar design to the vehicle of Figs. 16-18, but lacking a pilot's compartment;

Fig. 20 is a further pictorial illustration of an optional Unmanned vehicle, having a slightly different engine installation than that of Fig.19;

Fig. 21 is a top view showing the vehicle of Fig. 16b as equipped with a extendable wing for high speed flight;

Figs. 22a and 22b are side and top views, respectively, illustrating a VTOL vehicle having a plurality of lifting fans to facilitate increased payload capability;

Fig. 23 is a schematic view of the power transmission system used in the vehicles of Figs. 14-19;

Fig. 24 is a schematic view of the power transmission system used in the vehicle of Fig. 20;

Figs. 25a-25c show schematic cross sections and design details of an optional single duct Unmanned vehicle;

Fig. 26 is a pictorial illustration of a ram-air-'parawing' based emergency rescue system;

Figs. 27 illustrates optional means of supplying additional air to lift ducts shielded by nacelles from their sides;

Figs. 28a-28e are more detailed schematic top views of the medical attendant station in the rescue cabin of the vehicle described in 14b, 14c and 16b;

Fig. 29 illustrates in side view some optional additions to the cockpit area of the vehicles described in Figs. 14-18;

Figs. 30a-d show a vehicle generally similar to that shown in Fig.18, however having alternative internal arrangements for various elements including cabin arrangement geometry to enable carriage of 5 passengers or combatants;

Figs. 31 shows a top view of vehicle generally similar to that shown in Fig.30a-d, however the fuselage is elongated to provide for 9 passengers or combatants;

Figs. 32a-e illustrate means for enabling the external airflow to penetrate the walls of the forward ducted fan of the vehicles described in Figs. 1-21 and Figs.30-31 while in forward flight, for the purpose of minimizing the momentum drag of the vehicle;

Figs. 33a-e illustrate means for enabling the internal airflow to exit through the walls of the aft ducted fan of the vehicles described in Figs. 1-21 and Figs.30-31, while in forward flight, for the purpose of minimizing the momentum drag of the vehicle;

Fig. 34 illustrates means for directing the internal airflow to exit with a rearward velocity component for the purpose of minimizing the momentum drag of the vehicle in forward flight; and

Figs. 35a-c illustrate additional optional means for enabling the external airflow to penetrate the walls of the forward duct and the internal airflow to exit through the walls of the aft ducted fan of the vehicles described in Figs. 1-21 and Figs.30-31, while in forward flight, for the purpose of minimizing the momentum drag of the vehicle.

It is to be understood that the foregoing drawings, and the description below, are provided primarily for purposes of facilitating understanding the conceptual aspects of the invention and various possible embodiments thereof, including what is presently considered to be a preferred embodiment. In the interest of clarity and brevity, no attempt is made to provide more details than necessary to enable one skilled in the art, using routine skill and design, to understand and practice the described invention. It is to be further understood that the embodiments described are for purposes of example only, and that the invention is capable of being embodied in other forms and applications than described herein.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

As indicated earlier, the present invention provides a vehicle of a novel construction which permits it to be used for a large variety of tasks and missions with no changes, or minimum changes, required when converting from one mission to another.

The basic construction of such a vehicle is illustrated in Fig. 1, and is therein generally designated 10. It includes a fuselage 11 having a longitudinal axis LA and a transverse axis TA. Vehicle 10 further includes two lift-producing propellers 12a, 12b carried at the opposite ends of the fuselage 11 along its longitudinal axis LA and on opposite sides of its transverse axis TA. Lift-producing propellers 12a, 12b are ducted fan propulsion units extending vertically through the fuselage and rotatable about vertical axes to propel the air downwardly and thereby to produce an upward lift.

Vehicle 10 further includes a pilot's compartment 13 formed in the fuselage 11 between the lift-producing propellers 12a, 12 and substantially aligned with the longitudinal axis LA and transverse axis TA of the fuselage. The pilot's compartment 13 may be dimensioned so as to accommodate a single pilot or two (or more) pilots, as shown, for example, in Fig. 6a.

Vehicle 10 illustrated in Fig. 1 further includes a pair of payload bays 14a, 14b formed in the fuselage 11 laterally on the opposite sides of the pilot's compartment 13 and between the lift-producing propellers 12a, 12b. The payload bays 14a, 14b shown in Fig. 1 are substantially flush with the fuselage 11, as will be described more particularly below with respect to Figs. 6a – 6c and the pictorial illustration in Figs. 8a – 8d. Also described below, particularly with respect to the pictorial illustrations of Figs. 8a – 8d, are the wide variety of tasks and missions capable of being accomplished by the vehicle when

constructed as illustrated in Fig. 1 (and in the later illustrations), and particularly when provided with the payload bays corresponding to 14a, 14b of Fig. 1.

Vehicle 10 illustrated in Fig. 1 further includes a front landing gear 15a and a rear landing gear 15b mounted at the opposite ends of its fuselage 11. In Fig. 1 the landing gears are non-retractable, but could be retractable as in later described embodiments. Aerodynamic stabilizing surfaces may also be provided, if desired, as shown by the vertical stabilizers 16a, 16b carried at the rear end of fuselage 11 on the opposite sides of its longitudinal axis LA.

Fig. 2 illustrates another vehicle construction in accordance with the present invention. In the vehicle of Fig. 2, therein generally designated 20, the fuselage 21 is provided with a pair of lift-producing propellers on each side of the transverse axis of the fuselage. Thus, as shown in Fig. 2, the vehicle includes a pair of lift-producing propellers 22a, 22b at the front end of the fuselage 21, and another pair of lift-producing propellers 22c, 22d at the rear end of the fuselage. The lift-producing propellers 22a – 22d shown in Fig. 2 are also ducted fan propulsion units. However, instead of being formed in the fuselage 21, they are mounted on mounting structures 21a – 21d to project laterally of the fuselage.

Vehicle 20 illustrated in Fig. 2 also includes the pilot's compartment 23 formed in the fuselage 21 between the two pairs of lift-producing propellers 22a, 22b and 22c, 22d, respectively. As in the case of the pilot's compartment 13 in Fig. 1, the pilot's compartment 23 in Fig. 2 is also substantially aligned with the longitudinal axis LA and transverse axis TA of the fuselage 21.

Vehicle 20 illustrated in Fig. 2 further includes a pair of payload bays 24a, 24b formed in the fuselage 21 laterally of the pilot's compartment 23 and between the two pairs of lift-producing propellers 22a – 22d. In Fig. 2, however, the payload bays are not formed integral with the fuselage, as in Fig. 1, but rather are attached to the fuselage so as to project laterally on opposite sides of the fuselage. Thus, payload bay 24a is substantially aligned with the lift-producing propellers 22a, 22c on that side of the fuselage; and payload bay 24b is substantially aligned with the lift-producing propellers 22b and 22d at that side of the fuselage.

Vehicle 20 illustrated in Fig. 2 also includes a front landing gear 25a and a rear landing gear 25b, but only a single vertical stabilizer 26 at the rear end of the fuselage aligned with its longitudinal axis. It will be appreciated however, that vehicle 20 illustrated in Fig 2 could also include a pair of vertical stabilizers, as shown at 16a and 16b in Fig. 1, or could be constructed without any such aerodynamic stabilizing surface.

Fig. 3 illustrates a vehicle 30 also including a fuselage 31 of a very simple construction having a forward mounting structure 31a for mounting the forward lift-producing propeller 32a, and a rear mounting structure 31b for mounting the rear lift-producing propeller 32b. Both propellers are unducted, i.e., free, propellers. Fuselage 31 is formed centrally thereof with a pilots compartment 33 and carries the two payload bays 34a, 34b on its opposite sides laterally of the pilot's compartment.

Vehicle 30 illustrated in Fig. 3 also includes a front landing gear 35a and a rear landing gear 35b, but for simplification purposes, it does not include an aerodynamic stabilizing surface corresponding to vertical stabilizers 16a, 16b in Fig. 1.

Fig. 4 illustrates a vehicle, generally designated 40, of a similar construction as in Fig. 2 but including a fuselage 41 mounting a pair of unducted propellers 42a, 42b at its front end, and a pair of unducted propellers 42c, 42d at its rear end by means of mounting structures 41a – 41d, respectively. Vehicle 40 further includes a pilot's compartment 43 centrally of the fuselage, a pair of payload bays 44a, 44b laterally of the pilot's compartment, a front landing gear 45a, a rear landing gear 45b, and a vertical stabilizer 46 at the rear end of the fuselage 41 in alignment with its longitudinal axis.

Fig. 5 illustrates a vehicle, generally designated 50, including a fuselage 51 mounting a pair of lift-producing propellers 52a, 52b at its front end, and another pair 52c, 52d at its rear end. Each pair of lift-producing propellers 52a, 52b and 52c, 52d is enclosed within a common oval-shaped duct 52e, 52f at the respective end of the fuselage.

Vehicle 50 illustrated in Fig. 5 further includes a pilot' compartment 53 formed centrally of the fuselage 51, a pair of payload bays 54a, 54b laterally of the pilot's compartment 53, a front landing gear 55a, a rear landing gear 55b, and vertical stabilizers 56a, 56b carried at the rear end of the fuselage 51.

Figs. 6a, 6b and 6c are side, top and rear views, respectively, of another vehicle constructed in accordance with the present invention. The vehicle illustrated in Figs. 6a –

6c, therein generally designated 60, also includes a fuselage 61 mounting a lift-producing propeller 62a, 62b at its front and rear ends, respectively. The latter propellers are preferably ducted units as in Fig. 1.

Vehicle 60 further includes a pilot's compartment 63 centrally of the fuselage 61, a pair of payload bays 64a, 64b laterally of the fuselage and of the pilot's compartment, a front landing gear 65a, a rear landing gear 65b, and a stabilizer, which, in this case, is a horizontal stabilizer 66 extending across the rear end of the fuselage 61.

Vehicle 60 illustrated in Figs. 6a – 6c further includes a pair of pusher propellers 67a, 67b, mounted at the rear end of the fuselage 61 at the opposite ends of the horizontal stabilizer 66. As shown particularly in Figs. 6c the rear end of the fuselage 61 is formed with a pair of pylons 61a, 61b, for mounting the two pusher propellers 67a, 67b, together with the horizontal stabilizer 66.

The two pusher propellers 67a, 67b are preferably variable-pitch propellers enabling the vehicle to attain higher horizontal speeds. The horizontal stabilizer 66 is used to trim the vehicle's pitching moment caused by the ducted fans 62a, 62b, thereby enabling the vehicle to remain horizontal during high speed flight.

Each of the pusher propellers 67a, 67b is driven by an engine enclosed within the respective pylon 61a, 61b. The two engines are preferably turbo-shaft engines. Each pylon is thus formed with an air inlet 68a, 68b at the forward end of the respective pylon, and with an air outlet (not shown) at the rear end of the respective pylon.

Fig. 7 schematically illustrates the drive within the vehicle 60 for driving the two ducted fans 62a, 62b as well as the pusher propellers 67a, 67b. The drive system, generally designated 70, includes two engines 71, 71b, each incorporated in an engine compartment within one of the two pylons 61a, 61b. Each engine 71a, 71b, is coupled by an over-running clutch 72a, 72b, to a gear box 73a, 73b coupled on one side to the respective thrust propeller 67a, 67b, and on the opposite side to a transmission for coupling to the two ducted fans 62a, 62b at the opposite ends of the fuselage. Thus, as schematically shown in Fig. 7, the latter transmission includes additional gear boxes 74a, 74b coupled to rear gear box 75b for driving the rear ducted fan 62b, and front gear box 75a for driving the front ducted fan 62b.

Fig. 8 pictorially illustrates an example of the outer appearance that vehicle 60 may take.

In the pictorial illustration of Fig. 8, those parts of the vehicle which correspond to the above-described parts in Figs. 6a – 6c are identified by the same reference numerals in order to facilitate understanding. Fig. 8, however, illustrates a number of additional features which may be provided in such a vehicle.

Thus, as shown in Fig. 8, the front end of the fuselage 61 may be provided with a stabilized sight and FLIR (Forward Looking Infra-Red) unit, as shown at 81, and with a gun at the forward end of each payload bay, as shown at 82. In addition, each payload bay may include a cover 83 deployable to an open position providing access to the payload bay, and to a closed position covering the payload bay with respect to the fuselage 61.

In Fig. 8, cover 83 of each payload bay is pivotally mounted to the fuselage 61 along an axis 84 parallel to the longitudinal axis of the fuselage at the bottom of the respective bay. The cover 83, when in its closed condition, conforms to the outer surface of the fuselage 61 and is flush therewith. When the cover 83 is pivoted to its open position, it serves as a support for supporting the payload, or a part thereof, in the respective payload bay.

The latter feature is more particularly shown in Figs. 8a – 8d which illustrate various task capabilities of the vehicle as particularly enabled by the pivotal covers 83 for the two payload bays. Thus, Fig. 8a illustrates the payload bays used for mounting or transporting guns or ammunition 85a; Fig. 8b illustrates the use of the payload bays for transporting personnel or troops 85b; Fig. 8c illustrates the use of the payload bays for transporting cargo 85c; and Fig. 8d illustrates the use of the payload bays for evacuating wounded 85d. Many other task or mission capabilities will be apparent.

Figs. 9a and 9b are side and top views, respectively, illustrating another vehicle, generally designated 90, of a slightly modified construction from vehicle 60 described above. Thus, vehicle 90 illustrated in Figs. 9a and 9b also includes a fuselage 91, a pair of ducted-fan type lift-producing propellers 92a, 92b at the opposite ends of the fuselage, a pilot's compartment 93 centrally of the fuselage, and a pair of payload bays 94a, 94b laterally of the pilot's compartment 93. Vehicle 90 further includes a front landing gear 95a,

a rear landing gear 95b, a horizontal stabilizer 96, and a pair of pusher propellers 97a, 97b, at the rear end of fuselage 91.

Fig. 10 schematically illustrates the drive system in vehicle 90. Thus as shown in Fig. 10, vehicle 90 also includes two engines 101a, 101b for driving the two ducted fans 92a, 92b and the two pusher propellers 97a, 97b, respectively, as in vehicle 60. However, whereas in vehicle 60 the two engines are located in separate engine compartments in the two pylons 61a, 61b, in vehicle 90 illustrated in Figs. 9a and 9b both engines are incorporated in a common engine compartment, schematically shown at 100 in Fig. 9a, underlying the pilot's compartment 93. The two engines 101a, 101b (Fig. 10), may also be turbo-shaft engines as in Fig. 7. For this purpose, the central portion of the fuselage 91 is formed with a pair of air inlet openings 98a, 98b forward of the pilot's compartment 93, and with a pair of air outlet openings 99a, 99b rearwardly of the pilot's compartment.

As shown in Fig. 10, the two engines 101a, 101b drive, via the over-running clutches 102a, 102b, a pair of hydraulic pumps 103a, 103b which, in turn, drive the drives 104a, 104b of the two pusher propellers 97a, 97b. The two engines 101a, 101b are further coupled to a drive shaft 105 which drives the drives 106a, 106b of the two ducted fans 92a, 92b, respectively.

Figs. 11a – 11d illustrate another vehicle, therein generally designated 110, which is basically of the same construction as vehicle 60 described above with respect to Figs. 6a – 6c, 7, 8 and 8a – 8d; to facilitate understanding, corresponding elements are therefore identified by the same reference numerals. Vehicle 110 illustrated in Figs. 11a – 11d, however, is equipped with two stub wings, generally designated 111a, 111b, each pivotally mounted to the fuselage 61, under one of the payload bays 64a, 64b, to a retracted position shown in Figs. 11a and 11b, or to an extended deployed position shown in Figs. 11c and 11d for enhancing the lift produced by the ducted fans 62a, 62b. Each of the stub wings 111a, 111b is actuated by an actuator 112a, 112b driven by a hydraulic or electrical motor (not shown). Thus, at low speed flight, the stub wings 111a, 111b, would be pivoted to their stowed positions as shown in Figs. 11a and 11b; but at high speed flight, they could be pivoted to their extended or deployed positions, as shown in Figs. 11c and 11d, to enhance the lift produced by the ducted fans 61a,

61b. Consequently, the blades in the ducted fans would be at low pitch producing only a part of the total lift force.

The front and rear landing gear, shown at 115a and 115b, could also by pivoted to a stowed position to enable higher speed flight, as shown in Figs. 11c and 11d. In such case, the front end of the fuselage 61 would preferably be enlarged to accommodate the landing gear when in its retracted condition. Vehicle 110 illustrated in Figs. 11a – 11d may also include ailerons, as shown at 116a, 116b (Fig. 11d) for roll control.

Fig. 12 illustrates how the vehicle, such as vehicle 60 illustrated in Figs. 6a – 6d, may be converted to a hovercraft for travelling over ground or water. Thus, the vehicle illustrated in Fig. 12, and therein generally designated 120, is basically of the same construction as described above with respect to Figs. 6a – 6d, and therefore corresponding parts have been identified with the same reference numerals. In vehicle 120 illustrated in Fig. 12, however, the landing gear wheels (65a, 65b, Figs. 6a – 6d) have been removed, folded, or otherwise stowed, and instead, a skirt 121 has been applied around the lower end of the fuselage 61. The ducted fans 62a, 62b, may be operated at very low power to create enough pressure to cause the vehicle to hover over the ground or water as in hovercraft vehicles. The variable pitch pusher propellers 67a, 67b would provide forward or rear movement, as well as steering control, by individually varying the pitch, as desired, of each propeller.

Vehicles constructed in accordance with the present invention may also be used for movement on the ground. Thus, the front and rear wheels of the landing gears can be driven by electric or hydraulic motors included within the vehicle.

Fig. 13 illustrates how such a vehicle can also be used as an ATV (all terrain vehicle). The vehicle illustrated in Fig. 13, therein generally designated 130, is basically of the same construction as vehicle 60 illustrated in Figs. 6a – 6d, and therefore corresponding parts have been identified by the same reference numerals to facilitate understanding. In vehicle 130 illustrated in Fig. 13, however, the two rear wheels of the vehicle are replaced by two (or four) larger ones, bringing the total number of wheels per vehicle to four (or six). Thus, as shown in Fig. 13, the front wheels (e.g., 65a, Fig. 6c) of the front landing gear are retained, but the rear wheels are replaced by two larger wheels 135a (or by an additional pair of wheels, not shown), to enable the vehicle to traverse all types of terrain.

When the vehicle is used as an ATV as shown in Fig. 13, the front wheels 65a or rear wheels would provide steering, while the pusher propellers 67a, 67b and main lift fans 62a, 62b would be disconnected but could still be powered-up for take-off if so desired. The same applies also with respect to the hovercraft version illustrated in Fig. 12.

It will thus be seen that the invention thus provides a utility vehicle of a relatively simple structure which is capable of performing a wide variety of VTOL functions, as well as many other tasks and missions, with minimum changes in the vehicle to convert it from one task or mission to another.

Figs. 14a-14e are pictorial illustrations of alternative vehicle arrangements where the vehicle is relatively small in size, having the pilot's cockpit installed to one side of the vehicle. Various alternative payload possibilities are shown.

Fig. 14a shows the vehicle in its basic form, with no specific payload installed. The overall design and placement of parts of the vehicle are similar to those of the 'larger' vehicle described in Figs. 8. with the exception of the pilot's cockpit, which in the arrangement of Fig.14 takes up the space of one of the payload bays created by the configuration shown in Fig.8. The cockpit arrangement of Fig. 14a frees up the area taken up by the cockpit in the arrangement of Fig.8 for use as an alternative payload area, increasing the total volume available for payload on the opposite side of the cockpit. It is appreciated that the mechanical arrangement of engines, drive shafts and gearboxes for the vehicle of Fig. 14. may be that described with reference to Fig. 7.

Fig. 14b illustrates how the basic vehicle of Fig. 14a may be used to evacuate a patient. The single payload bay is optionally provided with a cover and side door which protect the occupants, and which may include transparent areas to enable light to enter. The patient lies on a stretcher which is oriented predominantly perpendicular to the longitudinal axis of the vehicle, and optionally at a slight angle to enable the feet of the patient to clear the pilot's seat area and be moved fully into the vehicle despite its small size. Space for a medical attendant is provided, close to the outer side of the vehicle.

Fig. 14c shows the vehicle of Fig. 14b with the cover and side door closed for flight.

Fig. 14d illustrates how the basic vehicle of Fig. 14a may be used to perform various utility operations such as electric power-line maintenance. In the example shown if

Fig. 14d, a seat is provided for an operator, facing outwards towards an electric power-line. For illustration purposes, the operator is shown attaching plastic spheres to the line using tools. Uninstalled sphere halves and additional equipment may be carried in the open space behind the operator. Similar applications may include other utility equipment, such as for bridge inspection and maintenance, antenna repair, window cleaning, and other applications. One very important mission that the utility version of Fig. 14d could perform is the extraction of survivors from hi-rise buildings, with the operator assisting the survivors to climb onto the platform while the vehicle hovers within reach.

Fig. 14e illustrates how the basic vehicle of Fig. 14a may be used to carry personnel in a comfortable closed cabin, such as for commuting, observation, performing police duties, or any other purpose.

Fig. 15 is a pictorial illustration of a vehicle constructed typically in accordance with the configuration in Fig. 14 but equipped with a lower, flexible skirt for converting the vehicle to a hovercraft for movement over ground or water. While the vehicle shown in Fig.15 is similar to the application of Fig. 14e, a skirt can be installed on any of the applications shown in Fig. 14.

While Figs. 14-15 show a vehicle having a cockpit on the left hand side and a payload bay to the right hand side, it is appreciated that alternative arrangements are possible, such as where the cockpit is on the right hand side and the payload bay is on the left hand side. All the descriptions provided in Figs. 14-15 apply also to such an alternative configuration.

Figs. 16 illustrates four top views of the vehicle of Figs. 14a-14e with several payload arrangements:

Fig 16a is the basic vehicle with an empty platform on the right hand side of the vehicle. Fig 16b shows the arrangement of the right hand side compartment when configured as a rescue module. Fig 16c shows the conversion of the RHS compartment for carrying up to two observers or passengers. Fig 16d has two functional cockpits, needed mostly for pilot's instruction purposes. It should be emphasized that similar arrangements can be configured if so desired, with the pilot's compartment on the RHS of the vehicle, and the multi-mission payload bay on the left.

Fig. 17 is a see-through front view of the vehicle of Fig. 16a showing various additional features and internal arrangement details of the vehicle. The outer shell of the vehicle is shown in 1701. The forward ducted fan 1703 has a row of inlet vanes 1718 and a row of outlet vanes 1717 used together to maneuver the vehicle in roll and in horizontal side-to side translation. Detail A shows, as an example, the first five vanes being the closest to the RHS of the vehicle. These vanes are shown mounted at angles A5-A1 that are increasing progressively from nearly vertical mounting for vane 5 to some 15 degrees of tilt shown as the angle A1 in the figure. The progressive deflected mounting of the first rows of vanes align their chord line with the local streamlines of the incoming flow. This does not inhibit these vane's full motion to both directions of deflection around their basic mounting angles. It should also be emphasized, that a similar, anti-symmetric arrangement of the vanes is used on the opposite side of the duct shown (LHS of the vehicle). Similarly, the vanes attached at the inlet to the aft duct, are also tilted as required to orient themselves with the local inflow angle at each transverse position along the duct, where the angle is preferably averaged over the longitudinal span of each vane. This unique configuration of vanes can be varied in angles as a result of aerodynamic behavior of the incoming flow and due to engineering limitations. This configuration can be also used with any row of inlet vanes or outlet vanes installed on any single or multiple ducted fan vehicles.

The RHS engine of the vehicle 1708, is shown mounted inside its enclosure 1702, and below the air inlet 1709. It is connected to a 90 degree gearbox 1710, which is connected through a shaft (not shown) to a lower 90 degree gearbox 1720. From there, through a horizontal shaft, the power is transmitted to the main gearbox 1721 that also supports the lift producing rotor 1716. A similar arrangement for the LHS engine may be used (not shown). The pilot's compartment (cockpit) 1706 has a transparent top (canopy) of which the outer panel 1713 is hinged, to permit the pilot 1711 to enter and exit the cockpit. The pilot's seat 1712 may either be normal, or a rocket deployed ejection seat to facilitate quick egress of the pilot from the cockpit through the canopy, if the need arises. The pilot's controls 1714 are connected to the vehicles flight control system. The vehicle's RHS landing gear wheel 1719 is shown resting on the ground, and the LHS landing gear wheel 1715 is shown optionally retracted into the fuselage for reducing the drag in high

speed flight. The vehicles two pusher fans 1704, 1705 are shown mounted on the aft portion, with the wing / stabilizer 1707 generally spanning above and between said fans.

Fig. 18 is a longitudinal cross-section of the vehicle of Figs. 16b showing various additional features and internal arrangement details of the vehicle. The outer shell 1801 covers the whole of the vehicle, and transitions to the engine's enclosure 1825. Inside the shell, a forward duct 1802 and an aft duct 1803 are mounted, inside which a forward main lift propeller 1814 and an aft main lift propeller 1813 are mounted. The ducts and propellers are preferably statically disposed within the vehicle such that they are inclined forward (generally between 5 and 10 degrees although other values may be used) with respect to the vertical and rotated along the transverse axis of the vehicle, to better accommodate the incoming airflow at high speed. The forward duct 1802 has rows of longitudinal vanes 1809 at its inlet, as well as rows of longitudinal vanes 1810 at the exit. These vanes are predominantly used to control the vehicle in roll as well as lateral side-to-side translation. A similar set of longitudinally oriented vanes 1811 & 1812 are mounted at the entrance and exit of the aft duct 1803, respectively. Optionally, additional vanes, mounted in a transverse orientation may be mounted at the exit of the forward and aft duct, shown respectively as 1805 & 1804. These vanes are movable, and used to deflect the air exiting from the ducts, as shown schematically in 1815 for various flight regimes of the vehicle. Fig. 18 is generally a cross section through the center of the vehicle looking right, although it was decided to leave the pilot's compartment, and LHS engine and pusher fan installation visible for reference. The lower area of the center fuselage section of the vehicle 1808 serves as the main fuel tank. The outer shape of this body to its fore-aft sides is molded to serve the geometrical needs of both ducts 1802 & 1803. The lower side of the center fuselage has a cutout 1806 to ease the flow exiting the forward duct 1802 to align itself with the overall air flow around the vehicle at high speed flight. The upper portion 1807 of the center fuselage 1808 is suitably curved for accelerating the air entering the aft duct 1803, and thereby create a low pressure area on the top of the fuselage, relieving some of the lift production burden off the main lifting propellers 1813 & 1814. This upper portion 1807 of the center fuselage can also facilitates the mounting of a parachute/parafoil which will be used in emergency situations either to get to the ground safely or even to continue forward flight with the pusher fans thrust. The pilot 1818 is shown seated on his seat 1831

which may either be normal, or a rocket deployed ejection seat to facilitate quick egress of the pilot from the cockpit through the canopy, if the need arises. The pilot's controls 1819 are connected to the vehicles flight control system. Also shown in Fig.18 is one of the two the engines used in the vehicle shown as 1826 mounted inside its outer shell 1825 and below the air intake 1824. The 90 degree gearbox 1823 transmits the rotational power from the engine 1826 to the lower gearbox through a shaft. This lower gearbox (gearbox, shaft not shown) then connects to the main aft lifting propeller gearbox 1822, which also supports the propeller 1813. An interconnect shafting mechanism (not shown) further distributes the power to the forward gearbox 1823 that also supports the forward main lifting propeller. Also visible in Fig.18 is one of the pusher fans 1827, and a cross section through the stabilizer 1828 mounted above and between the pusher fans. It can also be noticed that a curved line 1830 forms a break in the smooth lines of the engine enclosure 1825, and the forward boundary for a deep cutout into enclosure 1825. The cutout is used to direct outside air to the pusher fans. The general shape of the curved line 1830 can also be seen in any one of the top views of Fig. 16. The forward end of the forward duct 1802 may have an optional forward facing circumferential slot 1829 that runs generally across the forward 1/4 circle of the duct 1802. The slot faces the incoming flow, in a region of the flow that is high (near stagnation) pressure. The air coming into the slot is accelerated due to the geometric internal shape that is generally contracting, and is channeled through a second, inner slot 1830, at an air velocity that is greater than the flow inside the duct, and generally tangentially with the inside wall of the duct 1802. The resulting low pressure area created by this fast airflow from the slot and into the duct, affects the air above it flowing over the outer (upper) lip of the duct and provides suction to attach the latter flow to the duct's inner surface, and avoid flow separation at high speed. A second role played by the slots 1829 & 1830 is to direct some of the air flowing through duct 1802 through an additional opening, thereby reducing the amount of air flowing in above the duct's lip, and so also reducing the overall pitching moment (having an adverse effect on the vehicle) created by the forward duct at high speed flight. It should be noted that the slot 1829 may also have an optional door or doors to facilitate opening of the bypass airflow only as flight speed is increased. Such door/doors, if used, my be activated externally through an actuator or mechanism, or alternatively rely on the pressure distribution and difference

between the inside and outside of the duct, to self- activate a spring loaded door or doors, as required. The landing gear wheels 1821 & 1820 are shown in the landing gear's extended position. An option (not shown) exists for retracting all four landing gears into the fuselage shell 1801 to reduce drag in high speed flight.

Fig. 19 is a pictorial illustration of an Unmanned application of the vehicle. Evident in the picture is the vehicles outer shell 1901 that is lacking any pilot's enclosure. Also visible is the forward duct 1909 with the rows of longitudinally mounted inlet vanes. The RHS engine enclosure 1903 is shown with an intake 1904 generally installed close to the top and to the front of the engine enclosure 1903. A similar arrangement can be seen for the LHS engine enclosure 1902 and the LHS engine intake port 1905. Two pusher fans 1906 & 1907 are shown, with a stabilizer 1908 spanning between them. The vehicle's fixed skid type landing gear is shown in 1910, and a typical pictorial installation of an observation system in 1911.

Fig. 20 is a further pictorial illustration of an optional Unmanned vehicle, having a slightly different engine installation than that of Fig.19. Here, in a manner similar to that of Fig. 19, the fuselage outer shell 2001 is also lacking a pilot's compartment. However, the vehicle's engine is mounted inside the fuselage in the area schematically shown as 2006. An air intake 2005 supplies air to the engine. Two pusher fans 2006 & 2007 are used, as well as a stabilizer 2008. The forward duct 2002 and aft duct 2003 have longitudinally mounted vanes. A typical pictorial installation of an observation system is shown in 2009. The vehicle's fixed skid type landing gear is shown in 2010.

Fig. 21 is a top view showing the vehicle of Fig. 16b equipped with an extendable wing for high speed flight. The RHS wing is designated 2101 in the extended position and 2102 when folded under the fuselage. An actuator 2103 is used for extending and retracting the wing as desired. The LHS wing is similar, as evident in the drawing.

Fig. 22a-22b are side and top views, respectively, illustrating a VTOL vehicle that employs a plurality of lift generating fans, arranged one behind the other, all connected to a common chassis, for the purpose of carrying an increased payload over that which is possible with two lifting ducted fans. A chassis designated 2001 houses a number of ducted fans 2002 for generating lift. The fans may be tilted slightly forward as shown in Fig.22a to achieve higher speed in cruise. Two elongated cabins 2003 and 2004 are preferably located

on both sides of the ducted fans to accommodate passengers or other cargo. A pilot 2005 may be seated in a cockpit 2006 at the front end of one of the cabins,such as the left cabin 2004. Two engines 2012 are located to the aft of the cabins and have air intakes 2013. Two variable pitch pusher fans 2014, enclosed in shrouds, are mounted to the rear of the cabins. A stabilizer 2015 is mounted between the pusher fans to facilitate nose-down trimming moments in forward flight. Multiple inlet roll, yaw and side force control vanes 2007 are preferably mounted longitudinally in all ducts, supplemented by similar vanes 2008 at the duct's exits. Transversally mounted guide vanes 2009 may also be mounted to reduce friction losses and flow separations of the flow exiting from the ducts. Side openings 2016 may be optionally installed to enable outside air to be mixed with inflow from above, reducing the impact that the cabins may have on thrust augmentation of the ducted fans as well as the control effectiveness of the vanes installed in the inlets to these ducted fans. A variable pitch fan (rotor) 2010 is mounted in each duct. Preferably, one half of the fans (or as close to half as possible, such as in the case of a vehicle similar to that shown in Fig. 22 but having an odd number of lifting ducted fans)turn in the opposite direction as the other half . A plurality of landing gears 2001 support the vehicle on the ground and serve to attenuate the landing impact. Some of the wheels employed in the landing gear may be powered, or alternatively, forward ground movement can be accomplished through the use of the variable pitch pusher fans.

Fig. 23 shows an optional arrangement of a power distribution system for transmitting the power from each of the rear mounted engines to the two lifting fans and two pusher fans such as found in the vehicles shown in Figs. 14-19. As can be seen, two engines 2303 are preferably used to drive the two main lift rotors and the two pusher fans through a series of shafts and gearboxes. The power takeoff (PTO) of each engine is connected through a short shaft 2315 to the RHS and LHS Aft Transmissions designated 2302 and 2301 respectively. From these transmissions, the power is distributed both to the aft pusher props through diagonally oriented shafts 2304 as well as to the Aft Rotor Gearbox 2307 through two horizontally mounted shafts 2306. The two main lift rotors are connected to their respective gearboxes through prop flanges 2308. The shaft interconnecting both main lift rotors is divided into two segments designated as 2309 and 2312, connected by a Center Gearbox 2310 through flexible joints. This center gearbox

serves mainly to move the rotation center in parallel and connect both shafts 2309 and 2312 without affecting the direction of rotation (i.e. employing an uneven number of plane gears mounted along its length). At least one of the intermediate gears in Center Gearbox 2310 has a shaft that is open to the outside designated as 2311, enabling power for accessories on either side of the face of Gearbox 2310, resulting in opposing directions of rotation (rotorsnot shown). The rotors preferably turn in opposite directions to eliminate torque imbalance on the vehicle.

Fig. 24 shows an optional arrangement of a power distribution system for transmitting the power from a centrally mounted engine, or from two engines forming a 'twin-pack', to the two lifting fans and two pusher fans such as found in the vehicles typical of Fig. 9 and Fig. 20. As can be seen, the engine, designated as 2401 is used to drive the two main lift rotors and the two pusher fans through a series of shafts and gearboxes. The power takeoff (PTO) of the engine designated as 2408 is connected through a short shaft to a central Transmission designated 2402. An extension of the same shaft designated as 2409 transmits power directly to the forward lift fan gearbox designated as 2410. From the central transmission 2402, the power is distributed both to the aft lift fan gearbox through a shaft designated as 2406 as well as to two angled gearboxed such as 2404 through two horizontally mounted shafts 2403. From the angled gearboxes, two diagonal shafts 2405 transmit power to the aft pusher prop gearboxes 2405. The central transmission 2402 may also have an additional shaft that is open to the enabling power for accessories (rotors not shown). The rotors preferably turn in opposite directions to eliminate torque imbalance on the vehicle.

Figs. 25a shows a schematic cross section and design details of an optional single duct unmanned vehicle. The vehicle includes a powerplant designated as 2502, which may be based on turboshaft technology as shown schematically in Fig. 25a, although other means of propulsion are possible. A circumferential duct designated as 2501 surrounds the rotor (lifting fan) designated as 2504. The duct 2501 may also serve to house the flight control and communication equipment as well as the fuel for the duration of the mission. A fuel sump with pump is designated as 2505. A gearbox designated as 2503 is used to reduce the rotational speed of the engine's shaft to match that required by the fan 2504. Two layers of vanes (2506 and 2508) are used to control the vehicle in roll, pitch, yaw and lateral

and longitudinal translations. The vanes layers are preferably oriented in multiple planes as will be explained with reference to Fig. 25c. A payload typically consisting of a video camera may be housed in the clear spherical compartment designated by 2512.

Fig. 25b shows an alternative lifting fan arrangement where two rotors 2510 and 2511 rotate in opposite direction to cancel the torque effect that one fan, such as 2504, would have on the vehicle. A slightly larger gearbox designated as 2509 is used to rotate the two rotors in opposite directions through concentric shafts.

Fig. 25c shows different arrangements of vanes in the inlet to the duct, generally designated as view "A" in Fig.. 25a, but also typical for the bottom (exit) layer of vanes 2508. While the arrangements of Fig. 25c show a number of possibilities, many additional arrangements are possible. The common principle in the in-plane vanes arrangements of Fig. 25b designated 2513 thru 2519 is that typically one half of the vanes are oriented at an angle (typically 90 degrees but other angles are possible) to the other half, so as to produce any combination of force components that will result in a single equivalent force in any direction and magnitude in the plane of the vanes, be it the inlet vanes designated as 2506 in Fig. 25a or the exit vanes designated as 2508 in Fig. 25a. Various vane configurations are possible, such as the square pattern in Fig. 2516, the cross pattern in Fig. 2517, and the weave pattern in Fig. 2518.

Fig. 26 is a pictorial illustration of a ram-air-'parawing' based emergency rescue system. In an emergency, or for other purposes such as extended range, the ducted fan vehicle (manned or unmanned) designated as 2601 need not rely on its lifting fans (2606) to generate lift, but may instead release a lift generating ram-air 'parawing' shown pictorially and designated as 2605. Optionally, the 'parawing' may be steered through the use of steering cables shown schematically and designated as 2607. In the event that the vehicle's pusher fans designated as 2602 are operative, the vehicle can carry on in level flight to its destination. Upon reaching its destination, the vehicle can release the 'parawing' (2605) and continue flying using its lift fans (2606), or may elect to land using the 'parawing (2605) still attached to the vehicle. Alternatively, if the pusher fans (2602) are not producing sufficient thrust, the 'parawing' (2605) will glide the vehicle down to land, preferably extending its glide ratio significantly over a spherical 'standard' parachute.

Figs. 27 illustrates optional means of supplying additional air to lift ducts shielded by nacelles or aerodynamic surfaces from their sides, typical of the aft lift fans of the vehicles described in Figs. 1, 5, 6, 8, 9 and 11-22 . In Fig. 27, a lift generating ducted fan designated as 2703 is preferably partially shielded from the air around it by a nacelle 2702. Openings for the air, designated as 2704 and 2705, permit outside air to flow (2707) in through a channel (2706) from the sides and combine with the inflow from above (2708) to create relatively undisturbed flow conditions for the ducted fan (2703). With the openings 2704 and 2705 in place, the impact of the nacelle on thrust augmentation of the ducted fan as well as the control effectiveness of the vanes is minimized. Preferably, the exit portions of openings 2704 and 2705 meet and is substantially aligned with an upper lip of the duct of ducted fan 2703.

Figs. 28a-28e are more detailed schematic top views of the medical attendant station in the rescue cabin of the vehicle described in 14b, 14c and 16b. Fig. 28a shows schematically how the cabin is laid out with respect to the vehicle. Fig 28.b illustrates the medical attendant designated as 2802 seated facing forward, resting his/her arms on table 2801. Fig. 28c shows the medical attendant in seat's intermediate position, enabling medical attendant to reach comfortable the chest and abdomen area of patient designated as 2803, lying on a litter/stretcher that is free to move along a rail on table 2801, and can be locked in place in any intermediate position. Fig 28.d shows the medical attendant in extreme rotated position (2805), and patient litter moved to extreme 'inside cabin' position, to enable medical attendant to reach patient head from behind, necessary for performing procedure of clearing patient's airways. Fig.28e is a schematic depiction of a swiveling seat 2806 that can be used by medical attendant 2802. Also shown schematically in Fig.28e is patient's litter 2807 that is able to move along guiding rail 2810 guided by four wheels or rollers 2814, although a different number of wheels or rollers can be used. When the attendant is facing forward, as 2802 in Fig.28b, and for example when there is no patient on board, the seat 2806 in Fig.28e swivels to its rightmost position as schematically shown in 2811. When the litter is loaded it is normally placed as shown pictorially in Fig.28a, and schematically as 2808 in Fig.28e. In this position, the attendant 2802 swivels on seat 2806 to intermediate position 2813 and has access to patient's chest and abdomen. This seat position corresponds to attendant's position shown pictorially in Fig.28c as 2804. When

need arises for attendant to reach the head of patient 2803 from behind, the litter 2807 is moved along track 2810, while attendant now shown in Fig. 28c as 2805 swivels seat 2806 to leftmost position, shown schematically in Fig.28e as 2812.

Fig. 29 illustrates in side view various optional additions to the cockpit area of the vehicles described in Figs. 14-18. The pilot designated as 2901 is shown together with optional room for a crew member or passenger 2902 behind the pilot. Also shown are the medical attendant 2903, and the patient lying in an extreme 'inside cabin' position 2904 on the cabin table 2905. The cockpit floor designated as 2906 may be sealed to separate the pilot's compartment from the cabin.

Figs. 30a-d show a vehicle that is generally similar to that shown in Fig.18, but which shows alternative internal arrangements for various elements including cabin arrangement geometry to enable carriage of 5 passengers or combatants. Fig. 30a is a top view schematically showing the position of each occupant. Fig.30b is a longitudinal cross section showing placement of equipment and passengers inside the vehicle, and Figs. 30c and 30d are local lateral sections of the vehicle. A typical passenger or combatant 3002 is shown in Fig. 30c. The top of the cabin 3001 is raised above that of Fig.18 to accommodate passengers or combatants in center section of vehicle. A single main transmission unit (3004) is shown that is an alternative power transmission scheme to that of Fig. 18. Power is transmitted from engine 3003 to main transmission unit 3004. One angled shaft 3005 transmits power to the aft pusher fan 3009, and a second, generally horizontal shaft 3006 transmits power to the aft lift rotor gearbox 3010. The shaft 3006 is housed inside airfoil shaped housing 3008 that also supports mechanically the aft lift rotor gearbox 3010. A center fuselage secondary transmission 3007 is connected to each of the main lift rotor gearboxes 3010, 3011, and also houses attachment for auxiliary equipment.

Figs. 31 shows a top view of vehicle generally similar to that shown in Fig.30a-d, but where the fuselage is elongated to provide for 9 passengers or combatants.

Figs. 32a-g illustrate means for enabling the external airflow to penetrate the forward facing side 3201 of the forward ducted fan of the vehicles described in Figs. 1-21 and Figs.30-31 while in forward flight. One configuration that may be used to obtain such airflow penetration is shown in Fig. 32b and generally also shown at the forward end of Fig. 32a. Rows of generally vertical open slots 3204 for enabling throughflow of air are shown,

with remaining duct structure including an upper lip 3202 and a lower ring 3205. Airfoil shaped vertical supports 3203 serve to stabilize the structure and provide protection for the fan inside the duct. The slots 3204 remain open at all times. A second configuration for obtaining such airflow penetration is shown in Fig. 32c where the whole forward wall of the forward duct is cut to obtain two generally rectangular openings 3206 with an optional center support 3207. An additional option, which is an expansion of the method of Fig. 32b, is shown in Figs. 32d and 32e where externally actuated rotating valves 3208 are mounted inside each slot 3204. When the vehicle is hovering, the slots are closed by the valves as shown in Fig.32e. When the vehicle is in forward flight and flow of air into the duct is desired, the externally actuated valves 3208 rotate to the 'open' position shown in Fig. 32d, where the airflow 3209 is free to flow through the slots. An alternative to the concept of Figs. 32d-e, is shown in Figs. 32f-g where each of the vertical supports 3203 is attached to upper lip 3202 and lower ring 2305 by hinges that enable multiple vertical supports to pivot around multiple vertical axes 3210 and assume the position shown in Fig. 32g, where the multiple slots 3204 are closed to the external airflow.

Figs. 33a-e illustrate alternative means for enabling the internal airflow to exit through the walls of the aft ducted fan of the vehicles described in Figs. 1-21 and Figs.30-31, while in forward flight. One configuration for obtaining such airflow exit is shown in Fig. 33b and generally also shown at the aft end of the vehicle shown in Fig. 33a. Rows of generally vertical open slots 3304 for enabling exit of air are shown, with remaining duct structure including upper lip 3302 and lower ring 3305. Airfoil shaped vertical supports 3303 serve to stabilize the structure and provide protection for the fan inside the duct. The slots 3304 preferably remain open at all times. A second possible option of obtaining such airflow exit is shown in Fig. 33c where the whole rear wall of the aft duct is cut to obtain two generally rectangular openings 3306 with an optional center support 3307. An additional option, which is an expansion of the method of Fig. 33b, is shown in Fig. 33d and Fig. 33e where externally actuated rotating valves 3308 are mounted inside each slot 3304. When the vehicle is hovering, the slots are closed by the valves, as shown in Fig.33e. When the vehicle is in forward flight and exit of air through the duct wall is desired, the externally actuated valves 3308 rotate to the 'open' position, as shown in Fig.33d, where the airflow 3309 is free to flow through the slots. An alternative to the concept of Figs. 33d-e is shown

in Figs. 33f-g where each of the vertical supports 3203 is attached to upper lip 3202 and lower ring 2305 by hinges that enable multiple vertical supports to pivot around multiple vertical axes 3210 and assume the position shown in Fig. 33g, where the multiple slots 3204 are closed to the external airflow.

Figs. 34a-c illustrate alternative means for directing the internal airflow to exit with a rearward velocity component for the purpose of minimizing the momentum drag of the vehicle in forward flight. As shown, the lower forward portion of the forward duct 3401 is curved back at an angle that increases progressively along the circle-shaped forward duct wall, reaching a maximum angle at the center section. The curvature may vary from vertical all around the duct, such as at hover, to 30-45 degrees from vertical inclined backwards at center and decreasing progressively to the sides of the duct. In a similar manner, the lower forward center fuselage 3402, the lower aft portion of the center fuselage 3403 and the lower aft portion of the aft duct 3404 are curved back to direct the flow exiting from the ducts to better align with the incoming flow when the vehicle is in forward flight. The above geometrical reshaping of the ducts exits may be fixed (i.e. built into the shape of the ducts) as in Fig. 34a, or alternatively, may be of variable geometry such as flexible lower portion of ducts as shown in Fig. 34b. Various means of obtaining change of geometry to said lower duct portion are available. One option, illustrated in Fig. 34b shows the upper, fixed part of the duct 3405, to which is attached a flexible or segmented lower part 3406. The outer sleeve 3408 of a flexible 'push-pull' cable 3407 is connected to bottom of the flexible or segmented lower part 3406, whereby an actuator 3409, or optionally two actuators shown schematically as 3409 and 3410, mounted inside the fuselage would pull the cable 3407, thereby affecting the geometry of the duct as desired. The lower aft portion of the center fuselage 3404 is moved back in a manner similar to the lower forward portion of the forward duct 3401 as explained, but with the difference that moving the aft duct lower part backwards involves pushing a flexible 'push-pull' cable rather then pulling by the actuator/s from inside the fuselage, as was the case in Fig. 34b.

Figs. 35a-c illustrate additional alternative means for enabling the external airflow to penetrate the walls of the forward duct and the internal airflow to exit through the walls of the aft ducted fan of the vehicles described in Figs. 1-21 and Figs.30-31, while in forward flight, for the purpose of minimizing the momentum drag of the vehicle. As

shown in Fig. 35a, the forward part of the forward duct has an upper section 3501, an opening for incoming airflow 3502 and a lower ring 3506. Similarly, the aft portion of the aft duct has an upper section 3504, an opening for incoming airflow 3505 and a lower ring 3506. Optional center supports 3509, 3510 are provided at the forward and aft ducts respectively for supporting the lower rings 3503 and 3506. Figs. 35b and 35c show an enlarged cross-section through the forward duct with an optional flow blocker 3507. Flow blocker 3507 is preferably a rigid, curved barrier that slides up into the upper lip when in forward flight, and slides back down to block the flow when in hover.

Fig. 35c shows how the flow blocker 3507 is mechanically lowered, such as by actuators or other means not shown, to engage ring 3506 or other similar means on lower ring to block the external airflow, and preserve the straight cylindrical shape of the ducts down to the duct exits, while the vehicle is in slow flight or hover. A similar arrangement can be applied to the aft end of the aft duct. It is appreciated that flow blocker 3507 can either be one piece for each duct, or divided into two segments, such as where the option of adding vertical supports 3509 and 3510 is used.

While the invention has been described with respect to several preferred embodiments, it will be appreciated that these are set forth merely for purposes of example, and that many other variations, modifications and applications of the invention will be apparent.

WHAT IS CLAIMED IS:

1. A ducted air flow vehicle comprising:

a fuselage and associated air flow control surfaces;

at least one air flow duct having a peripheral wall, an upper inlet end and a lower outlet end, said duct mounted along a fuselage which includes a prime air mover to force surrounding air to flow through said duct in a direction from said upper inlet end to said lower inlet end, thereby creating force directed along a duct flow axis which provides vertical lift force and which, when the duct axis is tilted with respect to vertical, also provides a force component in the direction of tilt; and

at least one opening formed in said peripheral wall of said duct which, , allows for faster vehicle motion by reducing the drag contribution of said peripheral wall and which provides a more direct fluid flow into the duct wall during vehicle motion.

2. A vehicle as in claim 1 wherein said at least one opening comprises a plurality of pivotally mounted louvers which, in one position substantially close said at least one opening in said peripheral wall of said at least one air flow duct from air flow therethrough and which, in at least one other position substantially opens said at least one opening in said peripheral wall for air flow therethrough.

3. A vehicle as in claim 1 wherein said at least one air flow duct comprises first and second ducts respectively disposed fore and aft of a cabin area of said fuselage with their respective duct axes
substantially parallel to one another and tilted forward in the fuselage to provide a force component in the direction of tilt.

4. A vehicle as in claim 1 wherein said at least one air flow duct comprises a first duct disposed fore of a cabin area of said fuselage and a second duct disposed aft of said cabin area with their respective duct axes substantially parallel to one another, said vehicle further comprising:

a fuselage landing support structure which supports said aircraft in a non-flying position with said duct axes being inclined forwardly.

5. A vehicle as in claim 1 wherein said control surfaces include a plurality of control vanes disposed within and across at least a portion of said upper inlet end of said air flow duct.

6. A vehicle as in claim 5 wherein said control surfaces also include a plurality of control vanes disposed across at least a portion of said lower outlet end of said air flow duct.

7. A vehicle as in claim 5 wherein at least some of said plurality of vanes have spanwise axes substantially aligned with a longitudinal axis of said fuselage.

8. A vehicle as in claim 7 wherein at least some of said plurality of vanes are also disposed transversely across at least a portion of said lower outlet end of said air flow duct.

9. A vehicle as in claim 5 wherein said vanes have an airfoil cross sectional shape with a leading edge positioned towards a direction of main fluid inlet flow through said air flow duct.

10. A vehicle as in claim 9 wherein each of at least some of said airfoil shaped vanes has a variably oriented chord line along its spanwise axis that is oriented to approximately match expected duct airflow vector directions at respectively different positions along the vane spanwise axis.

11. A vehicle as in claim 10 wherein the chord lines of said vanes are oriented at angles that progressively change as a function of the location of the vane within said air flow duct.

12. A vehicle as in claim 1 wherein said at least one air flow duct comprises a first duct

disposed fore of a cabin payload area of said

fuselage and a second duct disposed aft of said cabin payload area,

and further wherein said at least one opening comprises an adjustable opening in a forward-facing side of a said first duct;

the outer upper and lower surfaces of said cabin payload area being aerodynamically shaped to (a) enhance production of aerodynamic lift forces by air flowing there-over and (b) reduce resistance to air flow exiting from said first duct.

13. A vehicle as in claim 12 wherein the outer upper surface of said cabin payload area is convexly shaped and the outer lower surface of said cabin payload area is concavely shaped.

14. A vehicle as in claim 1 wherein said at least one air flow duct comprises a first duct

disposed fore of a cabin payload area of said

fuselage and a second duct disposed aft of said cabin payload area,

said at least one opening comprising a first controllable opening in a forward facing peripheral wall portion of said first duct; and

a second controllable opening in a rearward facing peripheral wall portion of said second duct so as to further reduce drag and enhance fast forward motion of the vehicle.

15. A ducted fan vane apparatus comprising:

an air flow duct having opposite inlet and exit ends;

an air prime mover mounted within said duct to force ambient air therethrough from said inlet through said duct and its exit; and a plurality of parallel vanes mounted at spaced locations within and closely adjacent at least one of said inlet and said exit ends of the duct, said vanes being controllable to produce a desired transverse force component to a lift force produced by air flow through said duct, wherein each of a subset of said vanes has a chord line that is differently angled along the vane spanwise axis to better match local ducted air flow vectors.

16. A ducted fan vane apparatus as in claim 16 wherein:

said subset of vanes include first and second groups of vanes at least at one of said inlet and said exit.

17. A ducted fan vane apparatus as in claim 15 in combination with a VTOL vehicle wherein:

all of said plurality of vanes extend substantially parallel to a longitudinal axis of the vehicle.

18. A VTOL vehicle, comprising:

a fuselage having a longitudinal axis and a transverse axis; and

at least two lift-producing prime air movers contained inside respective air flow ducts fixedly disposed within said fuselage along said longitudinal axis, wherein said at least two ducts are inclined forward with respect to vertical.

19. A VTOL vehicle according to claim 18 wherein:

said inclination is between 5 and 10 degrees.

20. A VTOL vehicle according to claim 18 wherein:

each of said hollow ducts is provided with a plurality of controllable vanes mounted adjacent both inlet and exit ends thereof.

21. A VTOL vehicle according to claim 20 wherein:

said plurality of vanes associated with each of said ducts extend parallel to said longitudinal axis of said fuselage.

22. A VTOL vehicle according to claim 21 wherein:

each of a subset of said plurality of vanes at the inlet ends of said hollow ducts has a differently angled chord line along a vane spanwise axis to better match local ducted air flow vectors.

23. A VTOL vehicle according to claim 22 wherein:

said subset of vanes include first and second spaced groups of vanes at said inlet.

24. A VTOL vehicle according to claim 21 wherein:

a plurality of transversely oriented control vanes are located adjacent and downstream of said plurality of longitudinally oriented vanes at said exit ends of said ducts, respectively.

25. A VTOL vehicle, comprising:

a fuselage having a longitudinal axis and a transverse axis; and

at least two lift-producing prime air movers carried by said fuselage and contained inside two hollow ducts disposed within said fuselage along said longitudinal axis, each duct having a peripheral wall, an upper inlet end and a lower outlet end;

wherein a forward one of said two hollow ducts has a least one forward facing circumferentially-extending controllable aperture in its peripheral duct wall that, when open, channels external air through said aperture.

26. A VTOL vehicle as in claim 25 wherein:

said aperture is formed with a reducing cross-section in a direction towards said forward duct to accelerate air flowing through said aperture into said forward duct.

27. A VTOL vehicle as in claim 25 wherein:

at least one door is moveable into and out of said aperture to permit air flow into said forward duct through said aperture in fast speed operation or to block air flow through said aperture thereby forcing all air flow to pass over a duct inlet lip to enhance lift contribution of the duct in hover or slow speed operation.

28. A VTOL vehicle as in claim 25 wherein:

a lower surface of a center portion of said fuselage is formed with a concave shape to facilitate flow exiting the forward duct and aligning with an overall flow around the vehicle at high speed flight.

29. A VTOL vehicle as in claim 25 wherein:

a rearward one of said ducts has at least one rearwardly facing, circumferentially extending controllable aperture in its peripheral duct wall that, when open, channels external air through said aperture.

30. A VTOL aircraft as in claim 29 wherein:

said two hollow ducts are disposed both fore and aft of said center portion of said fuselage; and

cabins are disposed on both sides of said center portion of said fuselage thus channeling air flow over said center portion of said fuselage to enhance lift

forces generated thereby.

31. A VTOL aircraft as in claim 25 wherein an upper surface of said center portion has a convex surface configuration, thereby creating a lower pressure aerodynamic lift area above said fuselage.

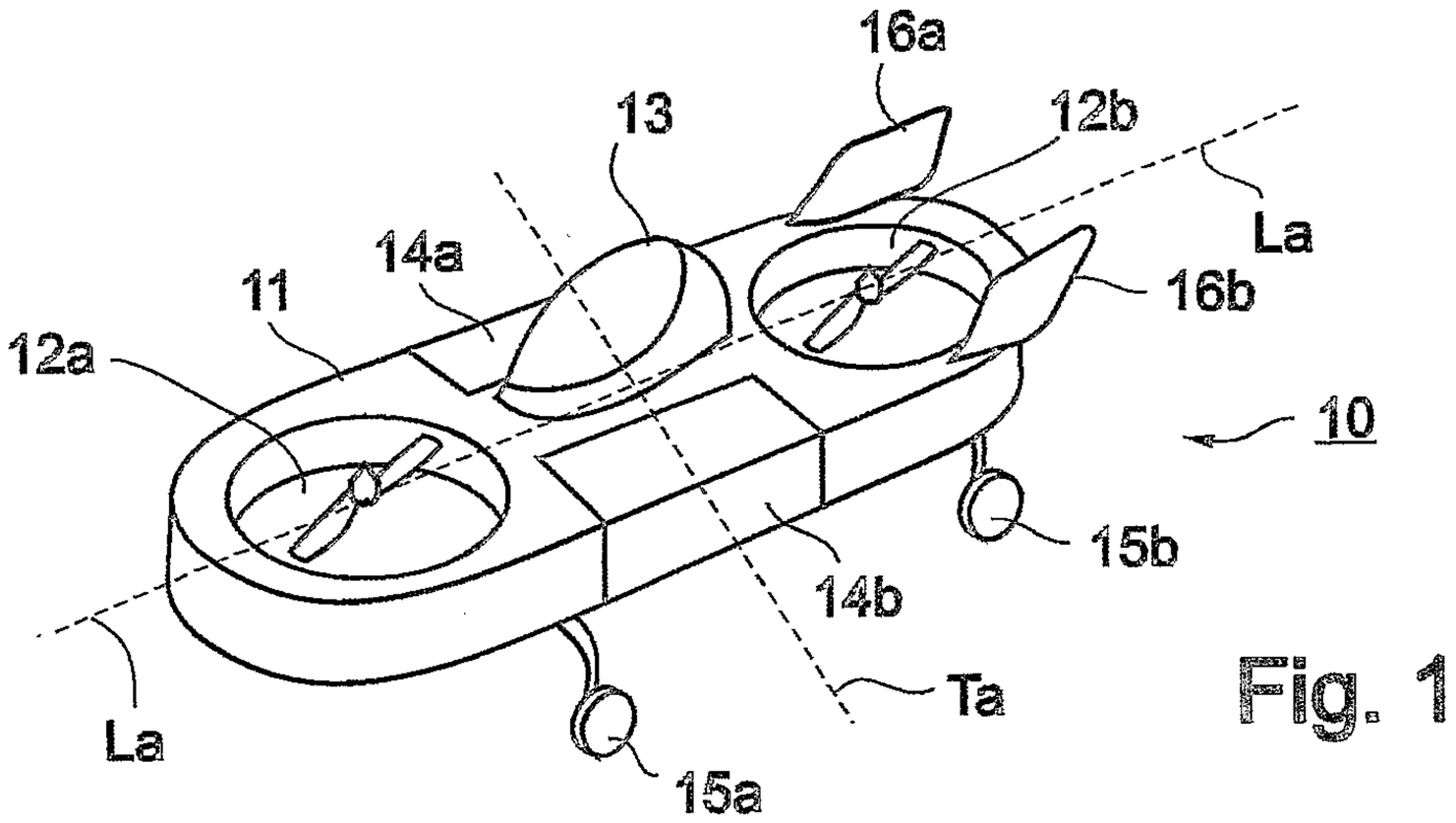


Fig. 1

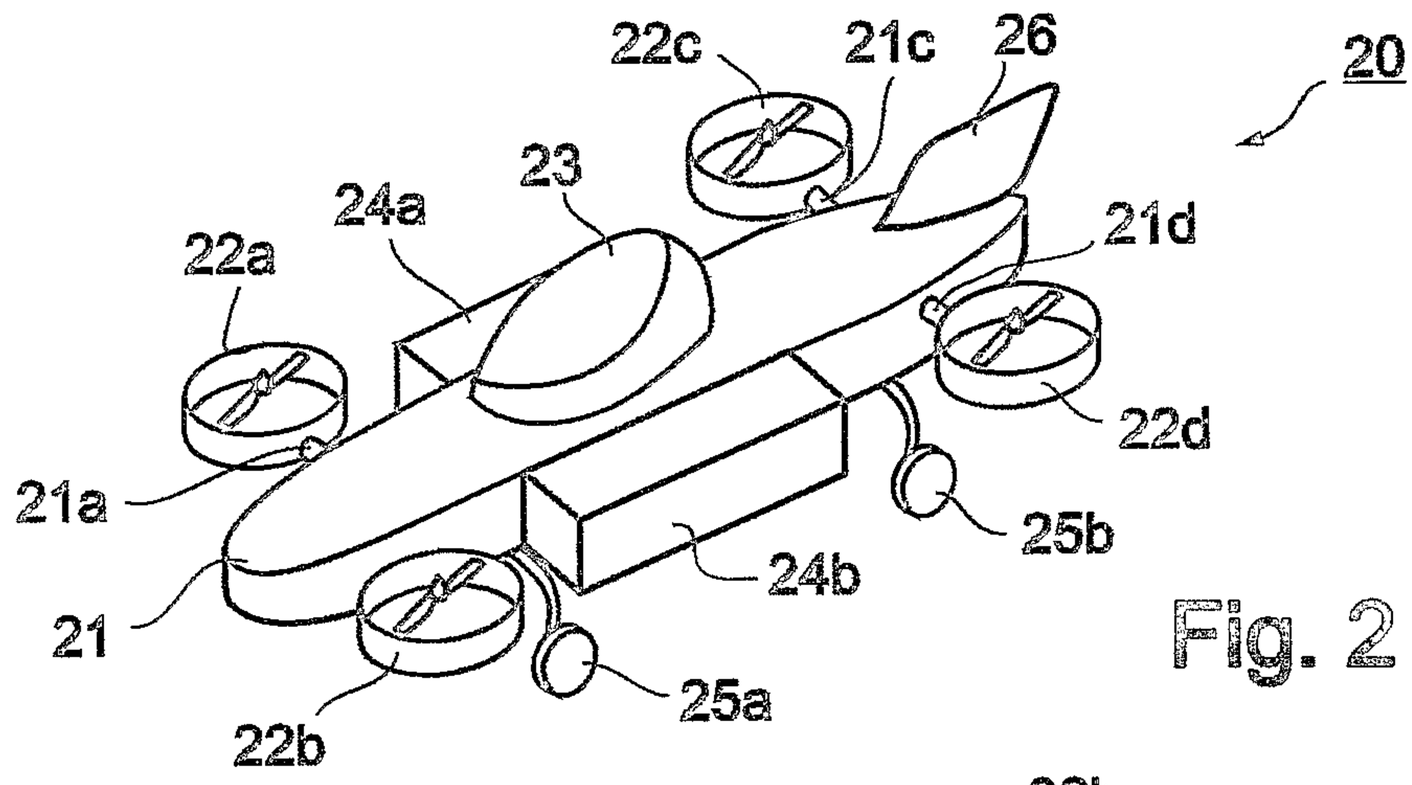


Fig. 2

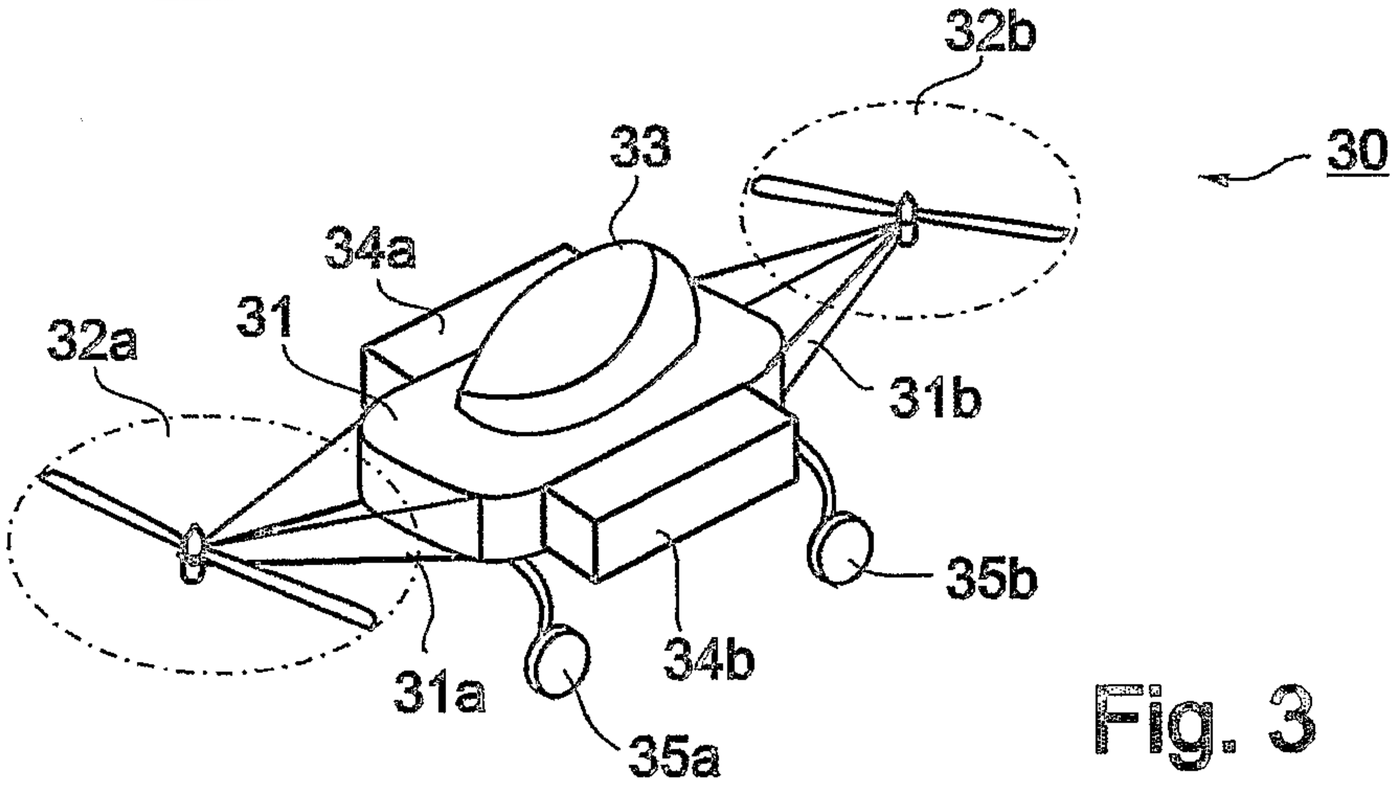
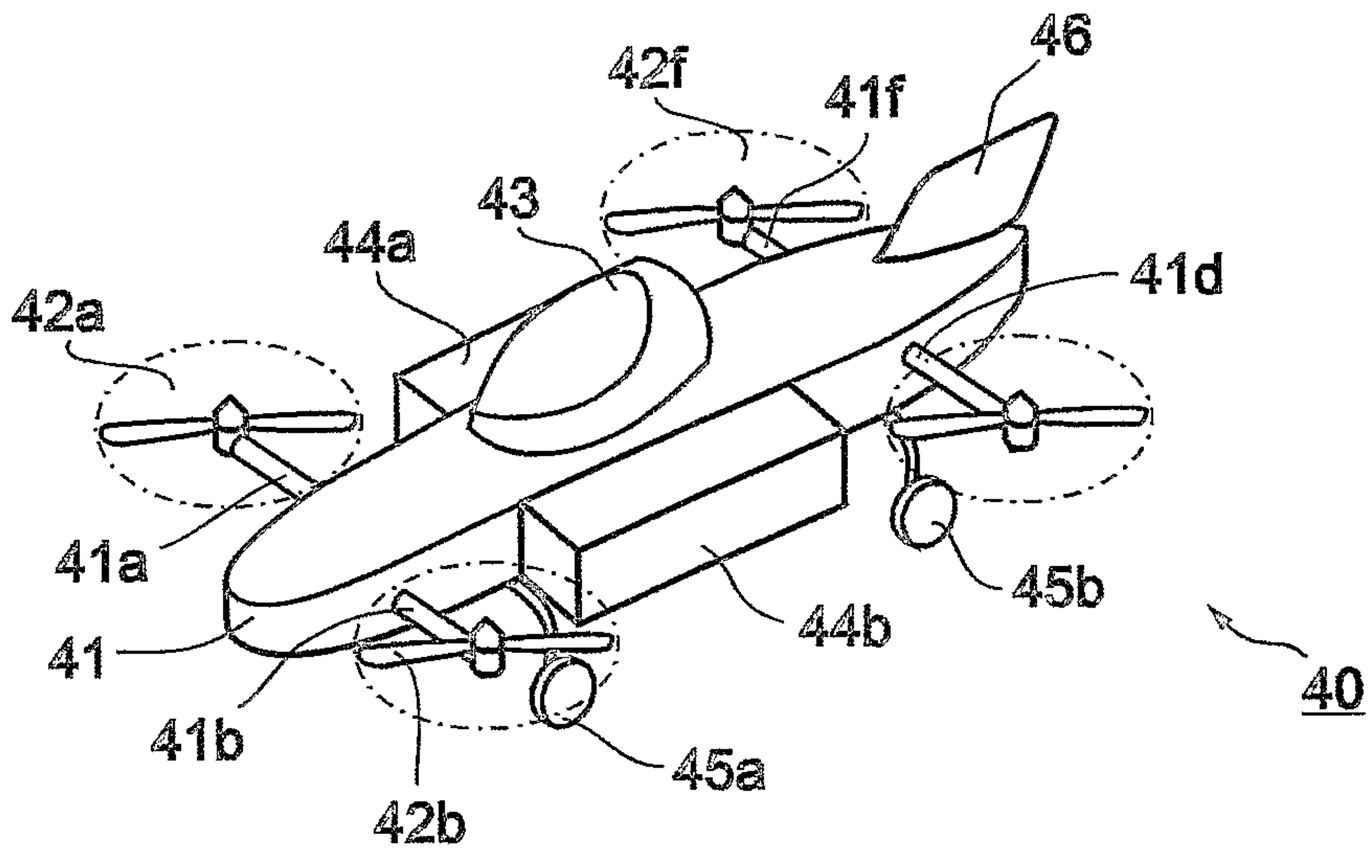


Fig. 3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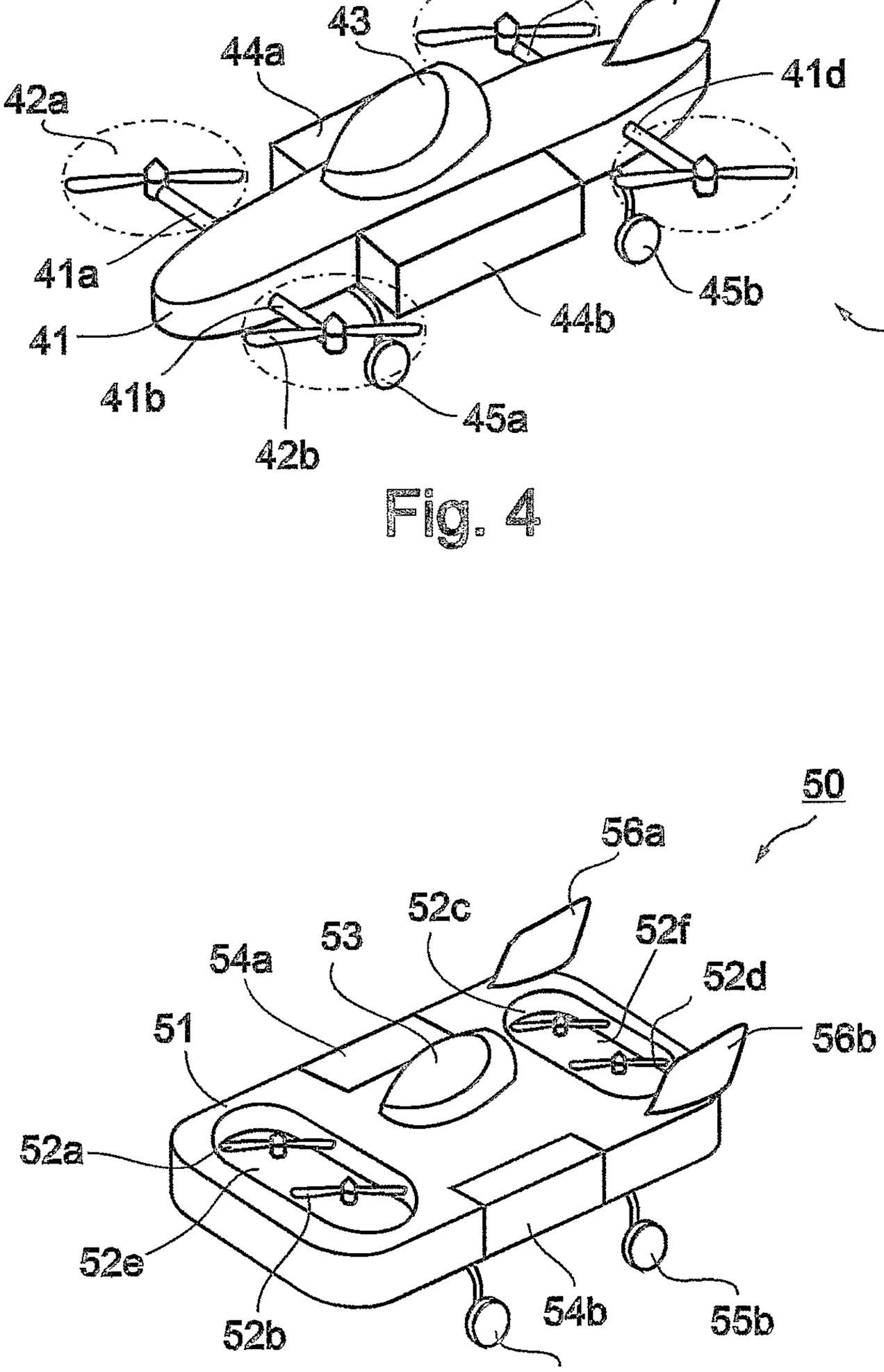
45a
40

Fig. 4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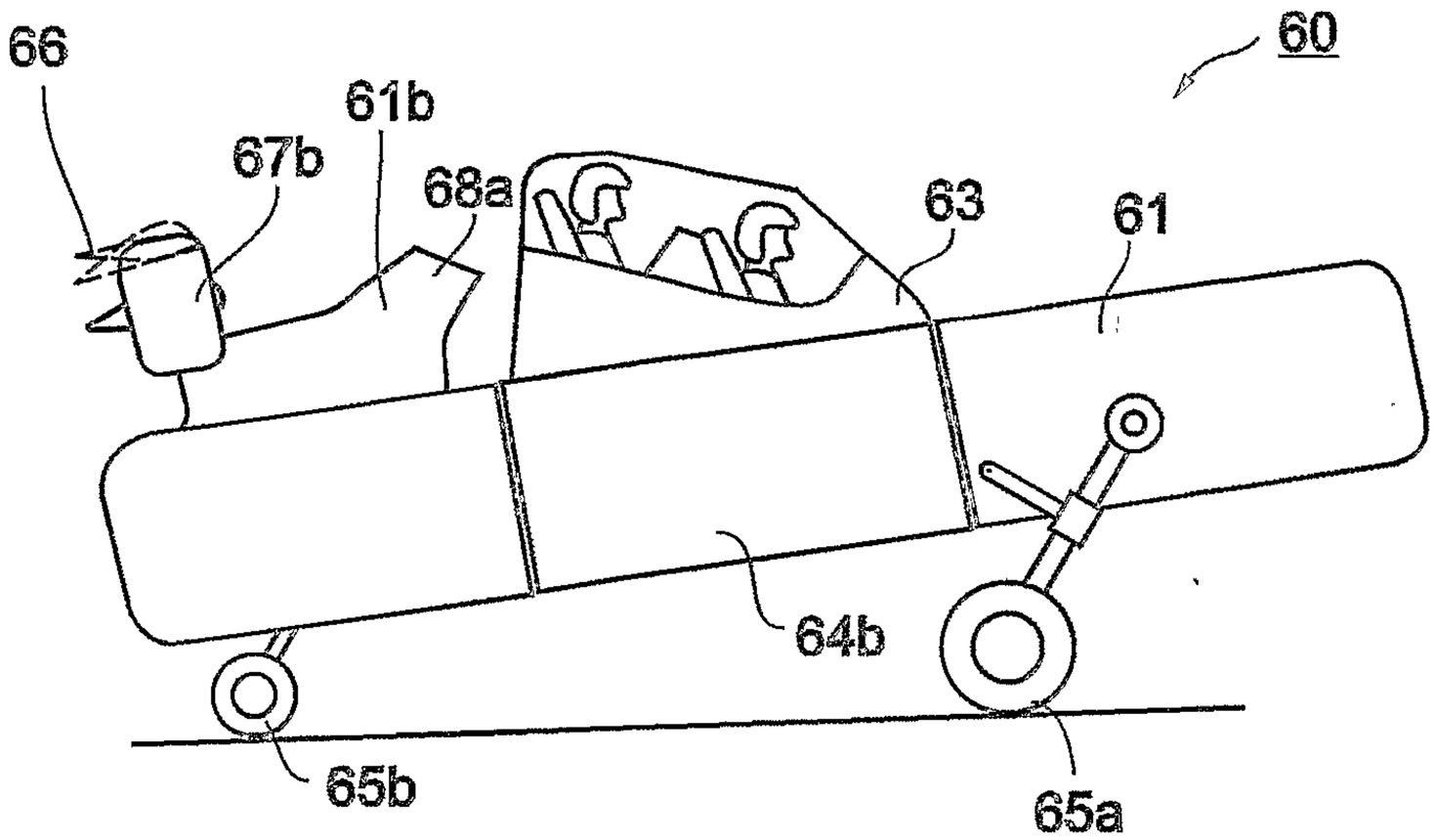
55a

Fig. 5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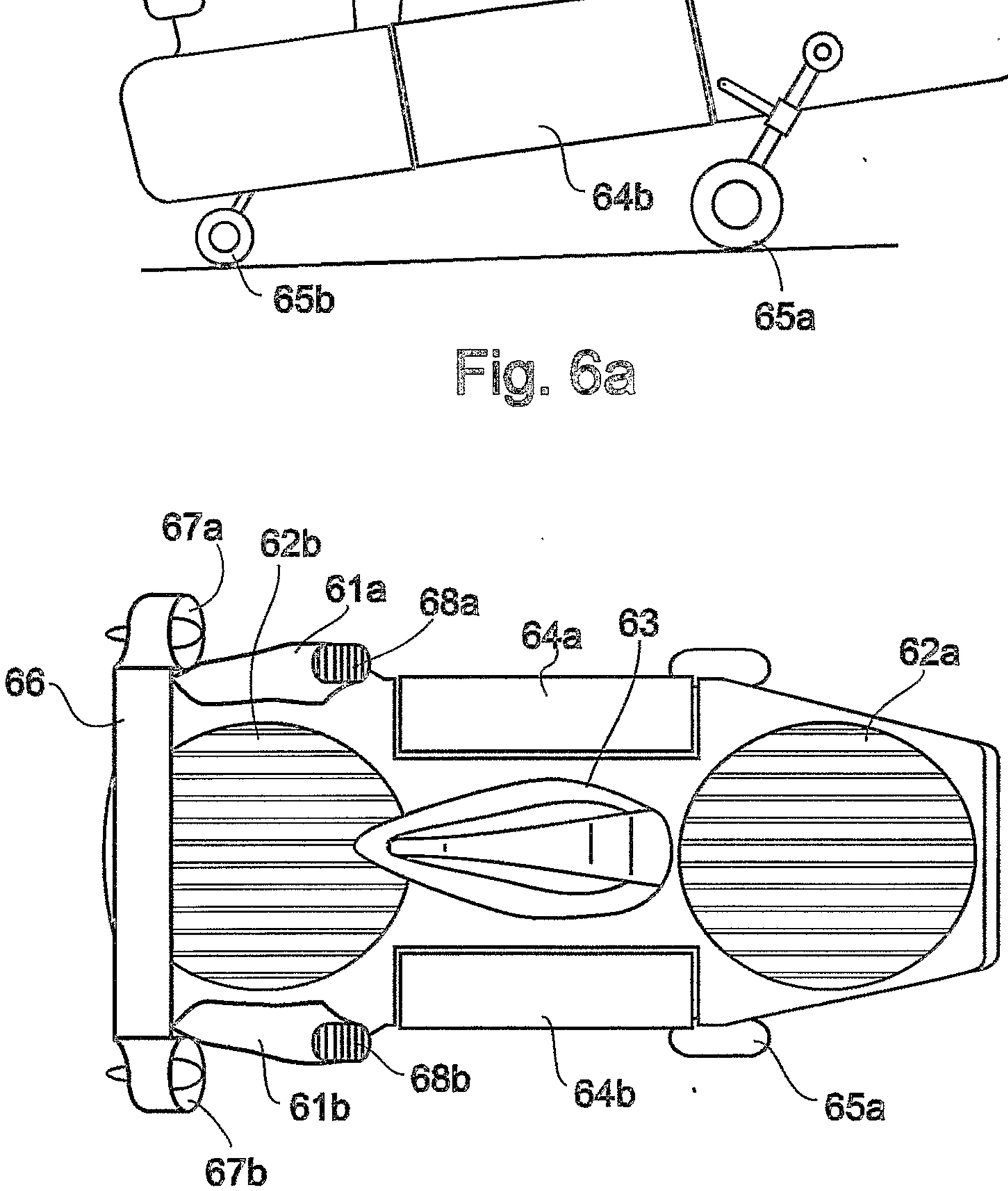
65a

Fig. 6a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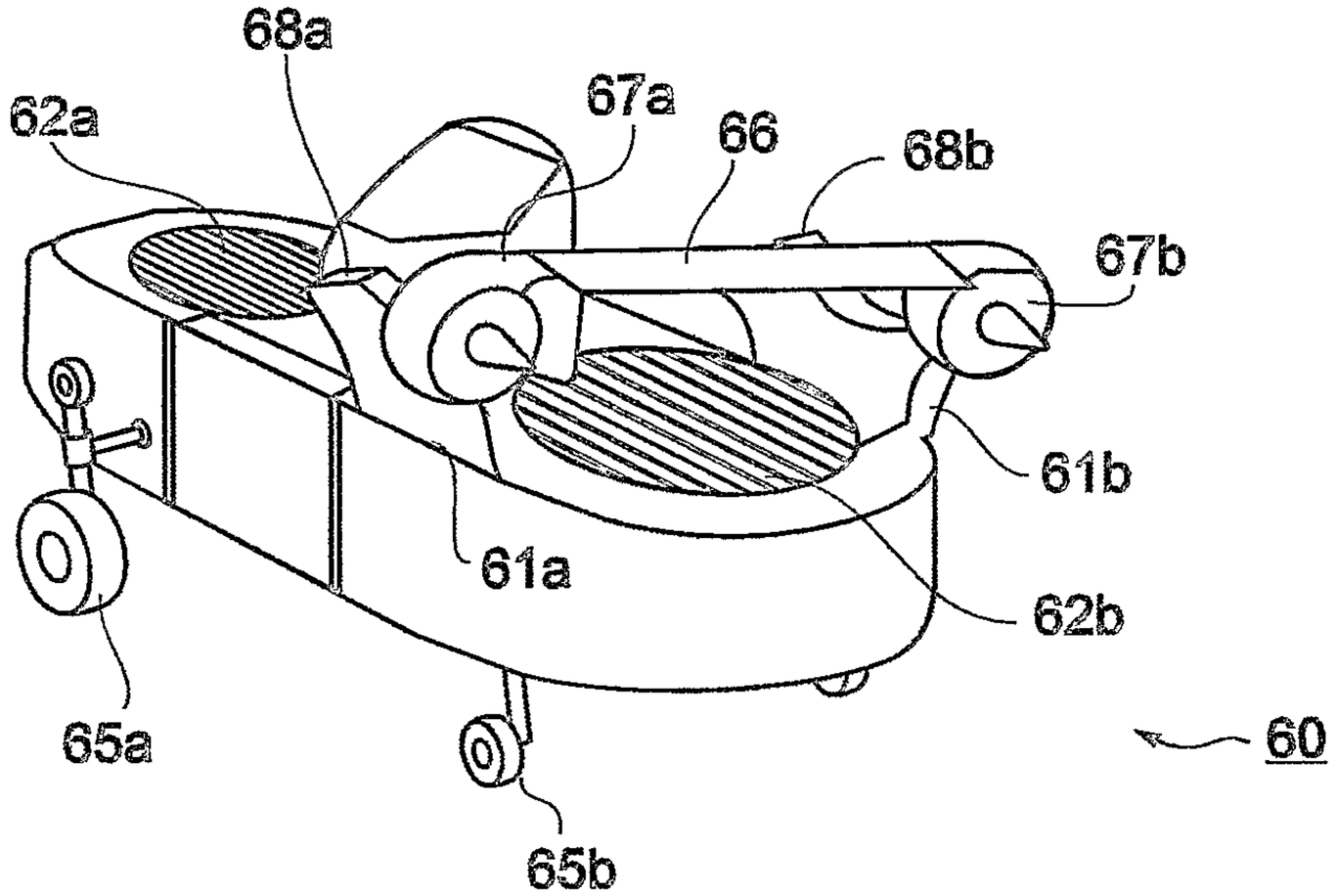
67b

Fig. 6b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67b
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65a
60
65b

Fig. 6c

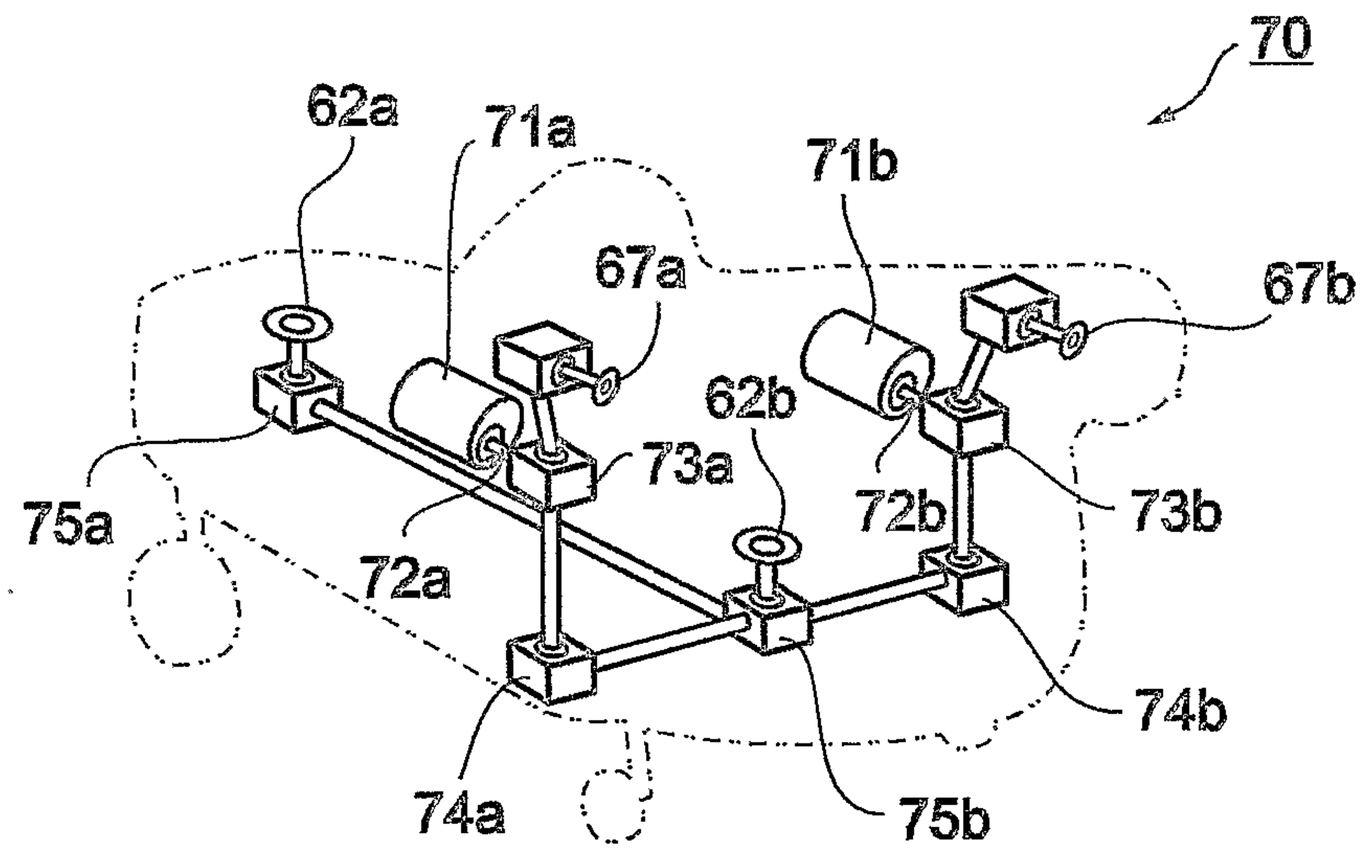
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Fig. 7

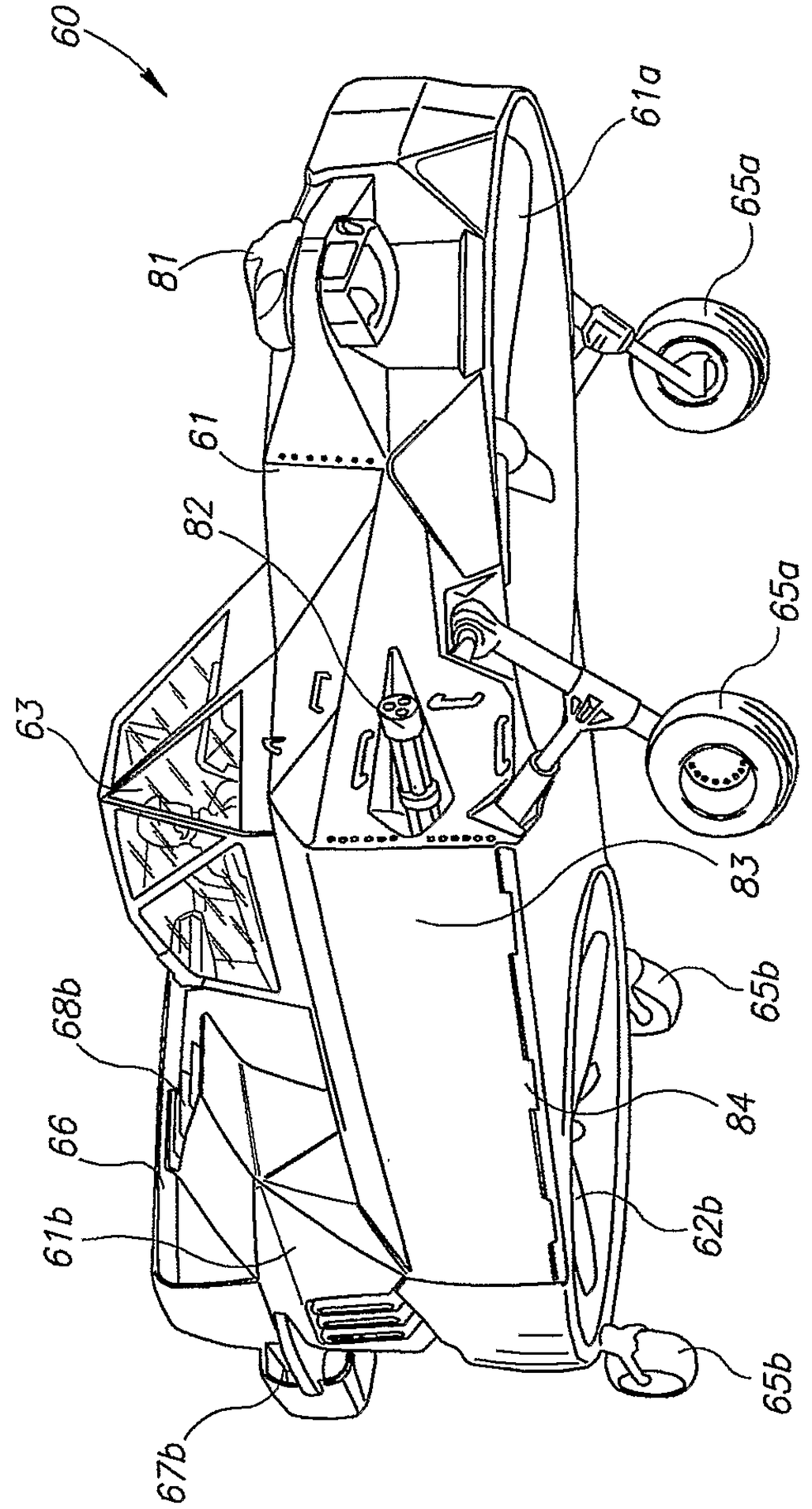

FIG.8

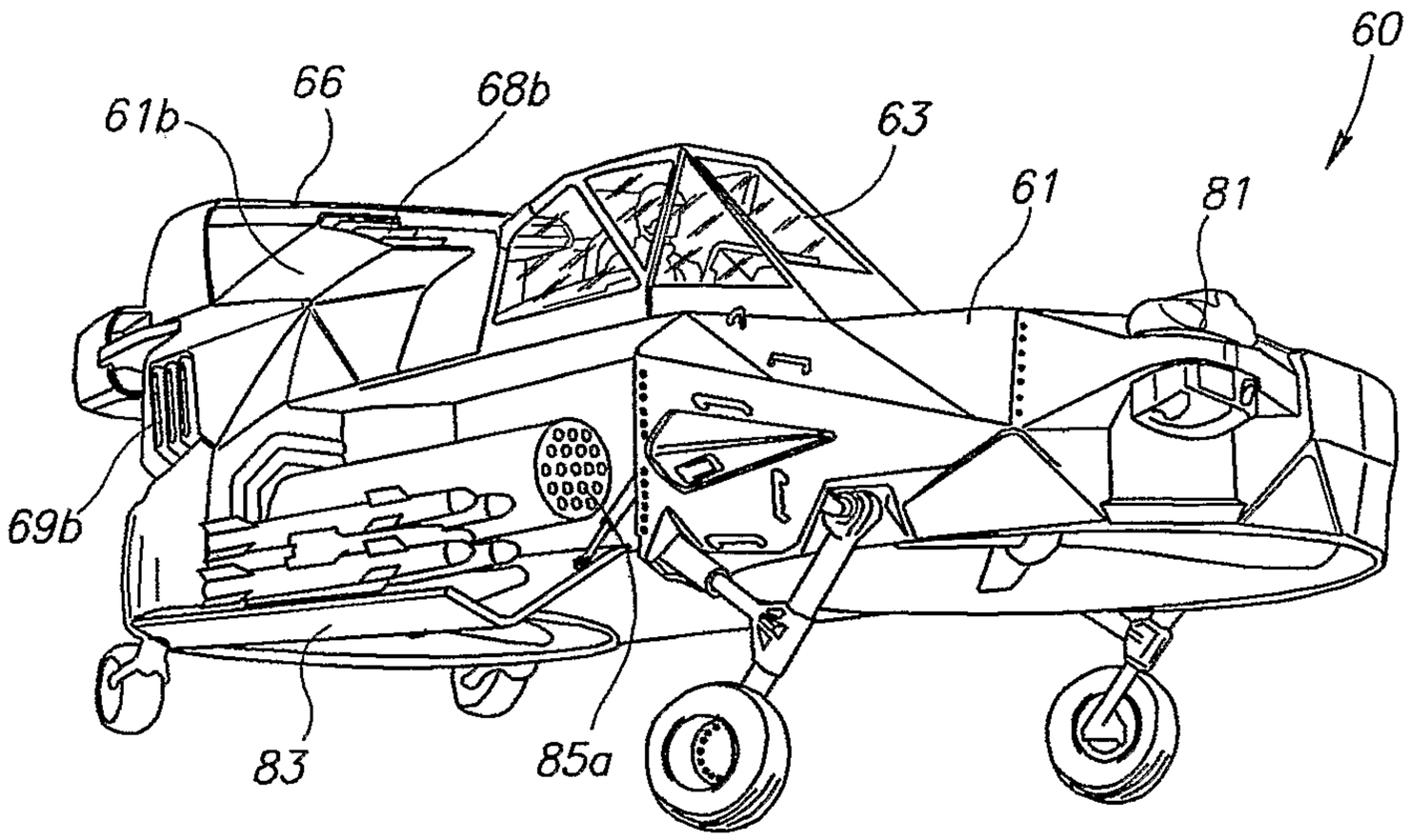

FIG.8A

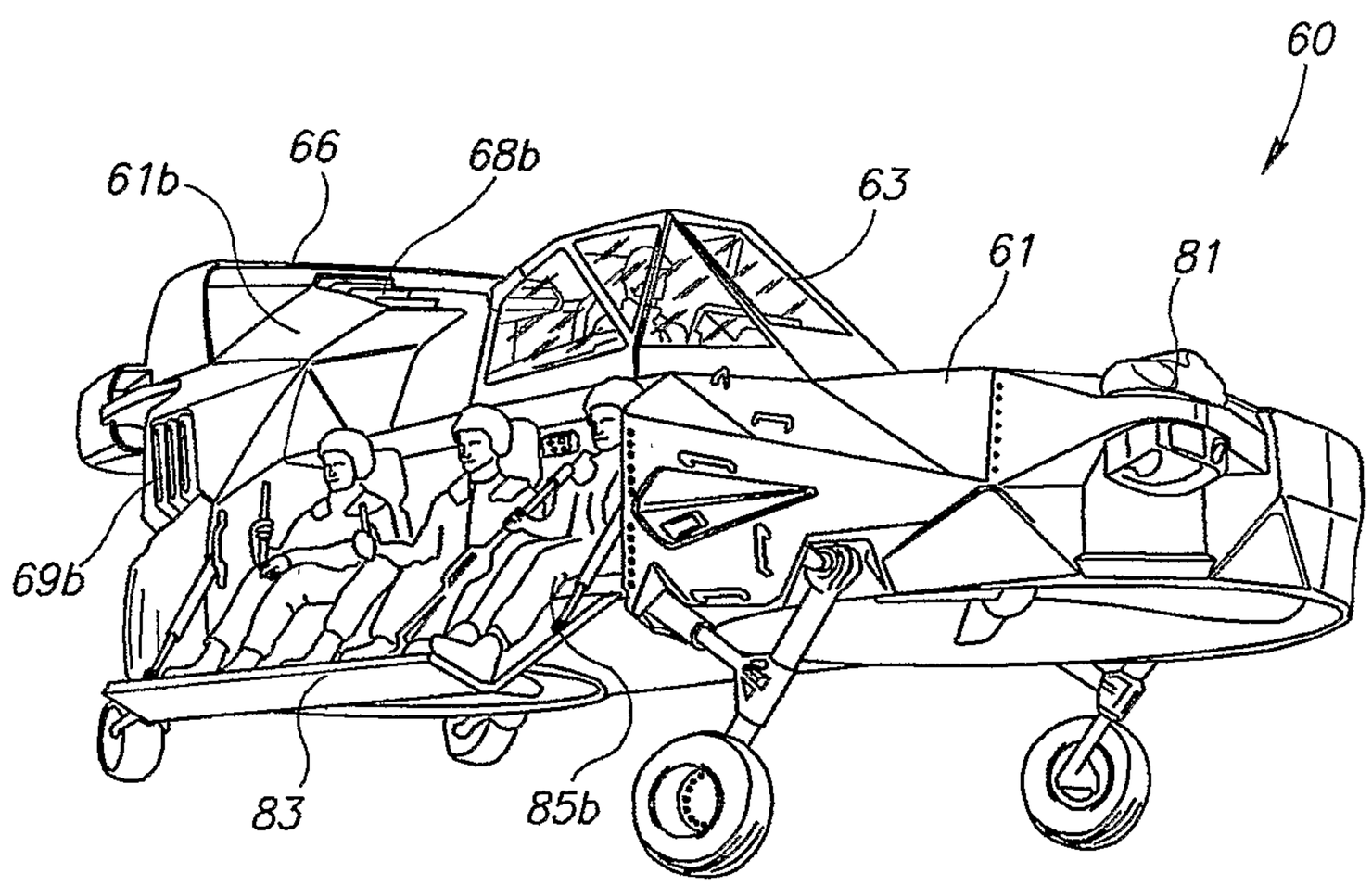

FIG.8B

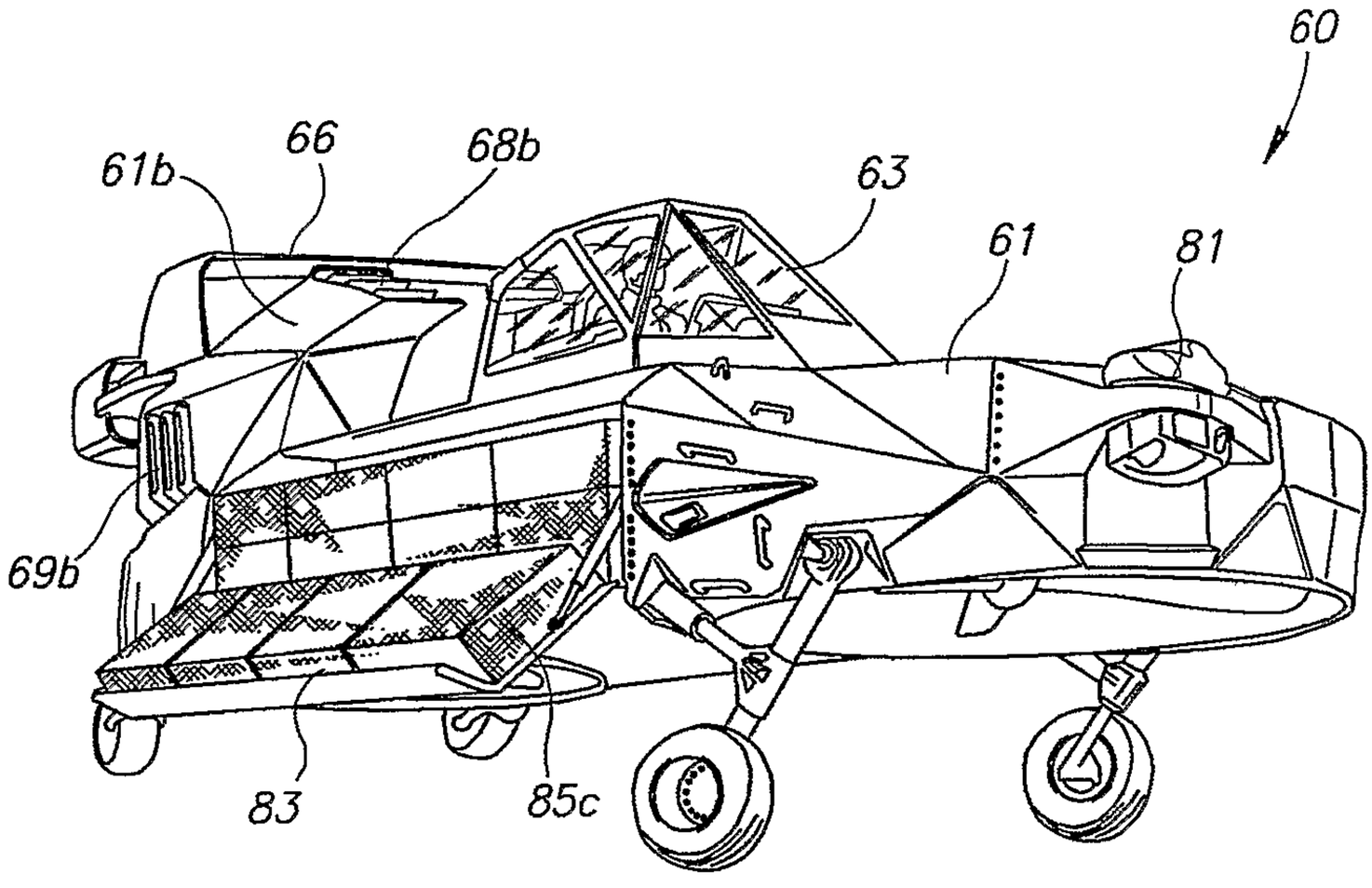

FIG.8C

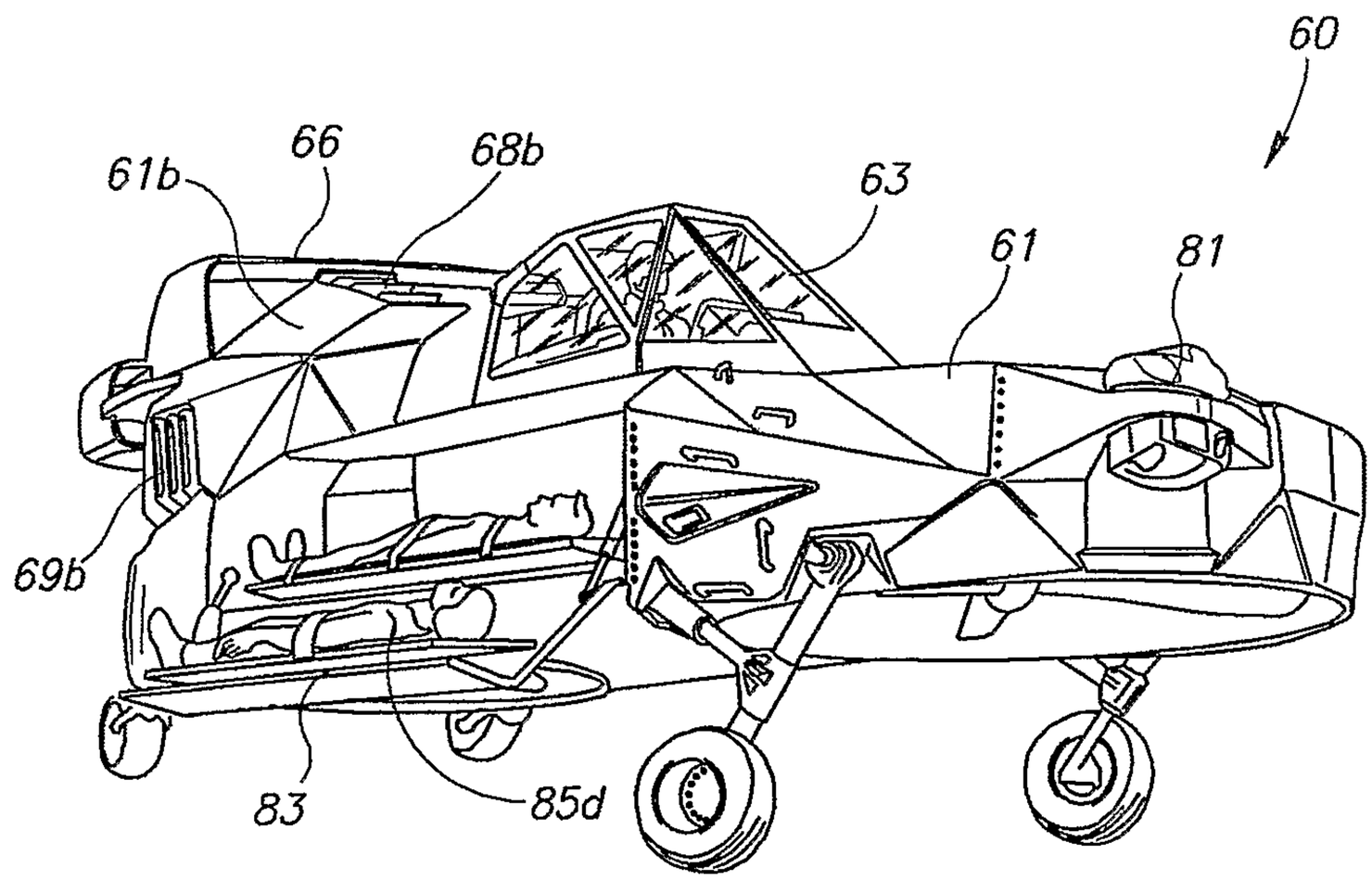

FIG.8D

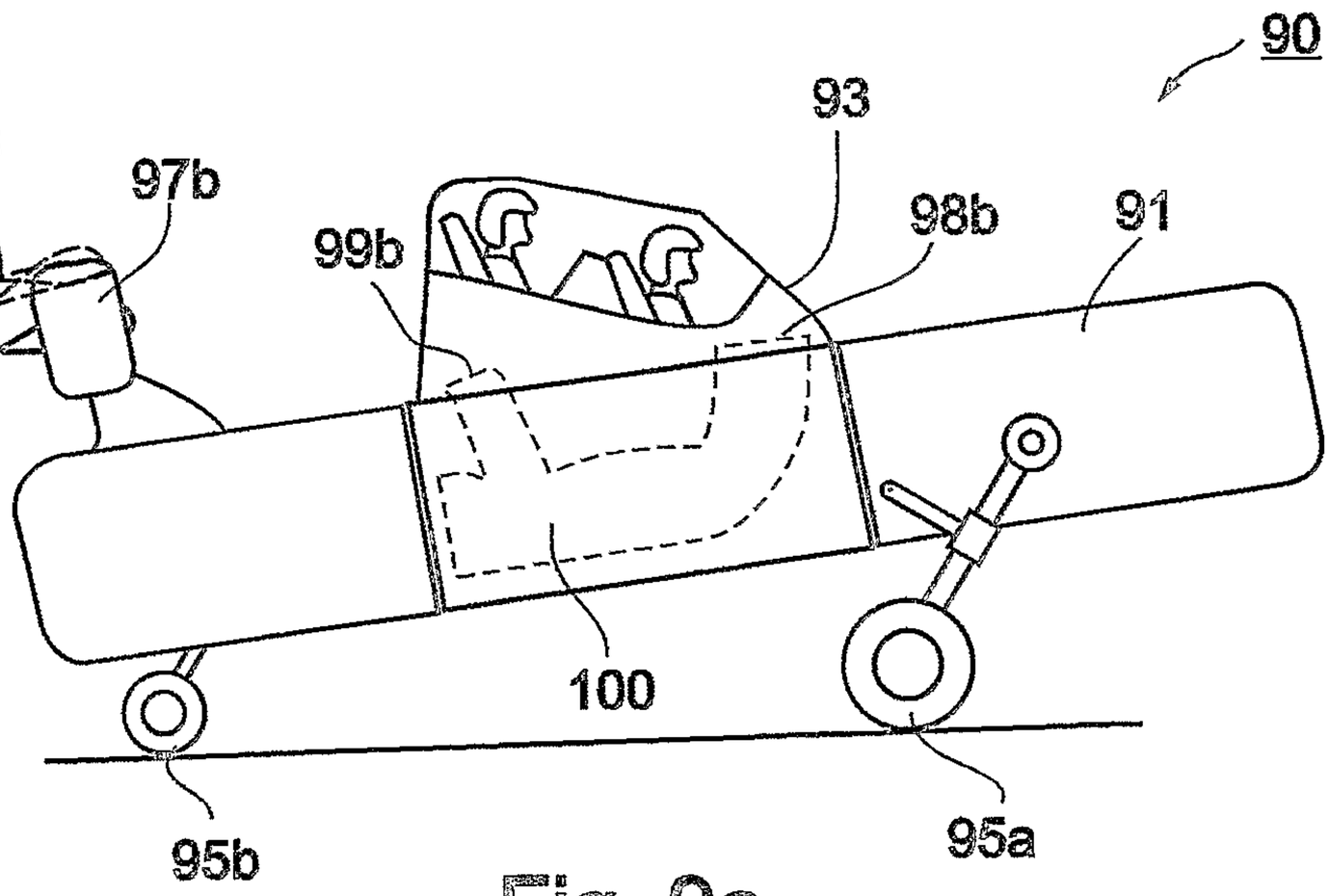
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Fig. 9a

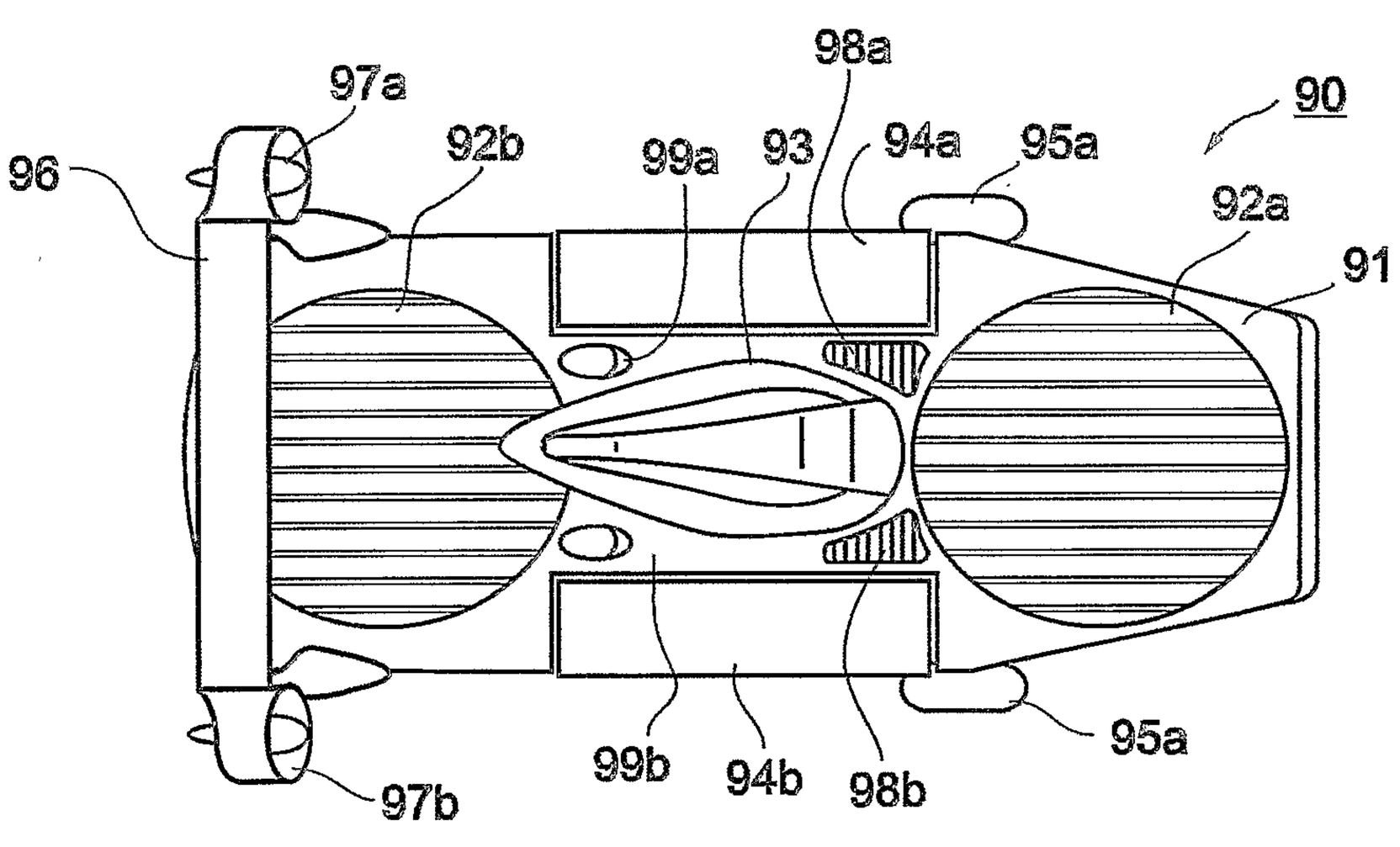
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Fig. 9b

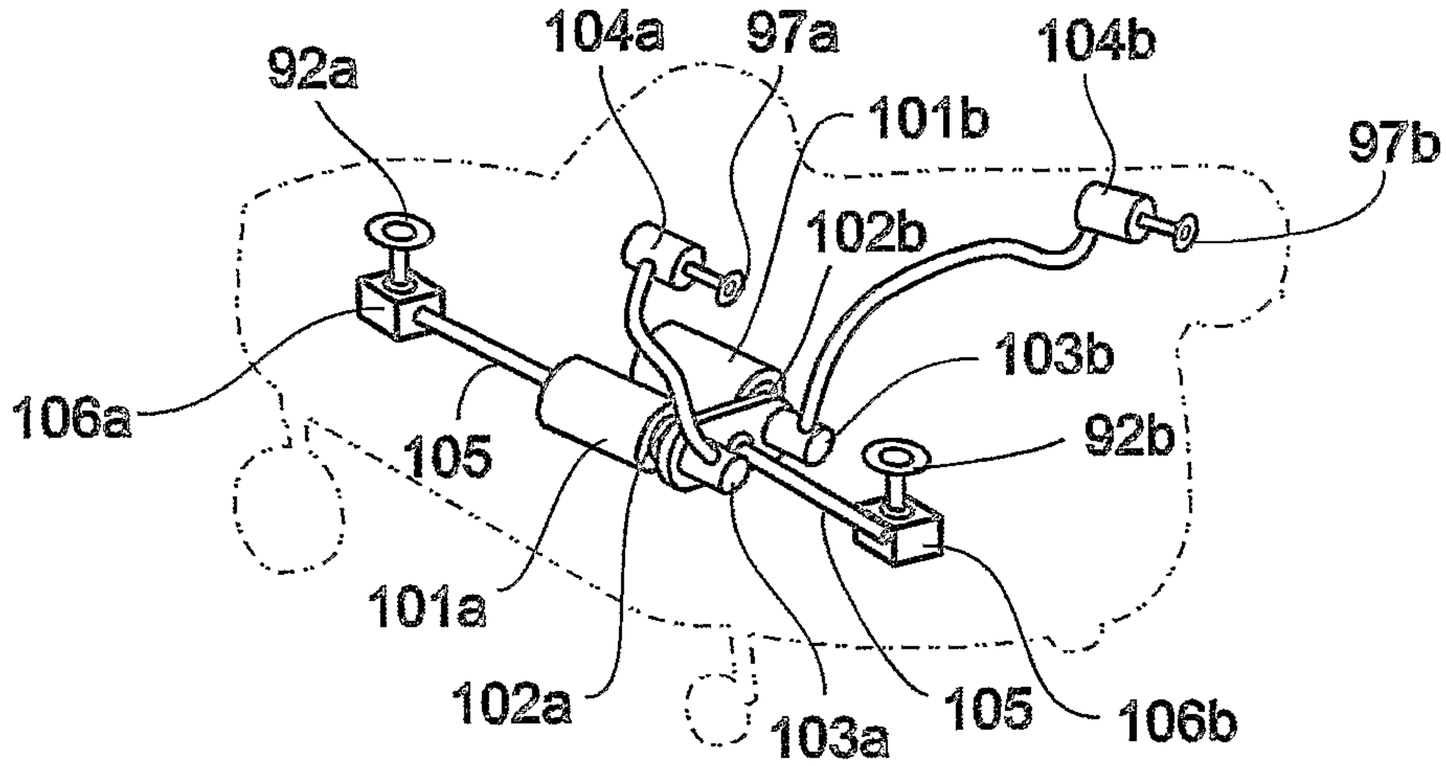
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Fig. 10

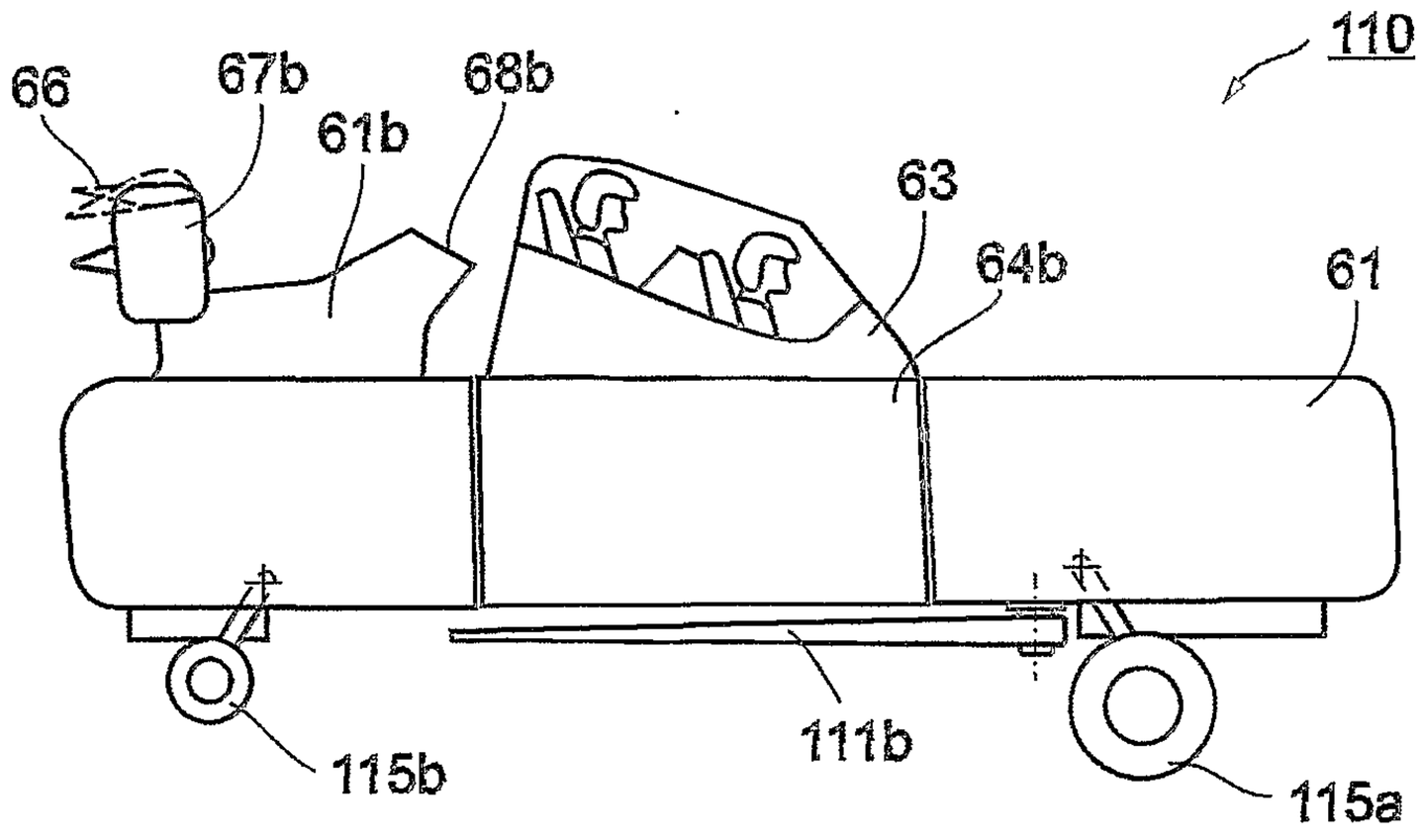

Fig. 11a

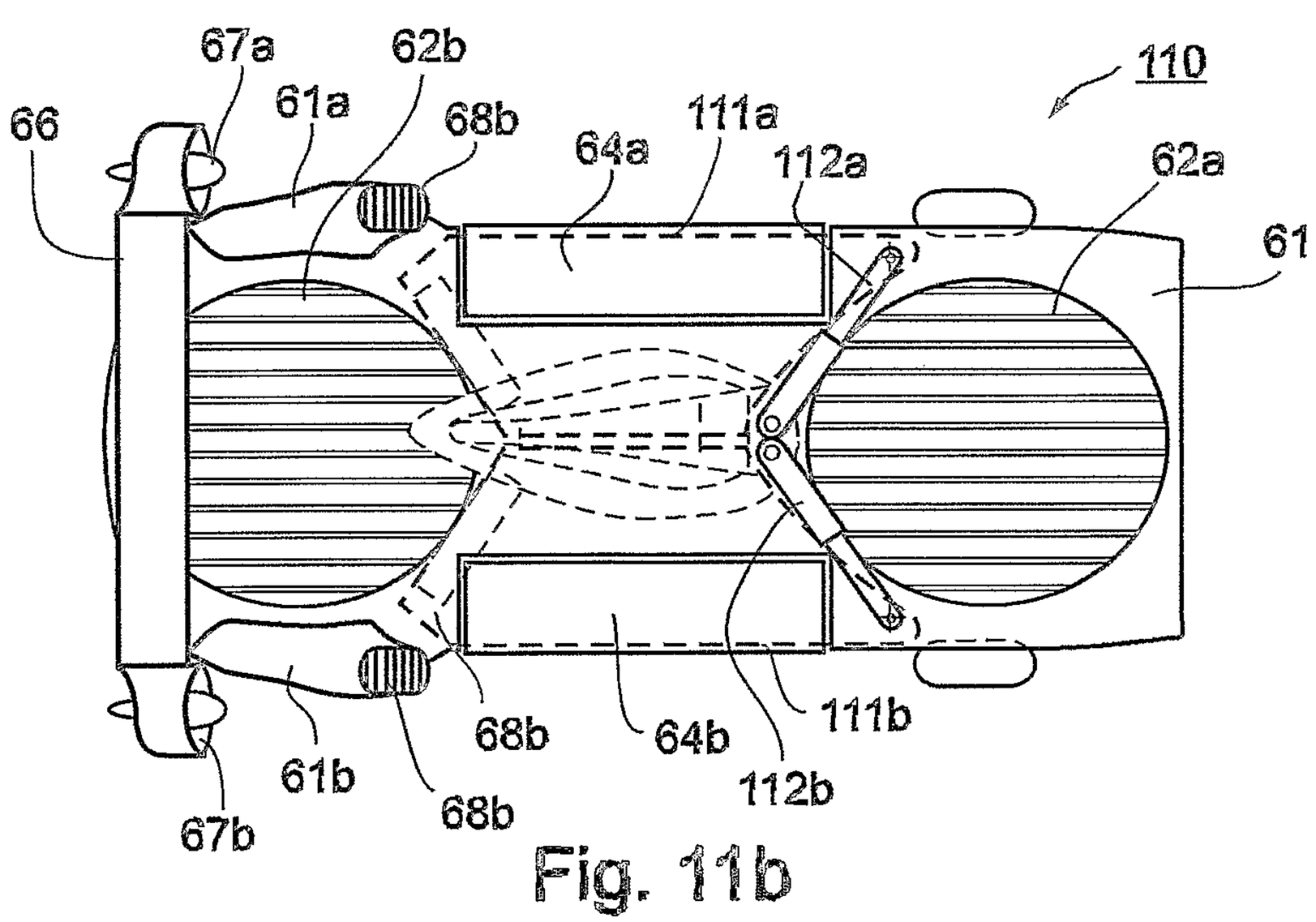

Fig. 11b

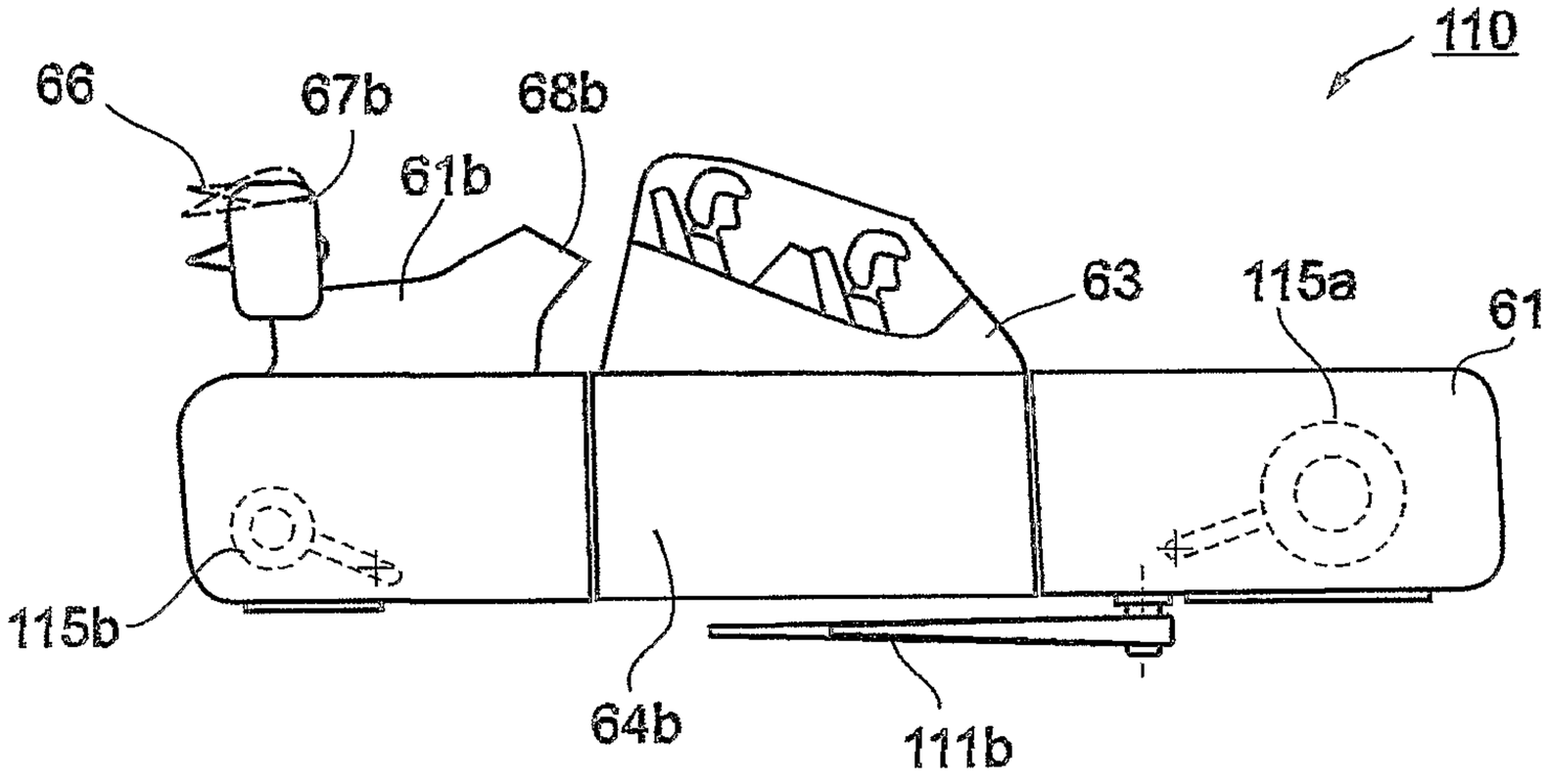

Fig. 11c

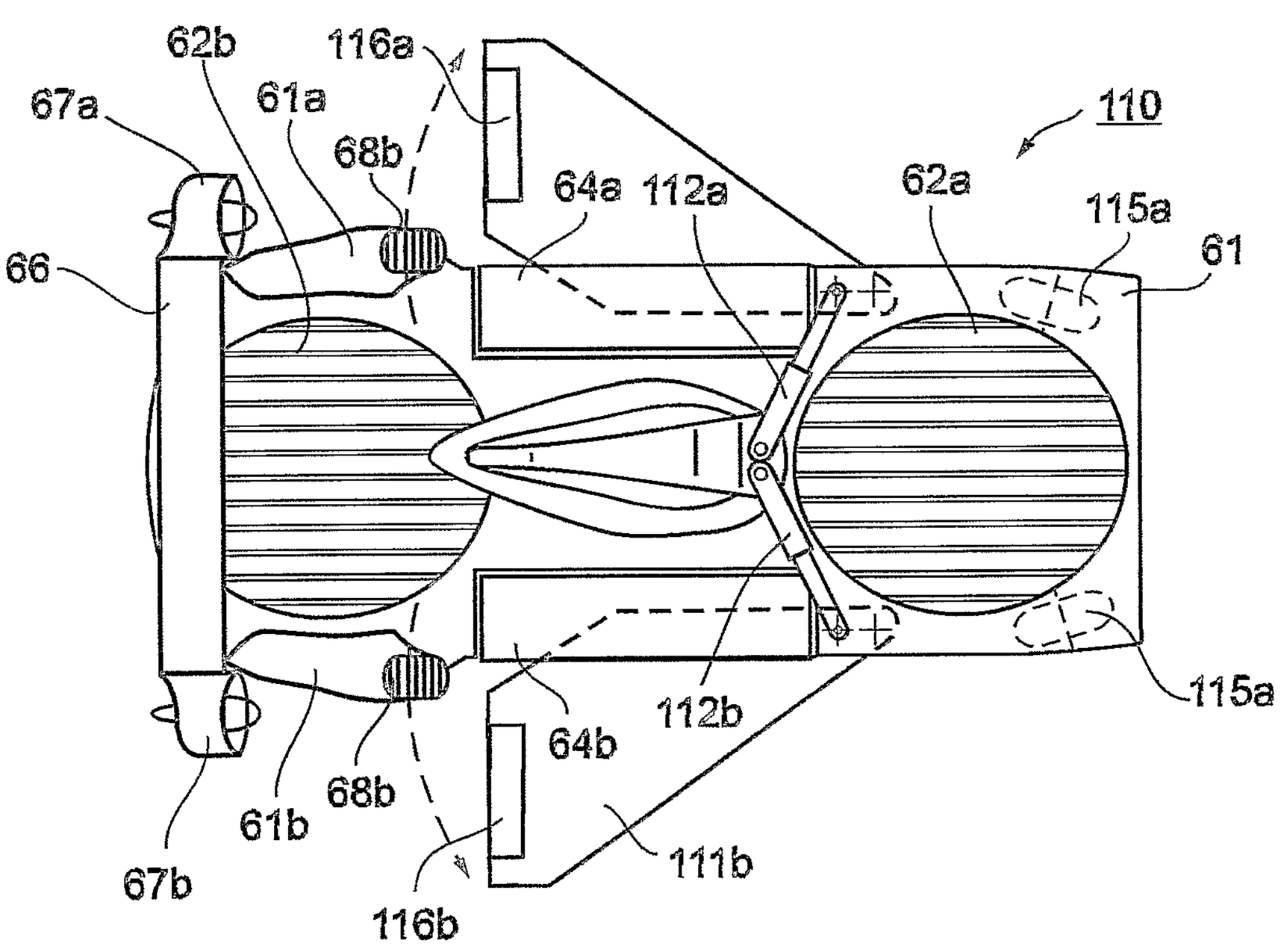

Fig. 11d

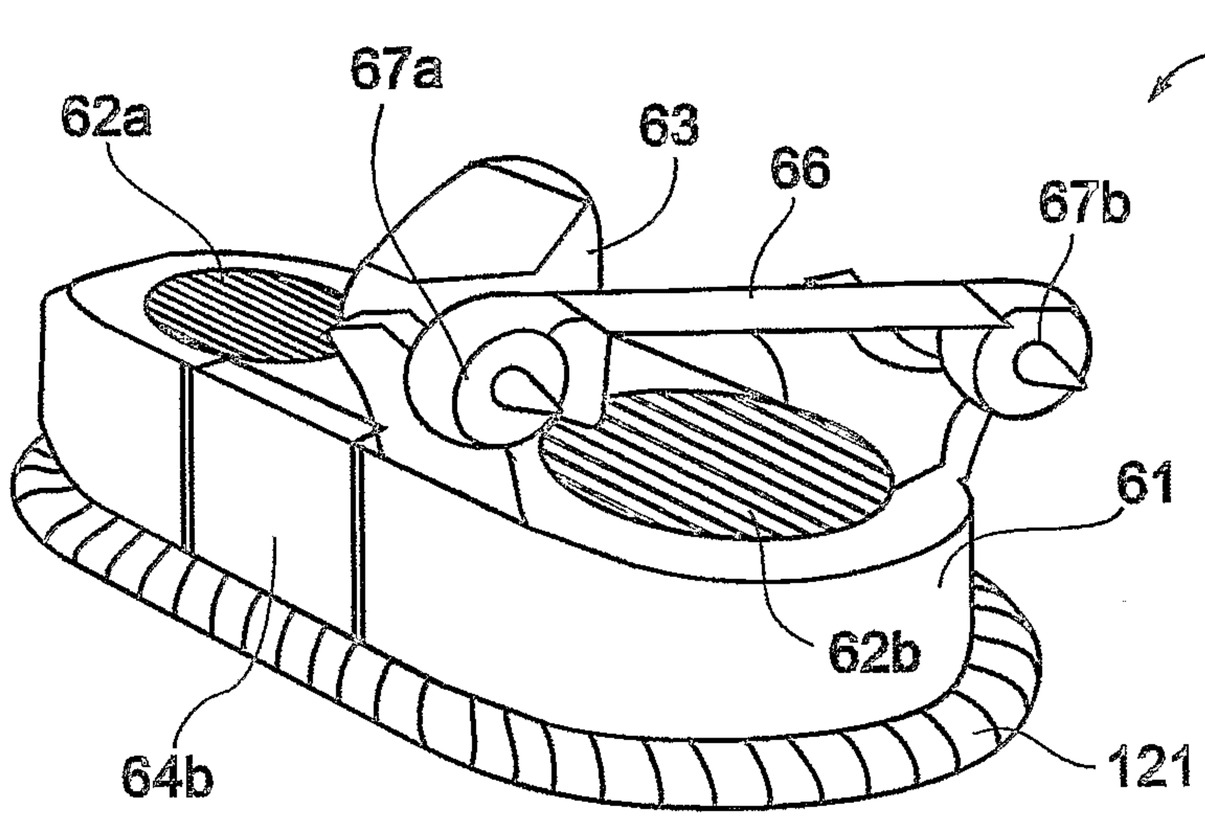
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Fig. 12

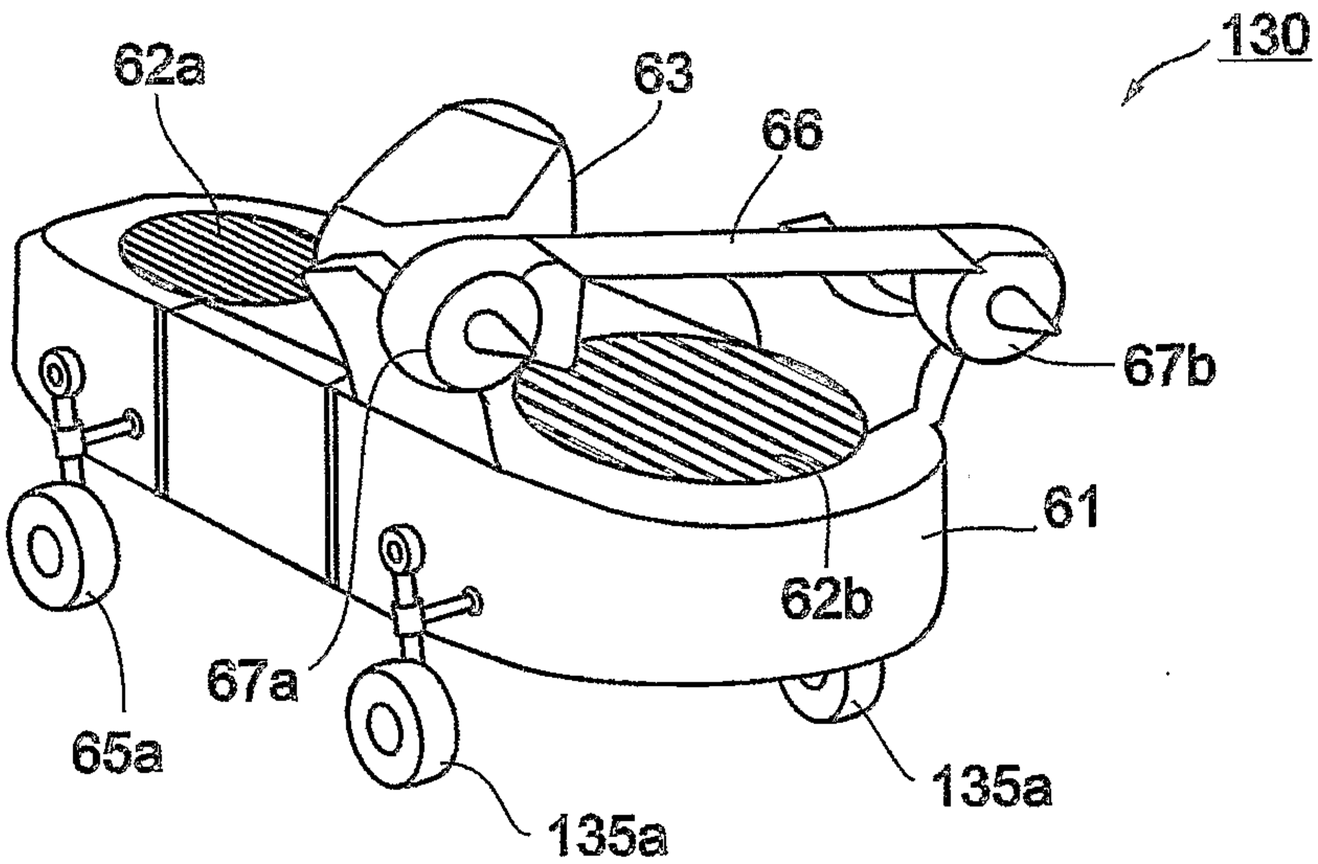
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Fig. 13

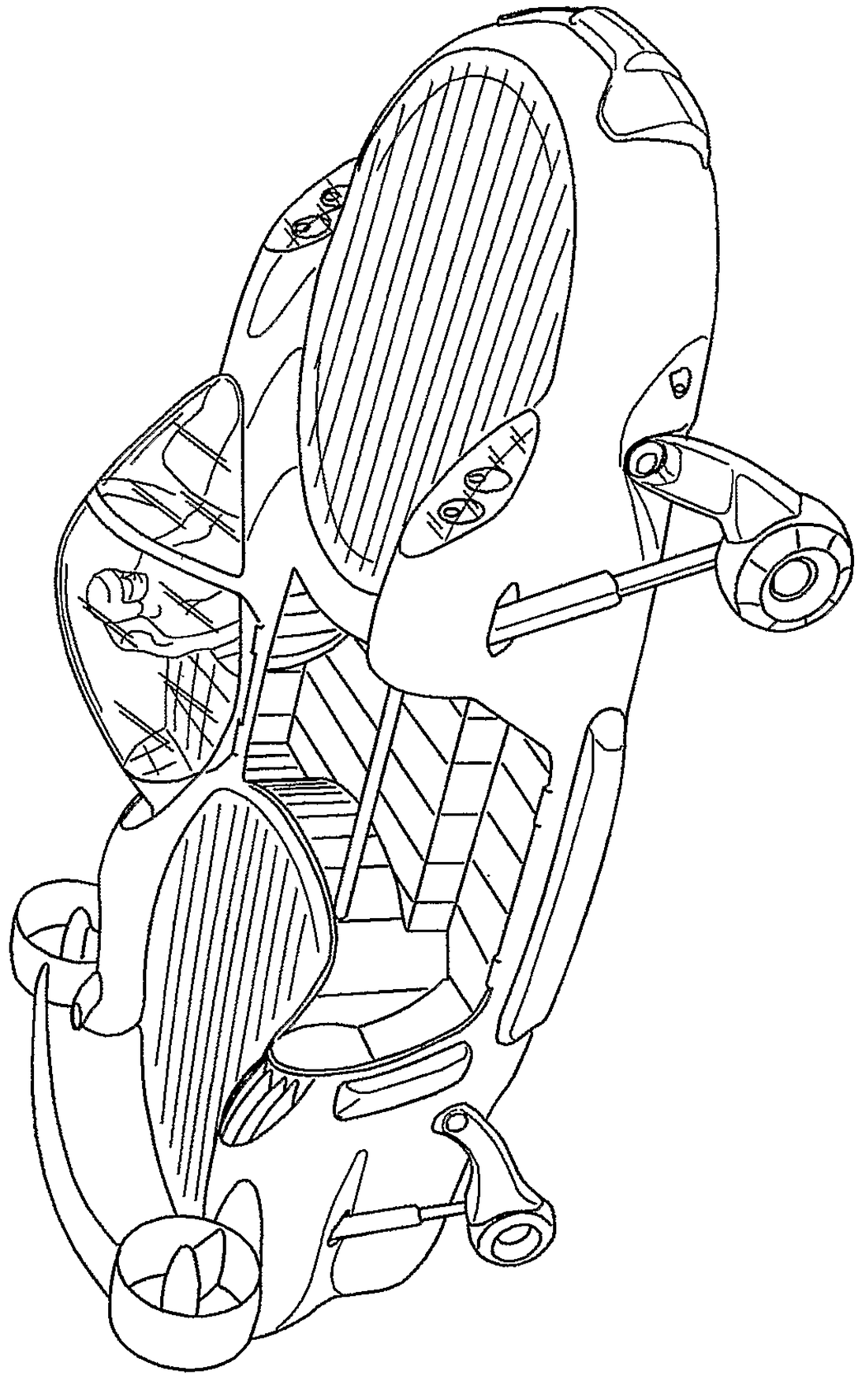


FIG.14A

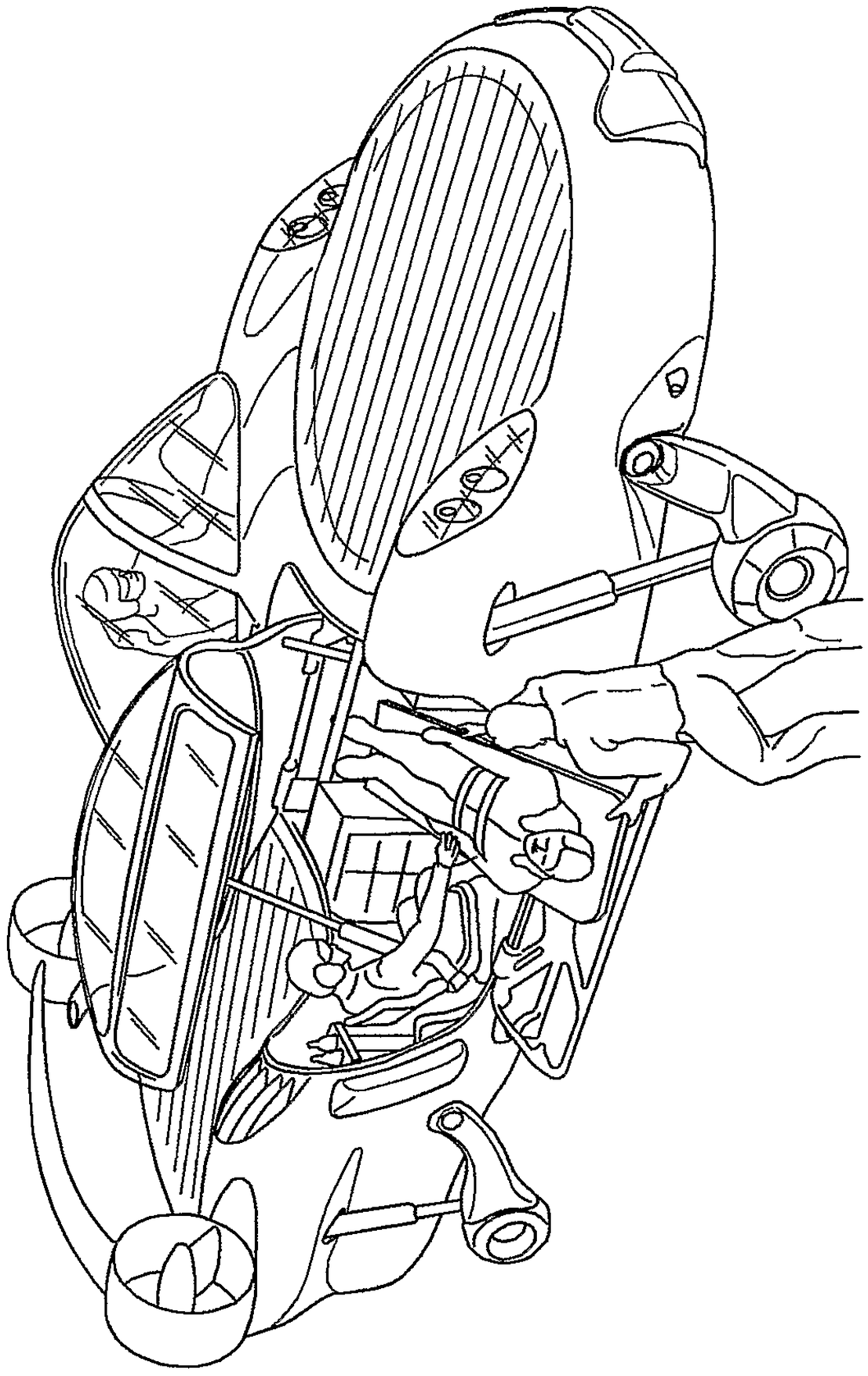


FIG.14B

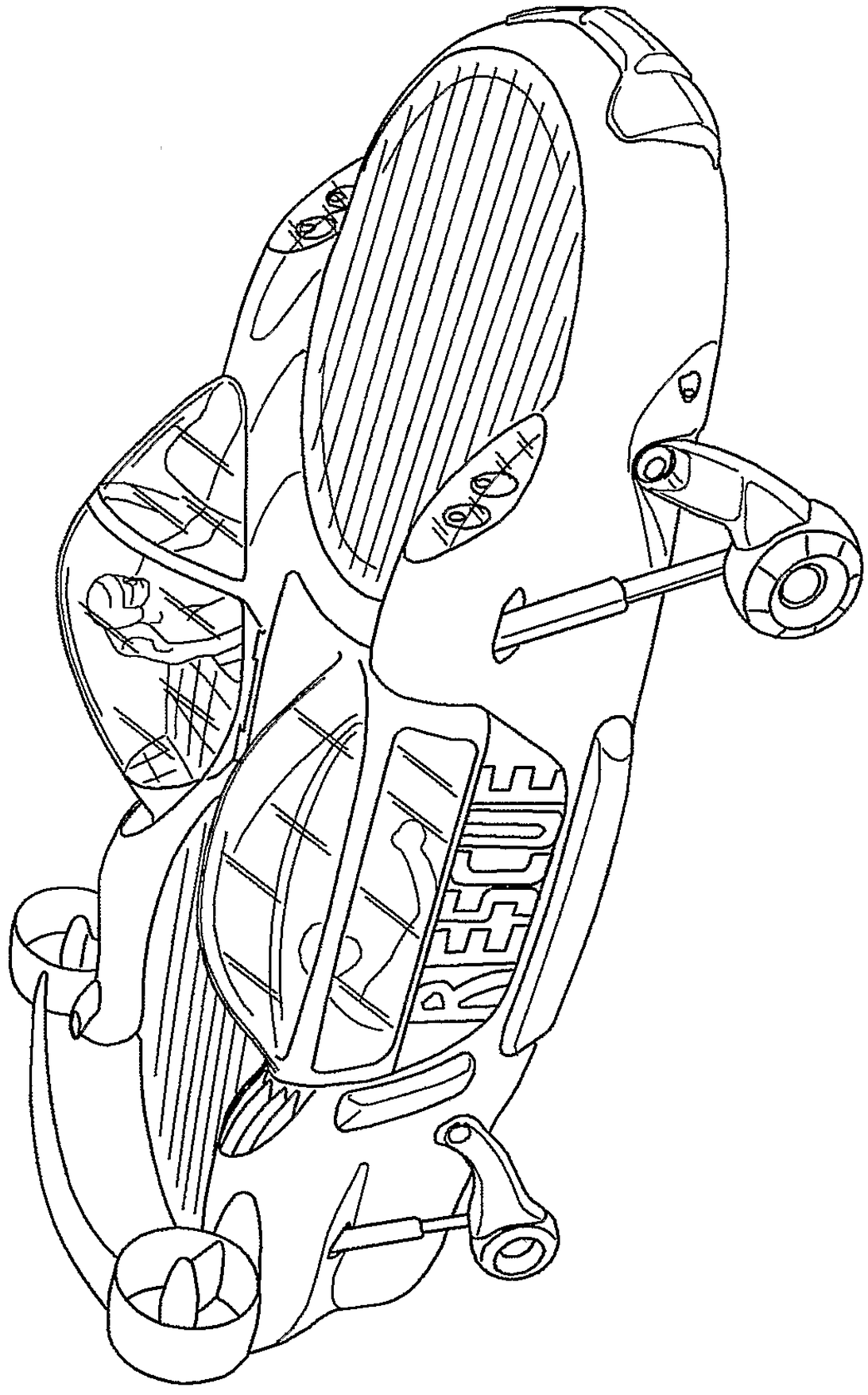


FIG.14C

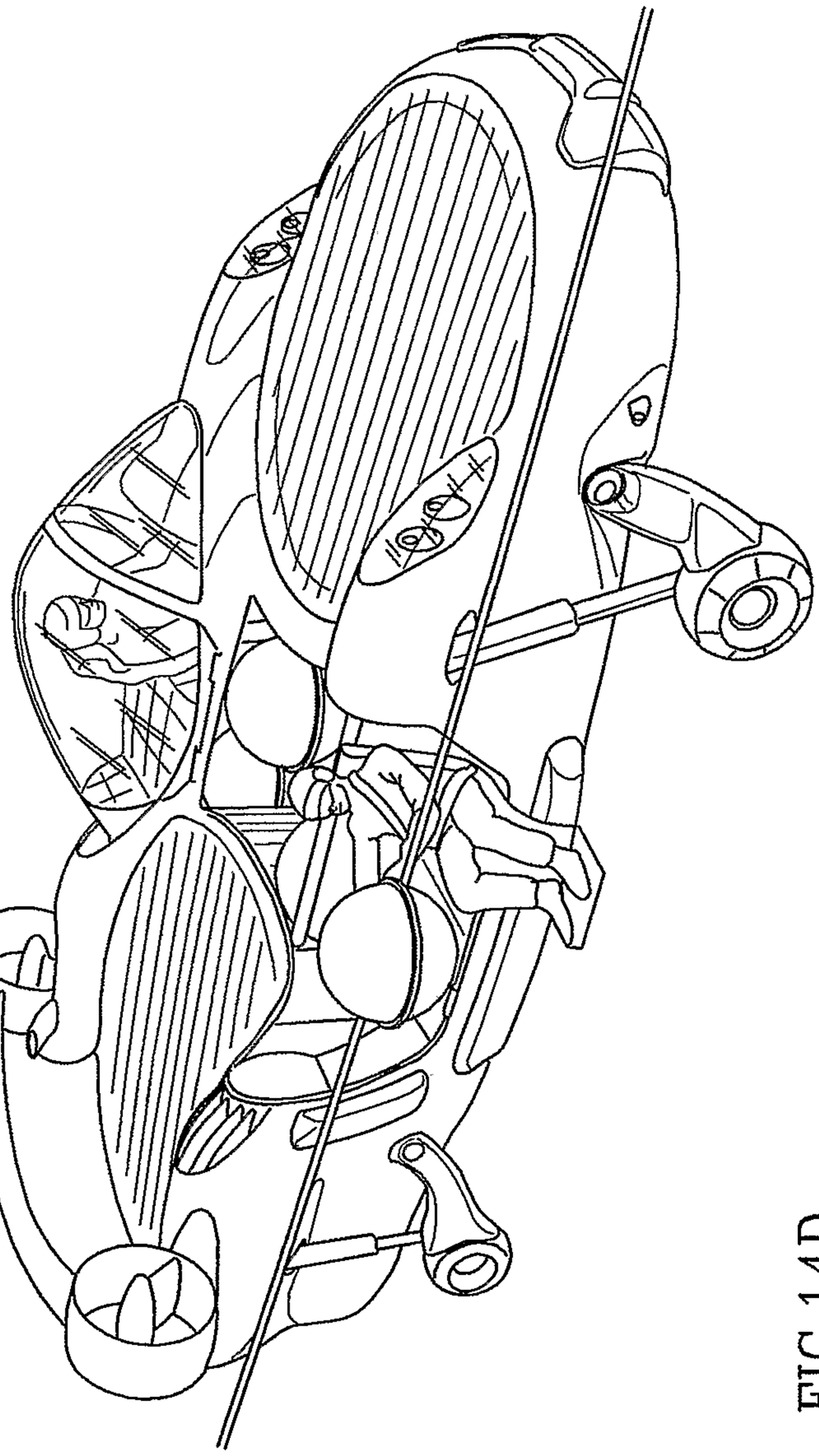


FIG.14D

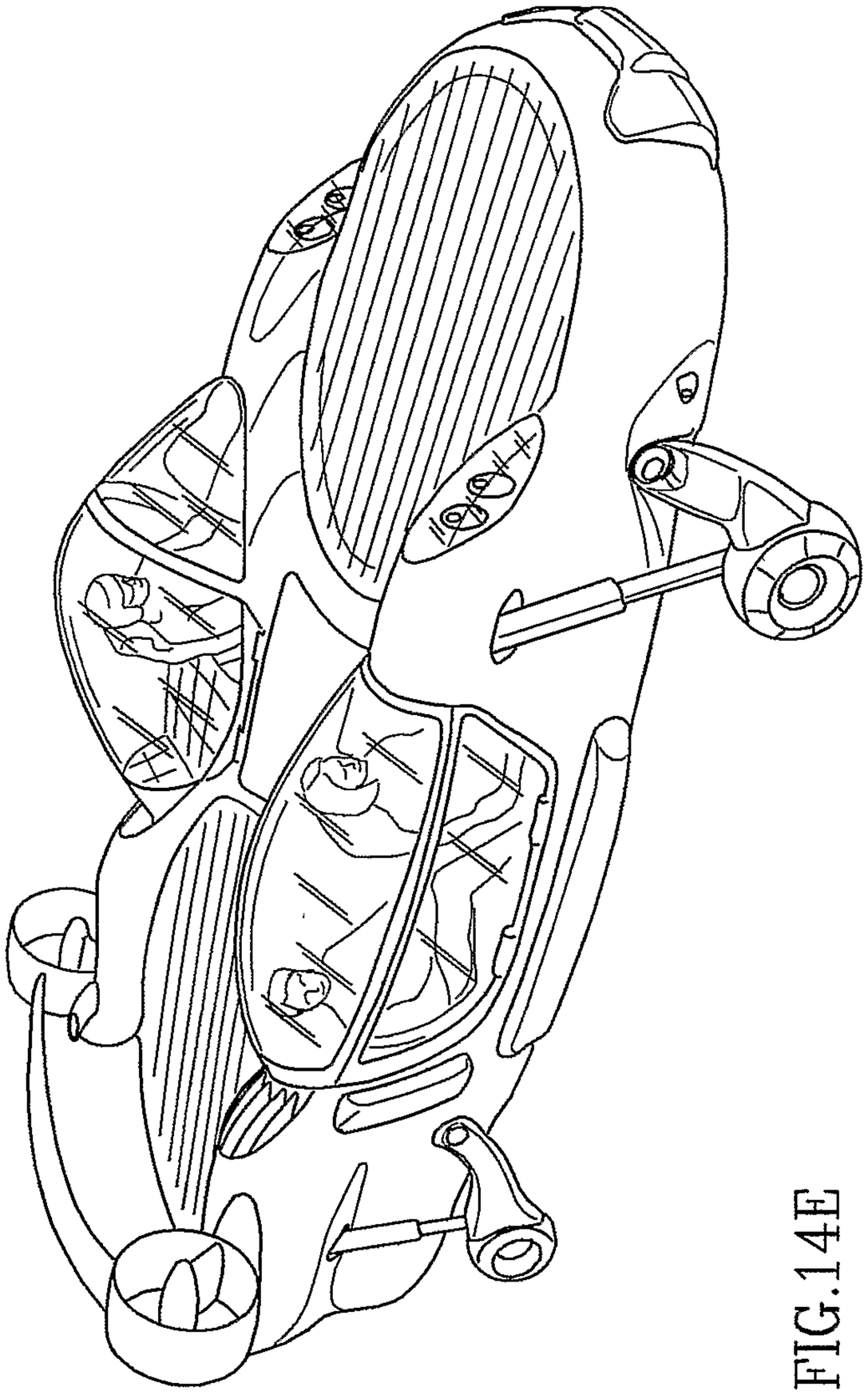


FIG.14E

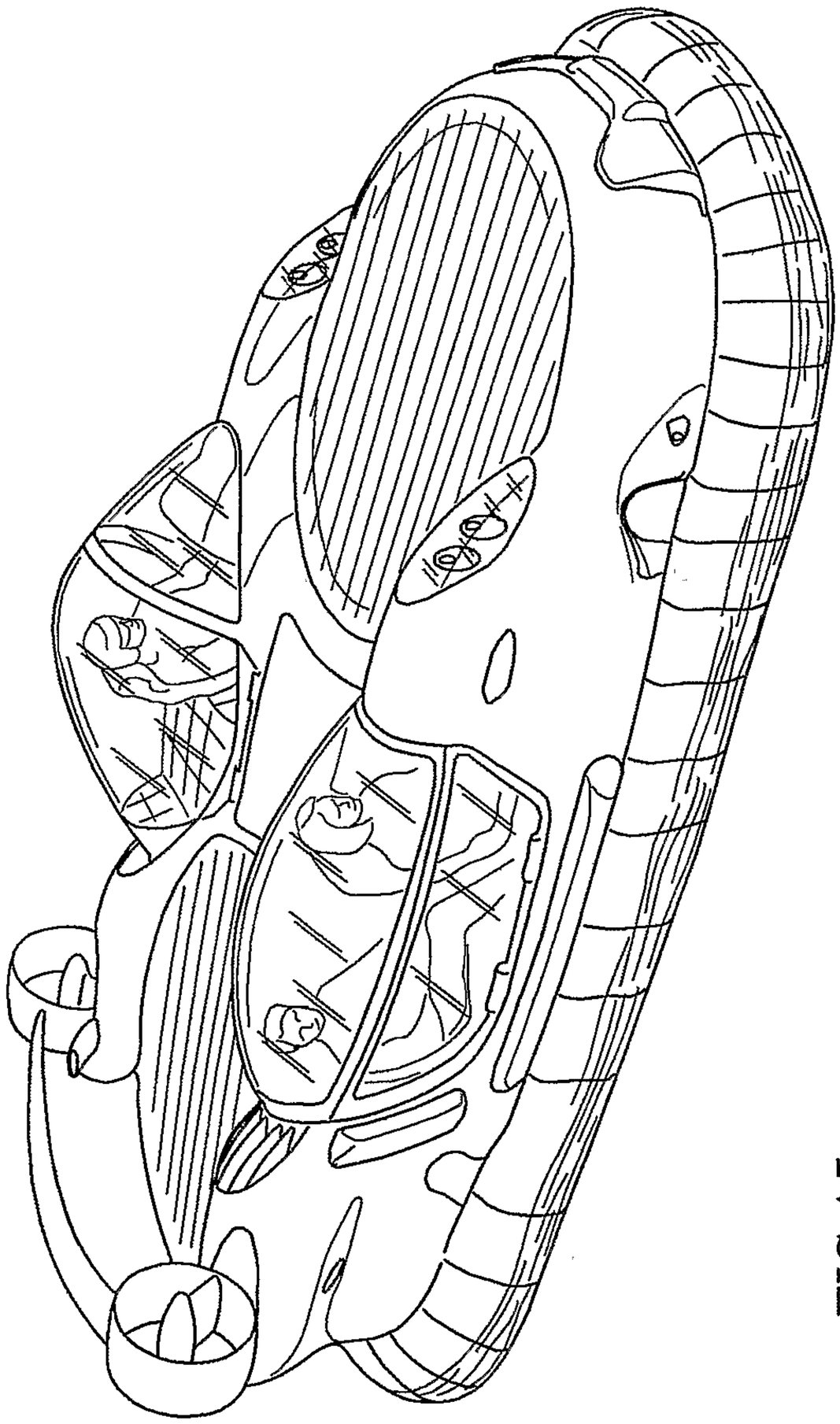


FIG.15

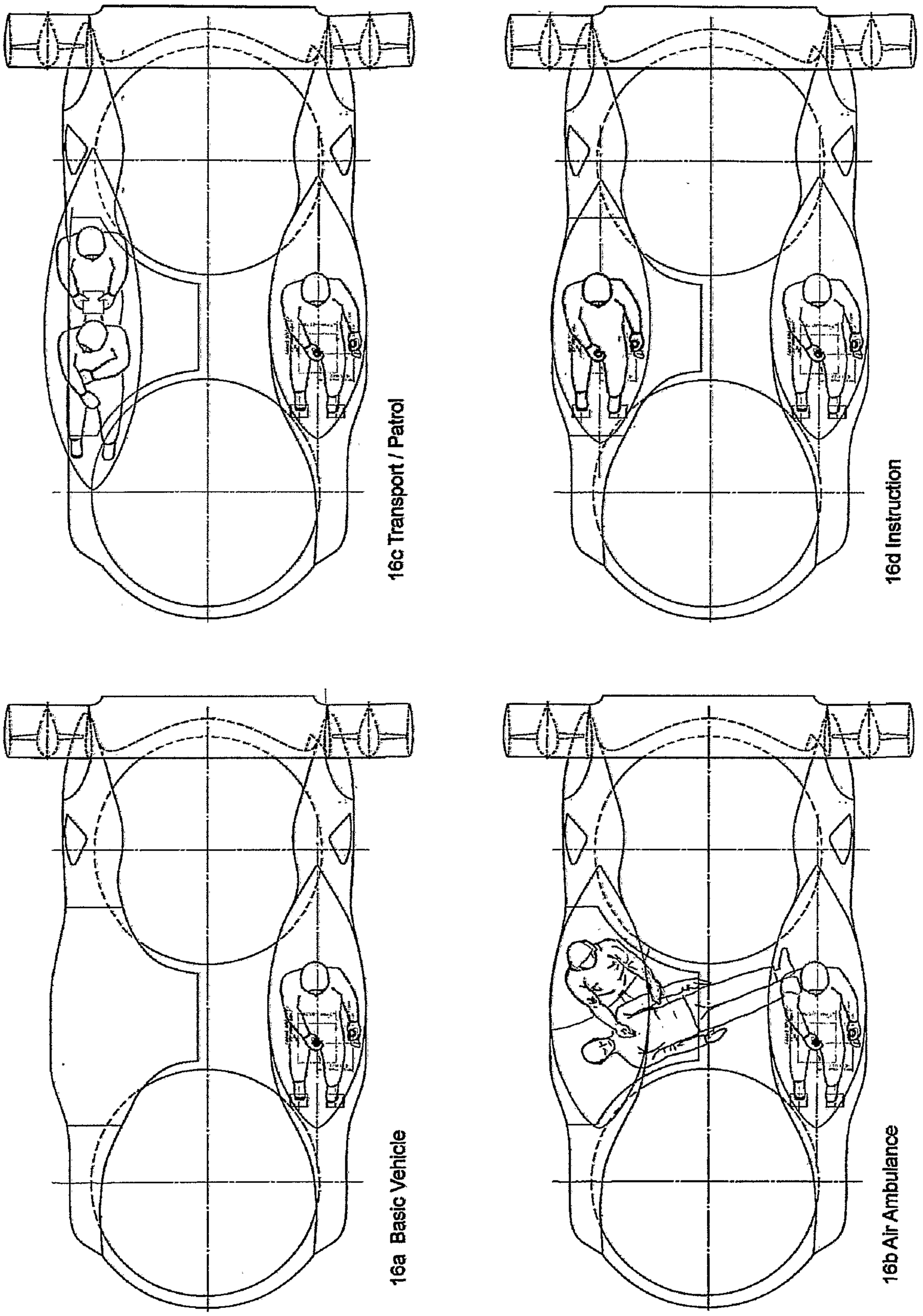
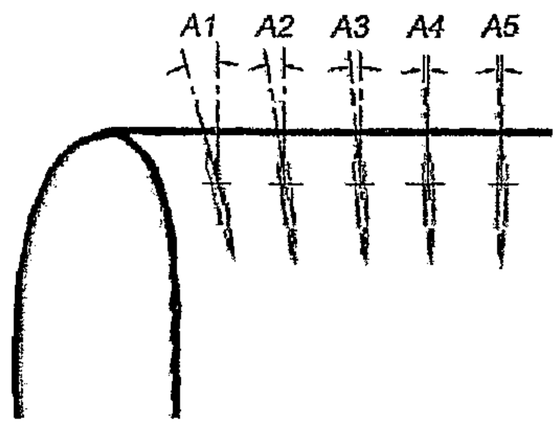

16a Basic Vehicle
16b Air Ambulance
16c Transport / Patrol
16d Instruction

Fig. 16



Detail A

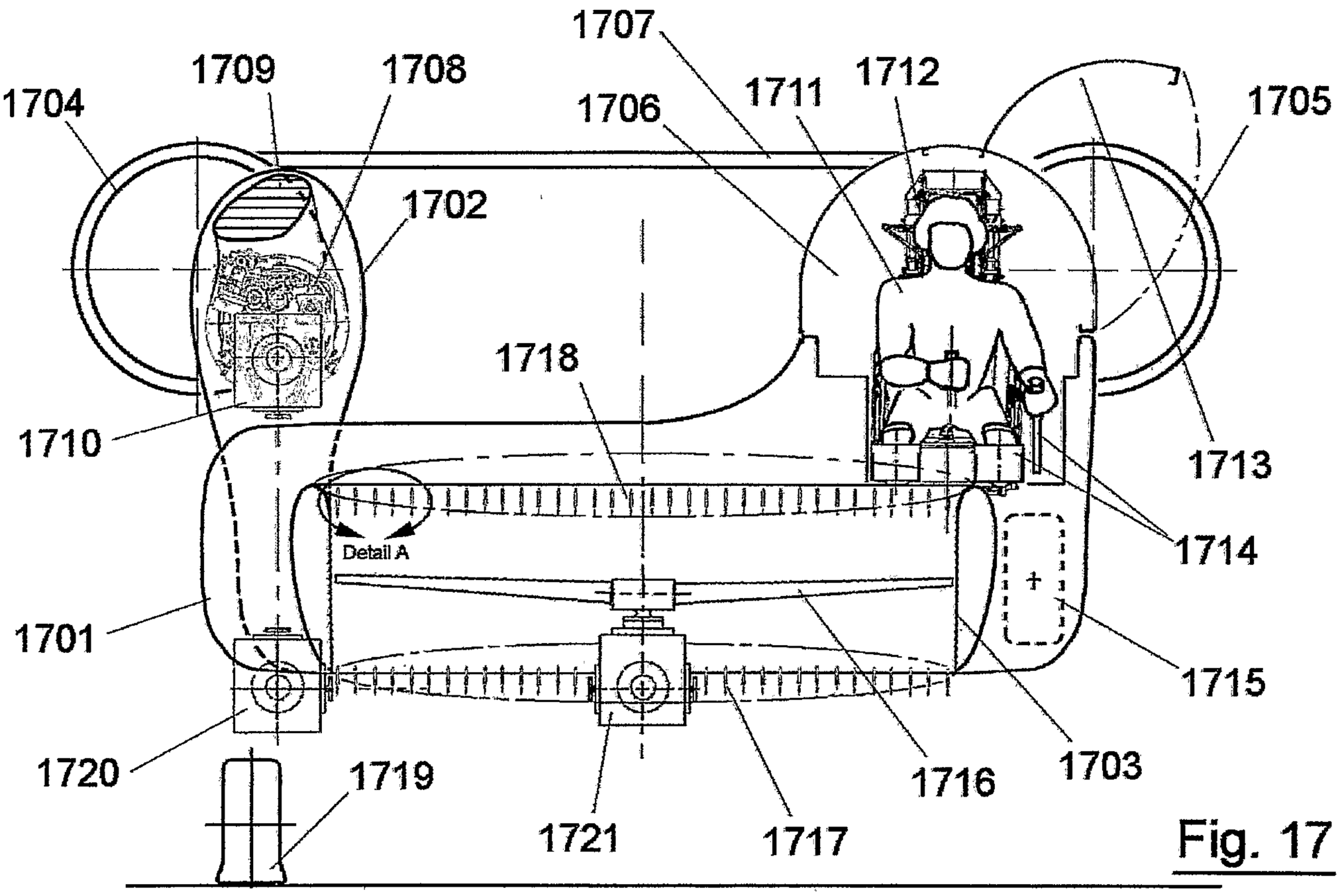
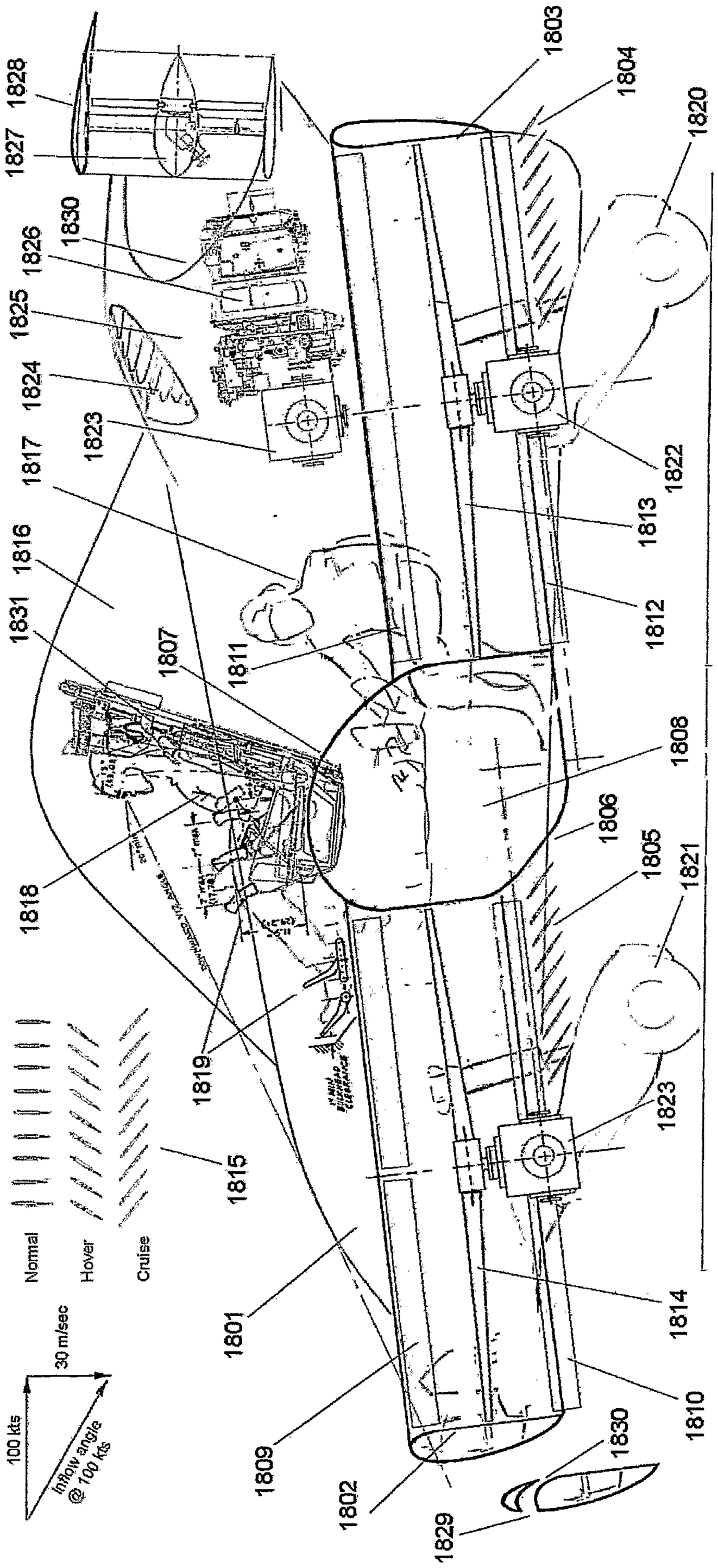


Fig. 17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1830
1810
1814
Normal
Hover
Cruise
100 kts
30 m/sec
Inflow angle @ 100 kts

Fig. 18

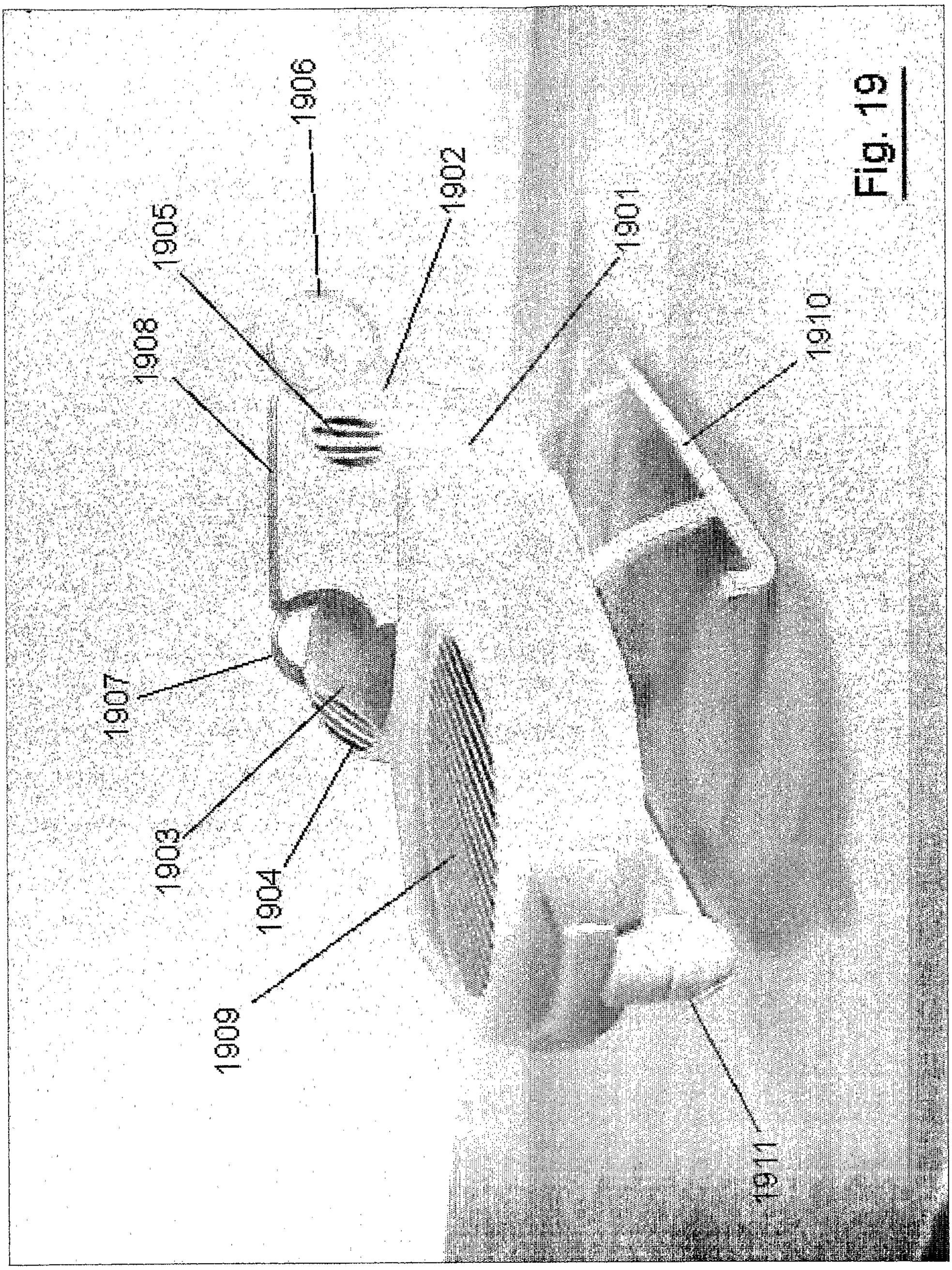

Fig. 19

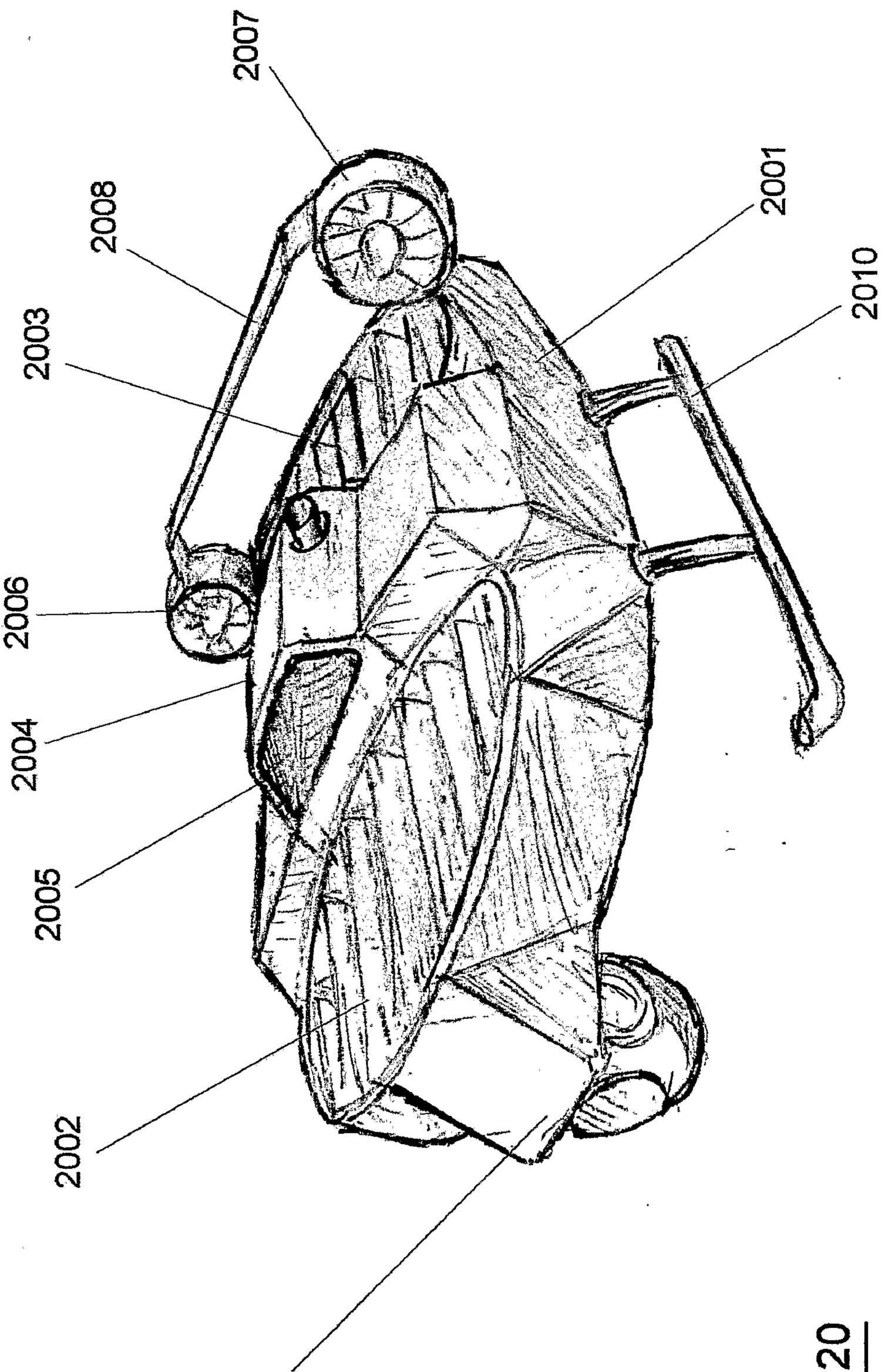

Fig. 20

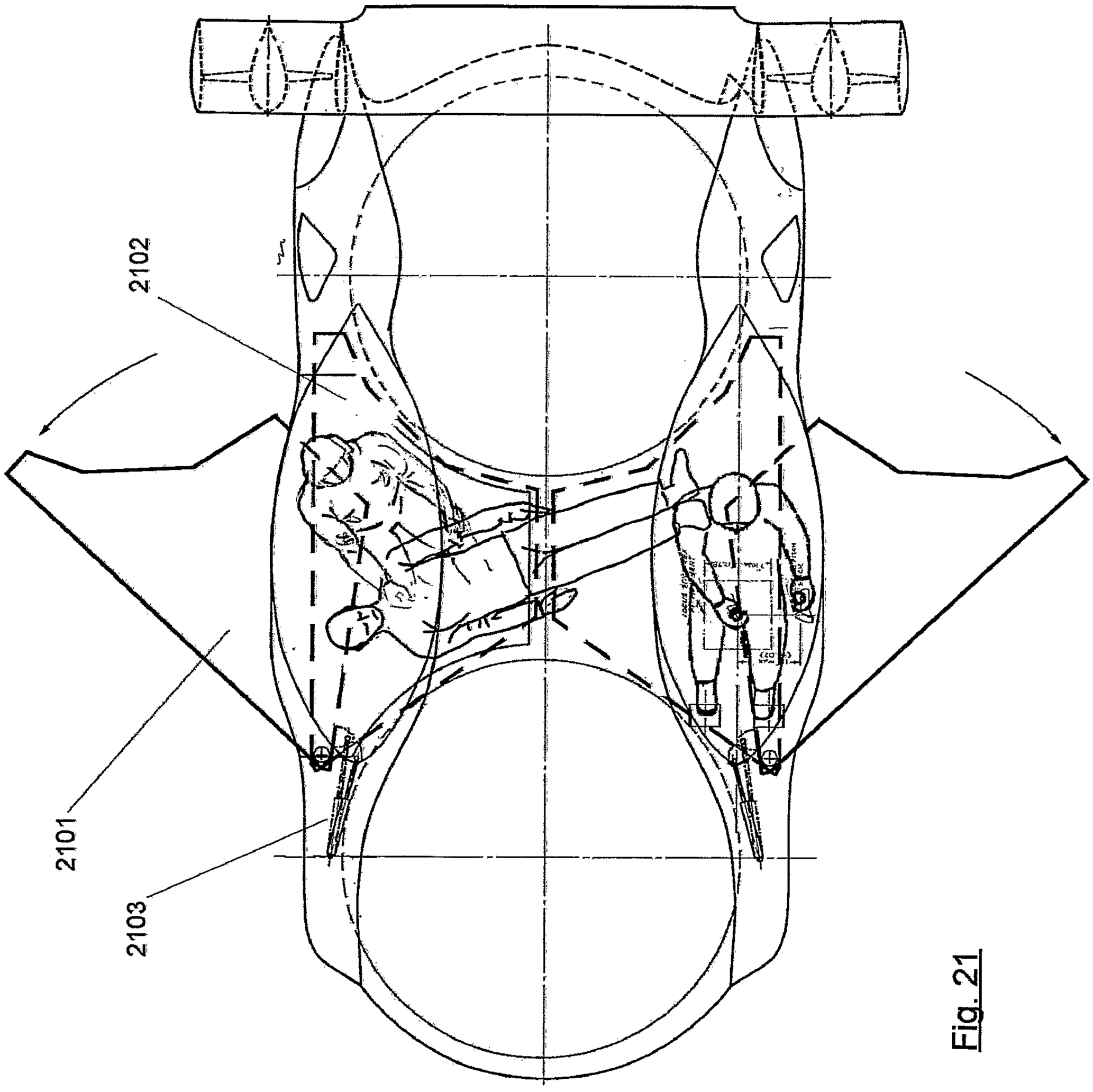

Fig. 21

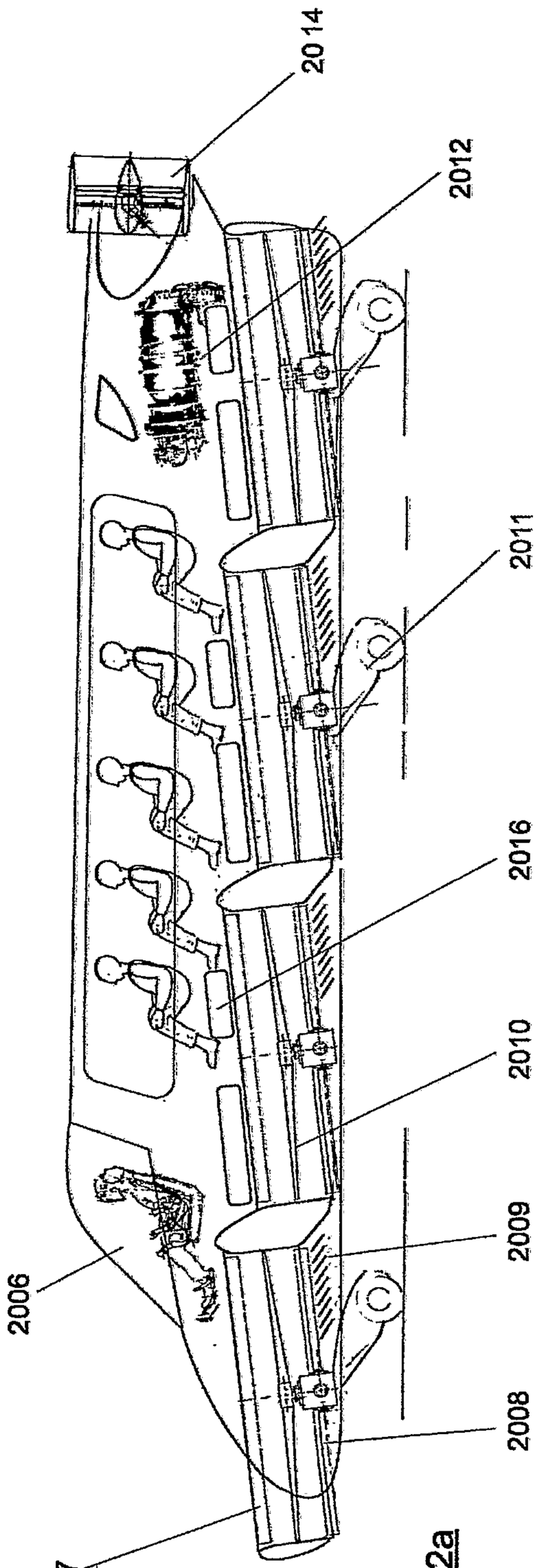

Fig. 22a

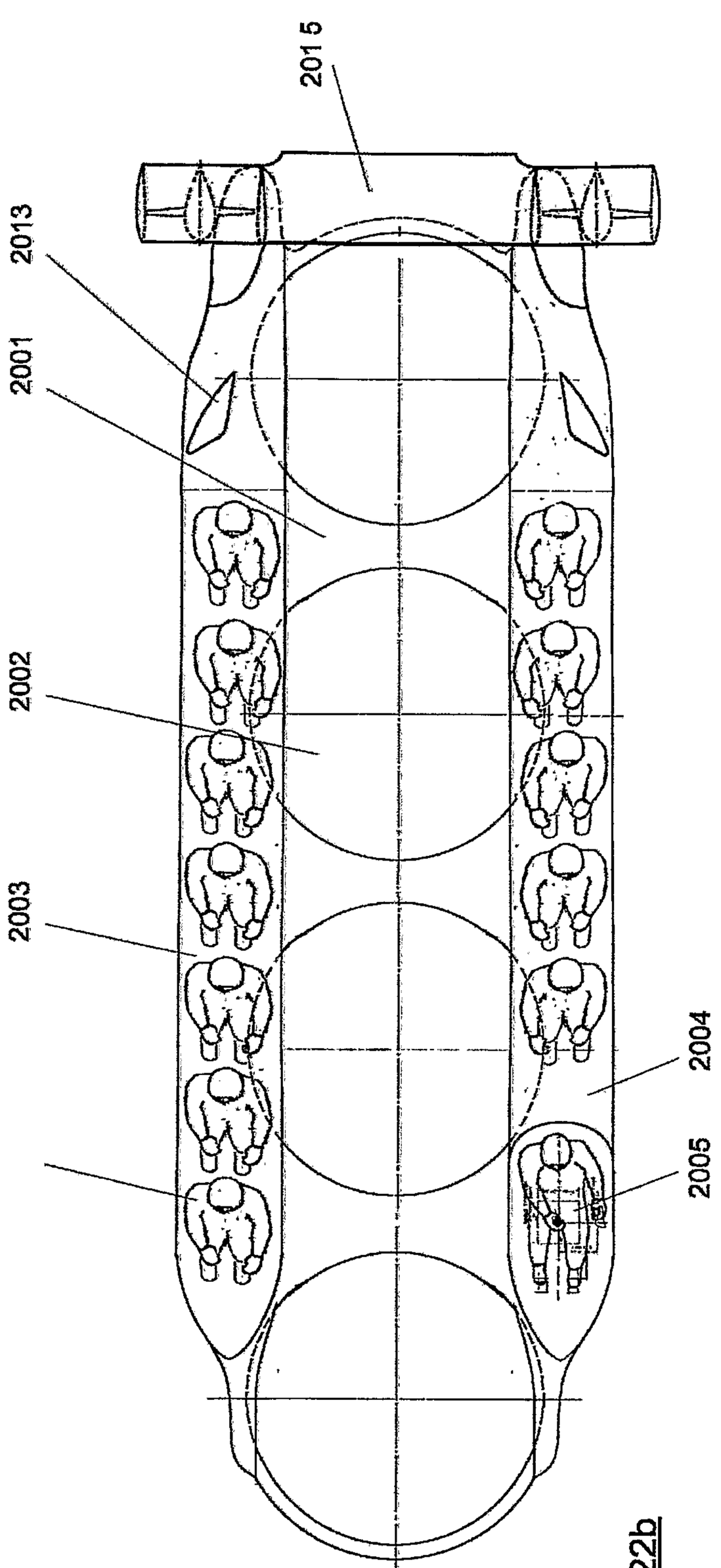

Fig. 22b

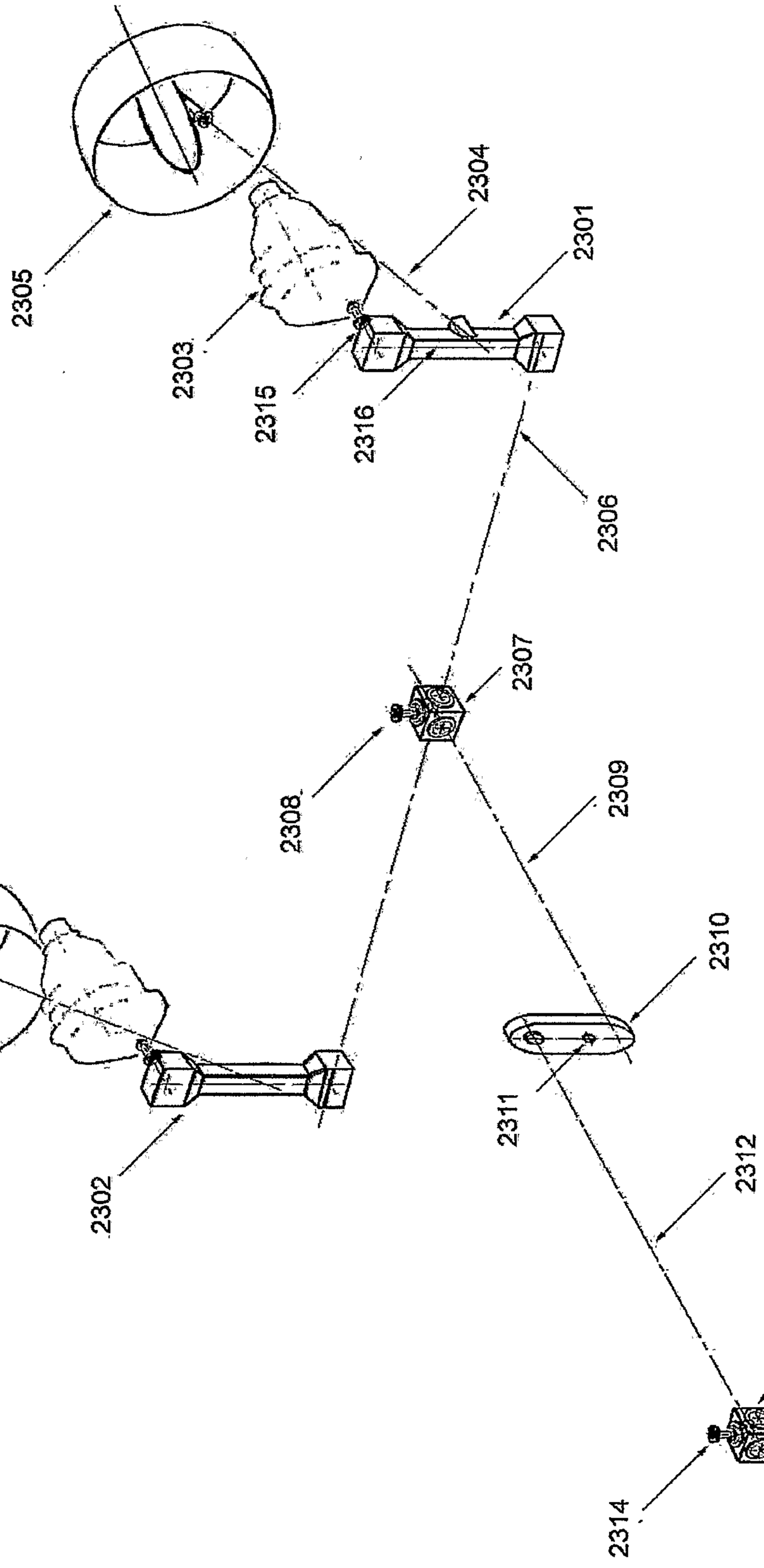
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Fig. 23

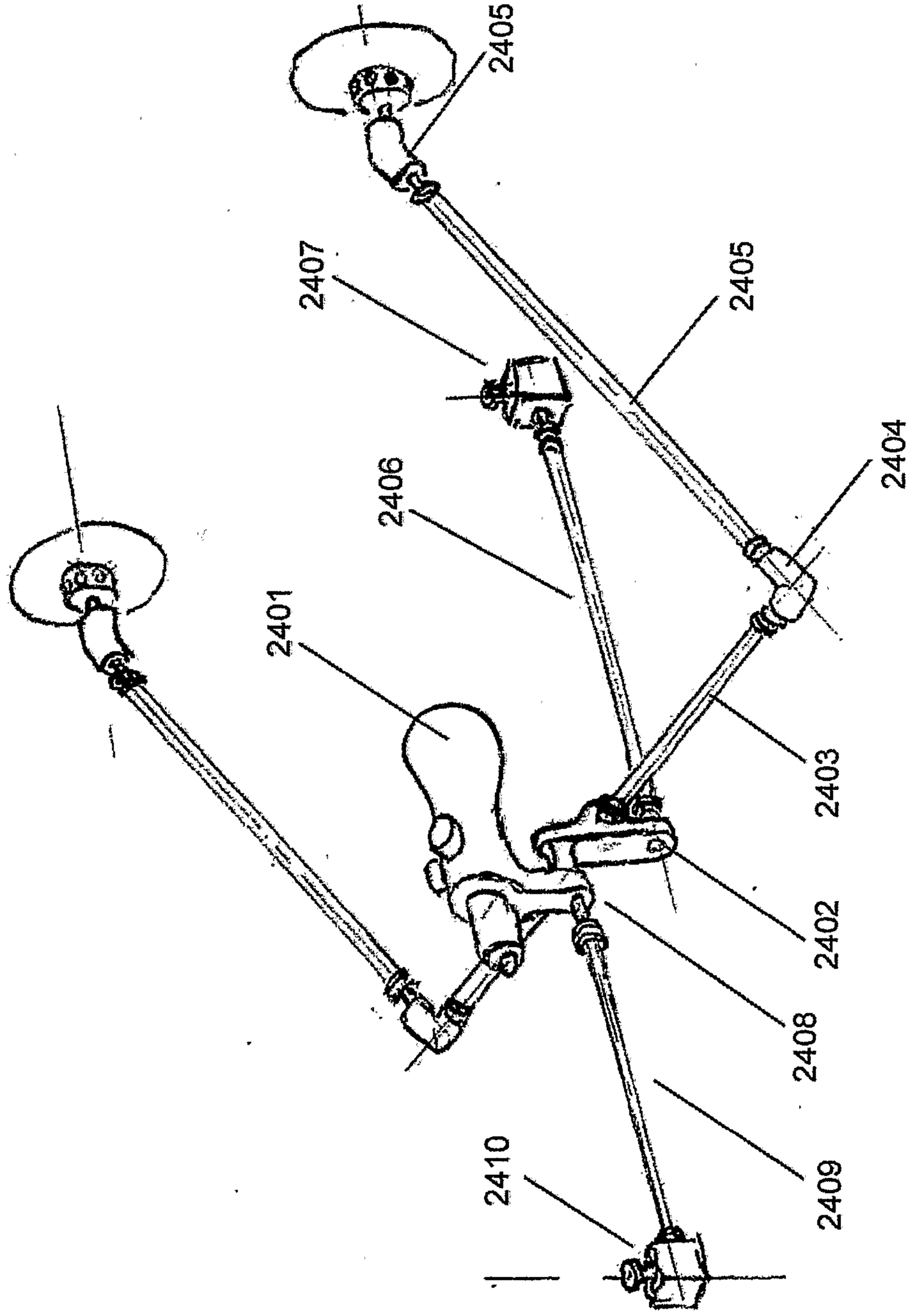


Fig. 24

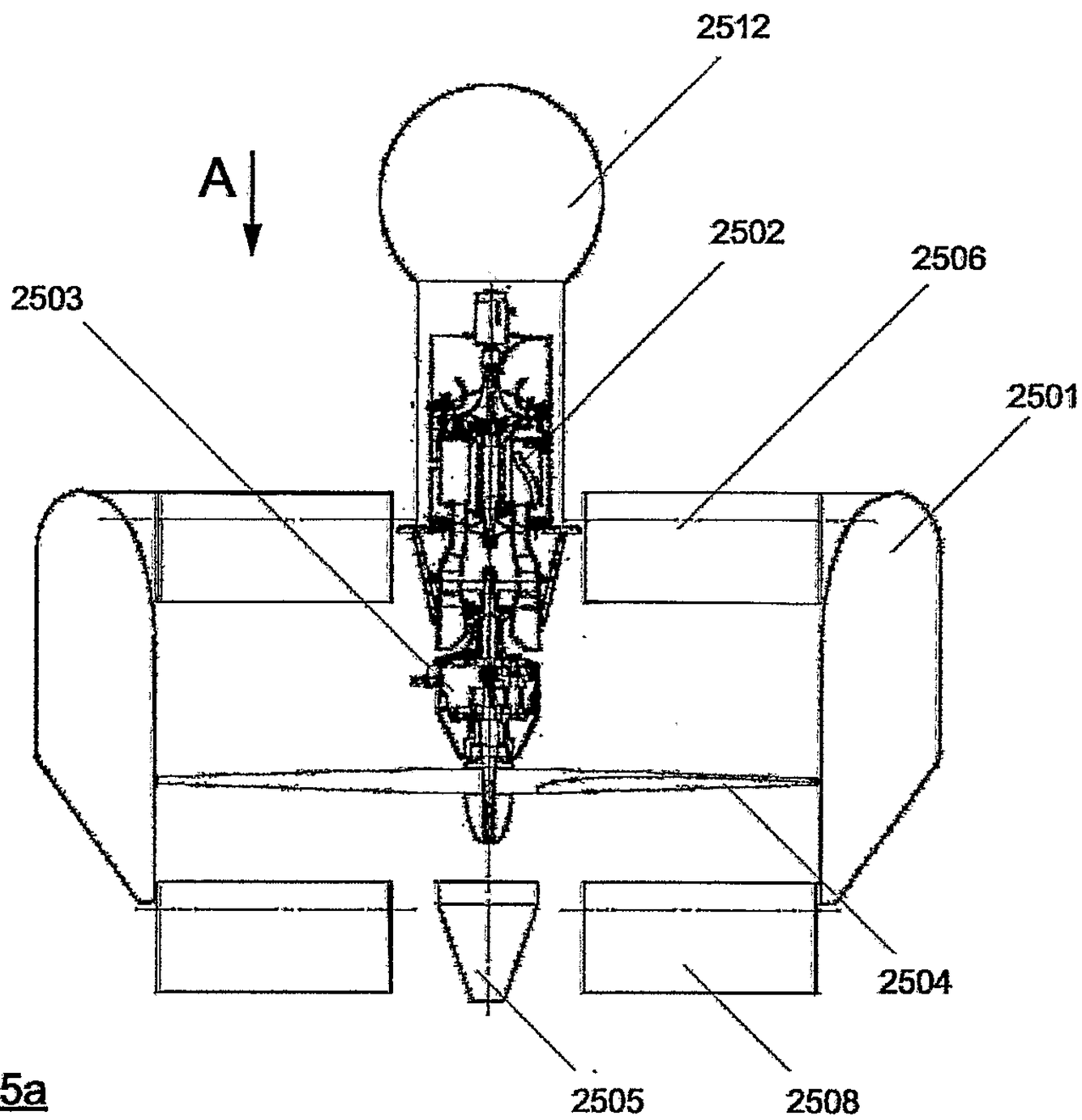


Fig. 25a

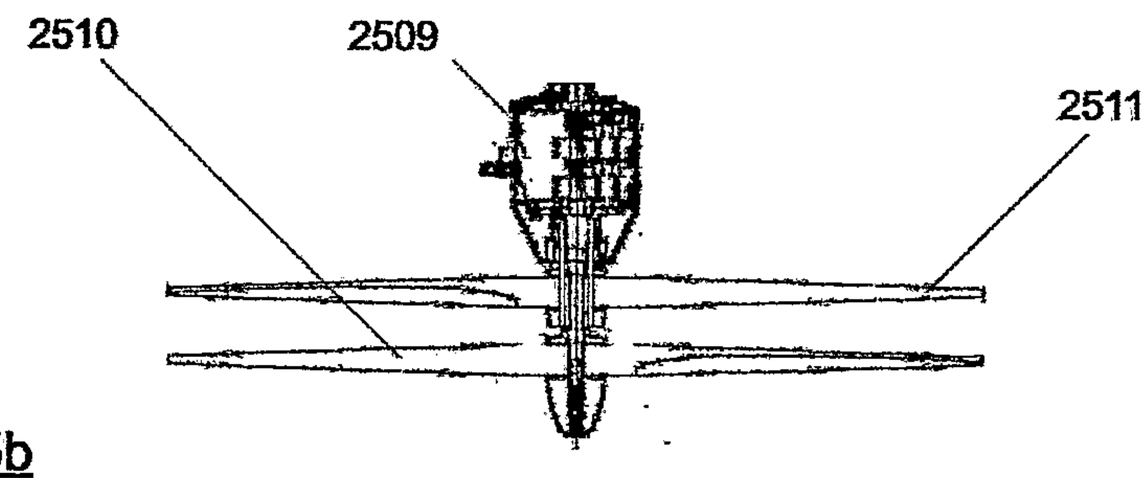


Fig. 25b

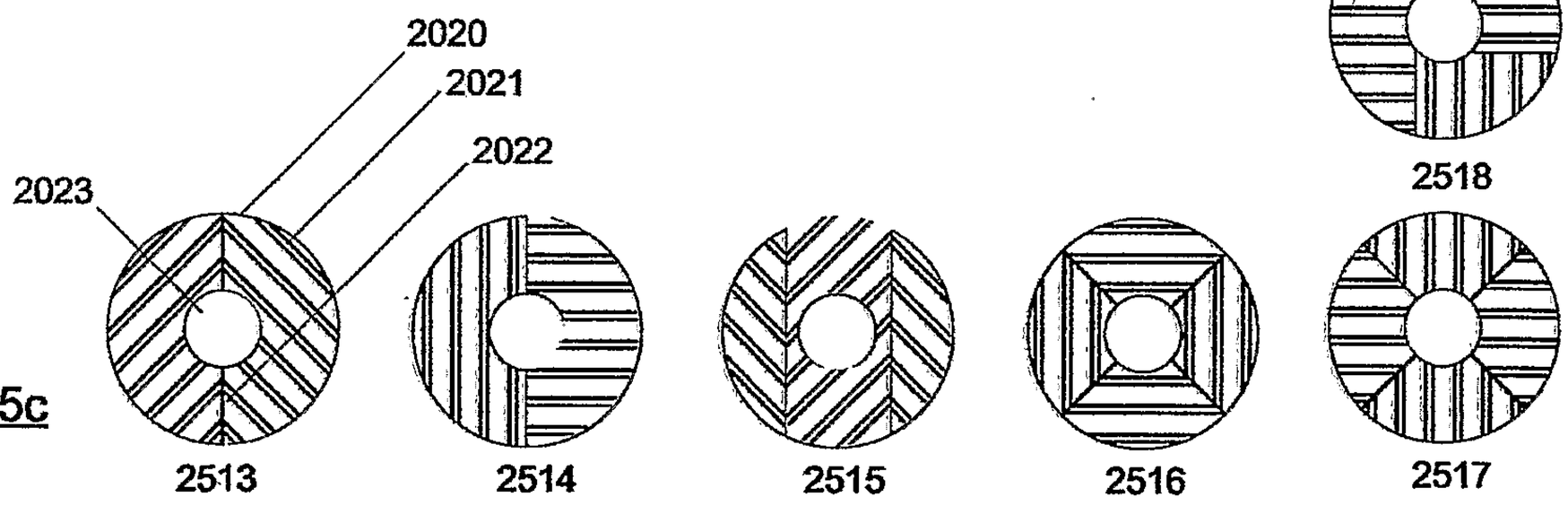


Fig. 25c

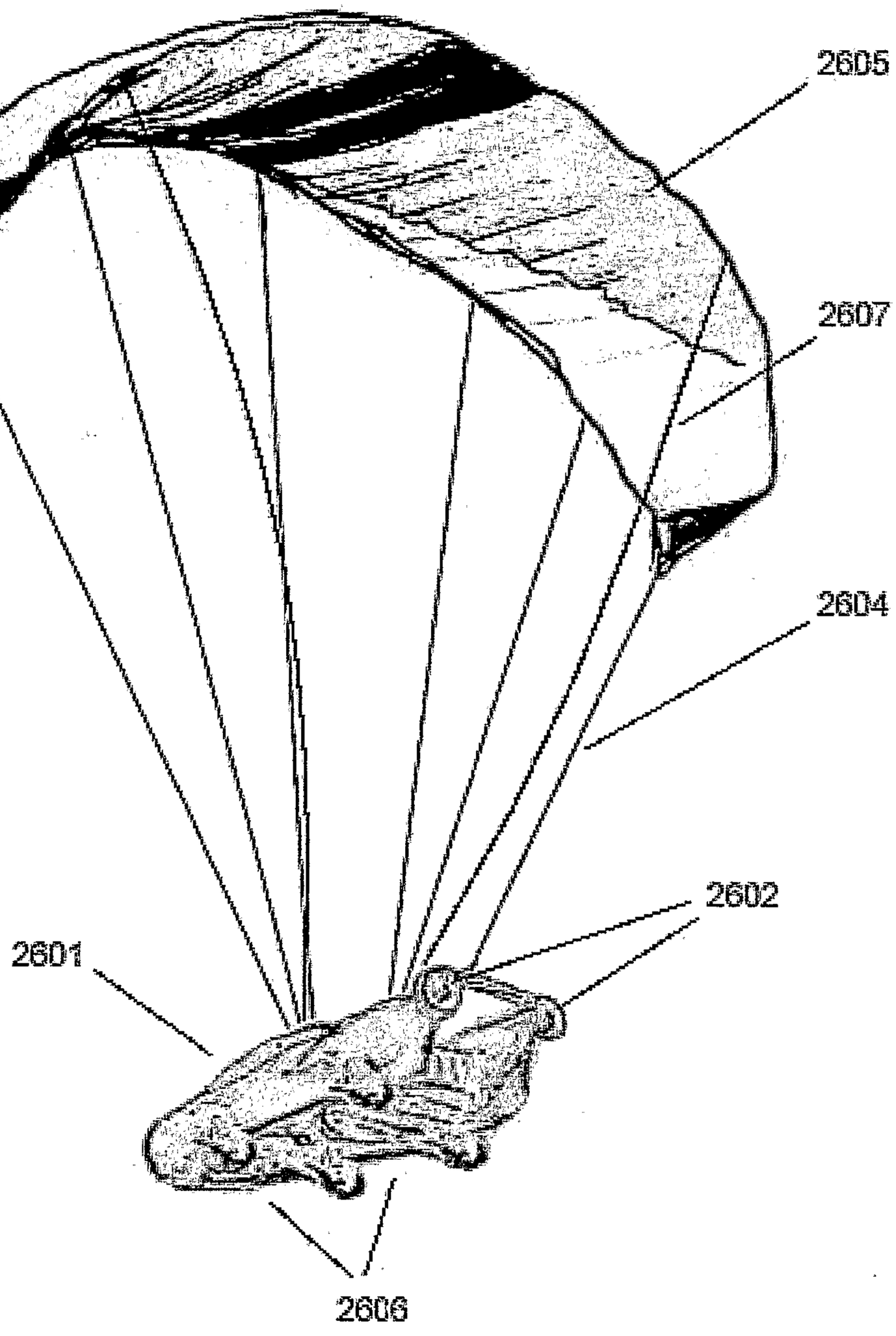


Fig. 26

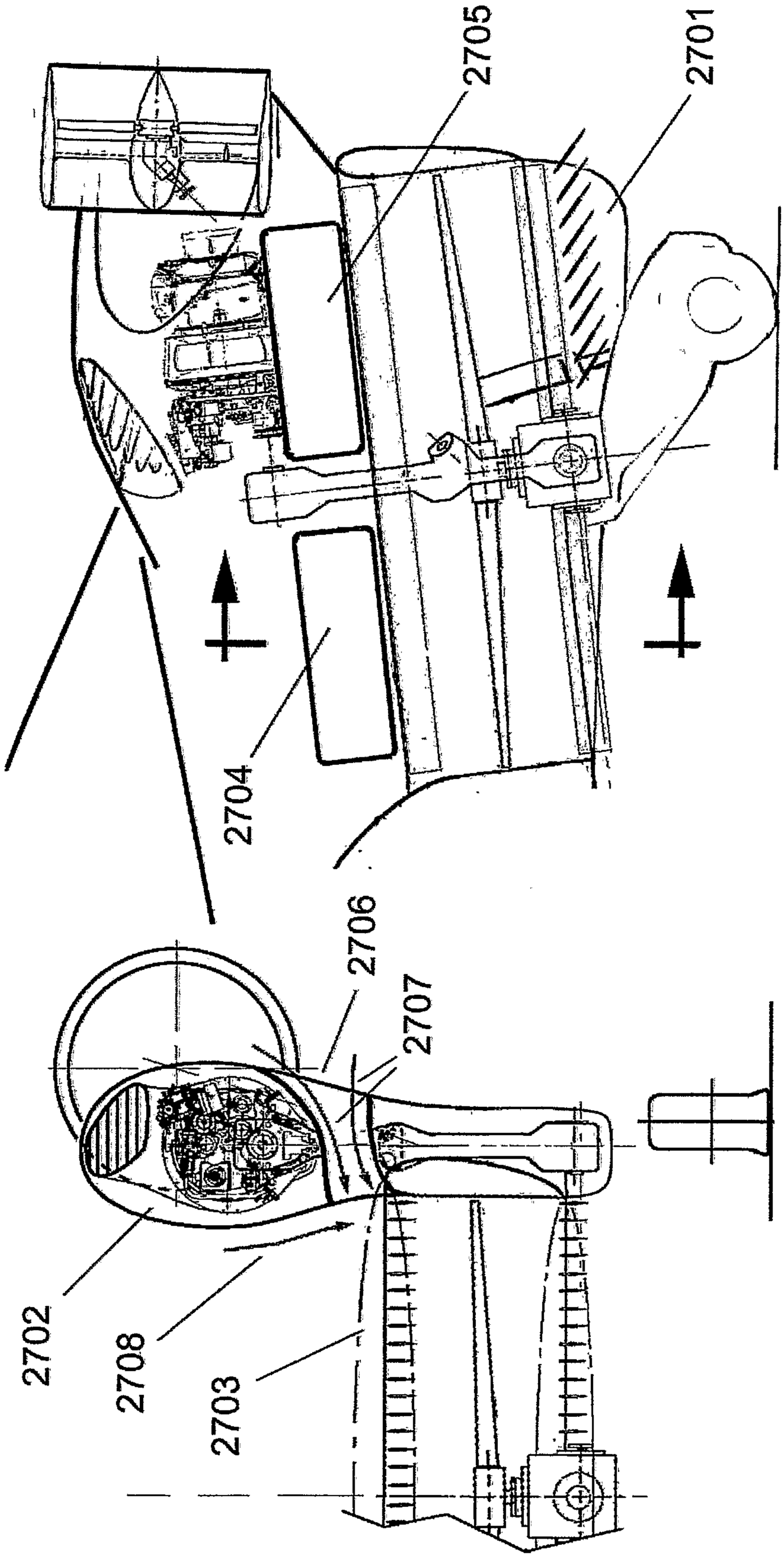


Fig.27

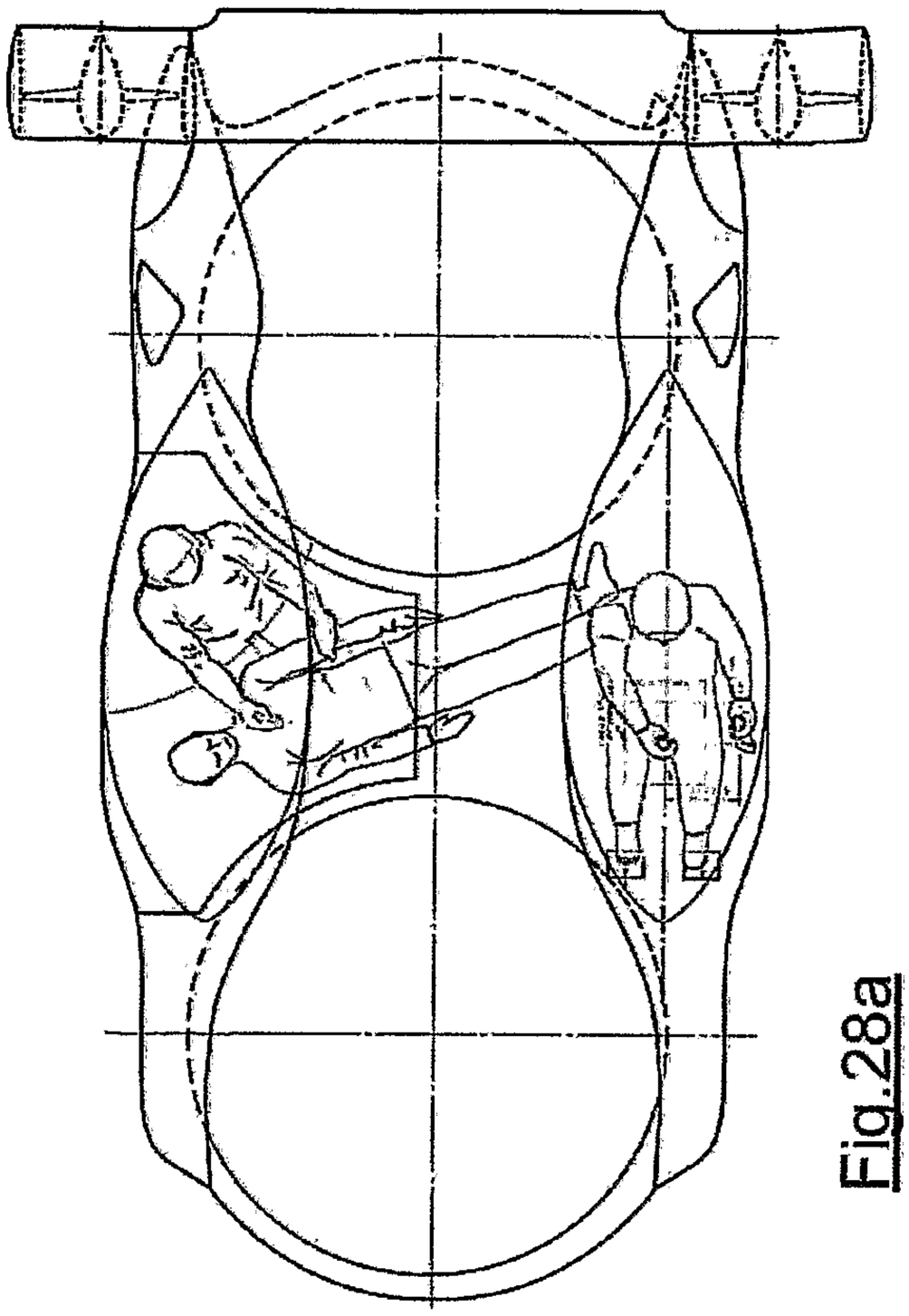


Fig.28a

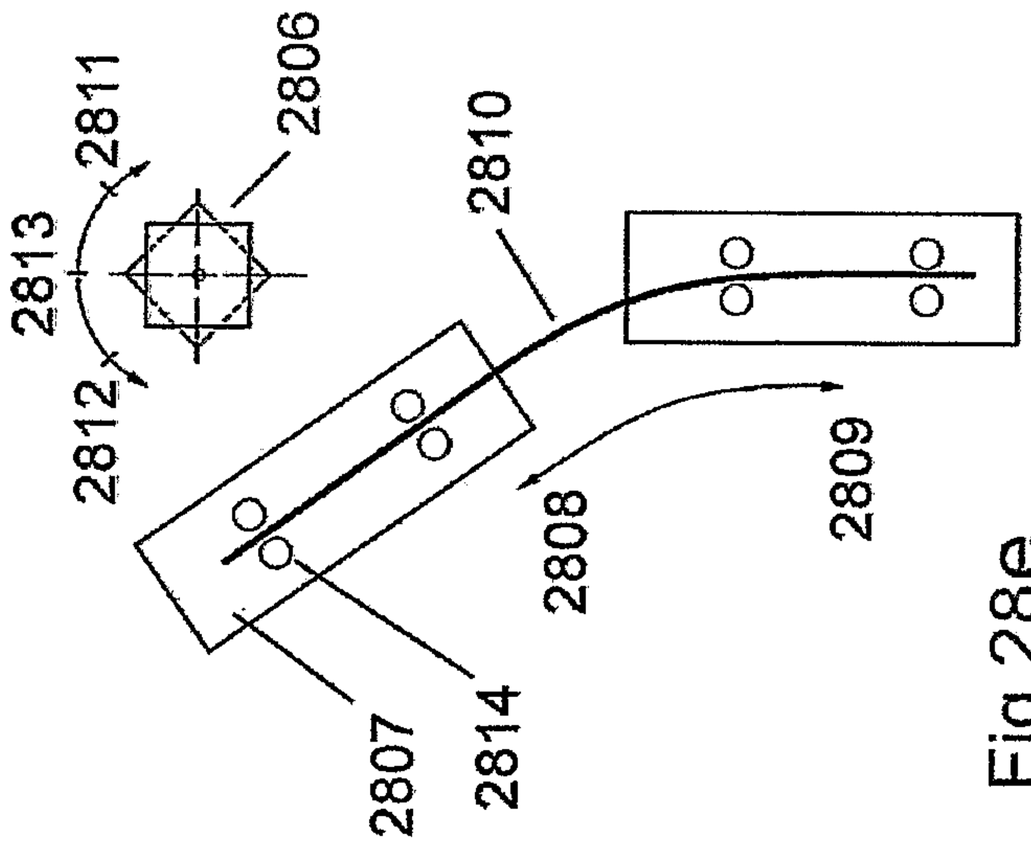


Fig.28e

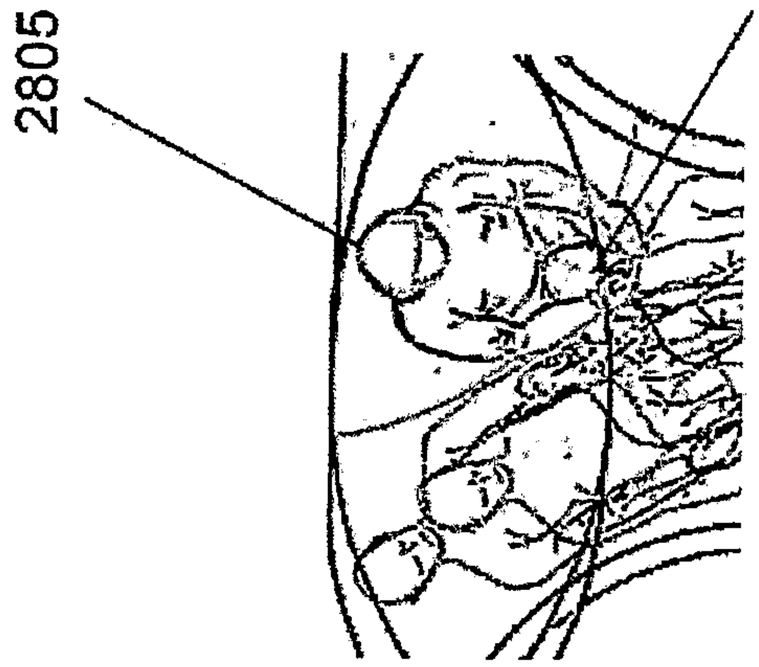


Fig. 28d

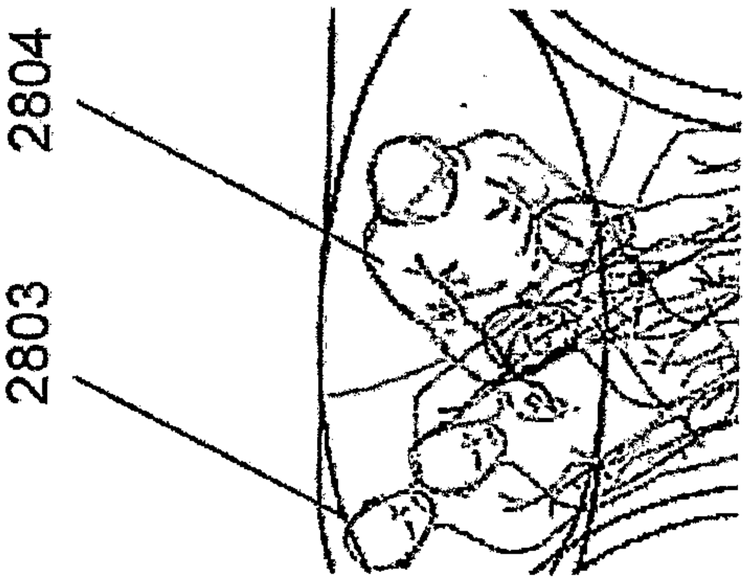


Fig. 28c

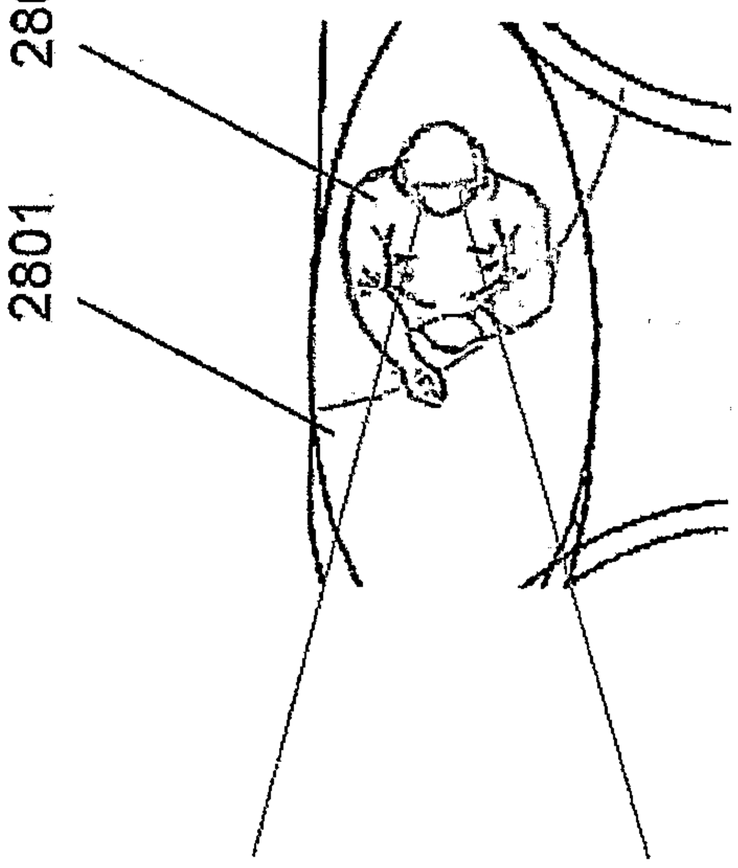


Fig.28b

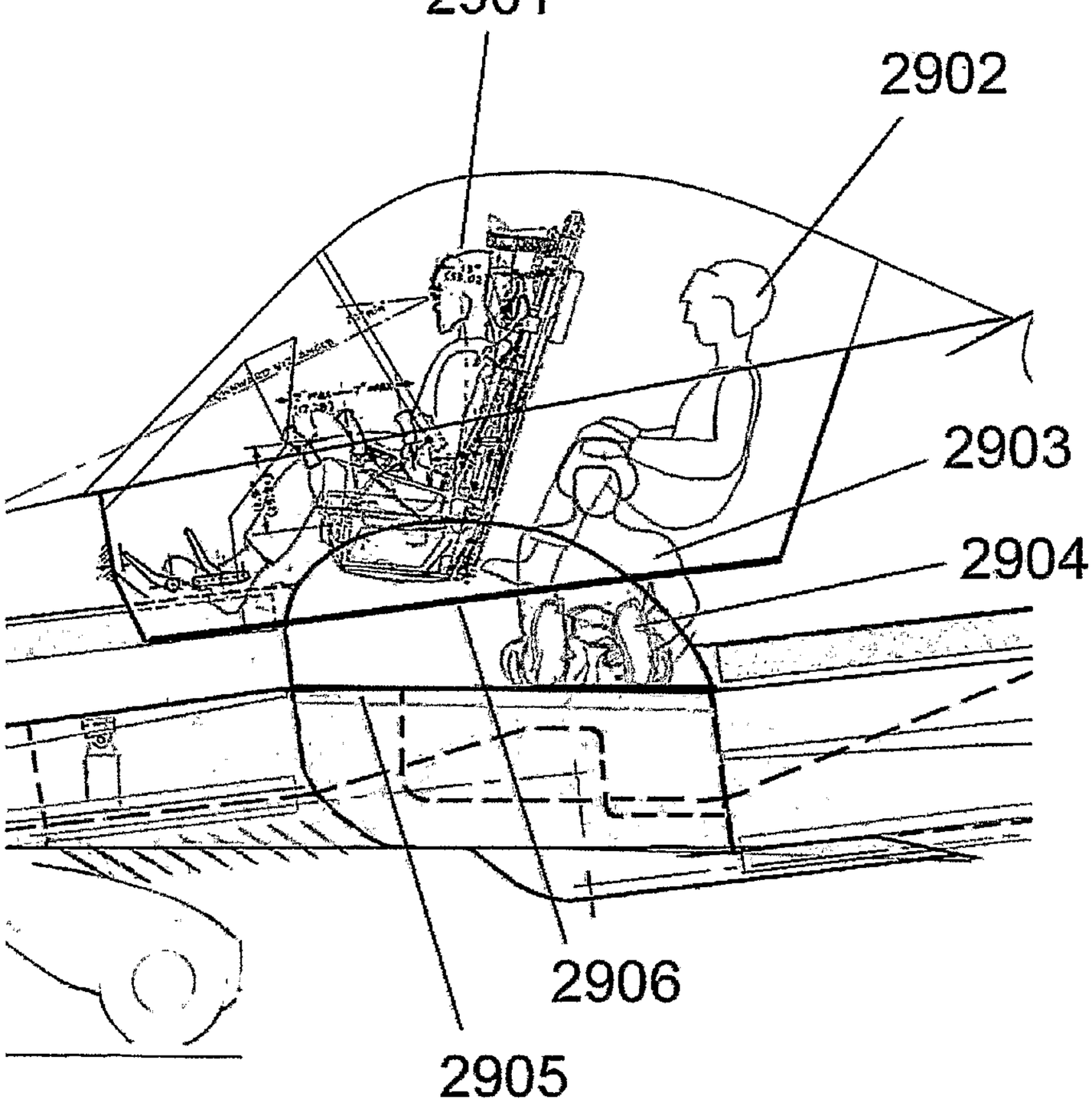


Fig. 29

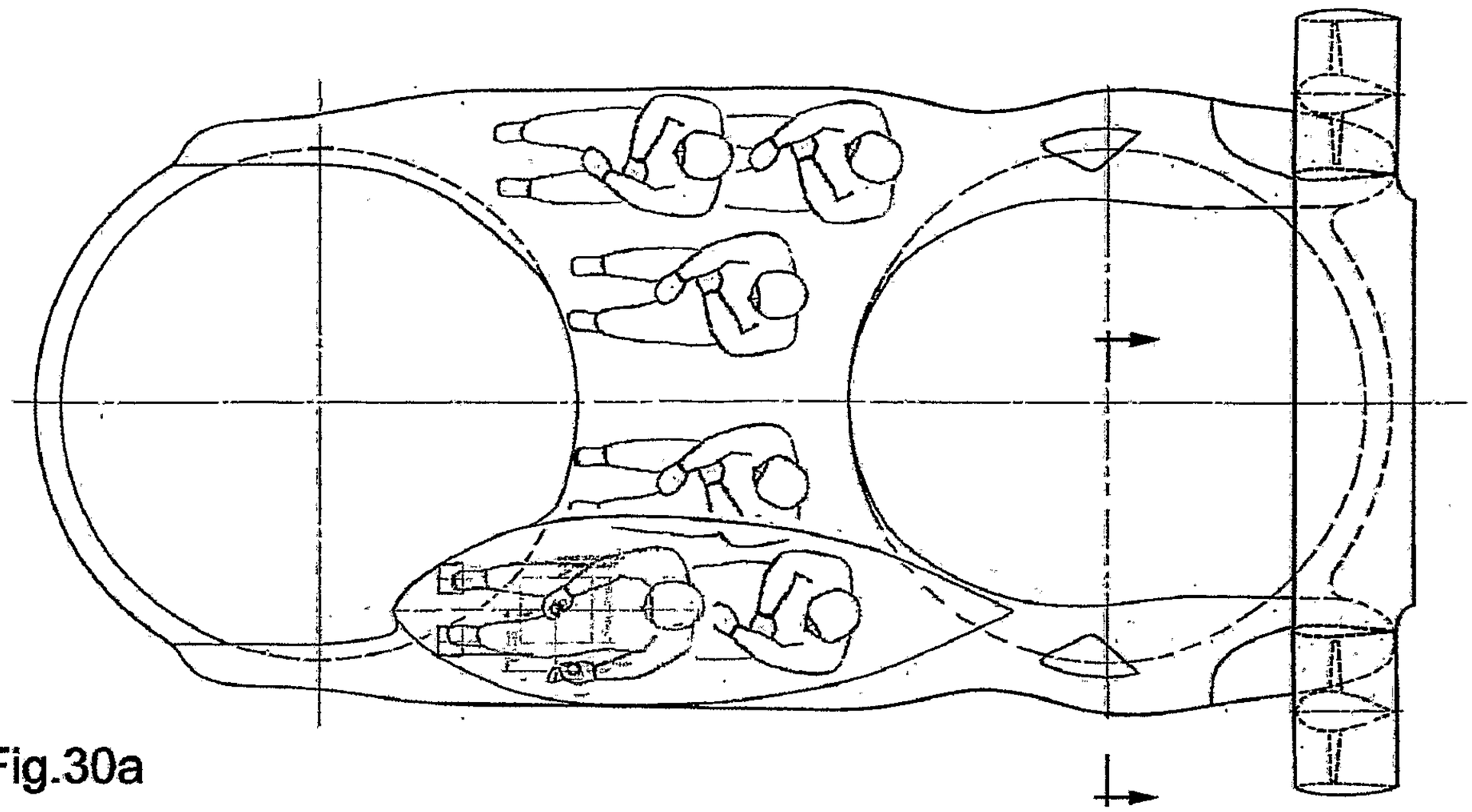


Fig.30a

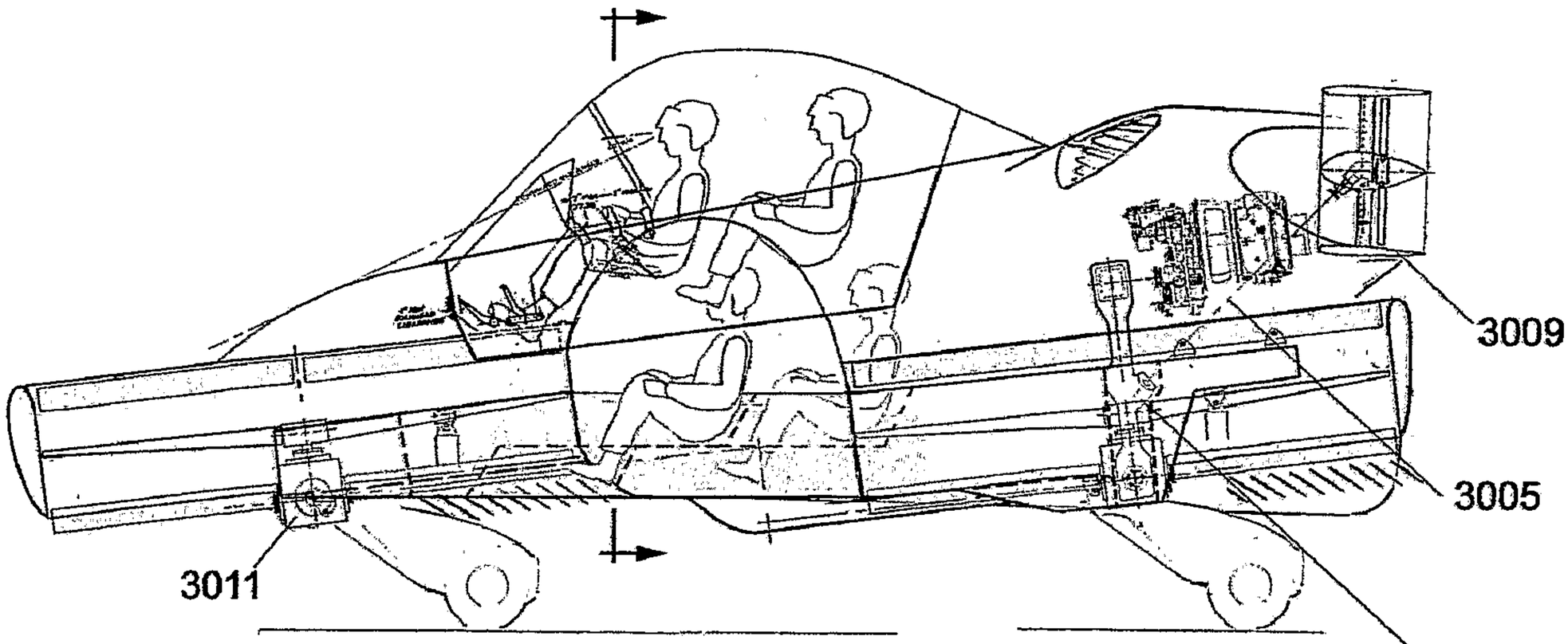


Fig.30b

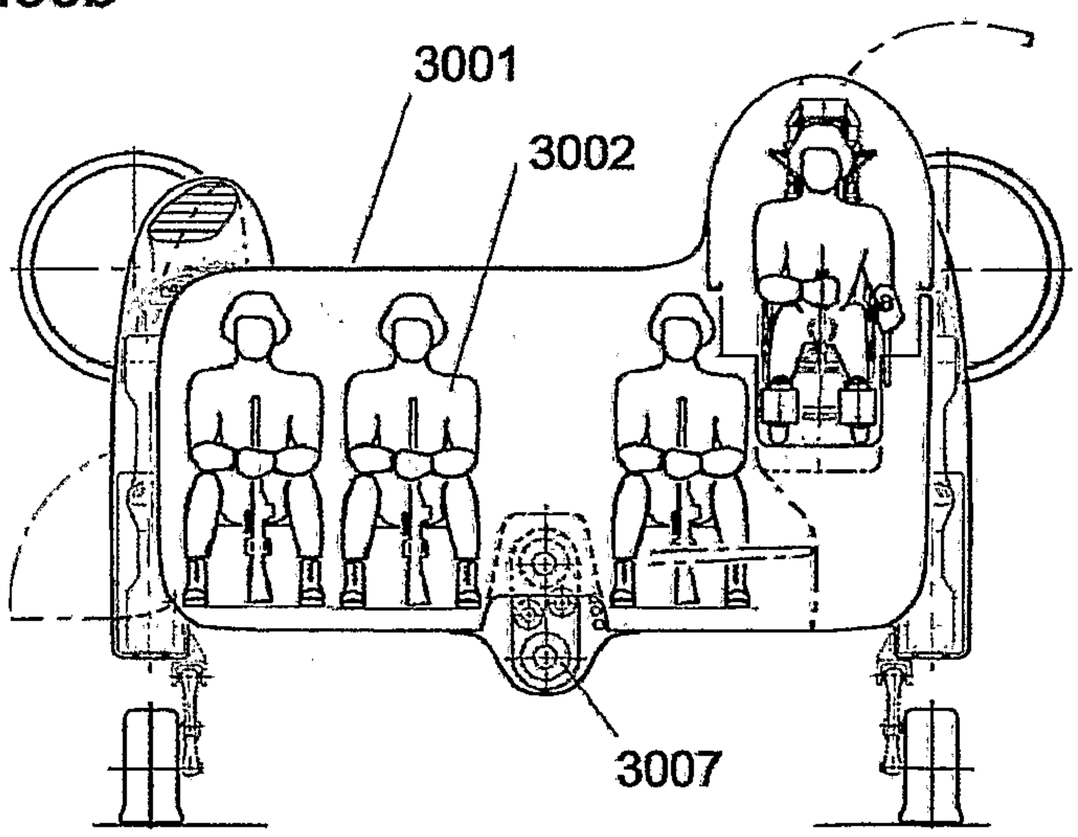


Fig.30c

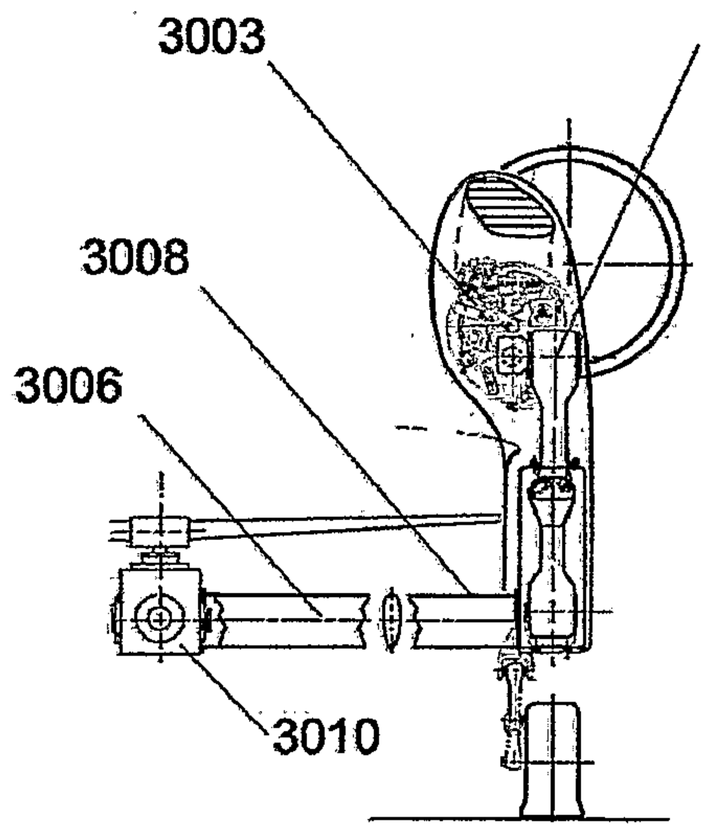


Fig.30d

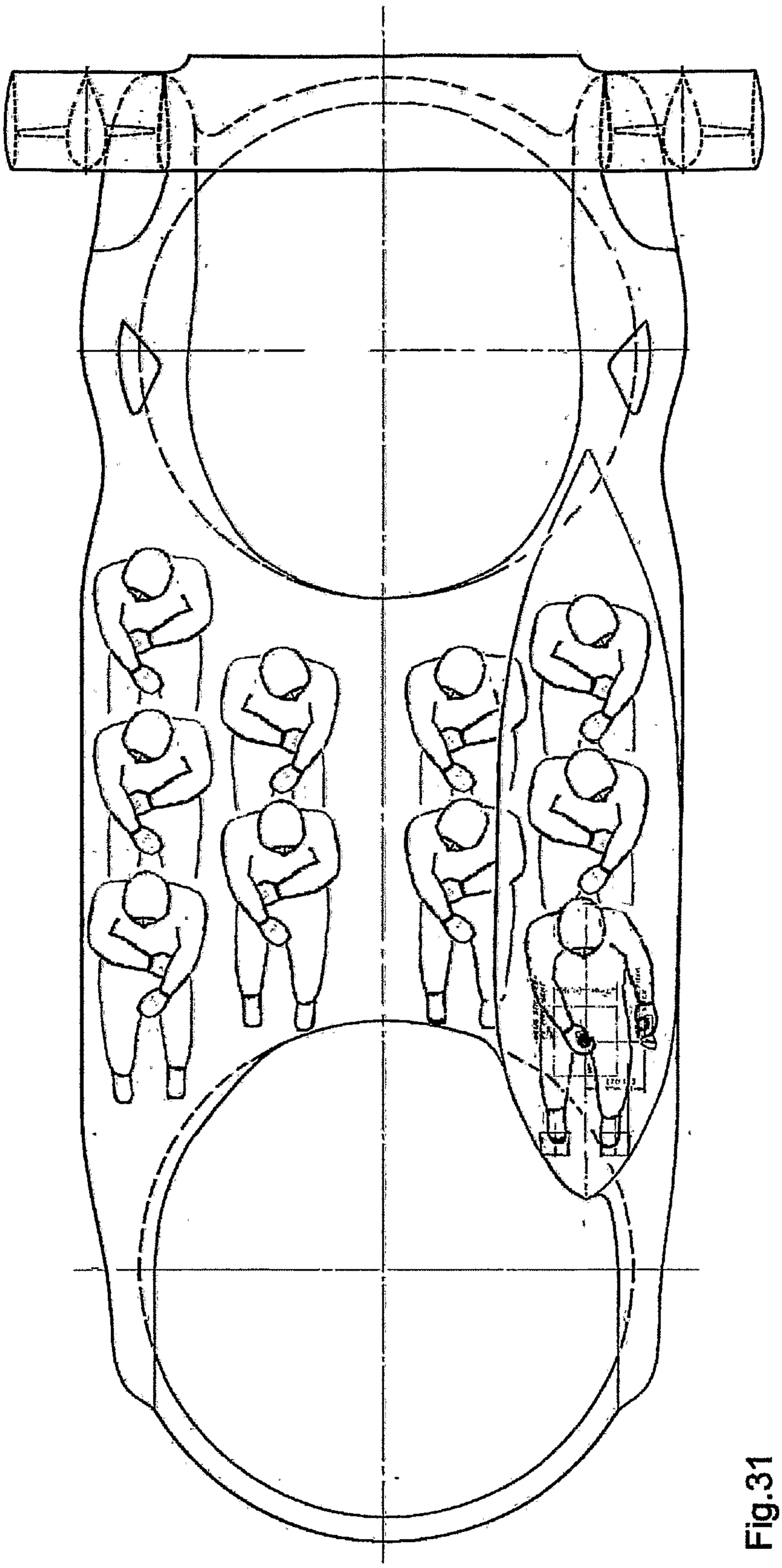


Fig.31

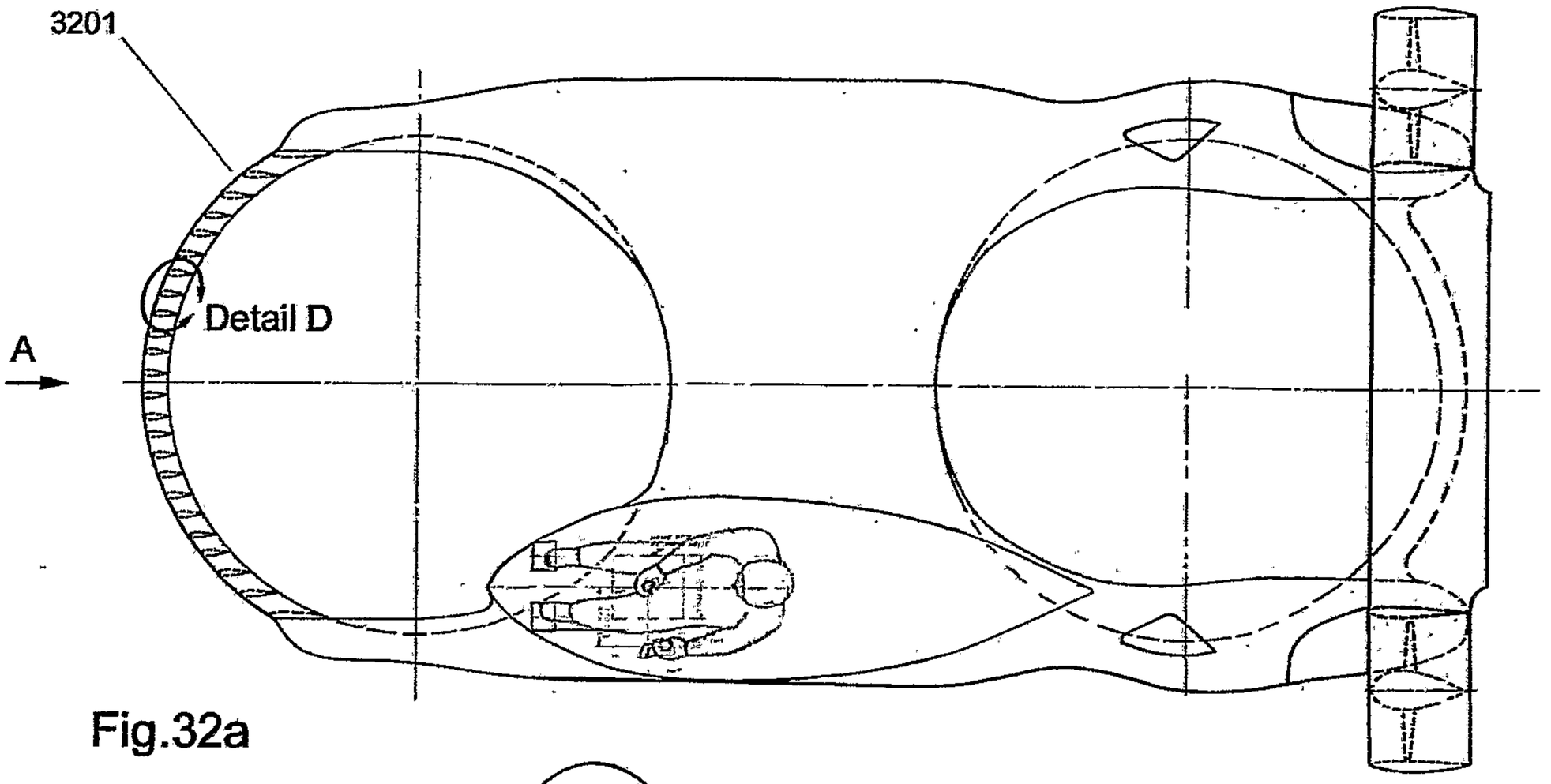


Fig.32a

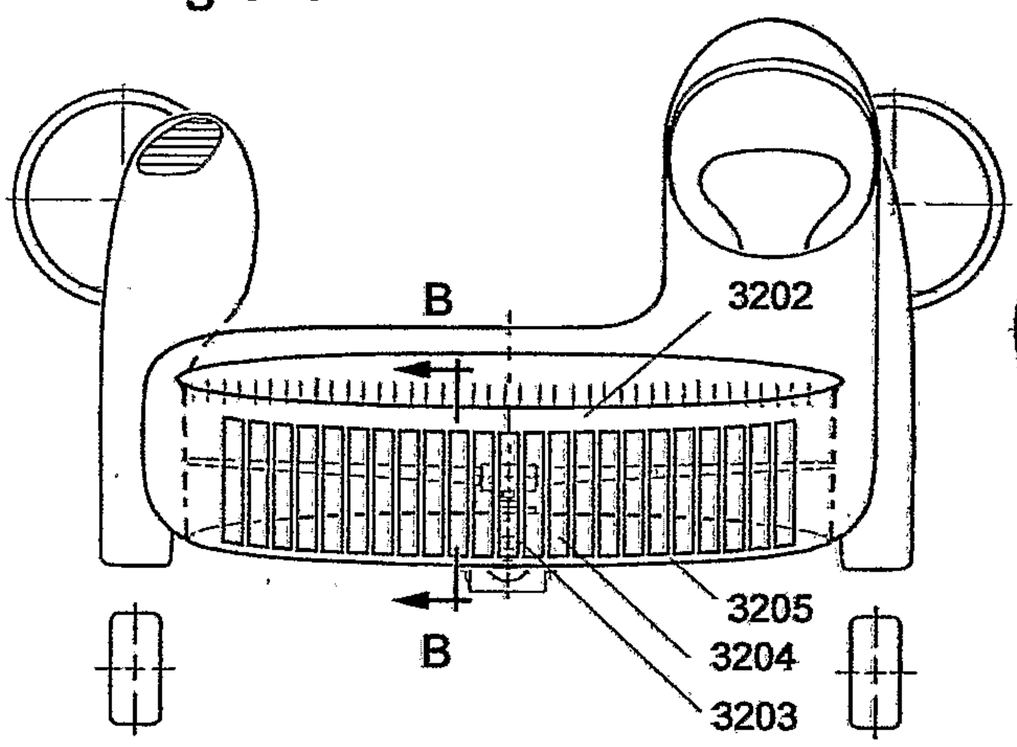


Fig.32b View A

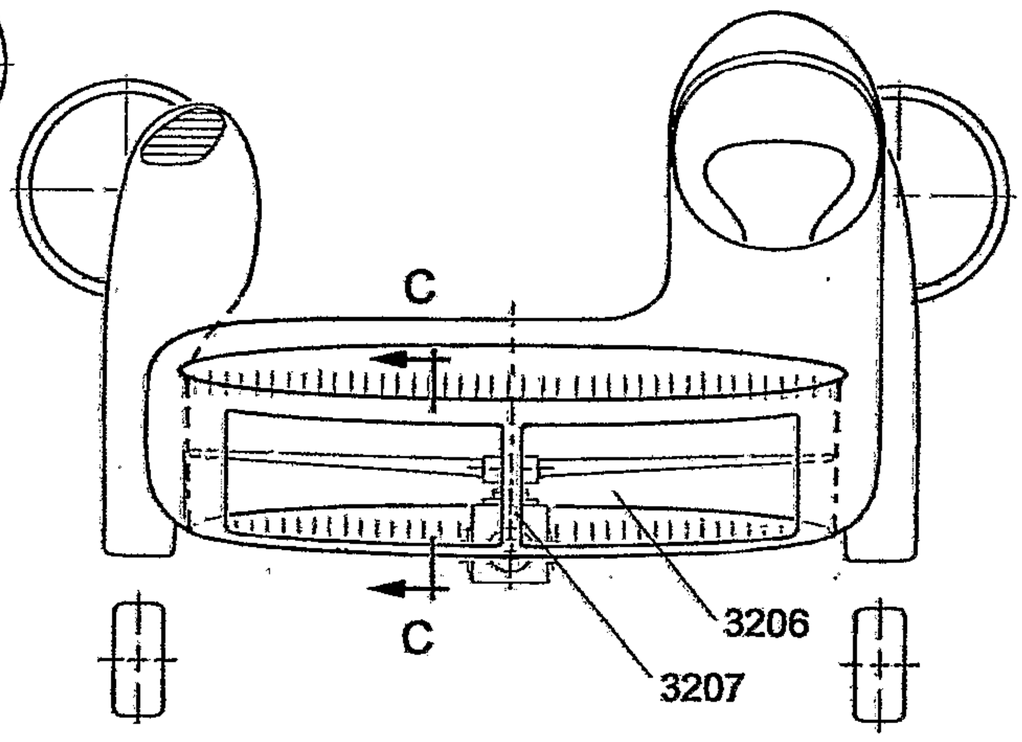


Fig.32c View A (optional)

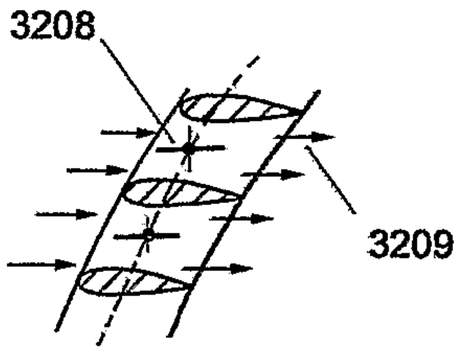


Fig.32d

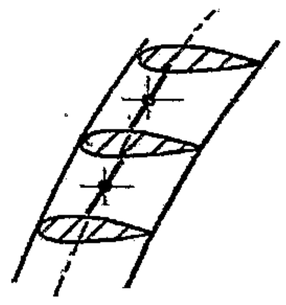


Fig.32e

Detail D

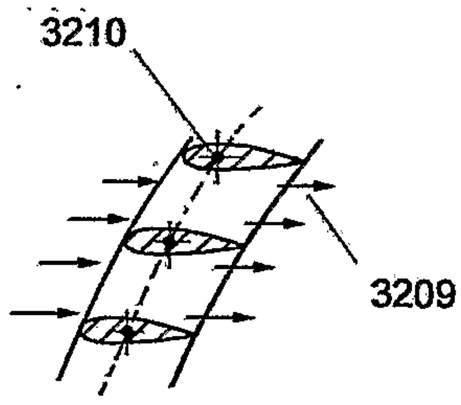
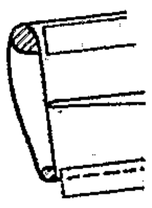
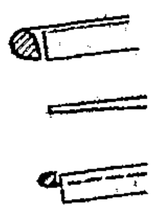


Fig.32f

Fig.32g



B-B



C-C

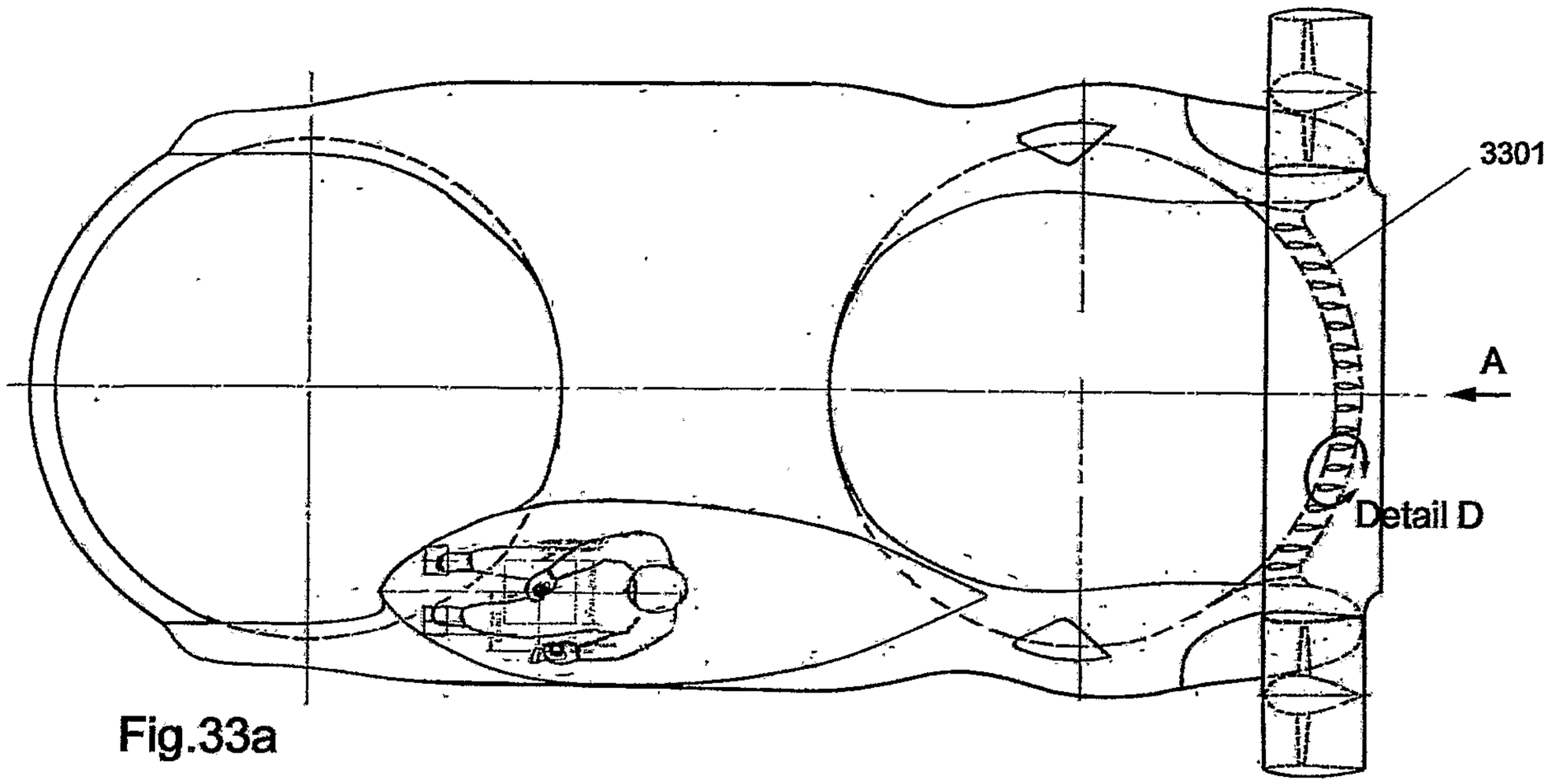


Fig.33a

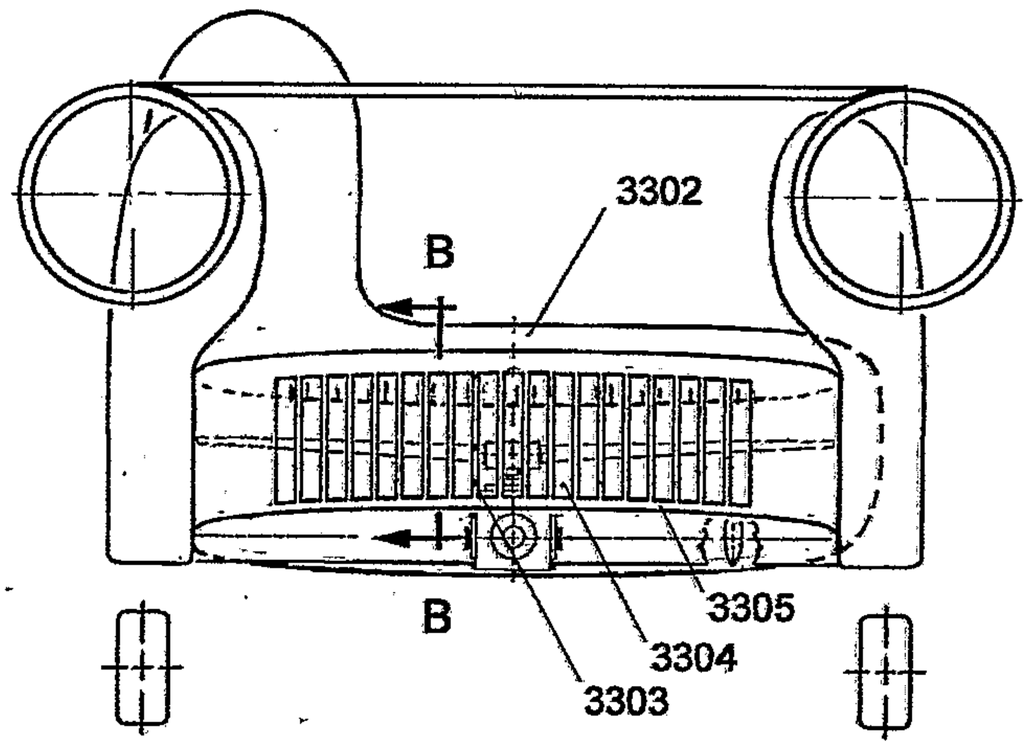


Fig.33b View A

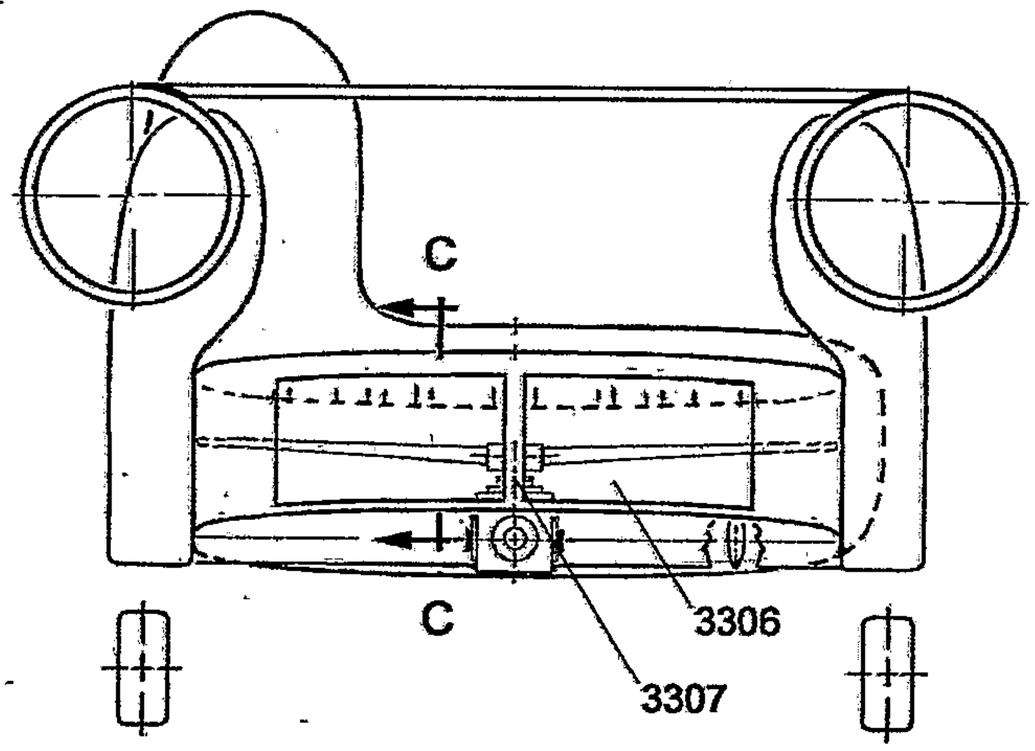


Fig.33c View A (optional)

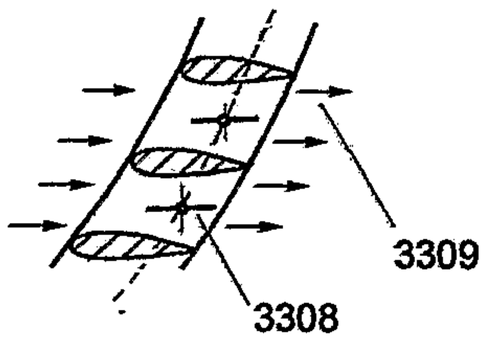


Fig.33d

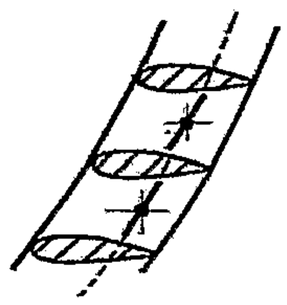


Fig.33e

Detail D

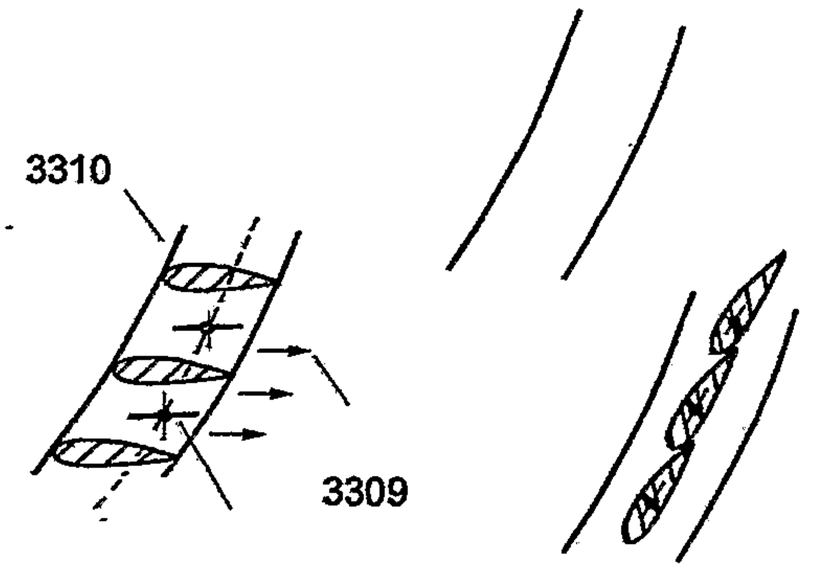


Fig.33f

Fig.33g

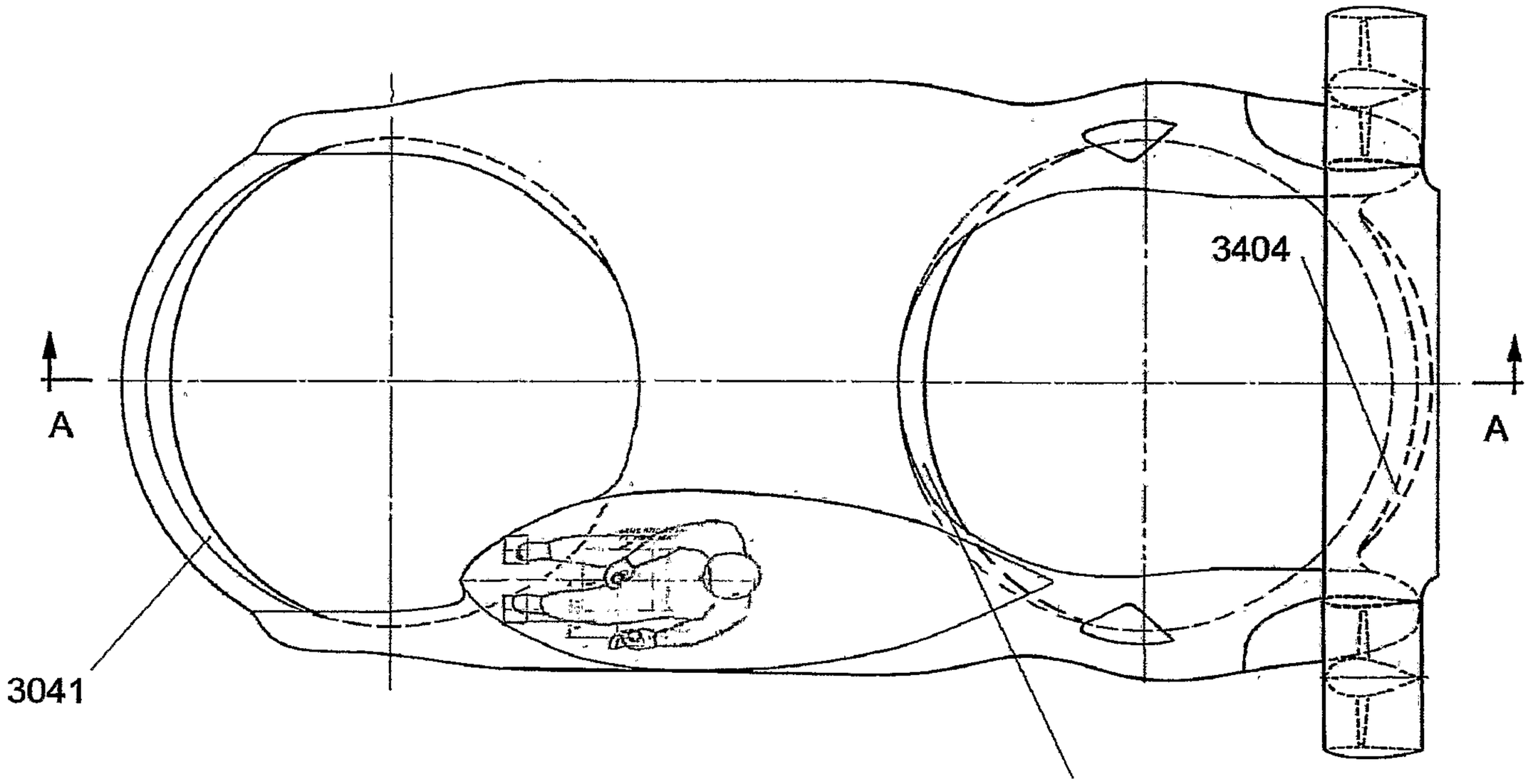
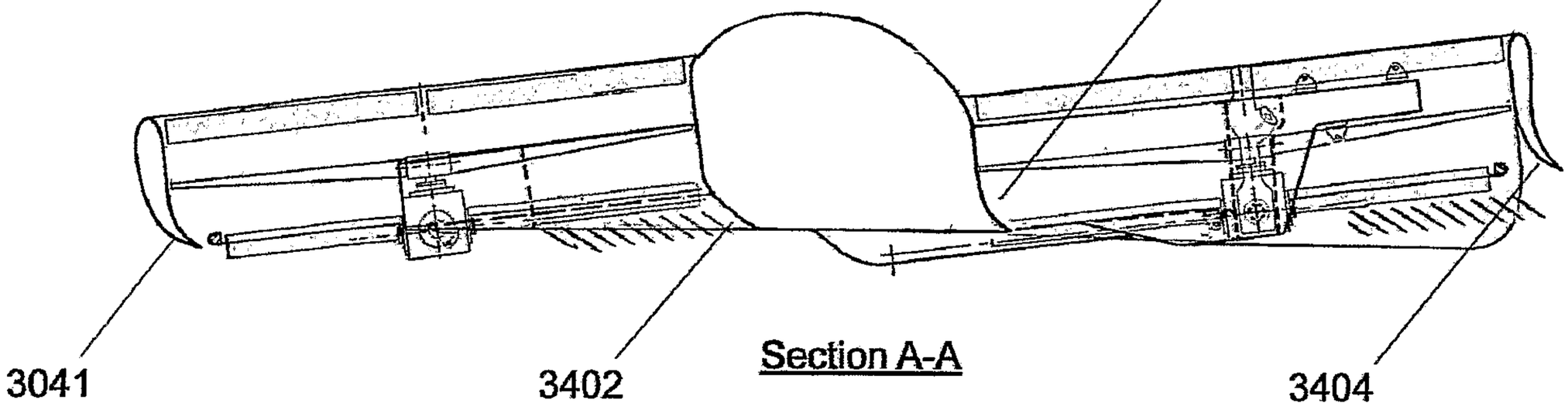


Fig.34a



Section A-A

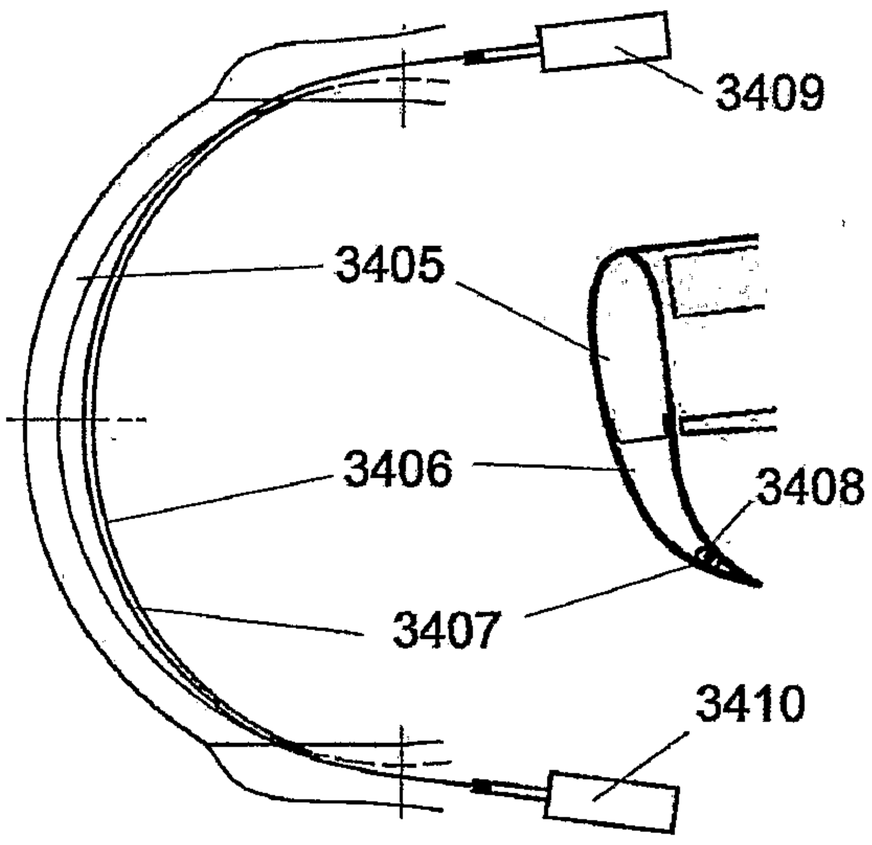


Fig.34b

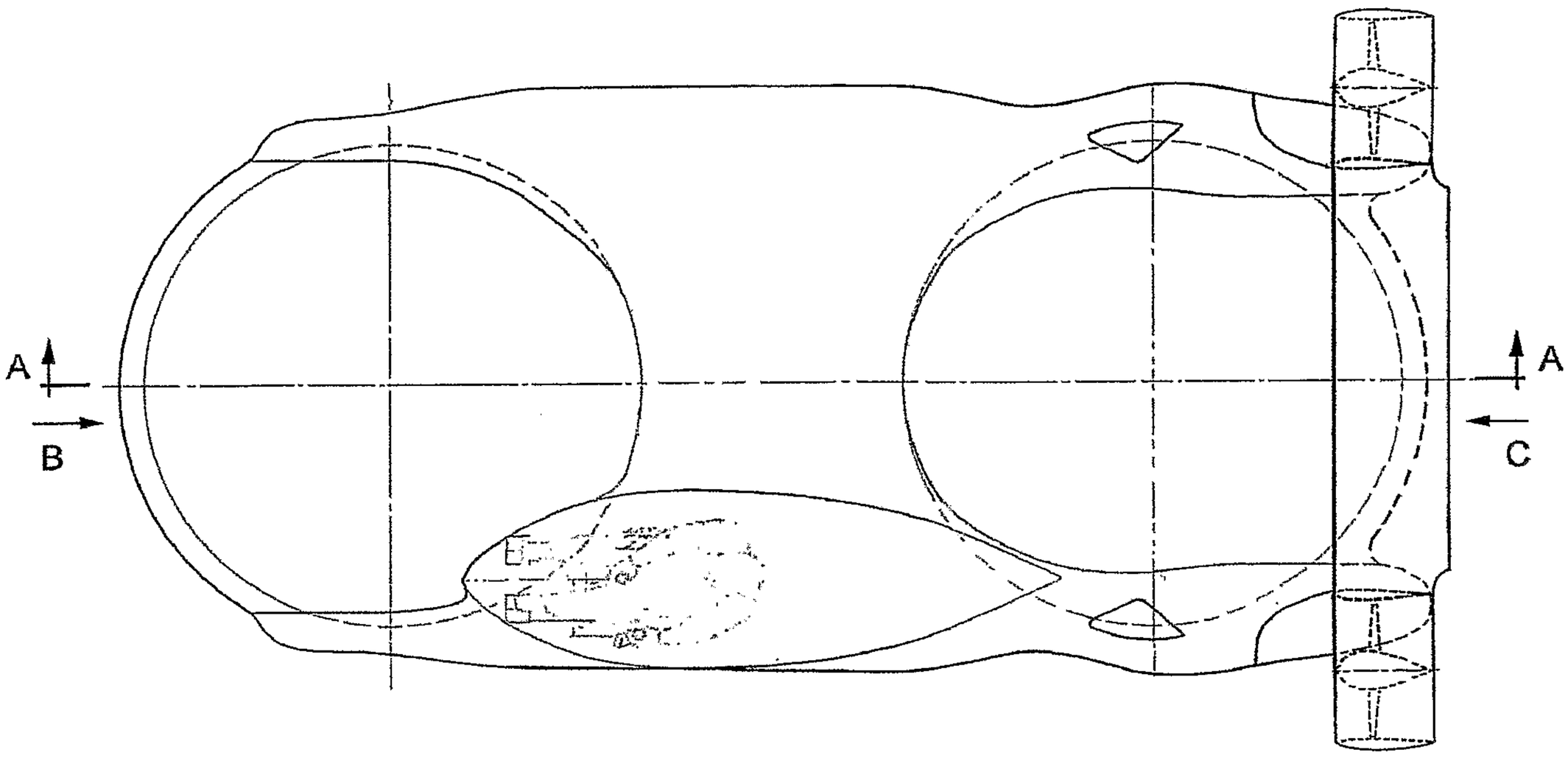
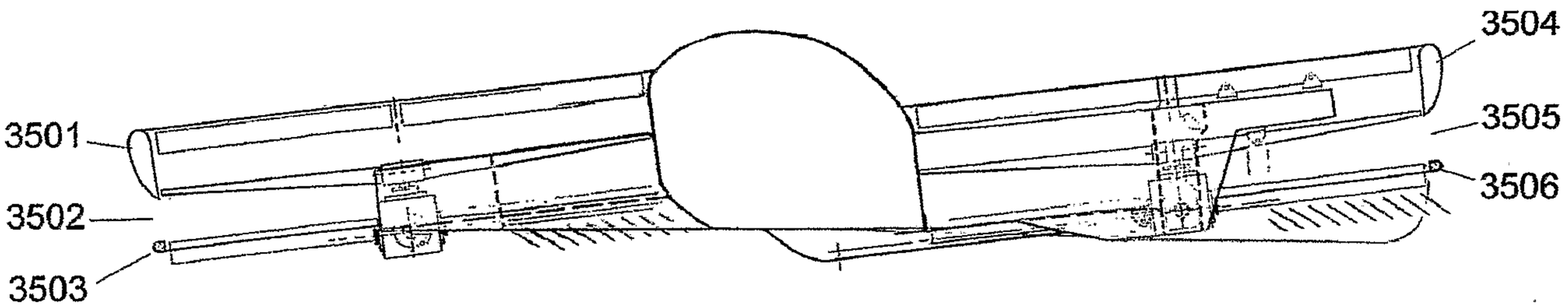


Fig.35a



Section A-A

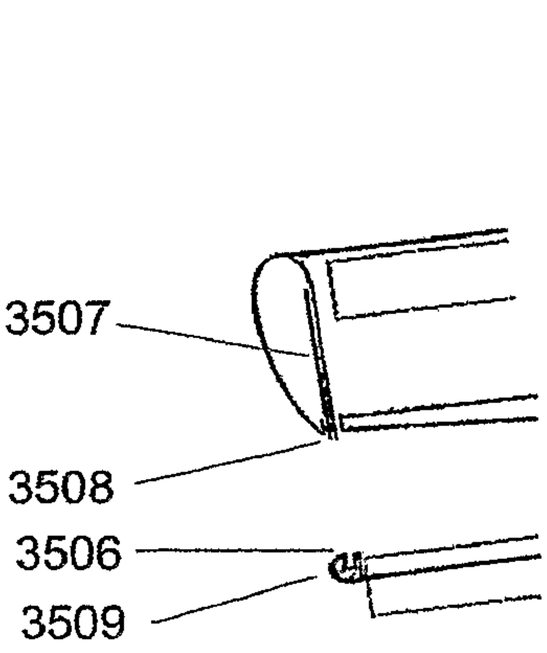


Fig.35b

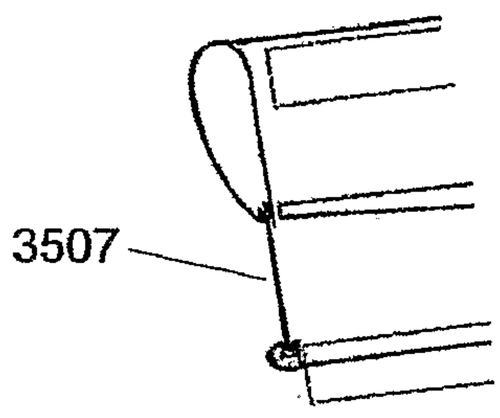
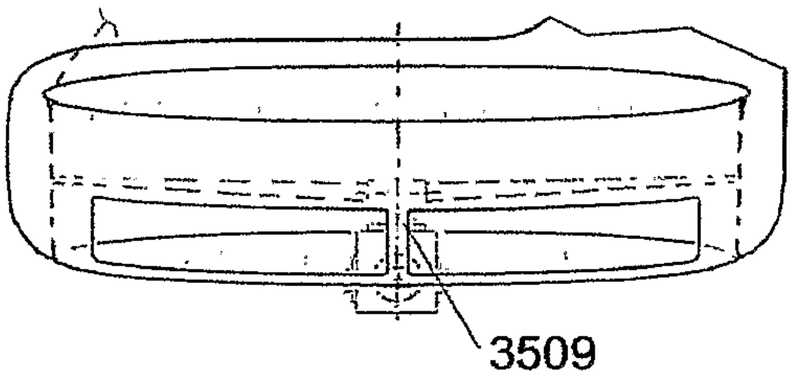
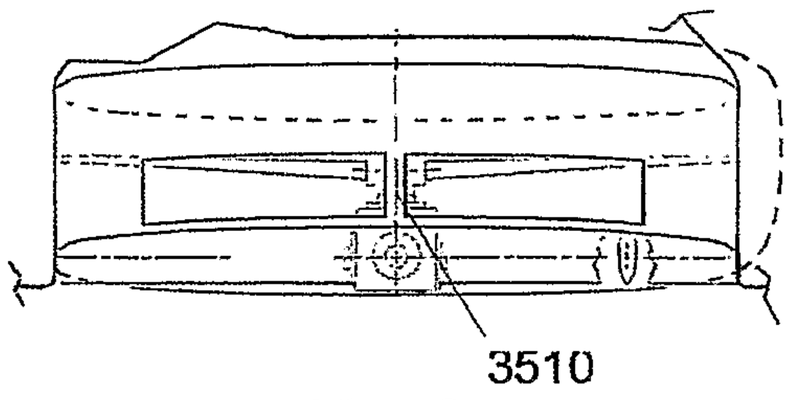


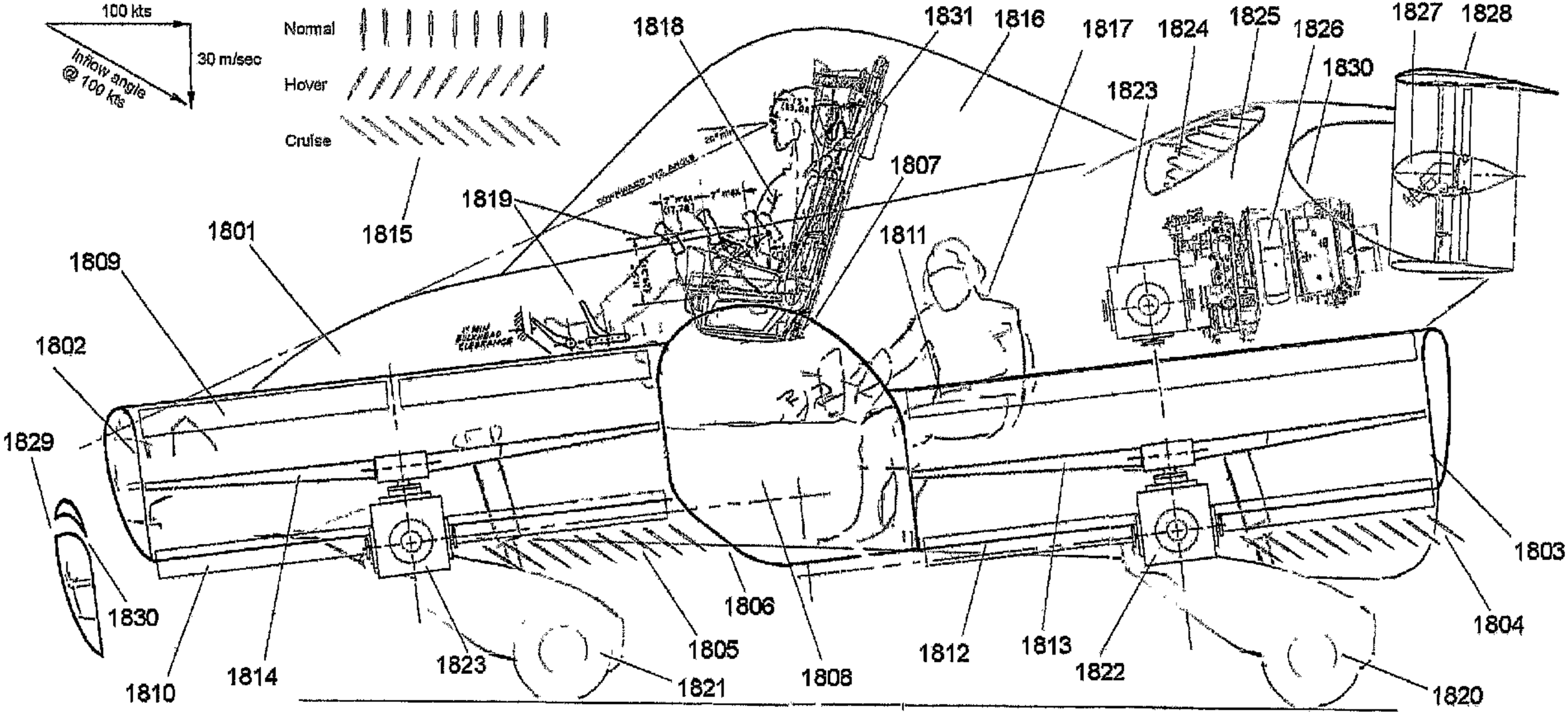
Fig.35c



View B



View C


100 kts
30 m/sec
Inflow angle @ 100 kts
Normal
Hover
Cruise
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