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(71) **Applicant and**
(72) **Inventor: WALDHORN, Joshua** [IL/IL]; 51Hazorea St., 46910 Kfar Shmariyahu (IL).

(74) **Agent: DR EYAL BRESSLER LTD**; 11 Tuval St, 52522 Ramat Gan (IL).

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(54) **Title:** AN AIRCRAFT CATAPULT SYSTEM ACTUATED BY AN ANAEROBIC DEFLAGRATION INTERNAL PISTON ENGINE

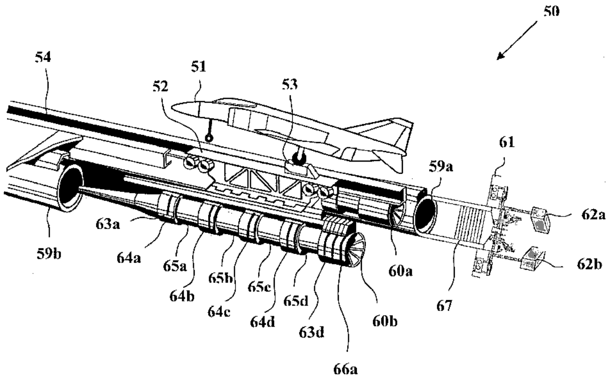

Fig. 5

(57) **Abstract:** A system (10) for launching aircraft (11) actuated by deflagration of anaerobic fuel is disclosed. The system comprises at least one cylinder (19) and reciprocating piston (20) accommodated therein; a plurality of fuel feeding systems (62a, 62b) located in or adjacent to the head (63) of said cylinder, each of said feeding systems adapted to feed a predetermined measure of anaerobic fuel in at least one step per one piston cycle to at least one deflagration chamber (116) located within said cylinder head; ignition means (115) adapted to ignite, in at least one step per piston cycle, at least one predetermined measure of said fuel in a scheduled manner,- and at least one pulling/pushing pad hold-back device (12b) coupling said piston with said aircraft. The piston is adapted to move in response to an impulse provided by expansion of gases following predetermined deflagration of said anaerobic fuel within said deflagration chamber, and said hold-back device is adapted to transmit said impulse to ' said aircraft with sufficient force to accelerate said aircraft to launch velocity.

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AN AIRCRAFT CATAPULT SYSTEM ACTUATED BY AN ANAEROBIC DEFLAGRATION INTERNAL PISTON ENGINE

FIELD OF THE INVENTION

The present invention generally relates to an aircraft catapult system, usable for launching an aircraft from a short runway, by providing a reciprocate motion to the aircraft along the runway at high required acceleration and speed.

The present invention particularly relates to an aircraft catapult system exploiting a powerful internal piston engine, especially a commercially available W. J. Ideal Engine™. The engine is actuated by either single or multiple scheduled predetermined deflagration steps, by at least one propelling material fuel, especially an anaerobic commercially available W. J. Ideal Fuel™, characterized by being either a homogeneous composition or a heterogeneous mixture. The aircraft catapult system is tailored to approach a wide variety of aircraft and aircraft loads, runway lengths, etc.

BACKGROUND OF THE INVENTION

Aircraft catapults are commonly used on aircraft carriers to assist in the launching of aircraft from the carrier deck, by pulling the aircraft along a runway that is too short for the aircraft to reach takeoff velocity unassisted. Currently available aircraft catapult systems consist of a track built into the flight deck, below which sits a large piston actuated by steam pressure. The catapult is attached to the nose gear of the aircraft through the track. Prior to launch, a release bar holds the aircraft in place as steam pressure builds up. The release bar breaks away, freeing the piston to pull the aircraft along the deck at a predetermined high acceleration so that the aircraft can achieve takeoff velocity on a short runway. Within about four seconds, the aircraft velocity is sufficient for aircraft to take off. Aircraft catapults were initially used in World War II and are still used on aircraft carriers. The extremely high mass of a fully loaded aircraft coupled with a high acceleration rate that has to be applied to the aircraft for reaching takeoff speed on a short runway require that the catapult engine system be exceptionally powerful.

Commercially available aircraft catapults are powered by steam engines requiring sizeable steam boilers to accommodate the catapult power requirements. The considerable amount of energy required to generate the steam necessary to power the four catapult systems of the typical aircraft carrier was one of the forces behind the development of nuclear-powered aircraft carriers. An average aircraft weighs 25 tons. For a typical aircraft carrier runway length of 90m, a Newton's second law force calculation shows that a force of approximately 760 kn and consequently a power of 28MW is needed to launch a typical aircraft. There are some serious drawbacks to the use of steam power. For example, the rate of aircraft takeoff is limited to one aircraft per 20sec due to the time required to heat the steam in the boiler after takeoff. Also, the extremely high power required to launch the aircraft further limits the maximum possible aircraft payload to approximately 1.5 tons and thus reduces the combat time of the aircraft. The use of steam also engenders dangers of scorching from steam released to the air and of explosion of the high-pressure steam boiler. The perspective view of FIG. **1** illustrates an artist's conception of an aircraft carrier deck with catapult technology at the current state of the art. Due to the limited time of 20 seconds between successive aircraft launches on a catapult, the limited 1.5 ton of payload allowed for an aircraft and the overall weapon systems required for combat, the aircraft carrier typically contains three catapult systems. FIG. **1** further depicts a control tower bridge for controlling launches off the deck, two aircraft at the sides of the deck and a third aircraft affixed to one of the catapults in the process of taking off. The high energy consumption by each catapult system, the power limits of a catapult steam engine, and the dangers associated with steam boilers indicate a need for alternative methods of powering such catapult systems, namely, methods that are more powerful, more efficient, and less dangerous.

Recently, catapult manufacturers have begun experimenting with systems utilizing electromagnetic power, i.e. linear induction motors. New electromagnetic catapults are more energy efficient and alleviate some of the dangers posed by using pressurized steam. On gas-turbine powered ships, an electromagnetic catapult can eliminate the need for a separate steam boiler for generating catapult steam. Electromagnetic catapults are still experimental, however, and have the serious drawback of requiring an uninterrupted supply of electrical power.

Consequently, there remains a long-felt need for a reliable and powerful catapult system that is free of the dangers and unreliability of currently existing catapult systems. The W. J. Catapult Engine System™ herein disclosed provides a solution for this long-felt need.

SUMMARY OF THE INVENTION

It is thus one object of the invention herein disclosed to provide a system for launching aircraft, comprising (a) at least one cylinder and reciprocating centering piston accommodated therein; (b) a plurality of fuel feeding systems located in or adjacent to the head of said cylinder, each of said feeding systems adapted to feed a predetermined measure of fuel in at least one step per one piston cycle to at least one deflagration chamber located within said cylinder head; (c) ignition means adapted to ignite, in at least one step per piston cycle, at least one predetermined measure of said fuel in a scheduled manner; and (d) at least one pulling/pushing pad (hold-back device) coupling said piston with said aircraft. It is within the essence of the invention wherein said fuel is an anaerobic fuel, and further wherein said centering piston is adapted to move in response to an impulse provided by expansion of gases following predetermined deflagration of said anaerobic fuel within said deflagration chamber, and further wherein said hold-back device is adapted to transmit said impulse to said aircraft with sufficient force to accelerate said aircraft to launch velocity.

It is a further object of this invention to provide a system as defined above, wherein said fuel feeding system further comprises (a) at least one cellulose chamber interconnected with said deflagration chamber, said cellulose chamber adapted for storage of cellulose; (b) at least one nitrating agent chamber interconnected with said deflagration chamber, said nitrating agent chamber adapted for storage of a nitrating agent, said nitrating agent chosen from the group consisting of (1) substantially pure HNO_3; (2) a solution of HNO_3 in water containing more than about 80% HNO_3 on a molar basis; (3) a solution of HNO_3 in water containing between about 70% and about 80% HNO_3 on a molar basis; (4) NO_2; (5) a mixture of NO_2 and water; (6) any other substance capable of nitrating cellulose in the gas phase; (7) any combination of the above; (c) means for transferring a predetermined quantity of cellulose from said cellulose chamber into said deflagration chamber; and (d) means for transferring a predetermined quantity of nitrating agent from said nitrating agent chamber into said deflagration chamber. It is within the essence of the invention wherein said ignition means is adapted to initiate chemical reaction between said cellulose and said nitrating agent to form nitrocellulose *in situ*, and to ignite nitrocellulose formed in said chemical reaction, and further wherein said anaerobic fuel comprises said nitrocellulose formed in said chemical reaction.

It is a further object of this invention to provide a system as defined above wherein the shape of said piston is adapted to trap the mass wave of the expanding gas produced by said predetermined deflagration of said anaerobic fuel, preferably a cone-like shape.

It is a further object of this invention to provide a system as defined above wherein said system further comprises a push rod, said push rod being characterized by two ends, the first of said two ends interconnected with said hold-back device and the second of said two ends interconnected with said engine piston.

It is a further object of this invention to provide a system as defined above wherein said system further comprises a fuel ignition device, disposed in said deflagration chamber, and further wherein said ignition device is adapted to periodically initiate in a controllable manner said predetermined deflagration.

It is a further object of this invention to provide a system as defined above wherein said system further comprises at least one fuel feeding sub-system comprising (a) at least one fuel container; (b) a lead-screw mechanism; and (c) a fuel safety valve. It is within the essence of the invention wherein said fuel feeding sub-system is adapted to feed, in a controllable manner, an adjustable quantity of said anaerobic fuel into said deflagration chamber.

It is a further object of this invention to provide a system as defined above wherein said system further comprises data collecting means and data storing means, said data collecting means being adapted for reading data from said at least one fuel container and for transmitting data to said data storing means, said data comprising parameters selected from a group consisting of (a) the type of fuel in each container, (b) the history of said fuel, (c) the history of said container, (d) the amount of fuel in said container, (e) identification parameters, and (f) any combination thereof.

It is a further object of this invention wherein said piston displacement is coupled to said hold-back device via at least one pulley device, said pulley device comprising at least one pulley and at least one metal cable.

It is a further object of this invention wherein said piston is coupled to said hold-back device via a lead-screw device, said lead-screw device comprising at least one thread helix.

It is a further object of this invention to provide a system as defined above wherein said engine is controlled by an electronic controller operating according to a predetermined protocol, said predetermined protocol adapted to provide control for operations chosen from the group consisting of (a) determining the quantity of said anaerobic fuel to be fed to said deflagration chamber; (b) feeding said anaerobic fuel into said deflagration chamber; (c) opening and closing of valves; (d) initiation of predetermined deflagration of said anaerobic fuel; (e) any combination of the above.

It is a further object of this invention to provide a system as defined above wherein said system further comprises computing means adapted to correlate various parameters such that optimal launching is obtained, said parameters selected from a group consisting of (a) the weight of said aircraft; (b) the profile of said aircraft; (c) the type of anaerobic fuel; (d) the grain size of said anaerobic fuel; (e) the grain shape of said anaerobic fuel; (f) the amount of said anaerobic fuel fed to said deflagration chamber; (g) the size of said deflagration chamber; (h) the shape of said deflagration chamber; (i) the profile of the exhaust from said deflagration chamber; and (j) any combination thereof.

It is a further object of this invention to provide a system as defined above wherein said system further comprises exhaust means adapted to transfer exhaust gases from said at least one cylinder to at least one heat exchanger.

It is a further object of this invention to provide a system as defined above wherein said system further comprises means to combust the inflammable fraction of high-CO content exhaust gases produced by said predetermined deflagration.

It is a further object of this invention to provide a system as defined above wherein said system further comprises exhaust means adapted to transfer exhaust gases resulting from said combustion to at least one heat exchanger.

It is a further object of this invention to provide a system as defined above, wherein said at least one heat exchanger is adapted to operate an apparatus chosen from the group consisting of (a) a secondary generator; (b) an air conditioner; (c) both of the above.

It is a further object of this invention to provide a system as defined above wherein said system further comprises (a) catalyst adapted for reducing the NO_x content of gases produced during operation of said system to less than about 7 ppm; (b) a container for said catalyst; (c) means for flowing said gases over said catalyst.

It is a further object of this invention to provide a system as defined above, wherein said piston, said push rod and said hold-back device are provided in a single linearly actuated piston assembly, and further wherein said assembly is interconnected with a multiply threaded screw.

It is a further object of this invention to provide a system as defined above, adapted to launch aircraft from an aircraft carrier deck.

It is a further object of this invention to provide a system as defined above, adapted to launch small airplanes from the deck of a ship.

It is a further object of this invention to provide a system as defined above, adapted to launch commercial aircraft from a runway located on the ground.

It is a further object of this invention to provide a system as defined above, adapted to launch drone craft from a vehicle chosen from the group consisting of (a) a truck, (b) a train, and (c) a trailer.

It is a further object of this invention to provide a system as defined above, adapted to launch an aircraft from an airborne platform.

It is a further object of this invention to provide a system as defined above, wherein at least one of said pistons is actuated by N deflagration steps, where N is an integer greater than 1, and further wherein each of said N deflagration steps is provided by at least one predetermined quantity of anaerobic fuel.

It is a further object of this invention to provide a system as defined above, wherein at least one of said pistons is a multi-sectional piston, said multi-sectional piston comprising a plurality of pressure rings adapted to divide the volume between the surface of said piston and the inner surface of said cylinder into a plurality of substantially isolated volumes and adapted for use in a cylinder comprising a plurality of gas inlet channels.

It is a further object of this invention to provide a system as defined above, wherein said at least one cylinder further comprises: (a) at least one channel substantially parallel to the housing of said piston, said channel fluidly interconnected at one end with said housing; (b) at least one additional deflagration chamber ("side chamber"), said at least one side chamber fluidly interconnected with the second end of said channel; (c) means for independently introducing a predetermined quantity of said fuel into said at least one side chamber; (d) ignition means for said fuel; (e) means for controlling the timing of said ignition of said fuel in said at least one side chamber relative to said ignition of said fuel in said deflagration chamber such that expanding gases produced by predetermined deflagration of said fuel in said at least one side chamber arrive at the point of interconnection with said channel substantially contemporaneously with the passage of said piston past said point of interconnection. It is within the essence of the invention wherein said expanding gases from said predetermined deflagration of said fuel in said side chamber provide additional to said piston.

It is a further object of this invention to provide a method for launching an aircraft, comprising the steps of: (a) obtaining an aircraft; (b) obtaining an aircraft launching system comprising: at least one cylinder and actuated piston accommodated therein, said piston adapted for reciprocal actuation through a piston cycle from a starting position to an ending position and vice versa, said ending position being associated with the length of said cylinder; a plurality of fuel feeding systems located in or adjacent to the head of said cylinder, each of said feeding systems adapted to feed a predetermined measure of fuel in at least one step per one piston cycle to at least one deflagration chamber located within said cylinder head; ignition means adapted to ignite, in at least one step per piston cycle, at least one predetermined measure of said fuel in a scheduled manner; and at least one pulling/pushing pad (hold-back device) coupling said piston to said aircraft; and (c) actuating said system. It is within the essence of the invention wherein said fuel is anaerobic fuel, and further wherein said step of actuating said system includes performing a predetermined deflagration of said anaerobic fuel such that expansion of gases produced by said predetermined deflagration of said anaerobic fuel provides an impulse to said at least one piston, so that said hold-pack device is moved with sufficient force to accelerate said aircraft to launch velocity.

It is a further object of this invention to provide a method as defined above, wherein said fuel feeding system further comprises (a) at least one cellulose chamber interconnected with said deflagration chamber, said cellulose chamber adapted for storage of cellulose; (b) at least one nitrating agent chamber interconnected with said deflagration chamber, said nitrating agent chamber adapted for storage of a nitrating agent, said nitrating agent chosen from the group consisting of (1) substantially pure HNO_3; (2) a solution of HNO_3 in water containing more than about 80% HNO_3 on a molar basis; (3) a solution of HNO_3 in water containing between about 70% and about 80% HNO_3 on a molar basis; (4) NO_2; (5) a mixture of NO_2 and water; (6) any other substance capable of nitrating cellulose in the gas phase; (7) any combination of the above; (b) means for transferring a predetermined quantity of cellulose from said cellulose chamber into said deflagration chamber; and (c) means for transferring a predetermined quantity of nitrating agent from said nitrating agent chamber into said deflagration chamber. It is within the essence of the invention wherein said step of actuating said system additionally comprises the further steps of (a) introducing a predetermined quantity of cellulose into said deflagration chamber; (b) introducing a predetermined quantity of said nitrating agent into said deflagration chamber; and (c) initiating chemical reaction between cellulose and said nitrating agent. It is within the essence of the invention wherein said anaerobic fuel is nitrocellulose formed during said chemical reaction.

It is a further object of this invention to provide a method as defined above, additionally comprising the step of shaping said piston for maximizing the trapping of the expanding gas wave formed by said deflagration of said anaerobic fuel.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) obtaining a push rod; (b) connecting one end of said push rod to said engine piston; and, (c) connecting the other end of said push rod to said hold-back device.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) providing said piston, said push rod and said hold-back device as a single linearly actuated piston assembly; (b) connecting said linearly actuated piston assembly to a rotating screw, said rotating characterized by at least one independent thread helix.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) obtaining a fuel ignition device, disposed in said deflagration chamber; and (b) actuating said ignition device periodically, in a controllable manner. It is within the essence of the invention wherein said step of actuating said ignition device initiates said predetermined deflagration.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) obtaining at least one fuel feeding sub-system, said fuel feeding sub-system comprising at least one fuel container, a lead-screw mechanism, and a fuel safety valve; and (b) feeding a predetermined quantity of said anaerobic fuel into said deflagration chamber.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) obtaining data collecting means and data storing means; (b) providing means for transmitting data from said at least one fuel container to said data collection means; (c) providing means for transmitting data from said data collecting means to said data storing means; (d) collecting data selected from a group consisting of (1) the type of fuel in each container, (2) the history of said fuel, (3) the history of said container, (4) the amount of fuel in said container, (5) identification parameters, and (6) any combination thereof; and (e) transmitting said data from said data collecting means to said data storing means.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) obtaining at least one pulley device comprising at least one pulley and at least one metal cable; (b) coupling said piston displacement to said hold-back device via said at least one pulley device.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) obtaining a lead screw device; (b) coupling said piston to said hold-back device via said lead-screw device.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) obtaining an electronic controller adapted to provide control for operations chosen from the group consisting of (1) determining the quantity of said anaerobic fuel to be fed to said deflagration chamber; (2) feeding said anaerobic fuel into said deflagration chamber; (3) opening and closing of valves; (4) initiation of predetermined deflagration of said anaerobic fuel; and (5) any combination of the above; (b) controlling said system by means of said electronic controller.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) obtaining computing means adapted to correlate various parameters such that optimal launching is obtained, said parameters selected from a group consisting of (1) the weight of said aircraft; (2) the profile of said aircraft; (3) the type of anaerobic fuel; (4) the grain size of said anaerobic fuel; (5) the grain shape of said anaerobic fuel; (6) the amount of said anaerobic fuel fed to said deflagration chamber; (7) the size of said deflagration chamber; (8) the shape of said deflagration chamber; (9) the profile of the exhaust from said deflagration chamber; and (10) any combination thereof; (b) computing correlations among said parameters to obtain an optimal actuation of said device.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) obtaining at least one heat exchanger; (b) obtaining means for transferring exhaust gases from said cylinder to said heat exchanger; (c) transferring said exhaust gases from said cylinder to said heat exchanger.

It is a further object of this invention to provide a method as defined above, additionally comprising the step of combusting the inflammable fraction of high-CO content exhaust gases produced by said predetermined deflagration.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) obtaining exhaust means adapted to transfer exhaust gases resulting from said combustion to at least one heat exchanger; (b) transferring said exhaust gases to said at least one heat exchanger.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) adapting said at least one heat exchanger to operate an apparatus chosen from the group consisting of (1) a secondary generator; (2) an air conditioner; (3) both of the above; (b) transferring said exhaust gases to said at least one heat exchanger; (c) operating said apparatus.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) obtaining a catalyst for reducing the NO_x content of a gas to less than about 7 ppm; (b) flowing a predetermined portion of said exhaust gas over said catalyst.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) obtaining an aircraft carrier; (b) placing said aircraft launching system on an aircraft carrier; and (b) launching military aircraft from said aircraft carrier.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) placing said aircraft launching system on an ocean-going vessel; and, (b) launching aircraft from said ocean-going vessel.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) constructing said aircraft launching system such that said hold-back device is adapted for use by an aircraft to be launched from a runway located on the ground; (b) launching said aircraft from said runway.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) constructing said aircraft launching system such that said hold-back device is adapted for use by a drone aircraft to be launched from a vehicle chosen from the group consisting of (1) truck, (2) train, (3) trailer; (b) launching said drone aircraft from said vehicle.

It is a further object of this invention to provide a method as defined above, additionally comprising the steps of (a) obtaining at least one additional deflagration chamber ("side chamber"); at least one channel substantially parallel to the housing of said piston, and fluidly interconnected at one end with said side chamber and at the other end with said piston housing; means for independently introducing a predetermined quantity of said fuel into said at least one side chamber; ignition means for said fuel; and means for controlling the timing of said ignition of said fuel in said at least one side chamber relative to said ignition of said fuel in said deflagration chamber such that expanding gases produced by predetermined deflagration of said fuel in said at least one side chamber arrive at the point of interconnection with said channel substantially contemporaneously with the passage of said piston past said point of interconnection; (b) introducing said fuel into said at least one side chamber; (c) igniting said fuel in said at least one side chamber; (d) timing said ignition such that expanding gases created by predetermined deflagration of said fuel in said side chamber arrive at said interconnection point with said piston housing substantially contemporaneously with the arrival of said piston at said interconnection point.

It is a further object of this invention to provide an ocean-going vessel adapted for launching aircraft, said vessel containing at least one deck adapted for launching aircraft and at least one system as defined above interconnected with said deck, and characterized by being sufficiently large, mechanically strong, and stable such that a plurality of aircraft may be stored therein and thereon and launched therefrom by using the system as defined above.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to understand the invention and to see how it may be implemented in practice, a plurality of preferred embodiments will now be described, by way of non-limiting example only, with reference to the accompanying drawings, in which

FIG. **1** illustrates (not to scale) a 3D perspective view of a typical aircraft carrier runway deck comprising three aircraft catapult systems;

FIG. **2** illustrates (not to scale) a side view of a W. J. Catapult Engine™ system on an aircraft carrier deck, with a cutaway view showing its principal working parts, according to an embodiment of the present invention;

FIG. **3** illustrates (not to scale) a side view of a W. J. Land Catapult System™ adapted for launching aircraft from the ground, with a cutaway view showing its principal working parts, according to an embodiment of the present invention;

FIG. **4** illustrates (not to scale) a side view of a W. J. Portable Land Catapult System™ adapted for launching drone aircraft from a vehicle such as a trailer, with a cutaway view showing its principal working parts, according to an embodiment of the present invention;

FIG. **5** illustrates a perspective view (not to scale) of an embodiment of the W. J. Catapult System™ with an aircraft affixed to it in which the W. J. Catapult Engine™ accommodates two W. J. Cylinders™ and two W. J. Pistons™;

FIG. **6** illustrates a perspective view (not to scale) of an embodiment of the W. J. Catapult System™ that comprises a pulley assembly used to multiply the force exerted by the W. J. Catapult Engine™;

FIG. **7** illustrates a perspective view (not to scale) of an embodiment of the W. J. Catapult System™ that comprises lead screw mechanism used to multiply the force exerted by the W. J. Catapult Engine™;

FIG. **8** illustrates a side view (not to scale) of an embodiment of the W. J. Catapult System™, with a cutaway view showing its principal working parts, in which it is adapted for use on a platform suspended in the air by W. J. Heavy Lifters™ high altitude air balloons;

FIG. **9** illustrates a side view (not to scale) of an embodiment of the W. J. Catapult System™ in which it is adapted for use on a platform suspended in the air by W. J. Heavy Lifters™ high altitude air balloons;

FIG. **10** illustrates (not to scale) a cylinder assembly adapted for actuating W. J. Multi-Section Pistons™; and

FIG. **11** illustrates a graph of pressure as a function of time in a W. J. Ideal Piston Engine™ in which multiple ignitions occur.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following description is provided in order to enable any person skilled in the art to make use of said invention and sets forth the best modes contemplated by the inventor of carrying out this invention. Various modifications, however, will remain apparent to those skilled in the art, since the generic principles of the present invention have been defined specifically to provide a unique commercially available W. J. Ideal Piston Engine™ with single or plural thrust used in the W. J. Catapult Engine™ accommodating high efficiency, high power and high internal piston engine power capacity.

In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of embodiments of the present invention. However, those skilled in the art will understand that such embodiments may be practiced without these specific details. Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. Thus, the appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment or invention. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

The drawings set forth the preferred embodiments of the present invention. The embodiments of the invention disclosed herein are the best modes contemplated by the inventors for carrying out their invention in a commercial environment, although it should be understood that various modifications can be accomplished within the parameters of the present invention. Therefore the invention is not limited by that which is illustrated in the figures and described in the specification, but only as indicated in the accompanying claims, with the proper scope determined only by the broadest interpretation of said claims.

The trademark **'W. J. Cylinders™'** refers herein to cylinders of a cylinder engine utilizing predetermined deflagration of anaerobic fuel.

The trademark **'W. J. Pistons™'** refers herein to pistons of a cylinder engine utilizing predetermined deflagration of anaerobic fuel.

The trademark **'W. J. Catapult Engine™'** refers herein to catapult engines utilizing predetermined deflagration of anaerobic fuel.

The trademark **'W. J. Ideal Piston Engine™'** refers herein to a generic piston engine utilizing predetermined deflagration of an anaerobic fuel and a plurality of ignitions in one engine cycle.

The trademark **'W. J. Ideal Fuel™'** refers herein to anaerobic fuel accommodating single or multiple predetermined deflagration process.

The trademark **'W. J. Ideal Engine™'** refers herein to a generic engine utilizing a single or plurality of predetermined deflagration of anaerobic fuel.

The trademark **'W. J. Catapult Engine System™'** refers herein to a catapult comprising a W. J. Catapult Engine as defined above and specially designed pistons and cylinders adapted for use therewith.

The trademark **'W. J. Land Catapult System™'** refers herein to a catapult system used accelerating aircraft on short land based runways.

The trademark **'W. J. Multi-Sectioned Piston™'** refers herein to a piston comprising a plurality of pressure rings that divide the volume between the surface of the piston and the inner surface of the cylinder within which it is contained into a plurality of independent volumes, and which is adapted for use with any of the engines or engine systems described herein.

The trademark **'W. J. Heavy Lifters Balloons™'** refers herein to specially designed hihg-altitude balloons adapted for carrying loads of up to about 50 tons at altitudes of up to about 15 km.

The trademark **'W. J. Containers™'** refers hereinafter to standard international shipping containers being special designed to be used for storage of anaerobic fuel able to keep the anaerobic fuel for very long period time.

The term **'predetermined deflagration'** (abbreviated as **PD**) refers herein in a non limiting manner to deflagration, the parameters of which (including but not limited to rate of deflagration, rate of fuel consumption, and rate of spread of deflagration) are controlled by the shape, size, and geometry of the fuel particles.

The term **'hold-back device'** refers herein in a non-limiting manner to a device that is coupled to and moves with a piston while pulling or pushing a heavy load attached to it.

The term **'centering piston'** refers herein to a piston that is characterized by a plurality of rings adapted simultaneously to keep the piston centered within the cylinder and to prevent the cylinder from distorting out of round.

The high power that can be provided by a piston engine such as a W. J. Ideal Piston Engine™ that is driven by PD of anaerobic fuel, e.g. W. J. Ideal Fuel™, according to the embodiments of the present invention, makes such an arrangement ideal for use in a catapult system for launching aircraft. The high power of a W. J. Ideal Piston Engine™ is derived from the characteristics of W. J. Ideal Fuel™. W. J. Ideal Fuel™ is a chemical composition containing all the oxygen required for the PD of this fuel and therefore does not require an external supply of oxygen as do fossil fuels. Consequently, PD W. J. Ideal Fuel™ engines exhibit high fuel efficiency and high energy capacity. The W. J. Ideal Piston Engine™ is adaptable to multiple fuel ignitions per engine cycle rather than the single ignition of other commercially available engines that require air to supply oxygen. The W. J. Ideal Piston Engine™ is controlled by a universal digital processing controller providing ignition devices' timing signals, fuel feeding signals, engine exhaust valves opening and closing signals. Furthermore, the embodiments of the present invention in which it is adapted for use as a catapult for launching aircraft provide higher power at higher efficiency without the drawbacks and limitations of existing catapult engines.

Because deflagration of anaerobic fuel does not require an external source of oxygen, the W. J. Ideal Piston Engine™ can be operated at high altitudes at which engines using fossil fuels are inoperable or barely operable because the partial pressure of oxygen in the atmosphere is low.

An anaerobic fuel (W. J. Ideal Fuel™) is maximally utilized by accommodating closed loop control electronics unit consisting in a non limited manner of a digital processing controller receiving input data from sensors and outputting control signals to the engine. Engine sensors measure in a non-limiting manner pressure gas produced by PD and the position of the piston. The digital controller transmits control signals to the various units, e.g. the ignition devices and fuel feeding sub-systems. The digital controller initiates the output control signals by comparing required sensors' outputs with actual measured sensor data and deriving the control signal.

Reference is now made to FIG. **1**, illustrating a 3D perspective view of the runway deck of an aircraft carrier. The runway deck is used as a parking space for the aircraft, for launching aircraft for combat missions, and for landing aircraft returning from combat missions. Three catapult systems are located below the runway deck, operating in parallel and hence increasing the launching rate of the aircraft from the aircraft carrier deck.

Reference is now made to FIG. **2**, illustrating a schematic view (not to scale) of a preferred embodiment **10** of the aircraft launching system disclosed in the present invention. In this embodiment, the launching system is adapted to launch an aircraft from the deck of an aircraft carrier. The wheels of an aircraft **11** are attached to a carriage (hold-back device) **12b** which is pulled by cable **26** in mechanical connection with the piston engine. The W. J. Ideal Piston Engine™ used in this embodiment further comprises a centering piston **20** (described in detail below) within a cylinder **19**. The cylinder **19** in this engine is as long as the distance through which the aircraft accelerates before reaching takeoff velocity, i.e., is approximately 90 m. The aircraft is accelerated by the catapult engine to approximately 265 km/hour, equivalent to an average acceleration rate of approximately 30 m/s^2 (~3 G). The W. J. Ideal Piston Engine™ produces sufficient power to accelerate a fully-loaded combat aircraft at this rate. Furthermore, the time between consecutive launches from a steam engine based catapult system is approximately 20s, the time necessary for steam pressure to build up sufficiently for the next aircraft launch, whereas this time is substantially reduced with a catapult system according to the present invention.

Because of the heavy weight of the piston and the horizontal orientation of the cylinder, there is a tendency for the piston to deviate from the true center and for the weight of the piston to distort the cylinder out of round. This distortion will lower the efficiency of the engine, as the pressure rings surrounding the piston will not be able to maintain a good seal with the inner surface of the cylinder. The centering piston **20** is specially designed to solve these problems. In addition to the pressure rings (and in the case of the multi-section piston described below, the additional rings subdividing the volume of the piston chamber), the piston is surrounded by a plurality of centering rings. In some embodiments of the invention, these rings are fit to special grooves of about 3 mm depth, while in others, they are affixed directly to the outer surface of the piston. These rings may be made of any appropriate hard material (e.g. ceramic, glass, metal, etc.) and serve to keep the piston centered in the cylinder. In addition, since the rings are made of a hard material, they will necessarily keep the cylinder at its ideal round shape.

The power for accelerating the aircraft to the desired velocity is provided by appropriately controlling the quantity of fuel fed to the W. J. Ideal Piston Engine™, and/or by using multiple fuel ignitions during the piston displacement, and/or by using an optional multi-sectioned piston that provides a substantial increase in the effective piston area relative to a single-section piston. Piston **20** is driven by PD of W. J. Ideal Fuel™ anaerobic fuel into deflagration chambers disposed at the piston head **21**. Two ignition plugs disposed at the piston head initiate deflagration in the deflagration chambers. The piston is at the start position is when the surface of the piston nearest to the deflagration chambers is located at a predetermined minimum distance from the exit aperture of the deflagration chamber or chambers located in the head **21** of the engine. Engine operation starts at this point when the deflagration chamber is filled with W. J. Ideal™ fuel and the fuel is then ignited by an ignition or heating device located in the cylinder head. Consequently, gas generated by the deflagration of the anaerobic fuel starts exerting force on the front surface of the piston assembly **20.** In response to the pressure created by the gas, the piston starts translating within the cylinder. Hold-back device **12b** is mechanically connected to the piston assembly, and slides within a channel **14** in concert with the motion of the piston. The aircraft is fastened via all or part of its landing gear to the hold-back device by clamp **13**. Thus, as the piston moves, the aircraft is simultaneously accelerated. The hold-back device is also affixed to a stretched cable **26**, constructed from twined metal strands or any other suitable material (the construction of such cables is well-known in the prior art). Cable **26** is also used to return the hold-back device to its starting position after the aircraft has been launched. In addition to depicting the hold-back device **12b** affixed to the aircraft, an empty hold-back device labeled **12a** is depicted at the engine start position. Cylinder **20** further includes at the far end (a) two cavities **16a** and **16b** used to exhaust the air within the cylinder during the translation of the piston away from the cylinder head, and to admit air to the cylinder during the return of the piston to its starting position, and (b) a spring stopper **17**.

The catapult system further includes a spare compressed gas tank **23** for emergency use in case of unexpected failure of the deflagration assembly **21**. The compressed gas is generated inside spare tank **23** by ignition of a predetermined quantity of W. J. Ideal Fuel™ fed into the deflagration chambers of the tank head assembly **24** from fuel containers **25a** and **25b**. If needed, compressed gas flows into the cylinder of the catapult system through pipe **22**; a valve between tank **23** and pipe **22** controls the gas flow.

Reference is now made to FIG. **3**, illustrating a side view (not to scale) of a land embodiment **30** of a catapult system used for reducing length of airport runways. The land embodiment of the catapult system is similar to the one used on an aircraft carrier, except that it is constructed in an underground structure rather than within an aircraft carrier. In this embodiment of the catapult system, clamp **33** is attached at one end to the landing gear of aircraft **31** and at the other to the hold-back device **32b** (the hold-back device is additionally illustrated in its starting position **32a**). The hold-back device moves along a channel **34** and is mechanically connected to piston **39** alongside by cable **46.** The hold-back device, pulled by piston **39** and cable assembly **46** accelerates the aircraft along the catapult runway **35** to takeoff velocity. Piston assembly **39** is a "multi-sectional" piston of a type described in detail below. The front part **38** of the piston is a spherically shaped stopper which stops the piston translation at the end of travel. The multi-sectioned piston structure according to this embodiment can be replaced in another embodiment of the present invention with a regular single surface piston. Cable assembly **46** which is affixed to the holdback device is stretched on wheels **47a** and **47b**. Tension in the cable is maintained by a cable tightening mechanism **47c**. In case of a malfunction of the main engine, auxiliary tank **43** is used. The auxiliary tank holds compressed gas generated by deflagration of anaerobic fuel supplied by fuel container **45** in a deflagration chamber located within the tank head **44**. The deflagration chamber is in fluid contact with the tank such that gases produced by PD within the deflagration chamber escape into the tank. If the main catapult engine should malfunction, a valve opens and the compressed gas flows from auxiliary tank **43** through pipe **42** into the catapult engine. The trench accommodating the catapult system is surrounded by a concrete wall **48**.

This embodiment can be used at high altitude where the partial pressure of oxygen in the atmosphere is so low that combustion engines are inoperative or barely operable. It is also adaptable for remote areas and is operable under extreme weather conditions, thus enabling the launch of aircraft of any type under conditions when normal runway launch is difficult or impossible.

Reference is now made to FIG. **4**, which illustrates a schematic view (not to scale) of an embodiment **40** of the device disclosed herein in which it is adapted to actuate an all weather portable catapult system for drone or unmanned radio controlled aircraft in which the catapult is carried inside a vehicle, e.g. a truck or trailer. In this embodiment, the actuating mechanism is essentially identical to those shown in the previous embodiments, as can be seen in the figure, in which a cutaway view of the inside of the vehicle revealing a side view of the catapult system, is shown. The catapult system, including the deflagration chamber, fuel delivery system, W. J. Ideal Piston Engine™, and cable system, is located within the vehicle.

Drone aircraft **401** sits atop vehicle **402** from which it is launched, and is mechanically connected to the catapult system via hold-back device analogous to those described above. The truck is stabilized via anchors **403** constructed according to principles well-known in prior art. A jack system **404** adjusts the launch angle to a predetermined value desired by the operator.

The mobile catapult system of this embodiment can be installed on any type of vehicle, e.g. trucks, wheeled trailers, light pickup trucks, trains, etc. Built in modularity enables installation of the system onto a standard 40 foot flat international standard shipping container or several containers connected to several units to according to the aircraft size and weight. Mobile catapult systems do not need special preoperational steps and can launch in a very short time any kind of drones or small unmanned reconnaissance planes.

Reference is now made to FIG. **5**, depicting a 3D perspective schematic view of a dual activation aircraft catapult system **50**. This embodiment comprises two independent W. J. Ideal Piston Engines™, which operate in parallel, thus doubling the force applied by the catapult system to the aircraft for launching. Aircraft **51** is mounted on the catapult system and affixed by its landing gear to hold-back device **52** by fastening clamp **53** which slides within channel **54**. The hold-back device is mechanically coupled to two independent "multi-sectional" pistons **60a** and **60b**, which move within cylinders **59a** and **59b**, respectively. In the embodiment of the invention illustrated in FIG. **5**, each piston is centered within a plurality of N rings ($N > 1$). In the embodiment illustrated, ring **63a**, located substantially at the end of the piston away from the deflagration chamber, serves to center the piston within the cylinder and to maintain the substantially parallel orientation of the long axis of the piston with respect to that of the cylinder. Piston rings **64a** – **64d** are pressure rings. When the piston is within the cylinder, these pressure rings divide the volume between the surface of the piston and the inner surface of the cylinder into $N - 1$ substantially isolated smaller volumes (i.e., there is substantially no fluid connection between them). The piston surfaces in gaps **65a** – **65d** between rings **64a** – **64d**, which form one enclosing surface of these volumes, are concave. It is acknowledged that the number of and exact spacing between rings **64** are not restricted to the values shown in the figures, but may be any convenient number, depending on the exact length of the piston and the specific use to which the invention is being put. Substantially at the end of the piston closest to the deflagration chamber, the piston is enclosed in a second alignment ring **63d** and high pressure pressure rings **64d** and **66a**. In the embodiment illustrated in FIG. **5**, the gas produced by PD of the fuel is introduced via gas inlet channels into gaps **65a** – **65d**. Consequently, force due to the pressure of the gas thus produced is exerted on the surface of each section, resulting in an increase in the total force exerted on the piston relative to a standard piston due to the higher effective surface area.

Another key feature of the W. J. Ideal Piston Engine™, further increasing the power applied to the piston, and hence its velocity of travel, is its ability to actuate a plurality of fuel ignition/deflagration cycles per piston cycle. The parallel lines **67** schematically represent multiple independent ignitions of the fuel during the course of the translation of the piston. During a single piston cycle, several predetermined quantities of W. J. Ideal Fuel™ are fed into the deflagration chambers (located within cylinder head **63**) from fuel containers **62a** and **62b**, or alternatively, the fuel grains themselves may be constructed in multiple layers such that as each layer is consumed, deflagration of the layer beneath begins. In an additional embodiment of the invention, pistons **60a** and **60b** include at the back an additional gas inlet **71** (not shown in FIG. **5**) for improved collection of the gas produced by PD and increased power applied to the back surface of the piston.

Reference is now made to FIG. **6**, depicting (not to scale) another embodiment of the present invention. In catapult system **80**, rather than coupling the hold-back device directly to the catapult engine, the coupling is made indirectly through a movable pulley assembly **81**. Connecting the piston assembly to the hold-back device via the pulley assembly increases the input force relative to direct coupling by a factor that depends on the details of the pulley assembly configuration. The output pulley cable speed is decreased by the same factor. Thus, relative to the previous embodiments, catapult system **80** represents of trade-off between velocity and force. The pulley assembly comprises a metal cable **83** constructed from any appropriate material and four pulley wheels. One wheel is anchored at end wall **86** of the catapult system, while the remaining three wheels move with the pistons. Each piston is mechanically connected to the pulley assembly via connecting plate **85**, which is attached at one end to piston assembly rods **84a**, **84b** and at the other end to metal cable **83**. Insert **87** is affixed to pulley assembly **81** and coupled to the hold-back device through a slot **88** in the hold-back device. The anchored pulley wheel is connected to the end wall via spring **82**. This spring also maintains the proper tension in cable **83**. In this configuration, the force applied to the hold-back device by the pulley assembly **81** is increased, and the velocity of its motion decreased, by a factor of approximately four. In the embodiment illustrated in FIG. **6**, a dual cylinder configuration is used to increase the power. It is acknowledged that in other embodiments, a single cylinder engine is used. Equal power can be provided by doubling the cross sectional area of the engine cylinder.

Reference is now made to FIG. 7, depicting yet another embodiment of the present invention. As in the preceding embodiment, the engine of the catapult system is not coupled directly to the hold-back device. In the present embodiment, the power conversion assembly includes a multiply-threaded lead screw (at least double-threaded), which can provide any desired power and speed according to need. In the embodiment illustrated, two pistons are shown; it is acknowledged, however, that in additional embodiments, any desired number of pistons can be used, with coupling to the hold-back device provided according to the general principles herein described. In the embodiment illustrated, lead screw **91** is coupled to a pair of engine pistons **60a, 60b** (in the embodiment illustrated, the pistons are shown with the additional input gas inlets **71a** and **71b** respectively; it is acknowledged that additional embodiments in which the pistons lack these additional gas inlets may be constructed as well) via a nut **95** located within block **52** through which the two piston assembly rods **94a** and **94b** pass and to which they are affixed by appropriate set screws. Block **52** fixes nut **95** such that it cannot rotate, but that it can translate along an axis parallel to the motion of the pistons. At its other end, lead screw **91** is affixed to anchoring wall **98** via a rod **97** inserted to the anchoring wall. Rod **97** allows free rotation of the lead screw about its axis while keeping it centered and properly oriented. The lead screw passes through a threaded insert **99** that is fixed within slot **93** of the hold-back device. Thus, actuation of the pistons by PD of the anaerobic fuel causes the nut to translate in concert with the piston, which causes the lead screw to turn about its axis. This rotation of lead screw **91** actuated as described above forces hold-back device **53** to move in concert with the pistons. In additional embodiments of the invention, lead screw **91** is multiply threaded, increasing the speed of travel of the threaded insert along the lead screw. In additional embodiments of the invention, the force exerted by the lead-screw is further increased by used of threads with a rectangular profile. Thus, the exact force exerted by the lead screw and the rate of translation of the hold-back device can be fixed at any values desired by the operator by choosing the appropriate lead screw diameter, thread pitch, and number of independent sets of threads.

Reference is now made to FIG. **8**, depicting (not to scale) a catapult system adapted for use in a platform suspended in the air at altitudes substantially those at which jet aircraft routinely fly (up to about 12 km above sea level). By placing the platform at an altitude above the jet stream, interference from strong winds is minimized, and maintaining the position of the platform relative to the ground is simplified. Catapult system **200** consists of a basic catapult system structure **220** with an aircraft **230** affixed to the catapult platform **240**, ready for launching. The platform is made of a stiff material (e.g. structural steel or reinforced concrete) capable of supporting weights of up to 400 t. The catapult system **220** is located beneath platform **240** within a containment **250** mechanically connected to the platform by any appropriate means such as are known in the prior art. The entire system is carried by a plurality of W. J. Heavy Lifters™ high-altitude balloons **210**. These balloons are designed for lifting heavy loads to high altitudes. They are essentially cylindrical in shape and formed around a rigid skeleton; in a preferred embodiment, the skeleton is made of a light metal such as titanium. In typical embodiments, the balloons have an outer diameter of 10 – 50 m, and a height of 500 – 1500 m. When filled with a lighter-than-air gas (in a preferred embodiment, helium), the balloons can lift even the platform shown in FIG. **8** (in typical embodiments, the platform weighs on the order of 1000 t) to a height of at least 12 km. In FIG. **8**, a number of the balloons can be seen behind the aircraft. Reference is further made to FIG. **9**, which depicts a top view of the catapult system depicted in FIG. **8**. The balloons are moored to the platform by rigid mooring means; as shown in FIG. **9**, the balloons are not directly over the platform in order to give aircraft a more open landing and launching path.

Reference is now made to FIG. **10**, showing a schematic view (not to scale) of a catapult piston engine accommodating a multi-sectional piston of the type described above, in another embodiment of the present invention. The engine head comprises a plurality N ($N > 1$; in the embodiment shown, $N = 2$) of igniting devices **115b-c**, deflagration chambers **116b-c**, fuel safety valves **117b-c**, and pressure relief valves **118b-c**. The deflagration chambers are in fluid connection with the main cylinder of the engine so that gas escaping from the deflagration chambers is constrained to enter the cylinder. It is acknowledged that other embodiments with different values of N can be constructed according to the same principles. The engine head additionally comprises a second sealed cylindrical chamber **125** external to the main cylinder and having independent igniting devices **115a,d**, deflagration chambers **116a,d**, fuel safety valves **117a,d**, and pressure relief valves **118a,d**. Again, the deflagration chambers are in fluid connection with cylindrical chamber **125** such that gas escaping from them is constrained to enter the cylindrical chamber. When the piston is at the start position, PD initiated by ignition of anaerobic fuel within the main cylinder creates a flow high-pressure gas at the top of section **110**. PD is initiated independently in the deflagration chambers in fluid connection with cylindrical chamber **125**, generating a second flow of high-pressure gas through chamber **125** into pockets **120** (also in fluid connection with chamber **125**) located on section **121** and applying pressure on that section as well. When the piston reaches the position depicted in FIG. **10**, a third independent PD process starts, creating a third flow of high-pressure gas, in this case entering pockets **130** located on section **131** of the multi-sectional piston. The net effect is to increase the effective piston area for a given piston diameter, hence substantially increasing the power capacity of the engine relative to a regular piston of the same diameter.

Reference is now made to FIG. **11**, which is a graph of a numerical simulation of the pressure within the cylinder head in MPa as a function of time in ms for the cylinder head of a W. J. Ideal Piston Engine™ in which multiple ignitions of anaerobic fuel per piston stroke are performed. The pressure reaches a maximum value of 10 bar at t = 40ms, at which point the pressure begins to decrease. Successive ignitions occur at t = 50ms, t = 80 ms, and t = 110 ms; after each ignition, the pressure recovers to its maximum value. Thus, an essentially constant pressure of approximately 10 bar is maintained as long as ignition is repeated. The desired maximum pressure and the length of time for which it is maintained can be controlled by the user by setting the quantity of fuel undergoing PD in each stage, the relative timing of successive ignitions, etc.

An additional advantage of the invention herein disclosed is the reliability of engines and propulsive systems based on W. J. Ideal Fuel™. These engines require an overhaul only about once in three years or more, due to the reduction in the number of moving parts relative to systems based on combustion or steam engines.

Storage of the W. J. Ideal Fuel™ is preferably provided in either commercially available or specially designed and made containers, such as W. J. Container™ containers, that are well isolated against heat, static electricity, sparks, lightning, fire, shocks and shock waves. A container-in-a-container arrangement is preferred. Standard containers are preferably yet not exclusively of 20 ft or 40 ft. The container may be in a CO_2 safety environment and/or will be in communication with fire extinguishing systems. A "black box" is used for recording safety data transmit to a distribution center events selected from a group consisting of fuel loading, discharge history, present location, shaking force, type of fuel presently stored and history of the container from day one. The W. J. Ideal Fuel™ can be loaded and unloaded from its container with a completely automated system. According to one embodiment of the present invention, the containers are arranged in a cascade or an array in which one container is in communication with at least another one, located e.g., next to it, above it, below it, etc. Said array is either provided in series or in parallel, and is either 2D or 3D or any combination thereof. The feeding is provided in any commercially available means known in the art, e.g., rail, conveyer belts, magazines, e.g., round magazines, pipes, conduits, snail-like or screw-like apparatuses, robots, linear tables, systems equipped with electric and/or pneumatic servo systems for fast and accurate movement, etc.

W. J. Ideal Fuel™ is a very compact and effective deflagration propagator, so that it requires only limited storage volume. Hence, recharging the container is required relatively infrequently. W. J. Ideal Fuel™ containers can safely store the fuel for extended periods (years to decades). Moreover, W. J. Ideal Fuel™ containers are environmentally friendly, and do not leak hazardous materials to their surroundings.

The gaseous products of deflagration of W. J. Ideal Fuel™ typically include several percent of inflammable gases such as CO. In an additional embodiment of the invention (not pictured), use is made of the CO in the exhaust gas. In particular, the exhaust of the catapult system is attached to a secondary generator adapted to combust the CO contained within the exhaust gases. In a preferred embodiment, the secondary generator is a standard gasoline (petrol) engine adapted for combustion of CO, but any apparatus of the types well-known in the art that can be adapted for combustion of inflammable gases may be used. The energy derived from this secondary combustion may be used for any of a number of purposes (e.g. propulsion of the ship). In an additional embodiment, the secondary generator is in thermal contact with a heat exchanger, and the heat thus generated used, e.g., for heating of water or in an air conditioning system.

It will be appreciated that the above described methods may be varied in many ways, including, changing the order of steps, and/or performing a plurality of step concurrently.

It should also be appreciated that the above described description of methods and apparatus are to be interpreted as including apparatus for carrying out the methods, and methods of using the apparatus, and computer software for implementing the various automated control methods on a general purpose or specialized computer system, of any type as well known to a person or ordinary skill, and which need not be described in detail herein for enabling a person of ordinary skill to practice the invention, since such a person is well versed in industrial and control computers, their programming, and integration into an operating system.

For the main embodiments of the invention, the particular selection of type and model is not critical, though where specifically identified, this may be relevant. The present invention has been described using detailed descriptions of embodiments thereof that are provided by way of example and are not intended to limit the scope of the invention. No limitation, in general, or by way of words such as “may”, “should”, “preferably”, “must”, or other term denoting a degree of importance or motivation, should be considered as a limitation on the scope of the claims or their equivalents unless expressly present in such claim as a literal limitation on its scope. It should be understood that features and steps described with respect to one embodiment may be used with other embodiments and that not all embodiments of the invention have all of the features and/or steps shown in a particular figure or described with respect to one of the embodiments. That is, the disclosure should be considered complete from combinatorial point of view, with each embodiment of each element considered disclosed in conjunction with each other embodiment of each element (and indeed in various combinations of compatible implementations of variations in the same element). Variations of embodiments described will occur to persons of the art. Furthermore, the terms "comprise," "include," "have" and their conjugates, shall mean, when used in the claims, "including but not necessarily limited to." Each element present in the claims in the singular shall mean one or more element as claimed, and when an option is provided for one or more of a group, it shall be interpreted to mean that the claim requires only one member selected from the various options, and shall not require one of each option. The abstract shall not be interpreted as limiting on the scope of the application or claims.

It is noted that some of the above described embodiments may describe the best mode contemplated by the inventors and therefore may include structure, acts or details of structures and acts that may not be essential to the invention and which are described as examples. Structure and acts described herein are replaceable by equivalents which perform the same function, even if the structure or acts are different, as known in the art. Therefore, the scope of the invention is limited only by the elements and limitations as used in the claims.

CLAIMS

1. A system for launching aircraft, comprising:
   a. at least one cylinder and reciprocating centering piston accommodated therein;
   b. a plurality of fuel feeding systems located in or adjacent to the head of said cylinder, each of said feeding systems feeding a predetermined measure of fuel in at least one step per one piston cycle to at least one deflagration chamber located within said cylinder head;
   c. ignition means igniting, in at least one step per piston cycle, at least one predetermined measure of said fuel in a scheduled manner; and,
   d. at least one pulling/pushing pad (hold-back device) coupling said piston with said aircraft;

wherein said fuel is an anaerobic fuel, wherein said centering piston is adapted to move in response to an impulse provided by expansion of gases following predetermined deflagration of said anaerobic fuel within said deflagration chamber, and further wherein said hold-back device transmit said impulse to said aircraft with sufficient force to accelerate said aircraft to launch velocity.

2. The system according to claim **1**, wherein said fuel feeding system further comprises
   a. at least one cellulose chamber interconnected with said deflagration chamber, said cellulose chamber adapted for storage of cellulose;
   b. at least one nitrating agent chamber interconnected with said deflagration chamber, said nitrating agent chamber adapted for storage of a nitrating agent, said nitrating agent chosen from the group consisting of (a) substantially pure HNO_3; (b) a solution of HNO_3 in water containing more than about 80% HNO_3 on a molar basis; (c) a solution of HNO_3 in water containing between about 70% and about 80% HNO_3 on a molar basis; (d) NO_2; (e) a mixture of NO_2 and water; (f) any other substance capable of nitrating cellulose in the gas phase; (g) any combination of the above;
   c. means for transferring a predetermined quantity of cellulose from said cellulose chamber into said deflagration chamber;
   d. means for transferring a predetermined quantity of nitrating agent from said nitrating agent chamber into said deflagration chamber;

and further wherein said ignition means is adapted to initiate chemical reaction between said cellulose and said nitrating agent to form nitrocellulose *in situ*, and to ignite nitrocellulose formed in said chemical reaction, and further wherein said anaerobic fuel comprises said nitrocellulose formed in said chemical reaction.

3. The system according to claim **1**, wherein the shape of said piston is adapted to trap the mass wave of the expanding gas caused by said predetermined deflagration of said anaerobic fuel, preferably a cone-like shape.

4. The system according to claim **1**, wherein said system further comprises a push rod, said push rod being characterized by two ends, the first of said two ends interconnected with said hold-back device and the second of said two ends interconnected with said engine piston.

5. The system according to claim **1**, wherein said system further comprises a fuel ignition device, disposed in said deflagration chamber, and further wherein said ignition device is adapted to periodically initiate in a controllable manner said predetermined deflagration.

6. The system according to claim **1**, wherein said system further comprises at least one fuel feeding sub-system comprising

a. at least one fuel container;

b. a lead-screw mechanism; and

c. fuel safety valve;

and further wherein said fuel feeding sub-system is adapted to feed, in a controllable manner, an adjustable quantity of said anaerobic fuel into said deflagration chamber.

7. The system according to claim **6**, wherein said system further comprises data collecting means and data storing means, said data collecting means being adapted for reading data from said at least one fuel container and for transmitting data to said data storing means, said data comprising parameters selected from a group consisting of (a) the type of fuel in each container, (b) the history of said fuel, (c) the history of said container, (d) the amount of fuel in said container, (e) identification parameters, and (f) any combination thereof.

8. The system according to claim **1**, wherein said piston displacement is coupled to said hold-back device via at least one pulley device, said pulley device comprising at least one pulley and at least one metal cable.

9. The system according to claim **1**, wherein said piston is coupled to said hold-back device via a lead-screw device, said lead-screw device comprising at least one thread helix.

10. The system according to claim **1**, wherein said engine is controlled by an electronic controller operating according to a predetermined protocol, said predetermined protocol adapted to provide control for operations chosen from the group consisting of (a) determining the quantity of said anaerobic fuel to be fed to said deflagration chamber; (b) feeding said anaerobic fuel into said deflagration chamber; (c) opening and closing of valves; (d) initiation of predetermined deflagration of said anaerobic fuel; (e) any combination of the above.

11. The system according to claim **1**, wherein said system further comprises computing means adapted to correlate various parameters such that optimal launching is obtained, said parameters selected from a group consisting of (a) the weight of said aircraft; (b) the profile of said aircraft; (c) the type of anaerobic fuel; (d) the grain size of said anaerobic fuel; (e) the grain shape of said anaerobic fuel; (f) the amount of said anaerobic fuel fed to said deflagration chamber; (g) the size of said deflagration chamber; (h) the shape of said deflagration chamber; (i) the profile of the exhaust from said deflagration chamber; and (j) any combination thereof.

12. The system according to claim **1**, wherein said system further comprises exhaust means adapted to transfer exhaust gases from said at least one cylinder to at least one heat exchanger.

13. The system according to claim **1**, wherein said system further comprises means to combust the inflammable fraction of high-CO content exhaust gases produced by said predetermined deflagration.

14. The system according to claim **13**, wherein said system further comprises exhaust means adapted to transfer exhaust gases resulting from said combustion to at least one heat exchanger.

15. The system according to either one of claims **13** or **14**, wherein said at least one heat exchanger is adapted to operate an apparatus chosen from the group consisting of (a) a secondary generator; (b) an air conditioner; (c) both of the above.

16. The system according to claim **13**, wherein said system further comprises

a. a catalyst adapted for reducing the NO_x content of gases produced during operation of said system to less than about 7 ppm;
b. a container for said catalyst;
c. means for flowing said gases over said catalyst.

17. The system according to claim **1** wherein said piston, said push rod and said hold-back device are provided in a single linearly actuated piston assembly, and further wherein said assembly is interconnected with a multiply threaded screw.

18. The system according to claim **1**, adapted to launch aircraft from an aircraft carrier deck.

19. The system according to claim **1**, adapted to launch drone craft from a vehicle chosen from the group consisting of (a) a truck, (b) a train, and (c) a trailer.

20. The system of claim **1**, adapted for launching an aircraft from an airborne platform.

21. The system according to claim **1**, wherein at least one of said pistons is actuated by N deflagration steps, where N is an integer greater than 1, and further wherein each of said N deflagration steps is provided by at least one predetermined quantity of anaerobic fuel.

22. The system as defined in claim **1**, wherein at least one of said pistons is a multi-sectional piston, said multi-sectional piston comprising a plurality of pressure rings adapted to divide the volume between the surface of said piston and the inner surface of said cylinder into a plurality of substantially isolated volumes and adapted for use in a cylinder comprising a plurality of gas inlet channels.

23. The system according to claim **1**, wherein said cylinder further comprises:

a. at least one channel substantially parallel to the housing of said piston, said channel fluidly interconnected at one end with said housing;
b. at least one additional deflagration chamber ("side chamber"), said at least one side chamber fluidly interconnected with the second end of said channel;
c. means for independently introducing a predetermined quantity of said fuel into said at least one side chamber;
d. ignition means for said fuel;
e. means for controlling the timing of said ignition of said fuel in said at least one side chamber relative to said ignition of said fuel in said deflagration chamber such that expanding gases produced by predetermined deflagration of said fuel in said at least one side chamber arrive at the point of interconnection with said channel substantially contemporaneously with the passage of said piston past said point of interconnection;

wherein said expanding gases from said predetermined deflagration of said fuel in said side chamber provide additional force to said piston.

24. A method for launching an aircraft, comprising the steps of:

a. obtaining an aircraft;

b. obtaining an aircraft launching system comprising:

i. at least one cylinder and actuated piston accommodated therein; said piston actuated reciprocally through a piston cycle from a starting position to an ending position and vice versa, said ending position being associated with the length of said cylinder;

ii. a plurality of fuel feeding systems located in or adjacent to the head of said cylinder, each of said feeding systems feeds a predetermined measure of fuel in at least one step per one piston cycle to at least one deflagration chamber located within said cylinder head;

iii. ignition means, igniting, in at least one step per piston cycle, at least one predetermined measure of said fuel in a scheduled manner; and,

iv. at least one pulling/pushing pad (hold-back device) coupling said piston to said aircraft; and,

c. actuating said system;

wherein said fuel is anaerobic fuel, and further wherein said step of actuating said system includes performing a predetermined deflagration of said anaerobic fuel such that expansion of gases produced by said predetermined deflagration of said anaerobic fuel provides an impulse to said at least one piston, so that said hold-pack device is moved with sufficient force to accelerate said aircraft to launch velocity.

25. The method according to claim **24**, wherein said fuel feeding system further comprises

a. at least one cellulose chamber interconnected with said deflagration chamber, said cellulose chamber adapted for storage of cellulose;

b. at least one nitrating agent chamber interconnected with said deflagration chamber, said nitrating agent chamber adapted for storage of a nitrating agent, said nitrating agent chosen from the group consisting of (a) substantially pure HNO_3; (b) a solution of HNO_3 in water containing more than about 80% HNO_3 on a molar basis; (c) a solution of HNO_3 in water containing between about 70% and about 80% HNO_3 on a molar basis; (d) NO_2; (e) a mixture of NO_2 and water; (f) any other substance capable of nitrating cellulose in the gas phase; (g) any combination of the above;

c. means for transferring a predetermined quantity of cellulose from said cellulose chamber into said deflagration chamber; and,

d. means for transferring a predetermined quantity of nitrating agent from said nitrating agent chamber into said deflagration chamber;

and further wherein said step of actuating said system additionally comprises the further steps of

a. introducing a predetermined quantity of cellulose into said deflagration chamber;

b. introducing a predetermined quantity of said nitrating agent into said deflagration chamber; and,

c. initiating chemical reaction between cellulose and said nitrating agent;

and further wherein said anaerobic fuel is nitrocellulose formed during said chemical reaction.

26. The method according to claim **24**, additionally comprising the step of shaping said piston for maximizing the trapping of the expanding gas wave caused by said predetermined deflagration of said anaerobic fuel.

27. The method according to claim **24**, additionally comprising the steps of

a. obtaining a push rod;

b. connecting one end of said push rod to said engine piston; and,

c. connecting the other end of said push rod to said hold-back device.

28. The method according to claim **27**, additionally comprising the steps of

a. providing said piston, said push rod and said hold-back device as a single linearly actuated piston assembly;

b. connecting said linearly actuated piston assembly to a rotating screw, said rotating characterized by at least one independent thread helix.

29. The method according to claim **24**, additionally comprising the steps of

a. obtaining a fuel ignition device, disposed in said deflagration chamber; and,

b. actuating said ignition device periodically, in a controllable manner;

wherein said step of actuating said ignition device initiates said predetermined deflagration.

30. The method according to claim **24**, additionally comprising the steps of

a. obtaining at least one fuel feeding sub-system, said fuel feeding sub-system comprising at least one fuel container, a lead-screw mechanism, and a fuel safety valve; and,

b. feeding a predetermined quantity of said anaerobic fuel into said deflagration chamber.

31. The method according to claim **24**, additionally comprising the steps of

a. obtaining data collecting means and data storing means;

b. providing means for transmitting data from said at least one fuel container to said data collection means;

c. providing means for transmitting data from said data collecting means to said data storing means;

d. collecting data selected from a group consisting of (a) the type of fuel in each container, (b) the history of said fuel, (c) the history of said container, (d) the amount of fuel in said container, (e) identification parameters, and (f) any combination thereof; and

e. transmitting said data from said data collecting means to said data storing means.

32. The method according to claim **24**, additionally comprising the steps of

a. obtaining at least one pulley device comprising at least one pulley and at least one metal cable;

b. coupling said piston displacement to said hold-back device via said at least one pulley device.

33. The method according to claim **24**, additionally comprising the steps of

a. obtaining a lead screw device;

b. coupling said piston to said hold-back device via said lead-screw device.

34. The method according to claim **24**, additionally comprising the steps of

a. obtaining an electronic controller adapted to provide control for operations chosen from the group consisting of (a) determining the quantity of said anaerobic fuel to be fed to said deflagration chamber; (b) feeding said anaerobic fuel into said deflagration chamber; (c) opening and closing of valves; (d) initiation of predetermined deflagration of said anaerobic fuel; and (e) any combination of the above;

b. controlling said system by means of said electronic controller.

35. The method according to claim **24**, additionally comprising the steps of

a. obtaining computing means adapted to correlate various parameters such that optimal launching is obtained, said parameters selected from a group consisting of (a) the weight of said aircraft; (b) the profile of said aircraft; (c) the type of anaerobic fuel; (d) the grain size of said anaerobic fuel; (e) the grain shape of said anaerobic fuel; (f) the amount of said anaerobic fuel fed to said deflagration chamber; (g) the size of said deflagration chamber; (h) the shape of said deflagration chamber; (i) the profile of the exhaust from said deflagration chamber; and (j) any combination thereof;
b. computing correlations among said parameters to obtain an optimal actuation of said device.

36. The method according to claim **24**, additionally comprising the steps of

a. obtaining at least one heat exchanger;
b. obtaining means for transferring exhaust gases from said cylinder to said heat exchanger;
c. transferring said exhaust gases from said cylinder to said heat exchanger.

37. The method according to claim **24**, additionally comprising the step of combusting the inflammable fraction of high-CO content exhaust gases produced by said predetermined deflagration.

38. The system according to claim **37**, additionally comprising the steps of

a. obtaining exhaust means adapted to transfer exhaust gases resulting from said combustion to at least one heat exchanger;
b. transferring said exhaust gases to said at least one heat exchanger.

39. The system according to either of claims **36** or **37**, additionally comprising the steps of

a. adapting said at least one heat exchanger to operate an apparatus chosen from the group consisting of (a) a secondary generator; (b) an air conditioner; (c) both of the above;
b. transferring said exhaust gases to said at least one heat exchanger;
c. operating said apparatus.

40. The method according to claim **37**, additionally comprising the steps of

a. obtaining a catalyst for reducing the NO_x content of a gas to less than about 7 ppm;

b. flowing a predetermined portion of said exhaust gas over said catalyst.

41. The method according to claim **24**, additionally comprising the steps of

a. obtaining an aircraft carrier;

b. placing said aircraft launching system on said aircraft carrier; and,

c. launching military aircraft from said aircraft carrier.

42. The method according to claim **24**, additionally comprising the steps of

a. obtaining an ocean-going vessel;

b. placing said aircraft launching system on said ocean-going vessel; and,

c. launching aircraft from said ocean-going vessel.

43. The method according to claim **24**, additionally comprising the steps of

a. constructing said aircraft launching system such that said hold-back device is adapted for use by an aircraft to be launched from a runway located on the ground;

b. launching said aircraft from said runway.

44. The method according to claim **24**, additionally comprising the steps of

a. constructing said aircraft launching system such that said hold-back device is adapted for use by a drone aircraft to be launched from a vehicle chosen from the group consisting of (a) truck, (b) train, (c) trailer;

b. launching said drone aircraft from said vehicle.

45. The method according to claim **24**, additionally comprising the steps of

a. obtaining at least one additional deflagration chamber ("side chamber"); at least one channel substantially parallel to the housing of said piston, and fluidly interconnected at one end with said side chamber and at the other end with said piston housing; means for independently introducing a predetermined quantity of said fuel into said at least one side chamber; ignition means for said fuel; and means for controlling the timing of said ignition of said fuel in said at least one side chamber relative to said ignition of said fuel in said deflagration chamber such that expanding gases produced by predetermined deflagration of said fuel in said at least one side chamber arrive at the point of interconnection with said channel substantially contemporaneously with the passage of said piston past said point of interconnection;

b. introducing said fuel into said at least one side chamber;

c. igniting said fuel in said at least one side chamber;

d. timing said ignition such that expanding gases created by predetermined deflagration of said fuel in said side chamber arrive at said interconnection point with said piston housing substantially contemporaneously with the arrival of said piston at said interconnection point.

46. An ocean-going vessel adapted for launching aircraft, said vessel characterized by

a. at least one deck adapted for launching aircraft;

b. at least one of the system according to claim **1**;

c. said at least one system interconnected with said deck;

d. sufficiently large, mechanically strong, and stable such that a plurality of aircraft may be stored therein and thereon;

e. sufficiently large, mechanically strong, and stable that aircraft may be launched therefrom by using said system.

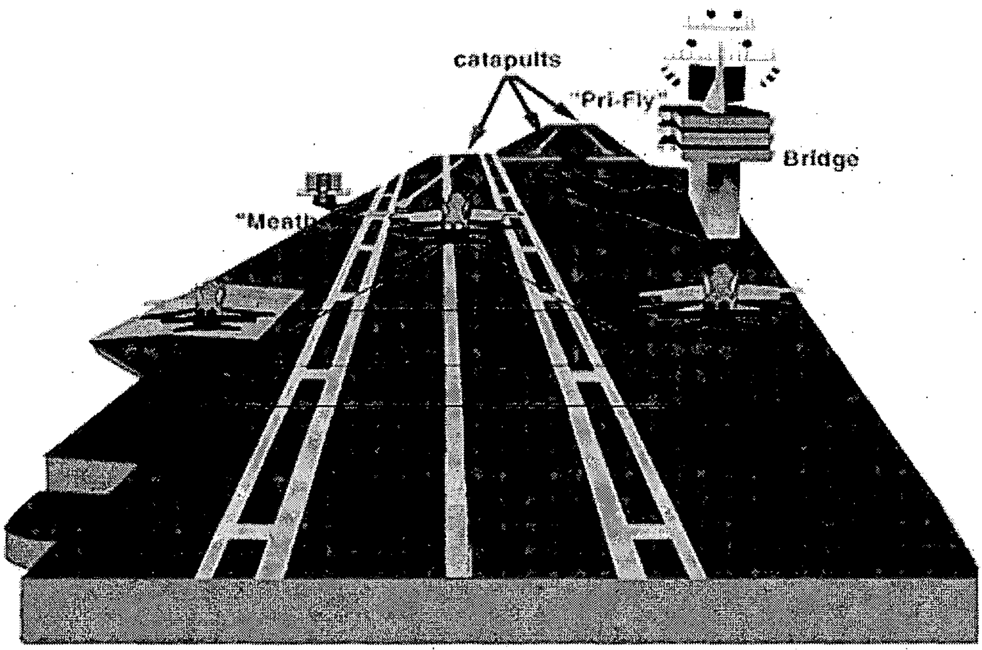

Fig. 1
(prior art)

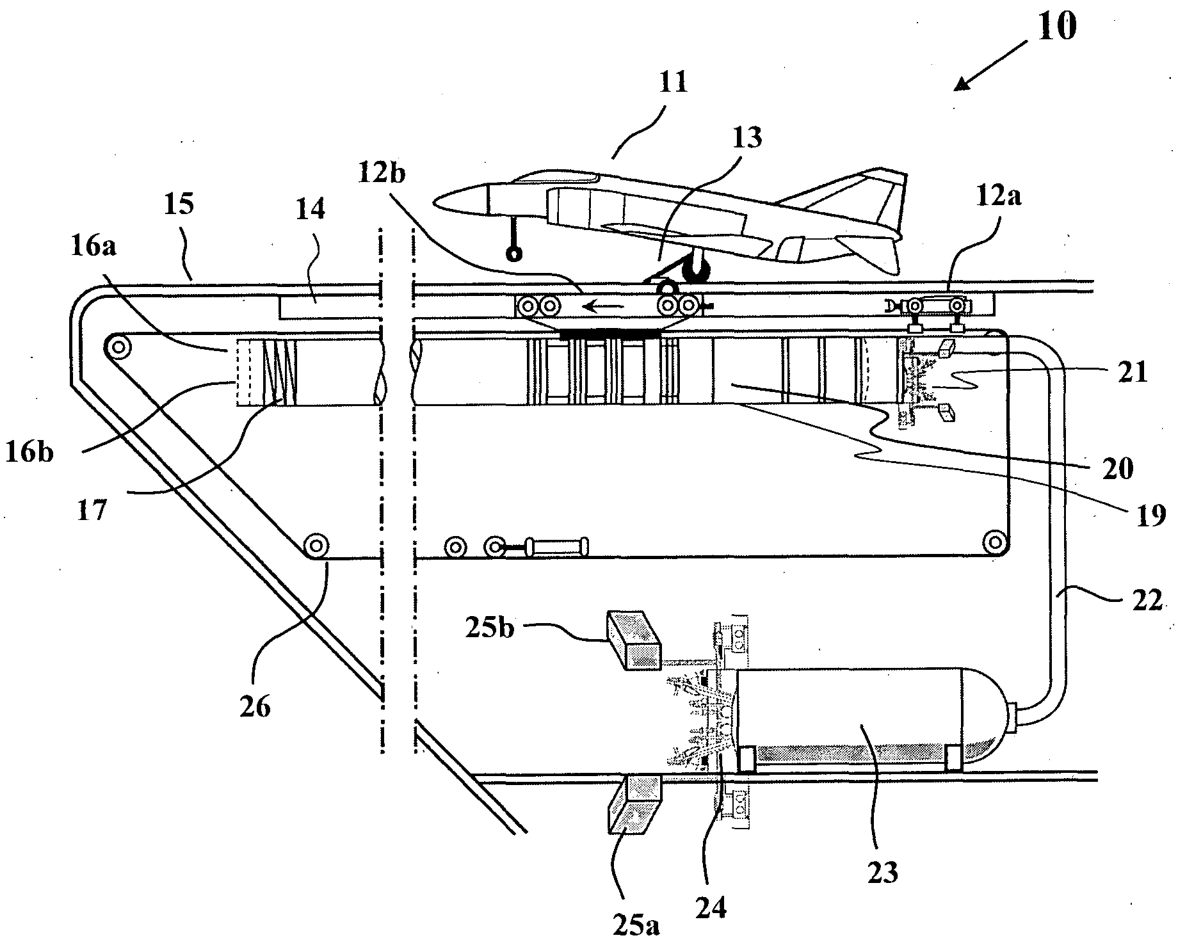

Fig. 2

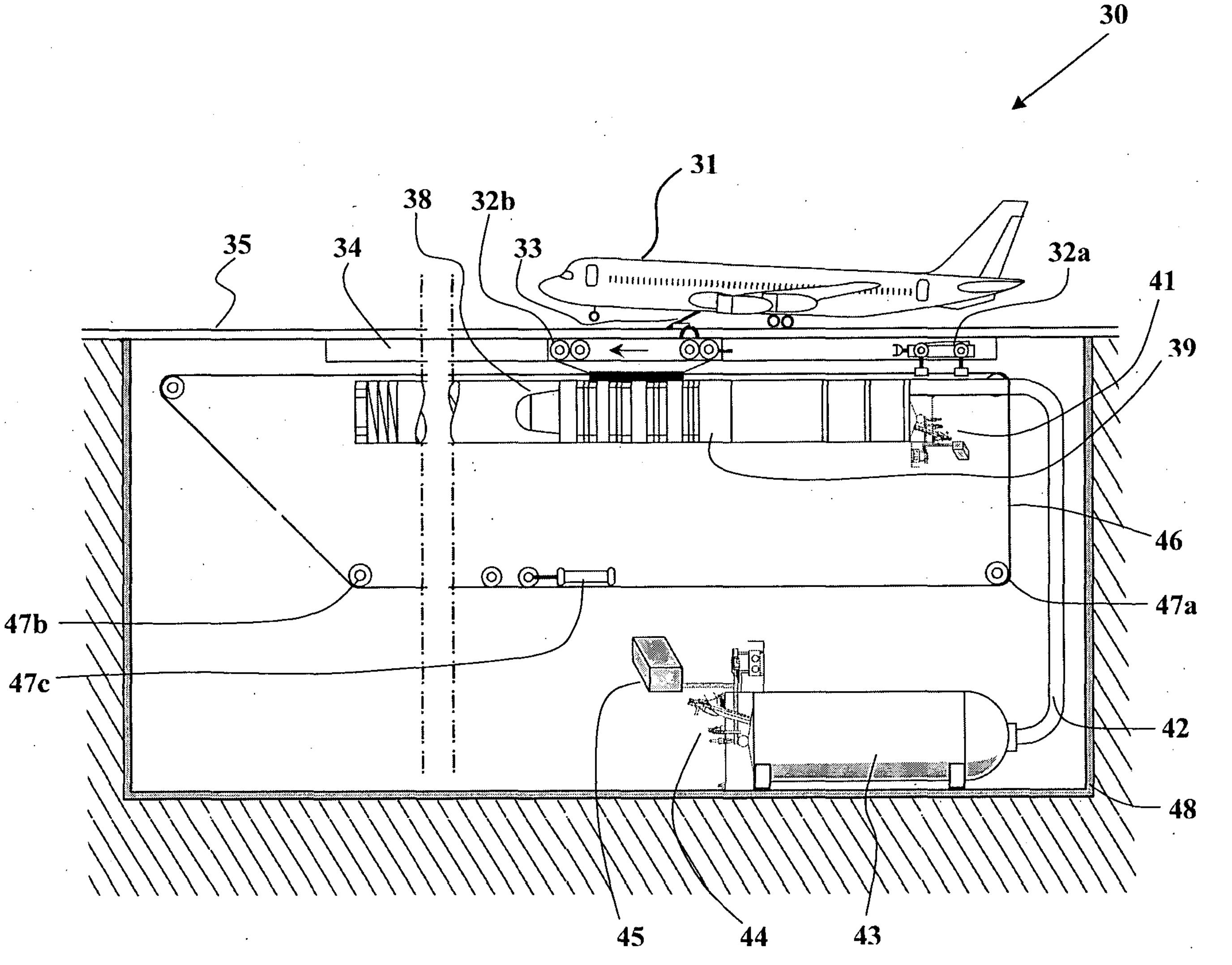

Fig. 3

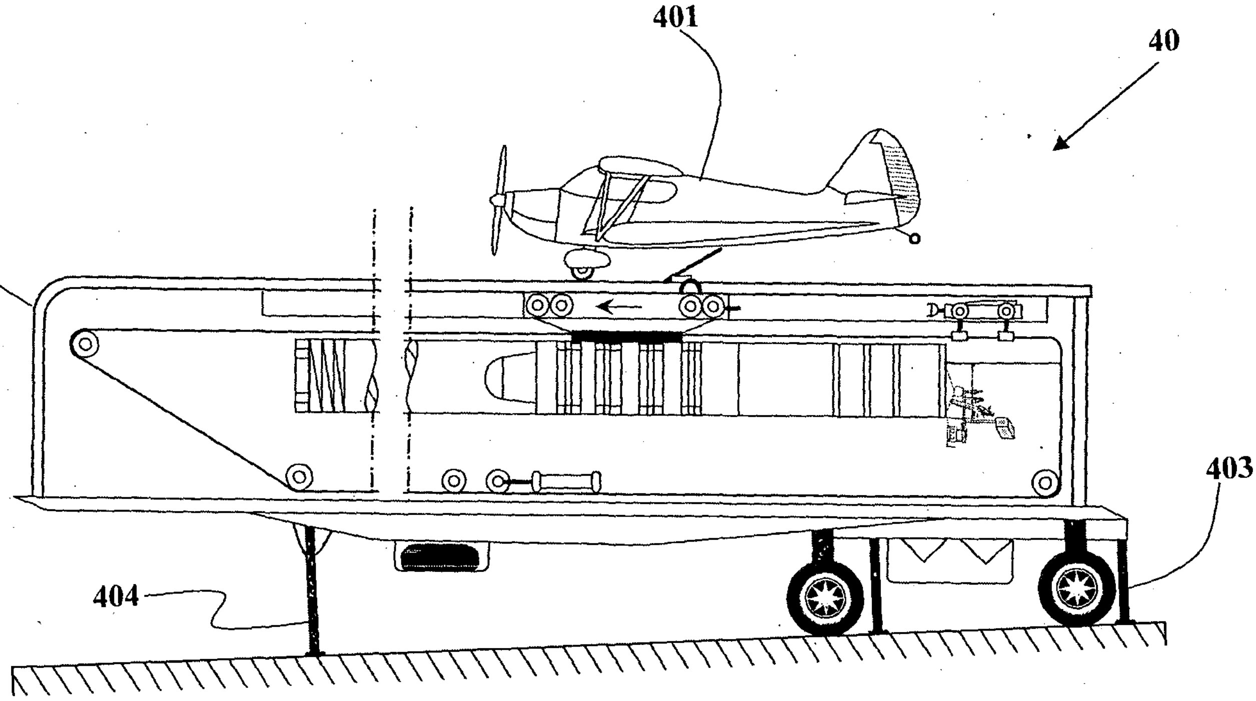

Fig. 4

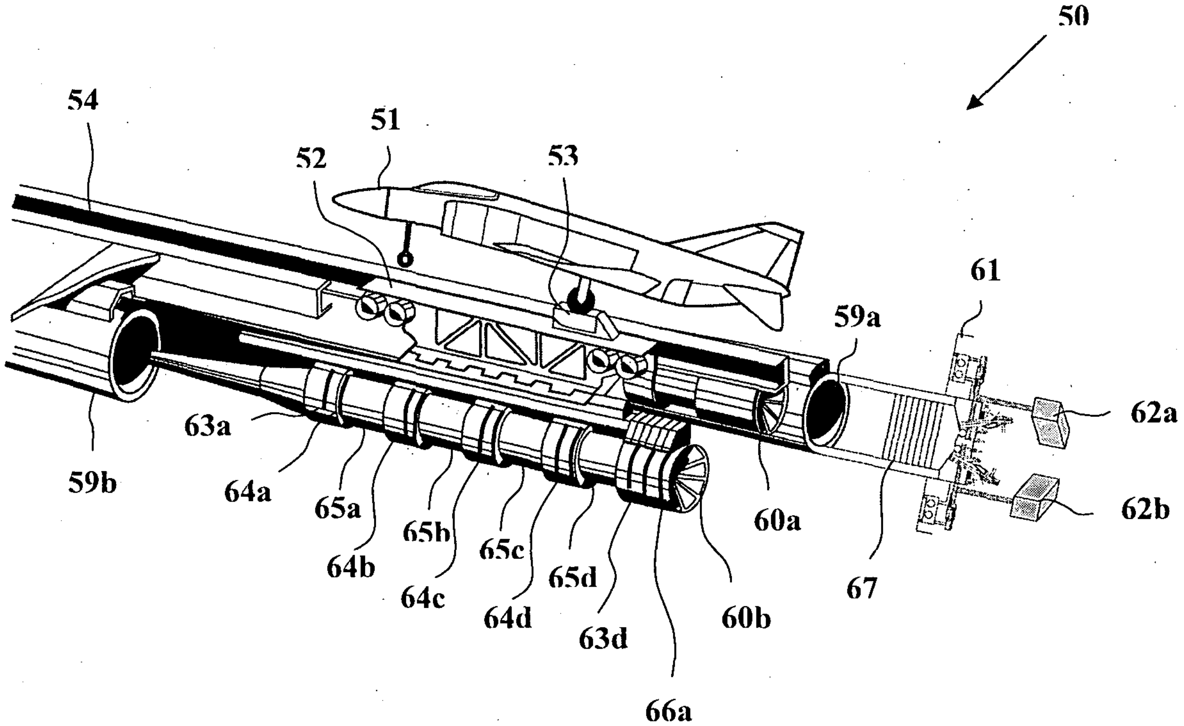
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Fig. 5

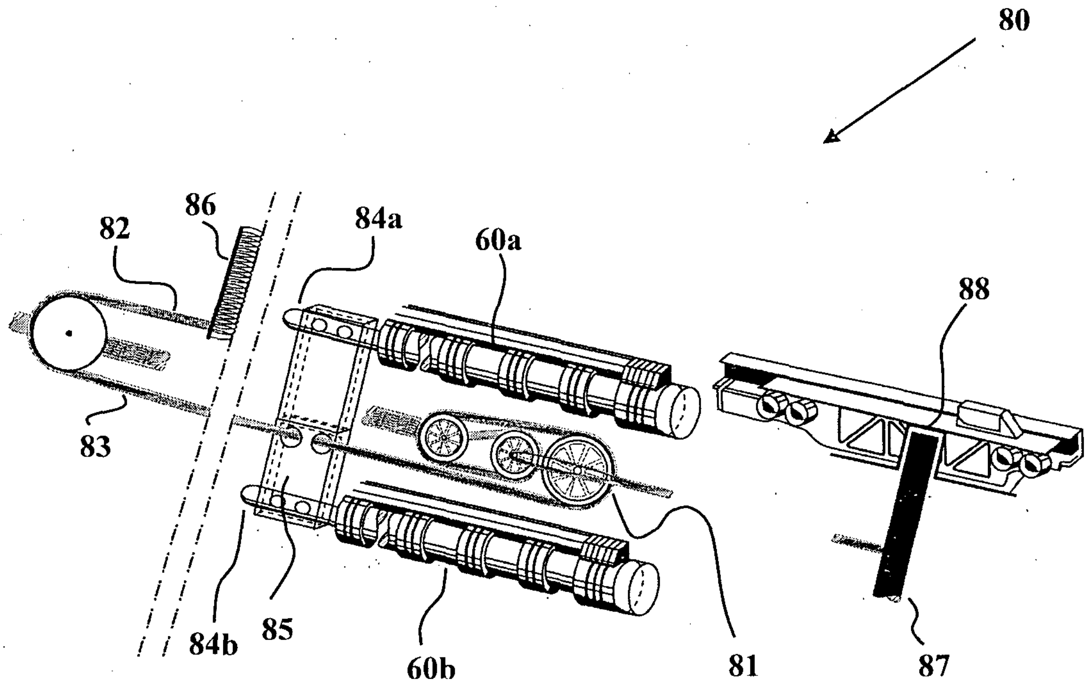

Fig. 6

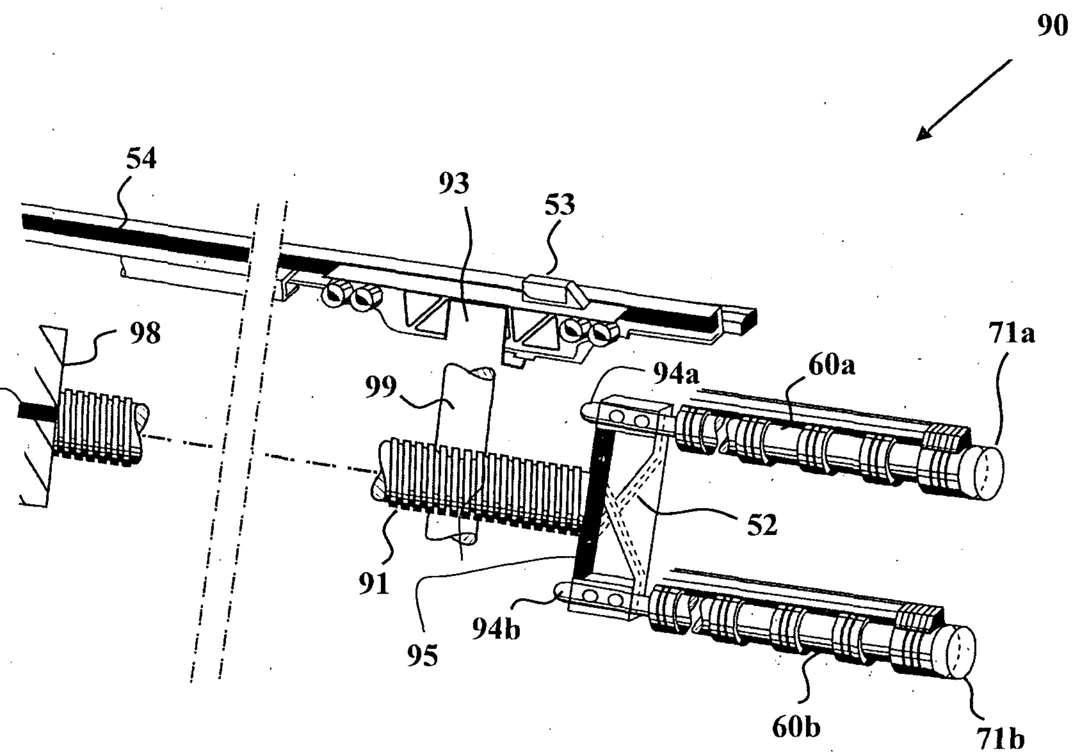

Fig. 7

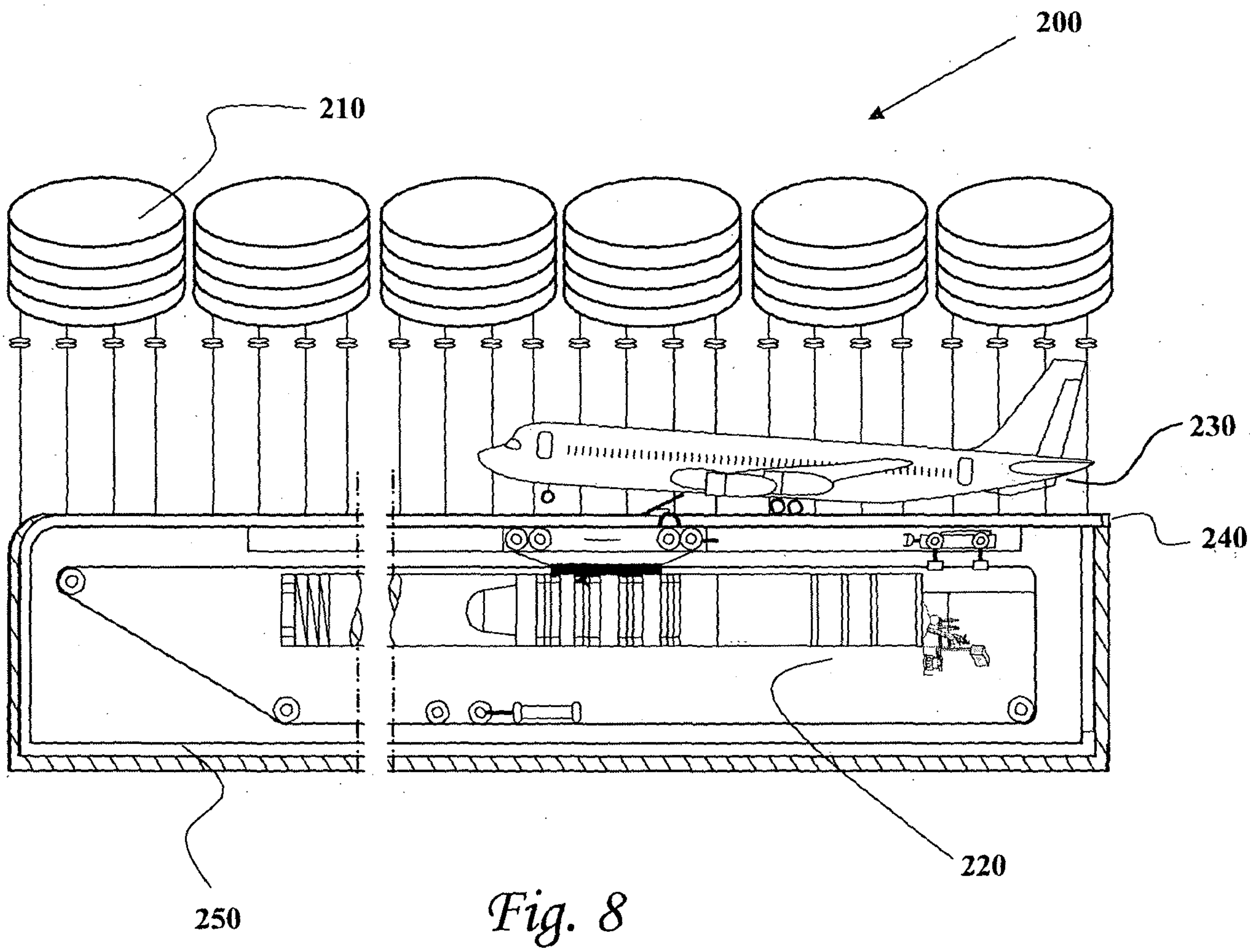

Fig. 8

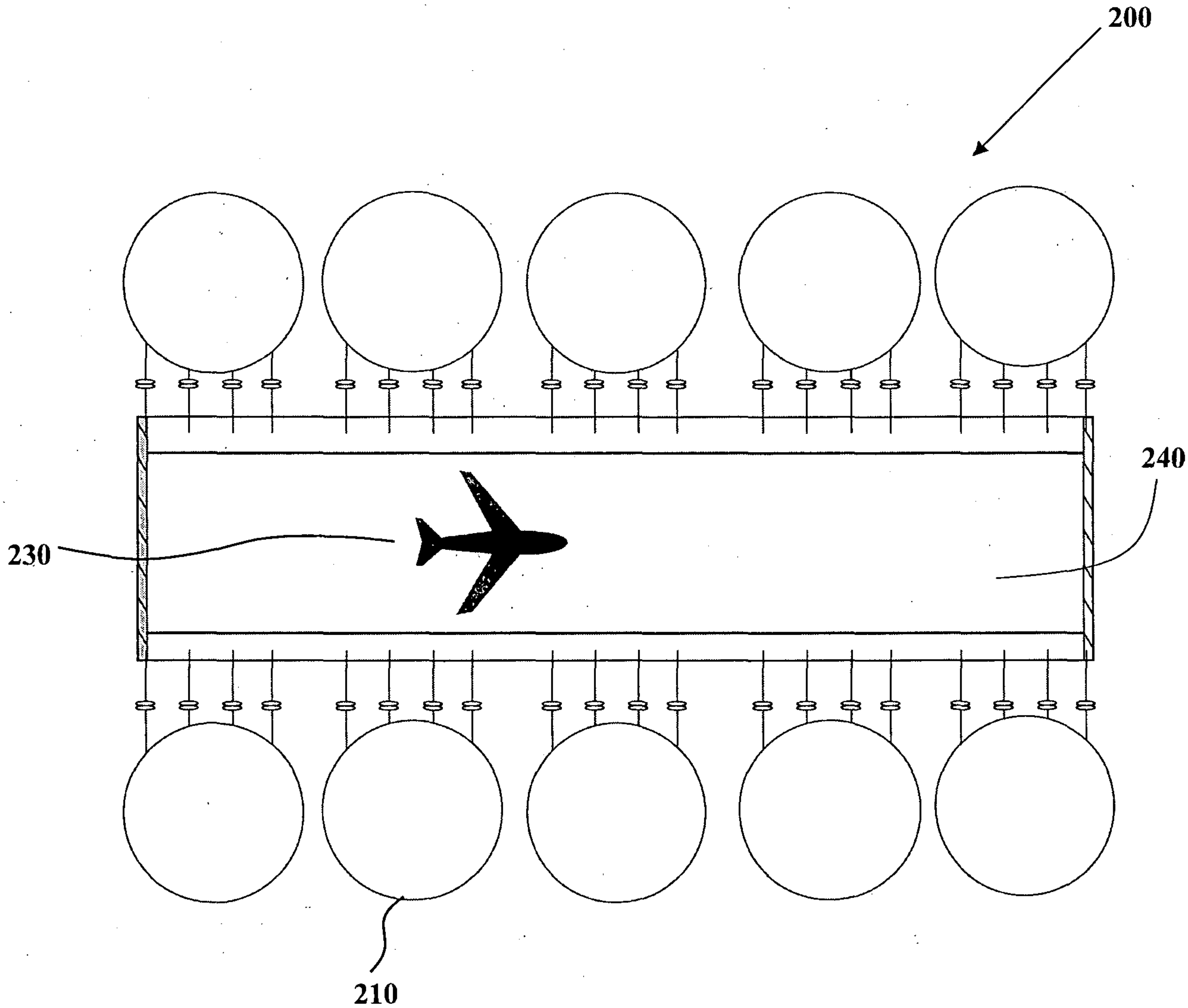

Fig. 9

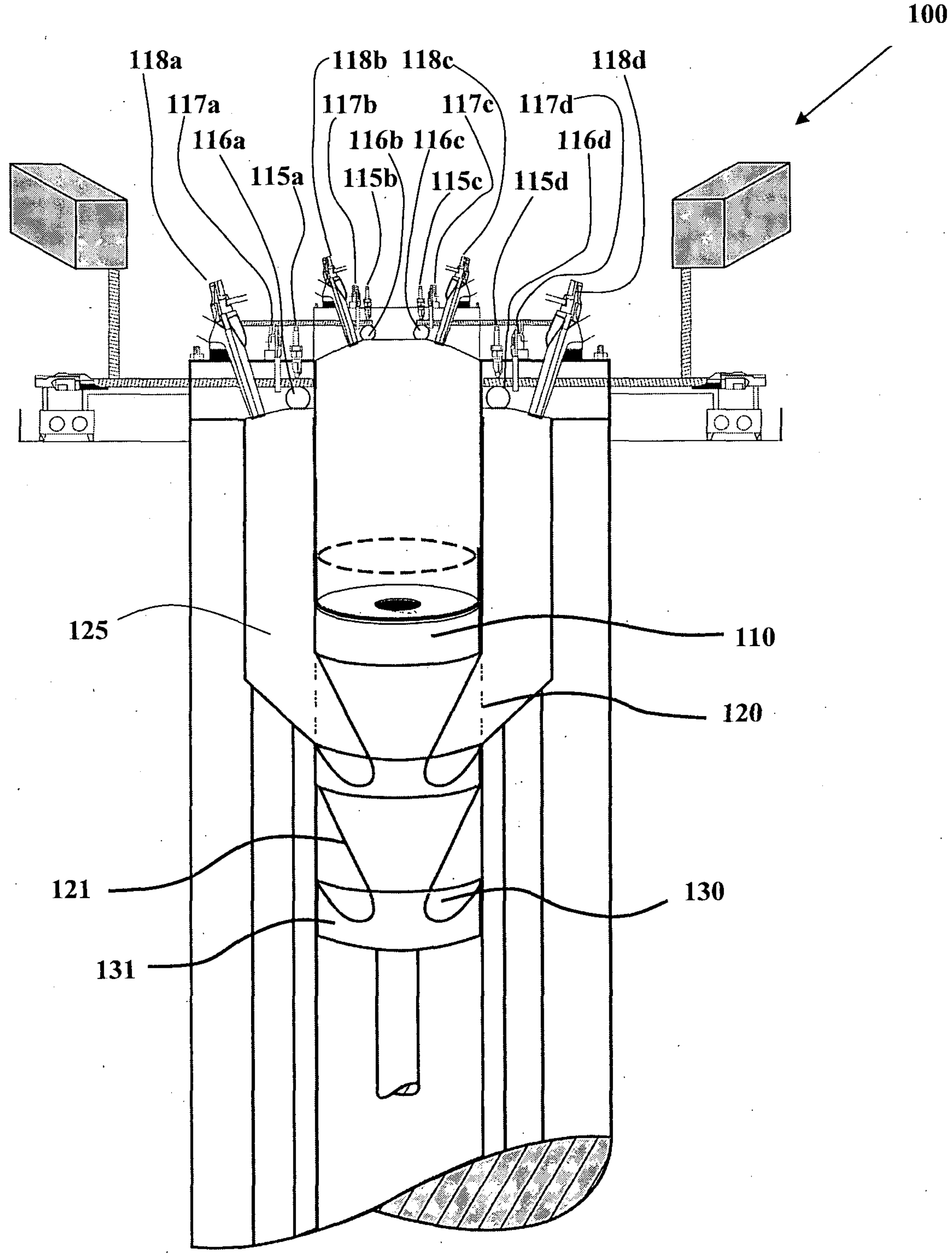
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Fig. 10

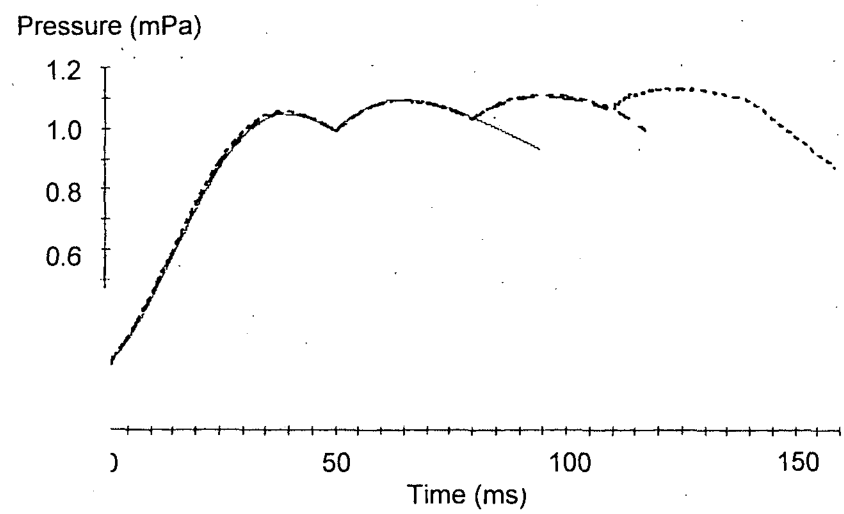

Fig. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/IL2008/001132

A. CLASSIFICATION OF SUBJECT MATTER
INV. B64F1/06

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B64F F41F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	GB 357 694 A (MACTAGGART SCOTT AND COMPANY L; COLIN CAMPBELL MITCHELL) 1 October 1931 (1931-10-01) page 1, line 8 - line 83; figure 1	1,24
A	US 2 799 988 A (LARRECQ ANTHONY J ET AL) 23 July 1957 (1957-07-23) column 2, line 43 - line 48; figures 1,2,7	1,24
A	US 3 077 144 A (BARKER JR CHARLES L ET AL) 12 February 1963 (1963-02-12) column 2, line 16 - line 29 column 3, line 14 - line 25; figure 2	1,24
A	US 1 960 264 A (ERNST HEINKEL) 29 May 1934 (1934-05-29) page 2, line 90 - line 110; figure 2	1,24

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 December 2008	12/12/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Kaysan, Rainer

International application No
PCT/IL2008/001132

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2 906 475 A (DOOLITTLE DONALD B ET AL) 29 September 1959 (1959-09-29) column 1, line 16 - line 18 column 4, line 24 - line 63; figures 1,11,12 -----	1,24

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IL2008/001132

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
GB 357694	A	01-10-1931	NONE	
US 2799988	A	23-07-1957	NONE	
US 3077144	A	12-02-1963	NONE	
US 1960264	A	29-05-1934	NONE	
US 2906475	A	29-09-1959	NONE	