April 23, 1968 T. P. CAREY ET AL 3,378,939

REGULATING VALVE FOR EJECTION SEAT TRAINER

Filed July 18, 1966 3 Sheets-Sheet 1

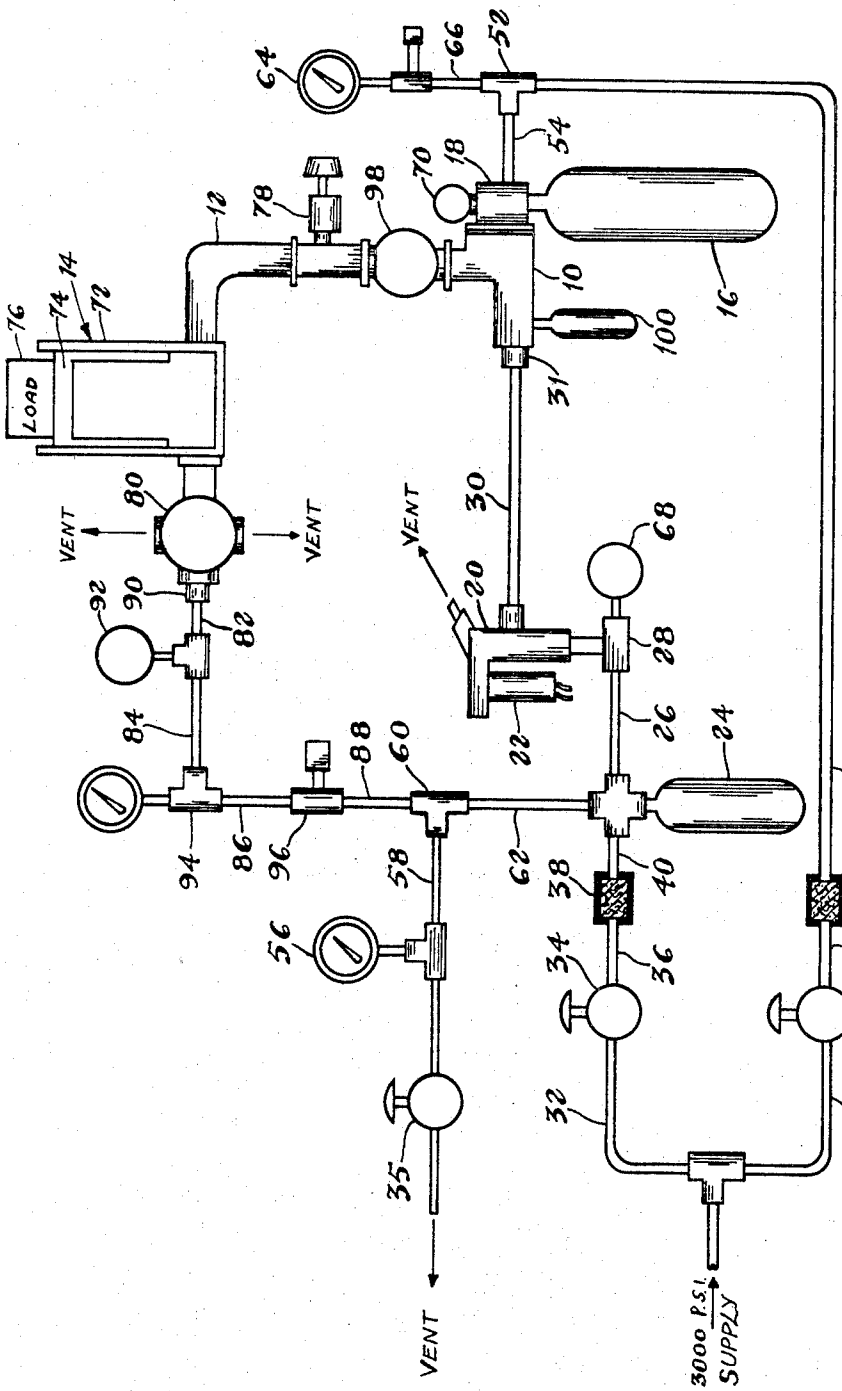


FIG. 1

INVENTORS
THOMAS P. CAREY
THEODORE T. HADELER
BY
John M. Peace
ATTORNEY

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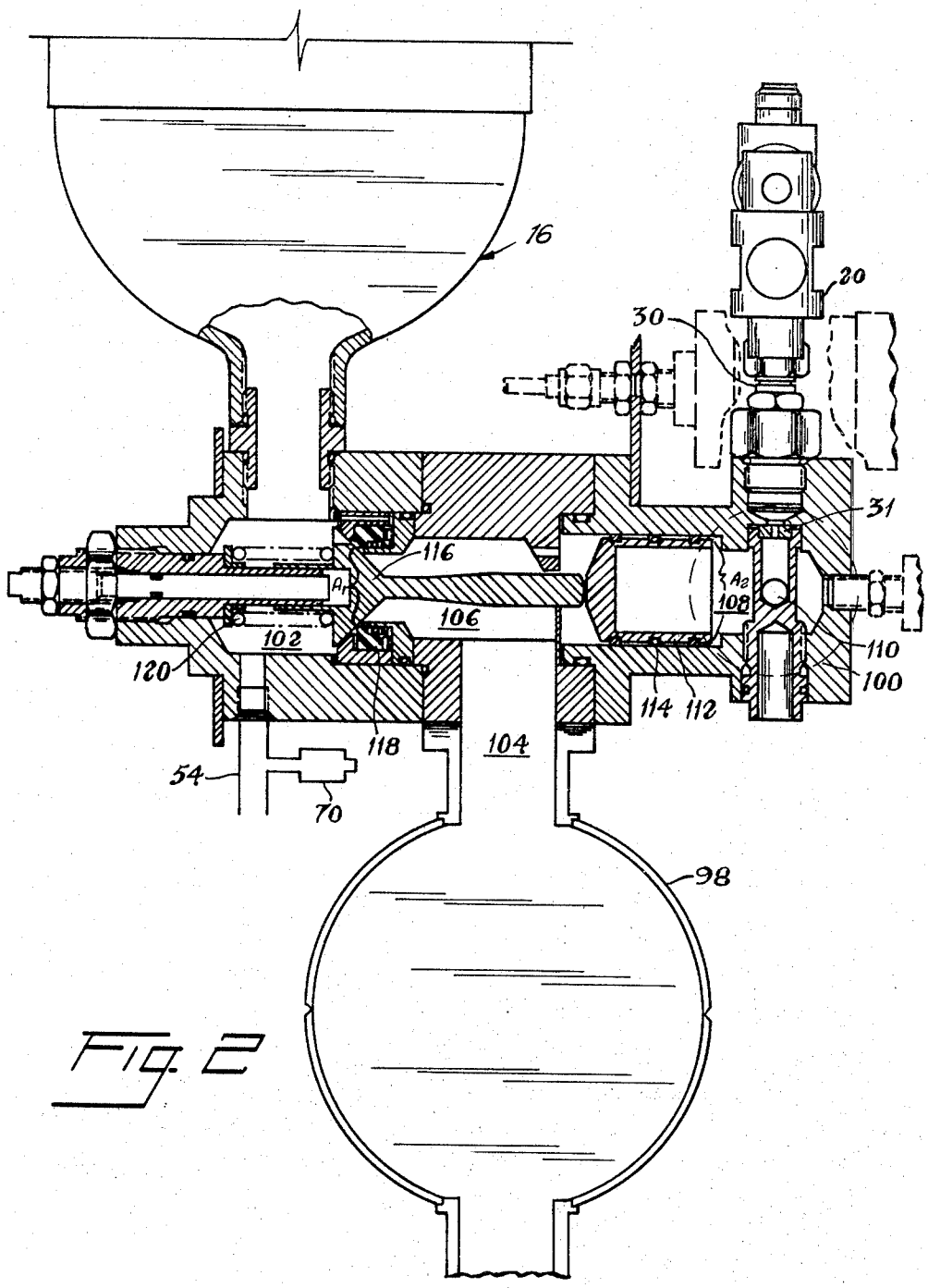


Fig. 2

INVENTORS
THOMAS P. CAREY
THEODORE T. HADELER
BY
John M. Pease
ATTORNEY

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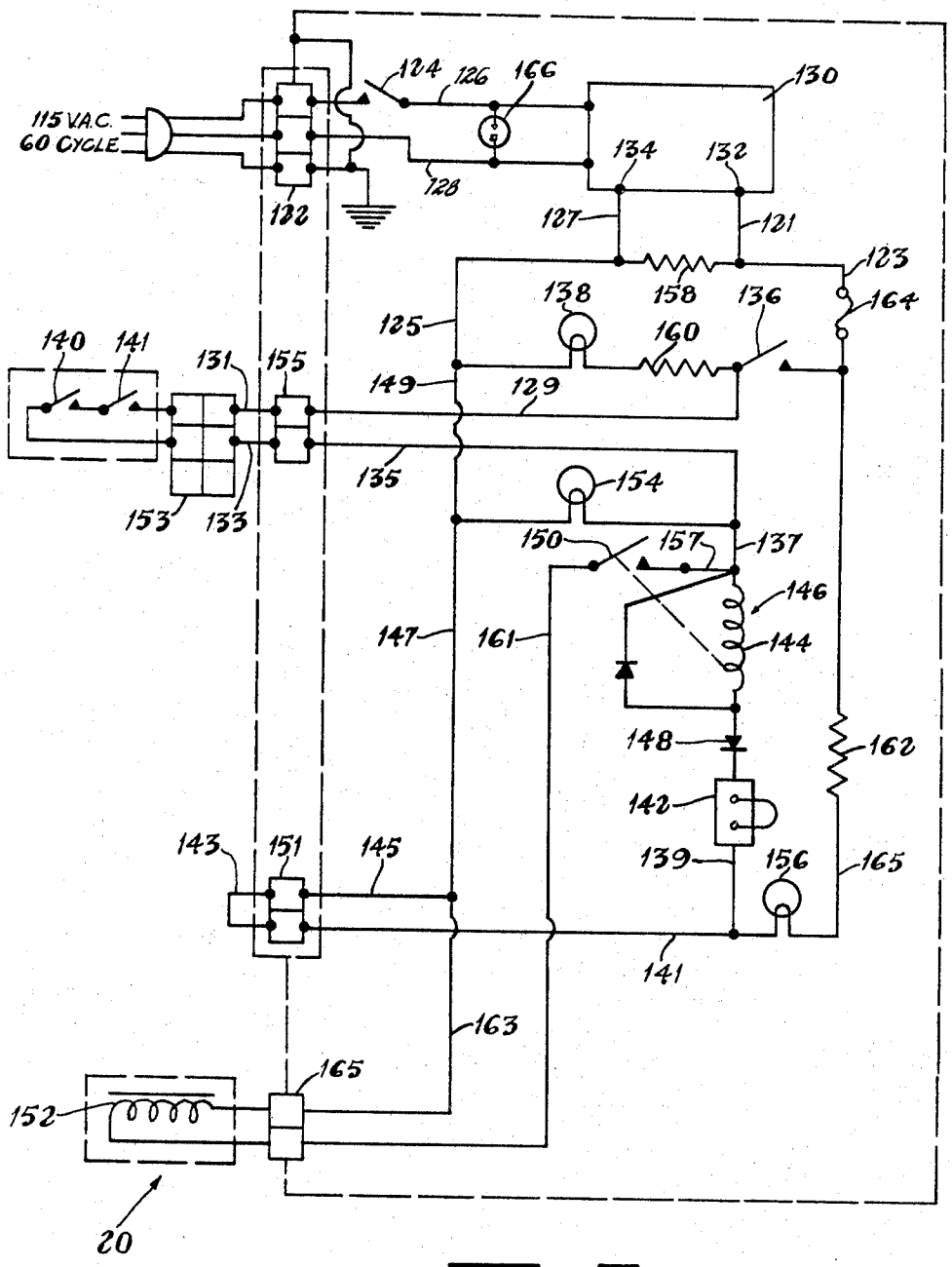


Fig. 3

INVENTORS
THOMAS P. CAREY
THEODORE T. HADELER
BY
John m. Pease
ATTORNEY

United States Patent Office

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REGULATING VALVE FOR EJECTION SEAT TRAINER

Thomas P. Carey, Durwood, Md., and Theodore T. Hadeler, Montvale, N.J., assignors, by mesne assignments, to the United States of America as represented by the Secretary of the Navy

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9 Claims. (Cl. 35—12)

ABSTRACT OF THE DISCLOSURE

This invention is characterized by the incorporation in a gas pressure actuated seat ejection system of an unbalanced single state loaded gas flow regulator connected to pass gas under pressure from a fixed volume power gas source to a piston type actuator under the initial actuation and control of a pilot gas pressure means, and wherein the effective gas pressure reception areas of a poppet valve and a pilot piston of said regulator are selected to provide a progressive opening of the regulator valving mechanism responsive to the continued passage of gas to the actuator, thereby accelerating the actuator piston at a rate which increases with time.

This invention relates to vehicle escape systems and more particularly to an improved pneumatic actuated ejection seat trainer.

In the past, an explosive charge has been utilized in ejection seat trainers as a means of propulsion. In this arrangement, attempts have been made to control the burning of the charge to simulate actual ejection rates without injury to personnel propelled in the trainer. However, it has been found that when the same charge used for actual ejections is employed in the trainer, back injury was suffered by some of the students after a few training sessions. Attempts made to proportion the charge to the weight of the trainee so as to prevent injury while still providing an effective simulation of ejection failed because the burning of the charge could not be closely controlled. Thus, the charges were unreliable and resulted in an unacceptable percentage of operations which either effected injury to the trainee or lack of effective simulated ejection.

The use of fluid under pressure as the propulsion means in the past has involved the problem of excessive shock from initial blast, or in the alternative, ineffective simulated projections.

It is an object of this invention to provide an improved ejection seat trainer of the pneumatic actuated type.

A further object is to provide an improved pressure flow regulating valve for a pneumatic actuated ejection seat trainer, the valve being capable of controlling gas pressure flow in such a manner that a seat ejection piston is accelerated at a rate which automatically increases with time.

Basically the invention comprises a seat ejection system including an actuator piston connected to a source of gas under pressure and an intermediate unbalanced single state loaded flow regulator responsive to supply pressure drop in effecting accelerated flow, together with perimeter limitation control means.

Other objects and advantages will appear from the following description of an example of the invention, and the novel features will be particularly pointed out in the appended claims.

In the drawings:

FIG. 1 is a schematic diagram of the gas conduit system of an ejection seat trainer embodying the invention;

FIG. 2 is a cross-sectional view of a gas flow regulator

indicated in FIG. 1 together with connections of the regulator to its supply source, actuator and control pressure source;

FIG. 3 is a schematic drawing of an electrical circuit provided to control the operation of the ejection seat trainer of FIGS. 1 and 2.

Referring to the drawings, FIG. 1 shows in schematic an ejection seat system embodying the invention. The system as shown includes a gas flow regulator 10 connected through a conduit 12 to pass gas under pressure to an actuator 14 from a fixed volume power gas supply source indicated by the tank 16, tank 16 being connected through a charging valve 18 to the regulator 10. Control of the regulator 10 is exercised through a solenoid operated, three-way pilot valve means 20 actuated through a solenoid 22 to pass pilot gas pressure from a source indicated by tank 24 through connecting line 26 and T 28 to the pilot valve means 20 and thence through a line 30 to the regulator 10. Pilot gas pressure tank 24 is supplied from a 3000 p.s.i. supply indicated through line 32, a manually operated pilot supply fill valve 34, a line 36, a filter 38 and a line 40. The power gas pressure source, tank 16, is supplied from the same 3000 p.s.i. source through a line 42, a fill valve 44, a line 46, a filter 48, a line 50, a T 52 and a line 54. Pressure in the pilot gas pressure source, tank 24, is measured by pressure gage 56 connected thereto through line 58, T 60 and line 62. Pressure in power gas supply source, tank 16, is measured by a gage 64 connected by line 66 to T 52. Tanks 24 and 16 are provided with relief valves 68 (2000 p.s.i.) and 70 (3000 p.s.i.) respectively.

The actuator 14 is shown schematically as comprising a housing 72 and piston 74, the piston 74 supporting a load 76 to be propelled. The rate at which the actuator piston is accelerated is controlled by the regulator 10 as will be described. However, this rate is preferably manually modified by providing an adjustable actuator flow control valve 78 in the line 12. A dome type pressure responsive actuator vent valve 80 is connected by lines 82, 84, 86 and 88 through a fixed restrictor 90, relief valve 92, T 94 and adjustable pressure regulator 96 to the T 60.

Referring to FIG. 2, the regulator 10 is formed with an inlet chamber 102, outlet chamber 104, intermediate passage 106 and a pilot gas pressure chamber 108. The regulator 10 is connected as shown to the charge line 54 and tank 16 via the inlet chamber 102, to the chamber member 98 (leading to line 12 and the actuator 14) via the outlet chamber 104, to the pilot valve means 20 via the pilot chamber 108 and line 30, and to the chamber member 100 via a port indicated at 110. Housed within the chambers 102, 106 and 108 are provided balancing type regulating valve means comprising a pilot piston 112 slidable in the pilot chamber 108 and having gas seal means indicated at 114 and a poppet valve 116 having its stem in engagement with the pilot piston to be biased thereby, together with seal means shown as ring 118 upon which the poppet valve 116 seats and biasing means shown as a spring 120 urging the poppet valve 116 toward closed position.

The rate at which the actuator piston is accelerated is controlled by the regulator 10. However, this can be modified by the adjustable actuator flow control valve 78.

The force exerted against the actuator piston 74 is controlled by dome pressure control actuator vent valve 80. The pressure at which the valve 80 opens is controlled by the adjustable pressure regulator 96. The system may therefore be adjusted according to the load on the piston 74, i.e. according to the trainee's weight, so that safe and effective simulated ejections may be accomplished. The pressure responsive vent vale 80 and the pressure regulator 96 combine to provide adjustable vent means to adjust

the rate at which gas pressure is bled from the actuator to aid in adjusting the system to the actuator load. Chamber members **98** and **100** are provided respectively on the discharge and control pressure sides of the regulator **10** to provide compensating volumes and avoid the development of undesired dynamic gas forces. Relief valve **92** is adusted to limit the maximum force exerted against the actuator piston.

It is to be noted that the effective pressure responsive area of the poppet valve **116**, indicated by the bracket A_1, is smaller than the effective pressure responsive area of the pilot piston, indicated by the bracket A_2. The relative sizes of pressure responsive areas selected depends upon the suply and pilot gas pressure being used. In relation to the pressures suggested herein the area A_2 is selected twice the size of area A_1.

Operation

The power gas suply source, tank **16**, is pressurized to **3000** p.s.i. and this high pressure gas exerts a force on the poppet valve **116** of **3000** p.s.i. times the area A_1 which is the area of the valve member at the line of contact with the seal **118**. The pilot gas pressure source, tank **24**, is pressurized to **1500**+ p.s.i. by the manually operated pilot supply fill valve **34** and vent valve **35**, the pressure being read on the gage **56**.

When the solenoid operated pilot valve means **20** is opened, by electrical circuit means as will be described, gas flows through the line **30** and fixed orifice **31** into the chamber **108**. When gas in the chamber **108** builds up to the regulated pressure of 1500+ p.s.i., i.e. slightly greater than 1500 p.s.i., the forces on piston **112** is 1500+ p.s.i. times area A_2, which equals 1500+ p.s.i. times area $2A_1$. This pressure is sufficient to overcome the forces exerted on the poppet valve **116** by the pressure in tank **16** plus the force of the biasing spring **120**. The valve member **116**, thus, is moved away from the seat **118** and gas flows to the atuator **14**.

As the gas in the tank flows to the actuator **14**, the pressure in tank **16** drops. The pressure in the control chamber **108**, however, remains constant. As the pressure at the outlet of the regulator **10** increases, the pneumatic force acting to close the valve **116** is the tank **16** pressure times the area A_1 minus the regulator outlet pressure time area A_1. The force tending to open the valve **116** is the control pressure 1500 p.s.i.+ times the area $2A_1$, minus the regulator outlet pressure times the area $2A_1$. However, because of the continued decrease in the pressure in tank **16**, the force acting to move the valve **116** toward seal **118** decreases at a faster rate than the force acting to open the valve **116**. The valve **116** is therefore moved farther away from the seal **118** as time passes to thereby continuously increase the pressure at the outlet of the regulator **10** and hence on the piston **74** of the actuator **14**. In this manner, the actuator piston **74** is accelerated at a rate which increases with time.

Referring to FIG. 3, in accordance with this invention, actuation by the solenoid **22** of the pilot valve means **20**, is controlled, as will not be described, by the student subsequent to permissive action by the instructor and with incorporated time delay means.

Thus, as shown in FIG. 3 power is obtained from a 115 volt A.C. source indicated and is transmitted through a terminal block **122**, to a power switch **124** and lines **126** and **128** to a step down converter and recifier indicated at **130** which converts the power to 28 volts D.C. with positive voltage at terminal **132** and negative voltage at terminal **134**. An ejection permit switch **136** and a permit light **138** are connected in series between terminals **132** and **134** by lines **121**, **123**, **125** and **127**.

Instructor switches **140** and **141** and a students switch **142** are connected in series with the coil **144** of a time delay relay **146** and with a diode **148** between the permit switch **136** and the converter negative output terminal **134**. Lines **129**, **131**, **133**, **135**, **137**, **139**, **141**, **143**, **145**, **147**, **149** and lines **125** and **127** are utilized as indicated. Suitable connecting terminal blocks as indicated at **151**, **153**, and **155** are provided.

The time delay relay **146** is provided with a pair of normally open contacts **150** connected in series with the solenoid coil **152** between line **137** and the negative output terminal **134** of the converter **130** by lines **157**, **159**, **161** and **163** together with previously mentioned lines **147**, **149**, **125** and **127**. A suitable terminal block **165** is provided for connecting the solenoid coil **152** to the lines **161** and **163**. An instructors light **154** is also connected between lines **137** and line **149** to indicate to the student the operative position of the instructors permissive switches **140** and **141**. A lamp **156** is connected to line **141** and by lines **165**, **123** and **121** to terminal **132** of the converted to indicate the energized and deenergized condition of the control circuit. Suitable resistor elements **158**, **160** and **162** are provided to provide proper voltages on the several elements of the circuit. A suitable fuse **166** is provided to protect the circuit and a neon light **166** is provided to indicate the energized condition of the converter **130**.

Operation (electrical)

When the student is ready for ejection simulation the ejection permit switch **136** is closed to place the electrical system in condition for operation. The permit light **138** is energized by closing of the switch **136** and indicates ready condition of the electrical system.

Thereafter, when the instructor is satisfied of the condition of the circuit and of safety aspects relating to the student, the instructor closes the switches **140** and **141**, two switches being provided to prevent inadvertent operation. Closing of switches **140** and **141** applies power to one side of the time delay relay coil **144** and energizes the instructors light **154** to indicate to the student that he may now actuate the ejection simulation trainer.

The student can now close the student switch **142** to cause current to flow through the relay coil **144** of the time delay relay **146**. Energizing relay **146** closes the contacts **150** after a time delay representative of the delay present in an actual airplane ejection seat mechanism. Closing of the contacts **150** energizes the solenoid coil **152** of the solenoid **22** which initiates actuation of the pneumatic system as previously described herein.

It is apparent from the above that each of the objects and advantages mentioned herein before are accomplished by the above described ejection seat trainer.

It is to be understood that various changes in the details, materials and arrangements of parts and steps, which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

What is claimed is:

1. An ejection seat trainer system for simulating ejection of a trainee from an aircraft comprising:
   - (a) a gas pressure responsive piston type actuator having a piston for reacting against a load corresponding to the trainee's weight,
   - (b) a fixed volume power supply source of gas under pressure,
   - (c) a gas flow regulator connected to pass gas under pressure from said power gas source to said actuator,
   - (d) a pilot gas pressure source of selected predetermined pressure,
   - (e) pilot valve means for interrupting and passing gas from said pilot source to said regulator,
   - (f) said gas flow regulator including a housing, a poppet valve means with seat seal and a pilot piston,
   - (g) said piston being engageable with said valve to urge it toward open position,
   - (h) means acting on said poppet valve to urge it to closed position,
   - (i) said pilot piston having seal means communicating with said pilot gas source,

(j) said pilot piston and seal means being dimensioned to provide a first effective gas pressure reception area of selected greater value than the pressure reception area of said poppet valve defined by said poppet seal such that upon slight opening of said poppet valve responsive to the admission of pilot gas pressure on said first area the drop in pressure of gas from said power gas source resulting from flow of gas to said actuator continues to open said poppet valve further as time passes and hence accelerates said actuator piston at a rate which increases with time.

2. An ejection seat trainer system according to claim **1**, including,

(a) an adjustable actuator flow control valve connected between said regulator and actuator to selectively modify the rate of flow of gas to said actuator to compensate for different actuator loads.

3. An ejection seat trainer system according to claim **1**, including,

(a) an adjustable relief valve means connected to said actuator for limiting the maximum force exerted against the actuator piston.

4. An ejection seat trainer system according to claim **1**, including,

(a) adjustable vent means connected to said actuator to adjust the rate at which gas pressure is bled from said actuator to aid in adjusting the system to the actuator load.

5. An ejection seat trainer according to claim **2**, including,

(a) an adjustable relief valve means connected to said actuator for limiting the maximum force exerted against the actuator piston.

6. An ejection seat trainer according to claim **3**, including,

(a) adjustable vent means connected to said actuator to adjust the rate at which gas pressure is bled from

said actuator to aid in adjusting the system to the actuator load.

7. An ejection seat trainer according to claim **2**, including,

(a) an adjustable relief valve means connected to said actuator for limiting the maximum force exerted against the actuator piston,

(b) adjustable vent means connected to said actuator to adjust the rate at which gas pressure is bled from said actuator to aid in adjusting the system to the actuator load.

8. An ejection seat trainer according to claim **4**, said adjustable vent means including

(a) a vent valve responsive to variation in gas pressure applied thereto to vary its rate of vent,

(b) an adjustable pressure regulator means connected to pass a selected gas pressure to said vent valve from said pilot gas pressure source to selectively regulate the rate of vent of said vent valve.

9. An ejection seat trainer according to claim **7** said adjustable vent means including

(a) a vent vave responsive to variation in gas pressure applied thereto to vary its rate of vent,

(b) an adjustable pressure regulator means connected to pass a selected gas pressure to said vent valve from said pilot gas pressure source to selectively regulate the rate of vent of said vent valve.

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EUGENE R. CAPOZIO, *Primary Examiner.*

R. W. WEIG, *Assistant Examiner.*