Nov. 22, 1966 D. D. MANGIERI 3,286,373

FULL PRESSURE SUIT ACTIVATION SYSTEM WITH EJECT CAPABILITIES

Filed July 26, 1965 6 Sheets-Sheet 1

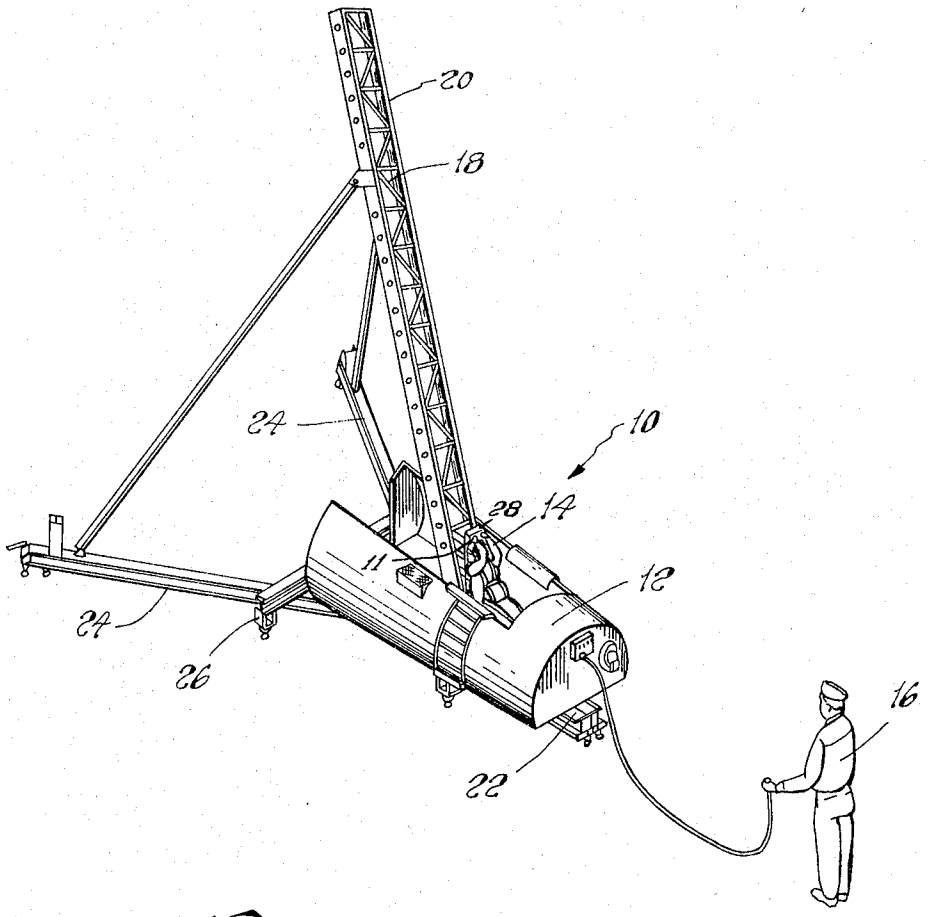


Fig. 1

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6 Sheets-Sheet 2

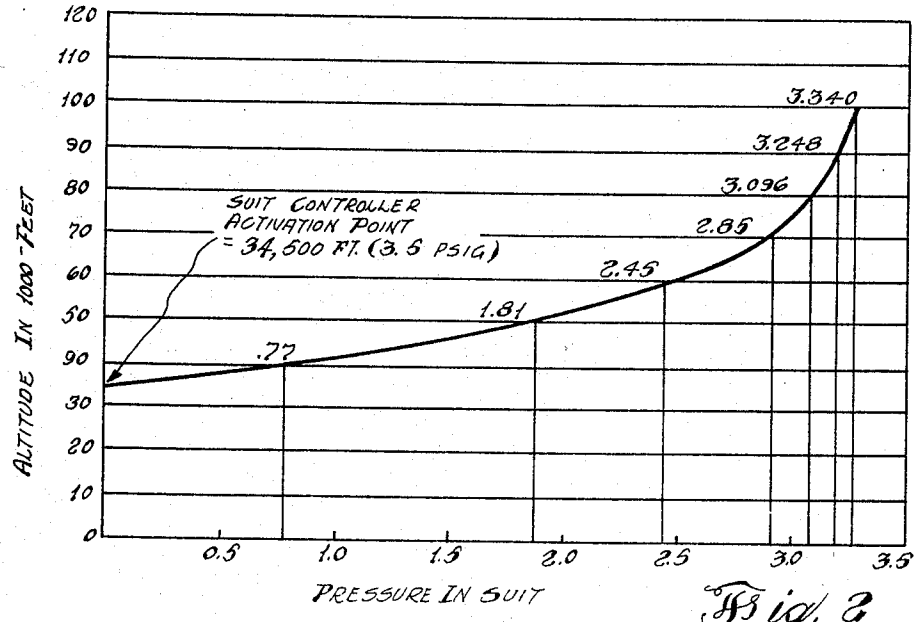


Fig. 3

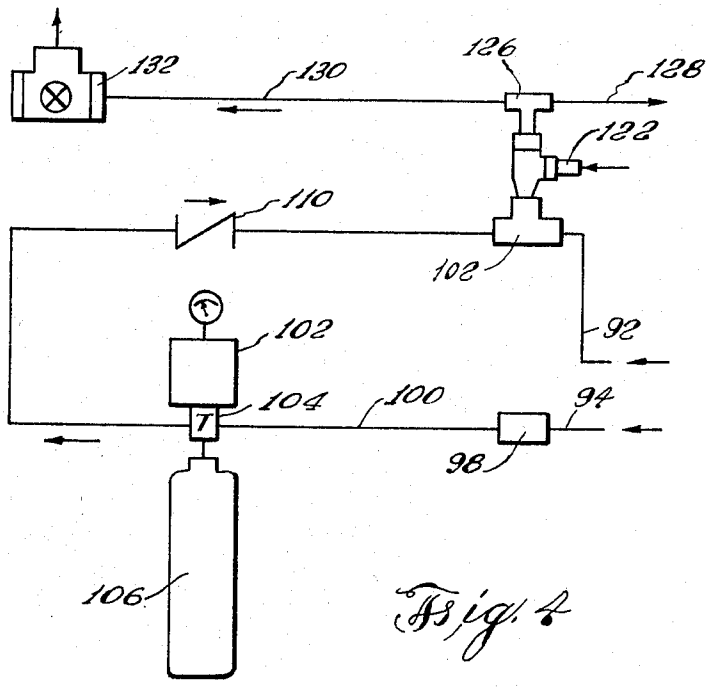


Fig. 4

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6 Sheets-Sheet 3

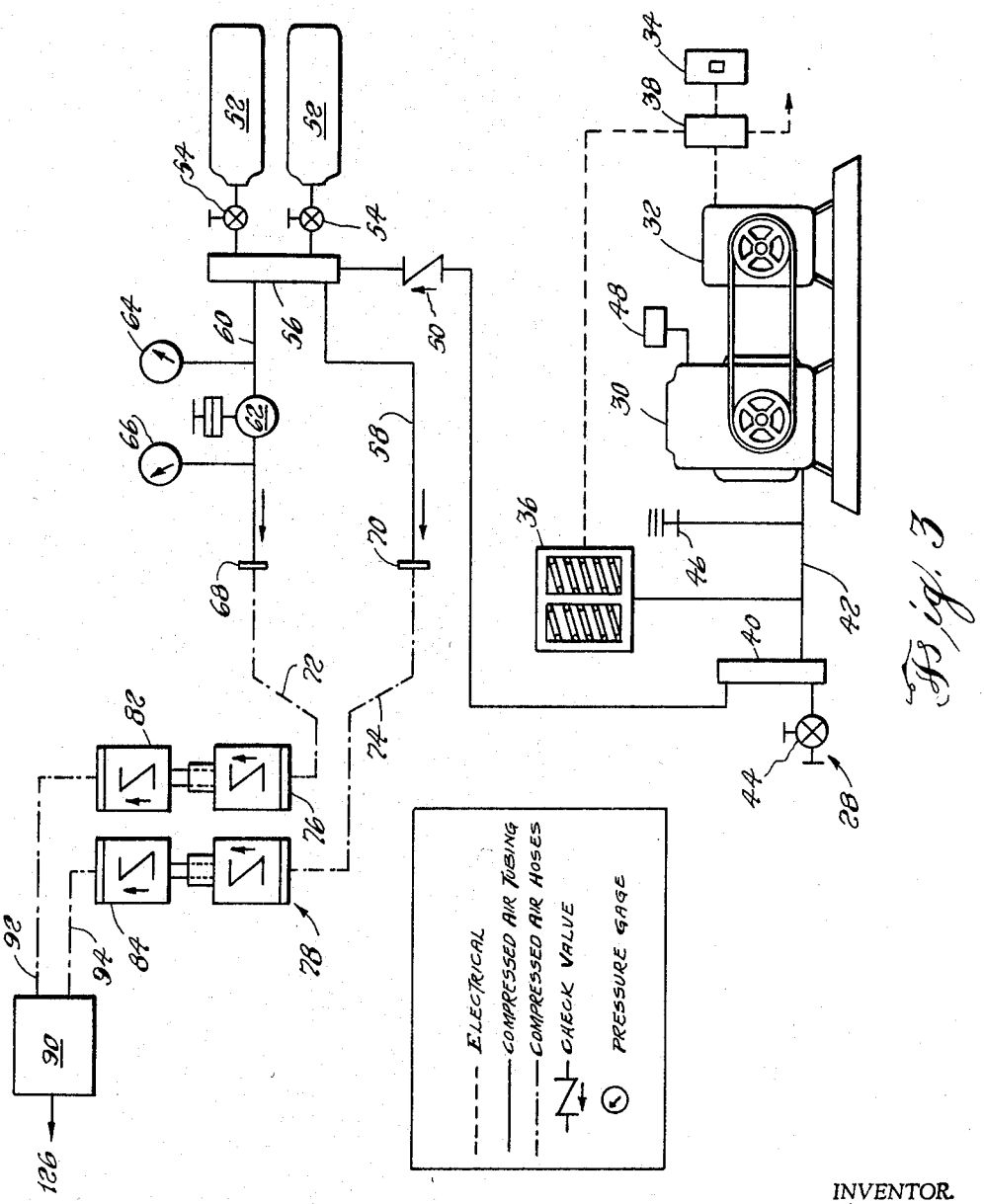


Fig. 3

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FULL PRESSURE SUIT ACTIVATION SYSTEM WITH EJECT CAPABILITIES

Filed July 26, 1965 6 Sheets-Sheet 4

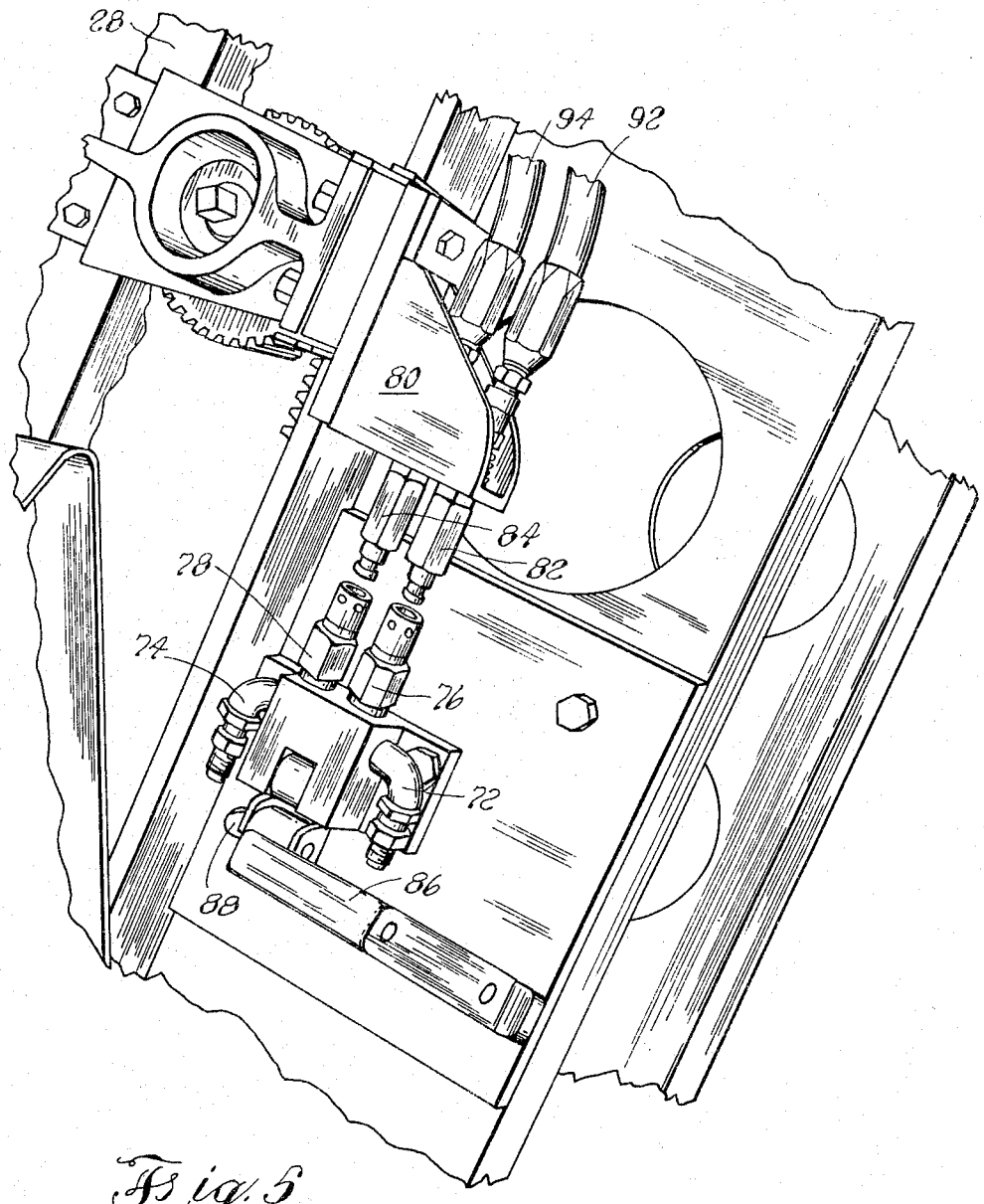


Fig. 5

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FULL PRESSURE SUIT ACTIVATION SYSTEM WITH EJECT CAPABILITIES

Filed July 26, 1965 6 Sheets-Sheet 5

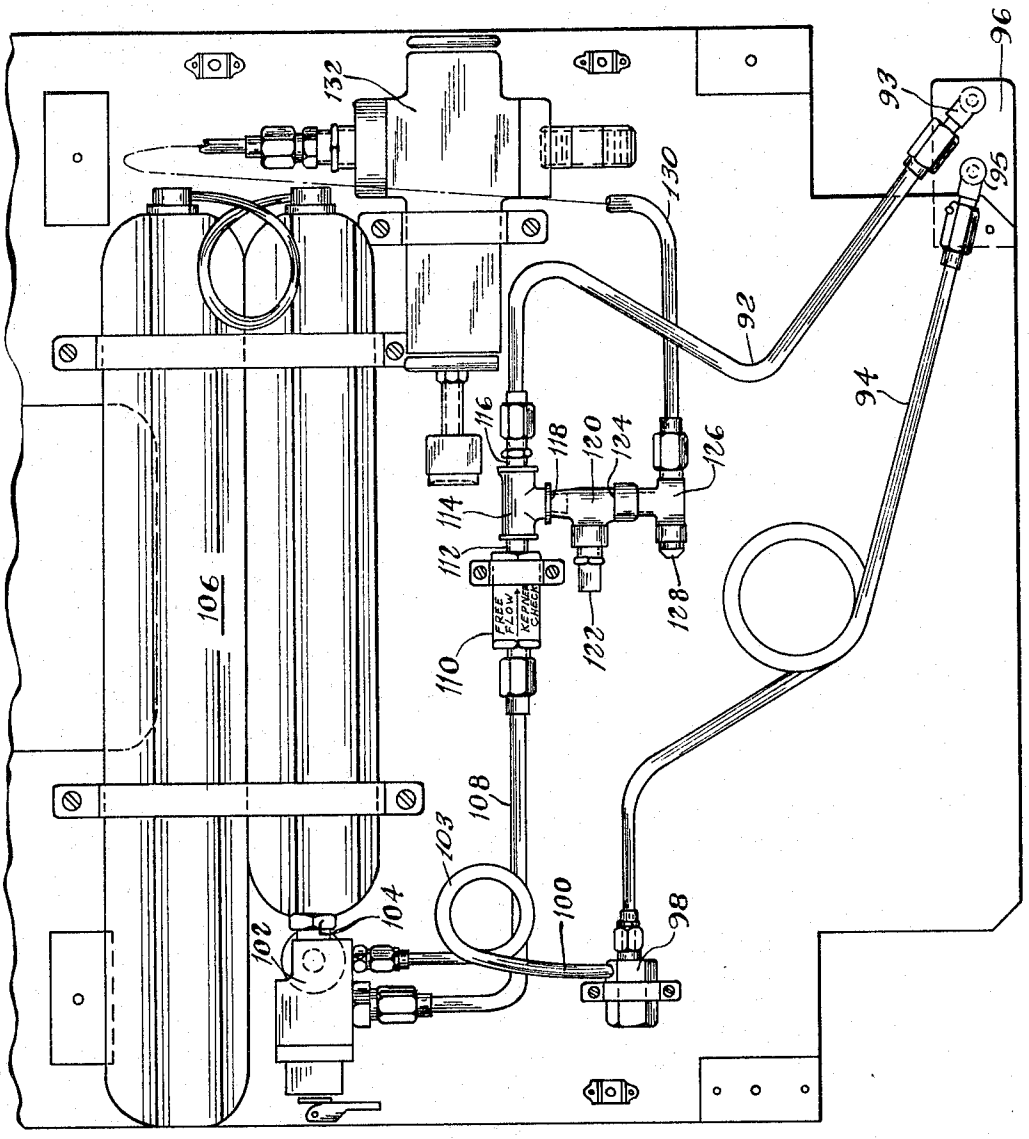


Fig. 6

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FULL PRESSURE SUIT ACTIVATION SYSTEM WITH EJECT CAPABILITIES

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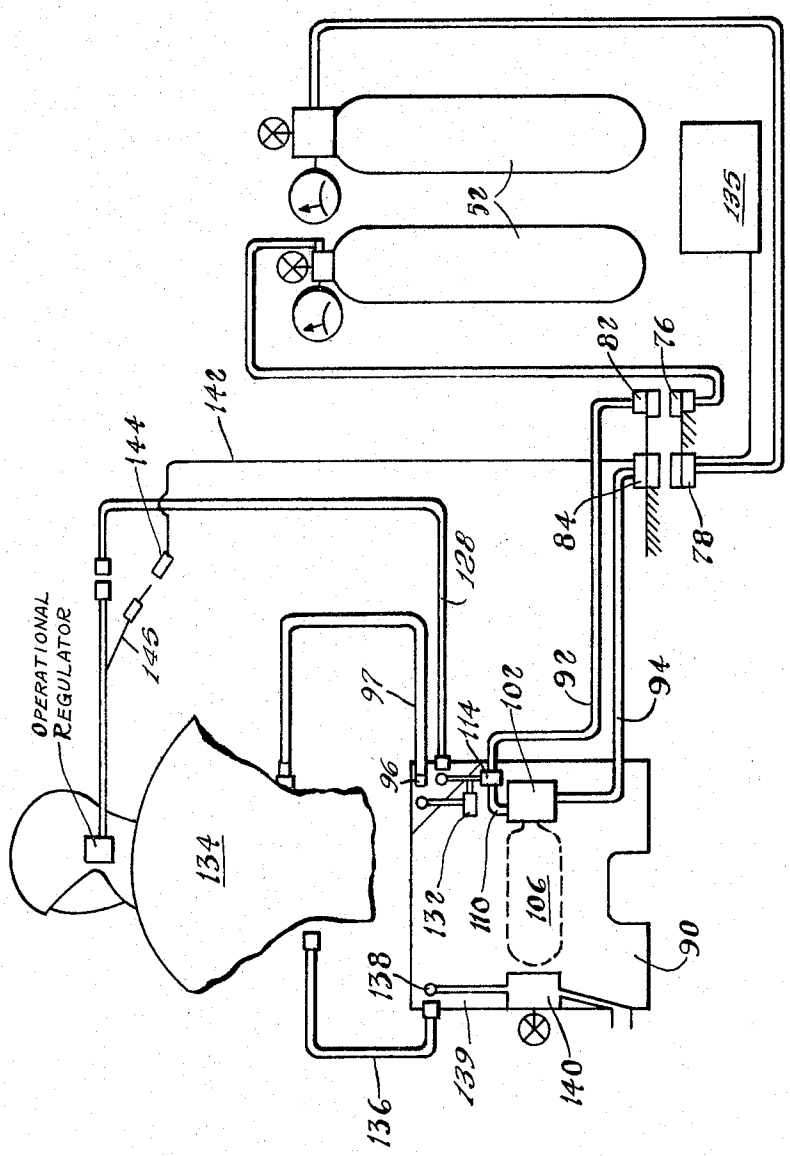


Fig. 6

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United States Patent Office 3,286,373 Patented Nov. 22, 1966

3,286,373

FULL PRESSURE SUIT ACTIVATION SYSTEM WITH EJECT CAPABILITIES

Daniel D. Mangieri, Commack, N.Y., assignor to the United States of America as represented by the Secretary of the Navy

Filed July 26, 1965, Ser. No. 475,025
5 Claims. (Cl. 35—12)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of royalties thereon or therefor.

This invention is a continuation-in-part of patent application Serial No. 435,097, filed February 24, 1965.

This invention relates to an ejection seat trainer and particularly to a full pressure suit activation device utilized in conjunction with the trainer.

The ejection seat trainer **10**, illustrated in FIG. 1, provides a realistic and efficient means of training pilots in the correct procedure and characteristics of seat ejection from planes. It promotes confidence by acquainting pilots with the sensations of cartridge-powered seat ejection under conditions of optimum safety. The cockpit, seat, and controls simulate or duplicate the physical dimensions and shapes of airborne equipment. The cockpit mockup **12** simulates controls and obstructions which the student must operate or avoid to eject successfully and without injury from an airborne cockpit; the trainer's obstructions yield safely and provide visual and audible signals if struck. Switches actuate signals on the instructor's panel as the student performs each step of the ejection procedure, enabling the instructor at all times to monitor the correctness and progress of the training procedure. The instructor, by means of switches on his panel, can at any time prevent the student from ejecting or can secure all power to the trainer. The location of the instructor's panel is such that the instructor at the panel and the student seated in the ejection seat are within view of and facing each other.

When the student **14** has followed the required procedural steps in preparing to eject, and the instructor, monitoring the instructor's panel and watching the student's movements, has satisfied himself concerning the correctness of the procedure, a catapult safety device is released by the instructor **16**. This action enables the student's final move to cause an ejection cartridge to be fired. Seat and student are ejected upward, out of the cockpit, along the tower guide rails **20**. The device produces a maximum seat travel of about 15 feet, and subjects the student to less than half the *g* force which he would experience in an actual airborne ejection. The elevated tower **18** contains the guide rail **20**. The descent of the seat down the tower guide rails is powered by gravity, controlled by mechanical governors, and is cushioned by a hydraulic-pneumatic seat catch system.

In addition, the ejection seat trainer provides breathing-and-ventilation-air sources, controls and fittings so that the seat ejection training may be accomplished with the student clothed in his Mark IV full pressure suit. When the student wears his full pressure suit and he is seated in the ejection seat prior to ejection, he is provided with breathing and ventilation air from an air compressor, and maintains voice communication with the instructor through integral intercommunication equipment. By manipulation of a manually-operated vent-exhaust control valve, the instructor may control the pressurization of the full pressure suit from zero p.s.i.g. to 3.5 p.s.i.g. This control by the instructor enables him to simulate for the student any corresponding pressure to which the student would be subjected in the event of partial or

complete loss of cabin pressurization at any altitude from 35,000 feet to 100,000 feet. Pressurization of the suit is an important feature of the training procedure because pressurization of the suit makes the student's movements more cumbersome. By acquainting himself with the sensations and exertions he must experience to accomplish the ejection procedure while subjected to pressurization of the suit, the student gains confidence in his ability to successfully complete the procedure. Upon ejection, the student is automatically disconnected from the simulated aircraft's breathing air and ventilation air source, i.e., the training device's air compressor.

A structural-steel base **22** bears the elevated tower **18** together with the seat which moves along the tower. The base functions as a strong, stable and level foundation when raised on its self-contained leveling jacks and when counter-balanced by spreading out its trail beams **24** to form a Y configuration. Heavy, self-contained casters **26** provide the base with mobility, and the outspread trail beams can be folded inward to reduce the overall width of the unit and increase its maneuverability. A plumb bob suspended from the tower and hanging over an inscribed plate affixed to the base, makes apparent at all times whether or not the base is truly level.

The tower **18** which functions as a guide track for the ejection seat which moves along the tower, is constructed from two steel channels assembled into a strong and rigid box section. It is hinged to the base so that it can be lowered to a horizontal position on the base for moving or storage, or can be raised to an angle of 73½ degrees and braced with steel tubes so as to offer an inclined track for travel of the ejection seat **28** (see FIG. 5). Along the length of the tower are mounted the two steel rails which guide and hold captive the seat sled and seat, and two steel racks which engage spur-geared governors mounted on the seat sled. The tower also acts as a frame to support a friction-type safety brake (not shown) to stop the seat should the seat overshoot its designed 15 foot travel up the tower. The tower also supports a pneumatic-hydraulic system seat catch which engages and stops the descending seat.

The cockpit **12** functions as a frame for seat and student and as a support for an access ladder, mounting platforms, rudder-pedal mockup, and devices such as throttle, emergency canopy release, and a simulated control stick.

It is an important object of the invention to provide full pressure suit capabilities for a pilot in order to train him under simulated conditions to experience the identical conditions in case of operational ejection from a plane.

It is another object to provide air under pressure to a pilot trainee when he is ejected from an aircraft under simulated conditions.

It is still another object to provide a quick disconnect means between the ejection tower and the ejection seat so that a supply of oxygen/air is provided for the period after ejection to simulate actual conditions of when the pilot is out in space, free of his aircraft.

It is yet another object to provide a constant supply of air under pressure to a storage source, so that it will be unnecessary to dismantle the training equipment and to replace exhausted supplies of air.

And it is another object to control the air under pressure so that the pressure utilized in actual operational performance is duplicated.

It is still a further object to provide a simplified structure, having general application for all types of aircraft, which control and supply air to the pilot trainee in close simulation of actual operating conditions.

And it is still yet another object to provide a device which is compact in construction, since the space that

may be utilized to provide the training equipment is limited.

It is yet another object to provide a two-way communication system between the instructor and the student where the freedom for the use of the hands is maintained.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a perspective view of an ejection seat trainer in use today;

FIG. 2 is a graph showing the relationship of compressed air requirements for a pressure suit with relation to altitude;

FIG. 3 is a schematic illustration illustrating provision of compressed air in the system;

FIG. 4 schematically illustrates the full pressure suit capability in the seat;

FIG. 5 illustrates the quick disconnect and compressed air cut-off construction;

FIG. 6 shows the seat pan and pressure suit capability as actually constructed; and

FIG. 7 schematically follows the provision of air to the pilot and to his pressure suit.

A cabin is pressurized and is ordinarily maintained at 5–15 p.s.i. When pressure is lost, the aircraft flies at ambient altitude. To survive, man must have at least 3.0 p.s.i. of pure oxygen. Since oxygen comprises roughly twenty percent of air (the other inert compounds not being material here), 3.0 p.s.i. of pure oxygen is the equivalent of 15 p.s.i. of air. Thus, at 35,000 feet altitude, 100% pure oxygen is required at 3 p.s.i. In FIG. 2, a curve illustrating the diminishing of pressure in the suit as the altitude rises over 35,000 feet, is shown. At 35,000 feet, no pressure in the suit is required. However, at 40,000 feet, about .77 p.s.i. is required, and so on until at a maximum altitude of 100,000 feet, a pressure of 3.34 p.s.i. is required. Thus, the pressure suit of the pilot provides differential pressure between ambient pressure and 3.5 p.s.i.g.

When the student utilizes his pressure suit in the training for ejection, he leaves the pressurized cockpit **12** in his ejection seat and now must be provided with air while in space to survive.

During the captive ascent and descent of the ejection seat up and down the tower the student is furnished with air for breathing from two bailout-oxygen bottles contained in the seat pan of the ejection seat. Because the capacity of the bailout-oxygen bottles is limited and must be conserved the vent-exhaust valve is closed by means of a lanyard to automatically close upon ejection of the seat, resulting in stoppage of ventilation with consequent maximum pressurization of the suit during ejection. The invention about to be described provides the necessary oxygen and suit pressurization.

The ejection seat trainer, may be employed with or without full-pressure-suit activation. To enable full pressure suit activation, an air compressor assembly is furnished as an integral part of the device. The air compressor assembly furnishes compressed air for ventilation, pressurization, and breathing through a 90 p.s.i. air hose and through an 1800 p.s.i. air hose. Regulators and fittings contained within the seat pan of the ejection seat receive compressed air from the compressor assembly during such times as the seat is in pre-ejection position, and feed the air, via hoses from seat pan to the full pressure suit. The seat pan also contains bailout-oxygen bottles which receive and store 1800 p.s.i. air from the compressor when the seat is in pre-ejection position. When the seat is ejected up the tower, the seat is separated from the compressed air couplings through which it formerly received air from the compressor, and at that time and during the remainder of ejection the compressed air bottles within the seat pan furnish the required pressurization and breathing air. To conserve the limited supply of air in the bailout-oxygen bottles, the ventilation-exhaust valve in the seat pan, to which the vent-exhaust hose from the suit is connected, is caused to automatically close by means of a lanyard if not manually closed prior to ejection. This results in stoppage of ventilation through the suit during ejection, and use of the air solely for breathing and pressurization. Used thusly, the supply of air in the bottles will last approximately five minutes. For reasons of safety, economy and practicability, compressed air is used for full-pressure-suit activation rather than aviator's breathing oxygen.

The air compressor **30** (FIG. 3) is a three-stage, air-cooled, 1500 r.p.m., 3.5 c.f.m., 2200 p.s.i.g., reciprocating-type unit driven by twin V-belts from a 3 H.P., 1750 r.p.m., 110 volt, single-phase 60-cycle capacity-start induction-run electric motor **32** drawing a maximum current of 34 amperes. Electrical power input to the motor's magnetic controller **38** is controlled by a start-stop toggle switch **34**. A pressure switch **36** in the air-discharge line of the air compressor is electrically connected to the magnetic controller **38** and automatically stops the air compressor when the discharge pressure reaches 1800 p.s.i.g. and restarts the compressor when the pressure falls to 1400 p.s.i.g. A contaminants discharge filter **40** in the air compressor discharge line **42** ensures delivery of oil-free and clean air to the pressure suit. A bleeder valve **44** at the bottom of the discharge-air filter is installed for starting-up the compressor, and relieving moisture and oil; it is manually opened when starting the compressor and closed after starting. The relief valve **46** acts as a safety and the inlet filter **48** cleans incoming air. A check valve **50** immediately downstream of the filter prevents any high-pressure air remaining in the accumulator tanks from a previous operation from escaping through the bleeder valve **28** when the valve is opened. Two air accumulator tanks **52** act as a reservoir and surge tank for the discharge air; each tank is provided with a separate shutoff valve **54** which, during operation, must remain normally open. The air inlet line from the compressor **30**, the accumulator tanks **52**, and the outlet line, are all connected to a common manifold **56**. The outlet line from the manifold feeds directly into the 1800 p.s.i. line **58**, and also provides 1800 p.s.i. air via the line **60** to the inlet of a 90 p.s.i. regulator **62**. The regulator **62** is a standard oxygen-type regulator, with integral inlet (high pressure) gage **64** and outlet (low pressure) gage **66**. Hose connectors **68** and **70** are fitted in the 90 p.s.i. line immediately past the 90 p.s.i. regulator **62**, and in the 1800 p.s.i. line **58** after the manifold **56**. Two flexible hoses **72** and **74**, color-coded to identify the 90 p.s.i. hose from the 1800 p.s.i. hose, are provided with the assembly. These hoses are used, to connect the air compressor assembly to female couplings **76** and **78** attached to the tower **18**; the couplings of the tower connector have integral check valves within them so that if the air compressor hoses are disconnected, compressed air will not back-flow from the seat pan and escape to the atmosphere.

As is shown in FIG. 5, permanently affixed on L-brackets to the left-side of the tower **18** near the cockpit (not shown) are the two female coupling-body assemblies **76** and **78** with integral check valves. The 90 p.s.i. hose **72** and the 1800 p.s.i. hose **74** from the air compressor assembly are connected, when full-pressure-suit activation is prepared for, to their respective couplings; the female ends of the couplings **76** and **78** remain exposed. On the seat sled is affixed an L-bracket **80** containing two male coupling nipple assemblies **82** and **84** which mate with the exposed female couplings **78** and **76** on the tower when the instructor manually employs the connect lever **86** and the cam **88** in the pre-ejection position. Like the couplings on the tower, the couplings on the sled also contain integral check valves within themselves.

When the seat is ejected and rises, causing the seat connector couplings **84** and **82** to disengage from the tower connector couplings **78** and **76**, the check valves in the couplings close, and so compressed air stored in the bailout-oxygen bottles **100** within the seat pan **90** will not escape to the atmosphere through the parted couplings of the sled. The sled couplings are connected by hose **92** for 90 p.s.i. air and by hose **94** for 1800 p.s.i. air to the seat pan fittings **93** and **95** (see FIG. 6).

The functions of the bottles, valves, fittings and gages contained within the seat pan **90** of the ejection seat are: (1) to store air within oxygen-bailout bottles to provide breathing and pressurization air to the full pressure suit when the seat is separated from the air compressor assembly during ejection; (2) to provide air at a reduced pressure of approximately 5 p.s.i. for ventilation of the full pressure suit during pre-ejection; (3) to provide breathing air at between 40 and 90 p.s.i. to the helmet of the suit; (4) to provide a means, by a manually controlled valve, of manually controlling the flow of ventilation-exhaust air exhausting from the suit and so controlling the suit pressurization; and (5) to provide electrical connection between the communication line from the suit helmet to the communication kit, via the instructor's panel.

As is best shown in FIGS. 4 and 5, the 1800 p.s.i. hose **94** from the seat-tower connector **84** supplies high pressure charging air through a check-valve (not shown) in the fitting **84** into the extension block **96**. From the block **96**, the hose **94** under high pressure connects to a charging adapter **98**, where the flow of oxygen or air is slowed down before connecting via the hose **100** to the inlet end of pressure reducer **102**. The flow is restricted and slowed in order to avoid excess pressures on the storage container, with the attendant danger of breakage. The hose **100** is convoluted at **103** to form a spring-like section so that unusual surges of fluid or excessive local pressures will be offset to prevent the hose line from rupturing. The inlet **104** of the pressure reducer **102** is connected directly to the storage containers **106**. Air is stored therein at 1800 p.s.i. and when needed, is returned to the pressure reducer **102**, where presure is reduced to 60 p.s.i. before the transfer via the conduit **108** to the inlet end of the check valve **110**. The use of the pressure reducer **102** both for inflow of fluid such as oxygen or air to the container **106** and for return flow from the container on its way to the pilot serves a two-fold function. A greater compactness of construction is possible. But in addition, a manifold connector is not required to supply outputs for oxygen or air. The other end of the check valve **110** is connected via the connector **112** to the T-valve **114**. The hose **92** supplies oxygen or air at 90 p.s.i. to the other end of the T-valve **114** via the connector **116**. This provides oxygen or air from two sources. Since the oxygen or air entering the T-valve **114** from the hose connection **116** is at 90 p.s.i. and is greater than the pressure of 60 p.s.i. supplied via the connector **112**, the check valve **110** is normally closed and the oxygen/air in the storage containers **106** is preserved for emergency use. Should the pressure in the line **92** fall below 60 p.s.i., the check valve would open, to supply oxygen or air from the reserve containers. Thus, when the pilot ejects from the cockpit, the hoses from the air compressor are disconnected and the 90 p.s.i. pressure is lost. Then, the check valve **110** will open to permit the oxygen or air from the containers **106** to flow through the connector **126** to the helmet and the pressure suit **134**. The remaining port **118** is directly connected to a transverse T-connector **120**. The T-connector **120** is provided with a safety plug **122** to protect the device against pressure reaching in excess of 120 p.s.i. In the event the regulator is not properly adjusted, or malfunctions, or if excessive pressure is admitted to the 90 p.s.i. hose, the safety plug will protect the helmet and regulator from damage. The other port **124** is connected to the distributor T-connector **126** for providing oxygen/air to the helmet of the pilot, and to the pressure suit he uses. This is provided by the hose **128** to the helmet regulator indicated on the pilot and by the conduit **130** to a pressure regulator **132**, where the pressure is further reduced to 5–10 p.s.i. prior to delivery to the inlet valve of the full pressure suit **134** by means of the quick disconnect member **96**. (See FIGS. 6 and 7.)

The vent exhaust hose **136** from the suit **134** mates with the vent exhaust fitting **138** which leads into the pan seat **90**. The end of a hose **139** inside the seat pan is connected to a manual gate valve **140** which opens to the atmosphere through the side of the seat pan. When this valve, referred to as the vent exhaust control valve **140**, is fully open, the air within the suit is permitted to exhaust to the atmosphere, and no pressure can build up within the suit except for a very small pressure due to the resistance of the suit itself to the air flow. A low pressure gauge mounted on the seat pan adjacent to the vent exhaust control valve **140** indicates the pressure in the vent exhaust line. With the valve **140** fully open the suit-pressure gauge will indicate zero pounds per square inch. When the valve is fully closed, air cannot exhaust from the suit, and the pressure within the suit will build up to a maximum of 3.5 p.s.i.g. By manipulating the valve to any degree of closure between fully open and fully closed, the pressure in the suit may be maintained at any desired pressure between the zero p.s.i.g. and 3.5 p.s.i.g. By this means, the suit may be pressurized to simulate any differential pressure to which the student would be subjected by ambient pressure on his suit at any altitude between 35,000 and 100,000 feet and above.

An electrical lead **142** extends up through the seat pan **90** and terminates in an electrical disconnect **144** for connection to the communication line **145** from the full pressure suit **134**. The other end of the lead **142** passes out through the seat and terminates in the electrical disconnect (not shown) on the seat sled which mates with an electrical disconnect (not shown) on the tower when the seat is in its pre-ejection position. When the seat is ejected and the electrical disconnects are separated, and voice communication between the student and the instructor is terminated.

A self-contained transistorized dual channel amplifier **135** is used for voice communication between the trainee and the instructor. The amplifier is powered by a nine volt dry cell battery (not shown). The communication amplifier **135** is energized by means of an on-off switch (not shown) ganged to the volume control of the incoming channel. No warm-up period is required to place the amplifier into operation. The instructor is provided with a two-way system (not shown) which he may utilize without requiring manual manipulation. This leaves his hands free for operational instruction of the trainee. In operation, a pilot **14** is seated on ejection seat trainer **10** preparatory to being ejected. He pulls the face curtain **11** over his head and when the cartridge is fired, he is ejected upward free of the cockpit **12**, in a realistic manner. When this occurs, the connectors **82, 84** disconnect from the fixed connectors **76** and **78** as is illustrated in FIG. 5.

Prior to this step, compressed oxygen or air at 1800 lbs. per square inch has been supplied to the storage tanks **106** via the hose **74**. Compressed air at 90 lbs. per square inch has been supplied to the T-connector **114** via the tubing **72**. The air from the storage chamber **106** is also supplied to the T-connector **114**, but is reduced prior to entry to about 60 lbs. per square inch by the pressure reducer **102**. When the pilot has been ejected, the valves **76, 82** and **78** and **84** are disconnected, and the supply from the connector **92** to the T-connector **114** is cutoff. This causes the air to flow from the pressure reducer **102** through the line **108** to the connector **114**. From the

connector 114, air is sent to the pilot's helmet via the line 128 and to the pressure suit via the line 97. It is desirable to circulate the air through the pressure suit, and this is accomplished through the line 136. A low pressure gauge (not shown) is provided in the seat adjacent to the pilot so that the instructor may see the pressure on the vent line. The communication line 145 permits communication between the instructor and the student until ejection.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. The method of training pilots to cope with ejection condition from an airplane comprising the steps of placing the pilot in a simulation airplane ejection apparatus having an upwardly inclined guide tower,

simultating oxygen conditions in an airplane,

accelerating the pilot along said upwardly inclined guide tower,

providing oxygen under pressure to the helmet and to the suit of the pilot while he is moving along said inclined guide tower in realistic similarity to actual ejection conditions, and

increasing the oxygen supplied to the suit as the simulated altitude becomes greater, whereby the pressure suit provides differential pressure between ambient pressure and that of 3.5 p.s.i.g.

2. The method of claim 1 and including the step of providing oxygen to the pilot at substantially 40–90 p.s.i. whereby normal breathing conditions are maintained.

3. The method of claim 2, and including the steps of,

providing communication between the pilot and an instructor by radio signals, and

disconnecting the communication line between the pilot and instructor upon accelerating of the pilot in order to end voice communication in the manner of actual ejection conditions.

4. The method of claim 1 and including the steps of the instructor facing the pilot and operating a control panel to prevent ejection of the pilot or to secure all power to the ejection apparatus.

5. The method of claim 1 and including the steps of the instructor monitoring on said control panel the correctness and progress of the pilot during the training procedure, and

when the procedure is correct operation by the instructor of a control switch to enable the pilot to actuate the pilot acceleration apparatus.

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