# United States Patent [19]

**Julian et al.**

[11] **3,818,613**

[45] **June 25, 1974**


[54] **HELICOPTER HOVER SIMULATOR**


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[22] Filed: **July 18, 1972**

[21] Appl. No.: **273,006**

[52] **U.S. Cl.** ..... **35/12 K**

[51] **Int. Cl.** ..... **G09b 9/08**

[58] **Field of Search**..... 35/12 K, 12 P, 12 E, 12 W; 272/31 A, 31 B; 248/421



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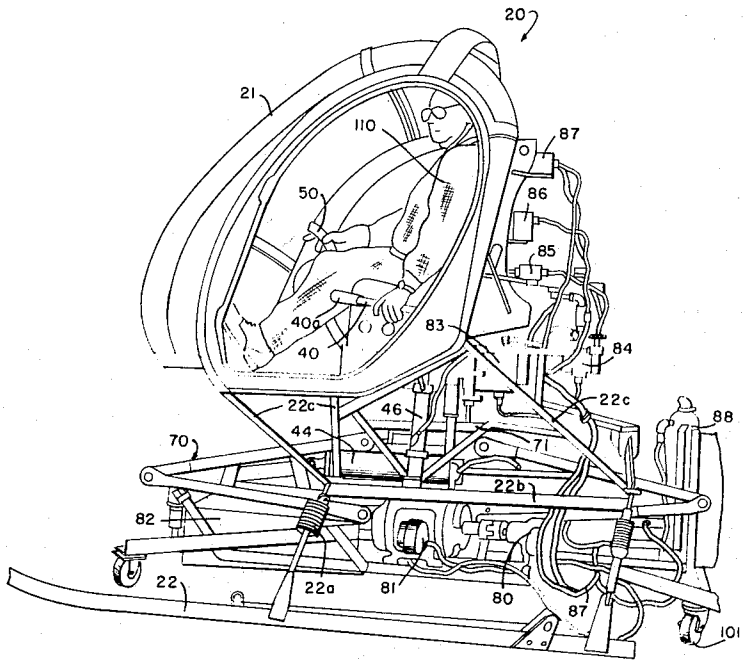
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*Assistant Examiner*—Vance Y. Hum
*Attorney, Agent, or Firm*—James E. Noble; William G. Gapcynski; Lawrence A. Neureither



[57] **ABSTRACT**

A helicopter hover simulator comprising a helicopter cabin with conventional flight controls comprising a collective pitch stick (ascent and descent), a cyclic pitch stick (attitude), antitorque pedals (rotational movement) and a throttle (rate of operation) mounted on a tiltable base member, which in turn is mounted on a ball and socket universal joint, which in turn is mounted on the upper base member of a vertically extendible pantograph assembly which includes a vertical lift hydraulic cylinder for raising and lowering the cabin. The helicopter cabin is tiltably moved in a fore and aft direction by a fore and aft hydraulic cylinder actuating the tiltable base member, and it is tilted laterally by a lateral hydraulic cylinder actuating the tiltable base member. The pantograph assembly is rotatably supported on a central shaft resting on the ground.


**12 Claims, 14 Drawing Figures**



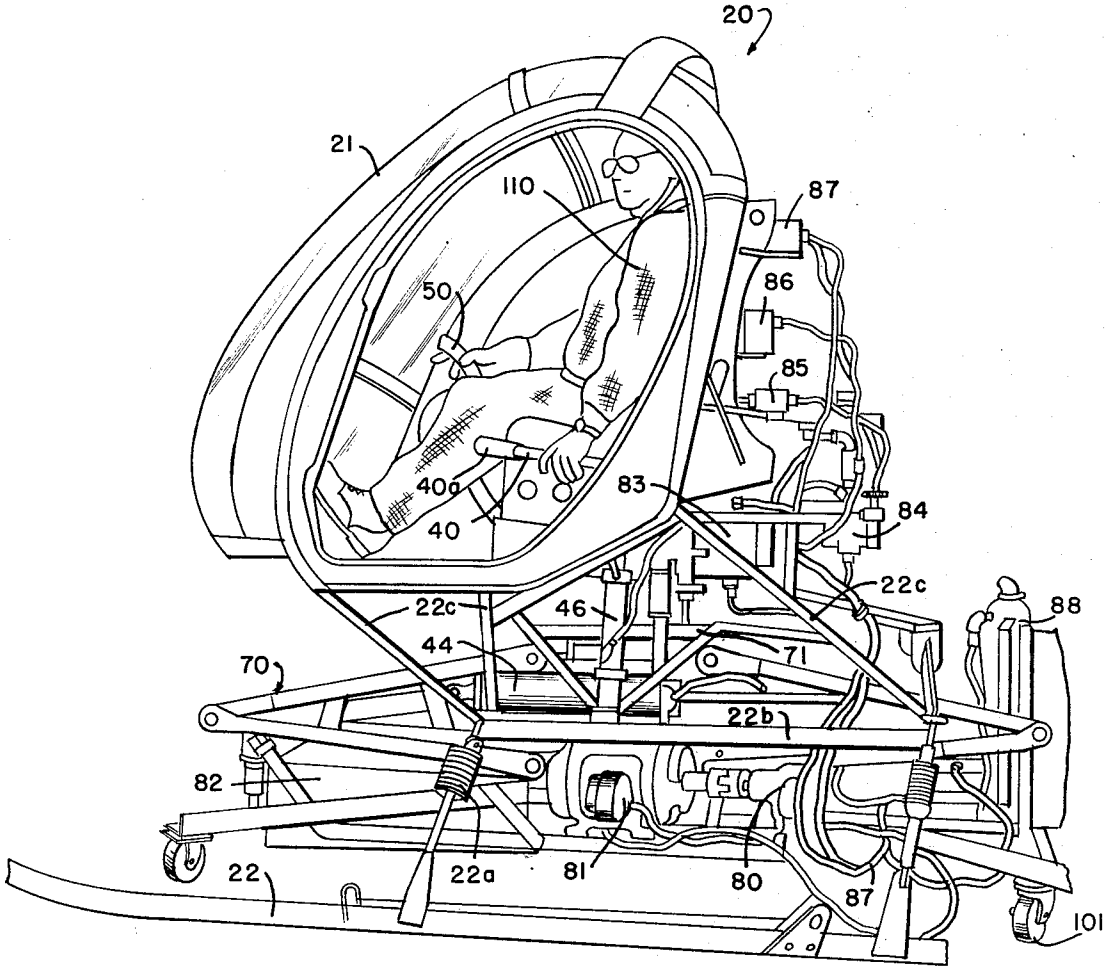

20
21
110
87
50
86
85
40a
40
83
84
22c
46
22c
88
44
71
70
22b
82
22
22a
81
80
87
101

FIG. 1

FIG. 2

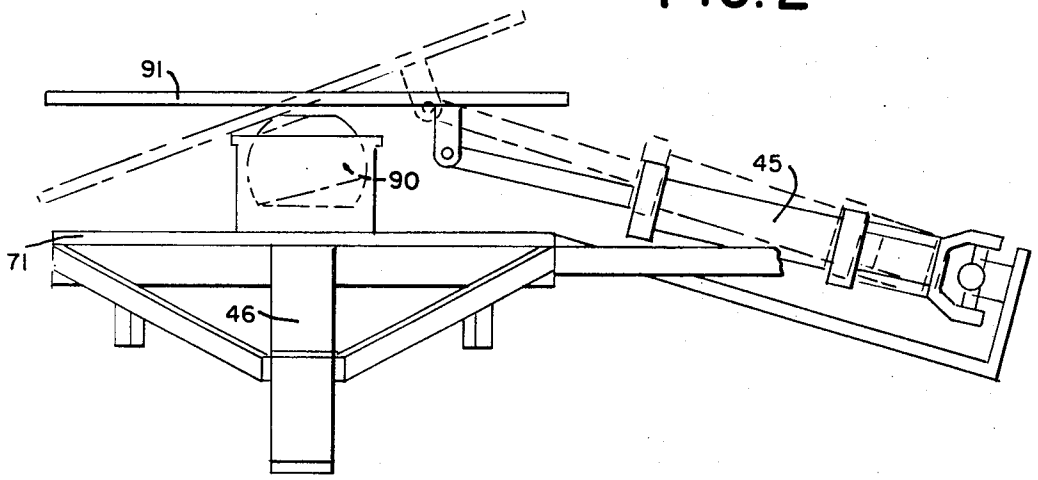

91
90
45
71
46

FIG. 3

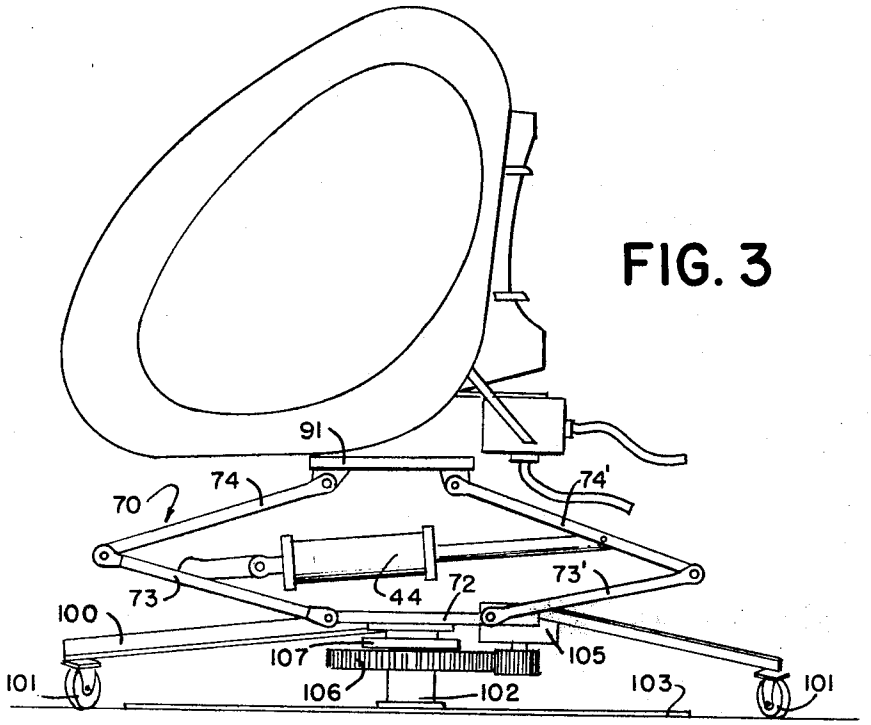
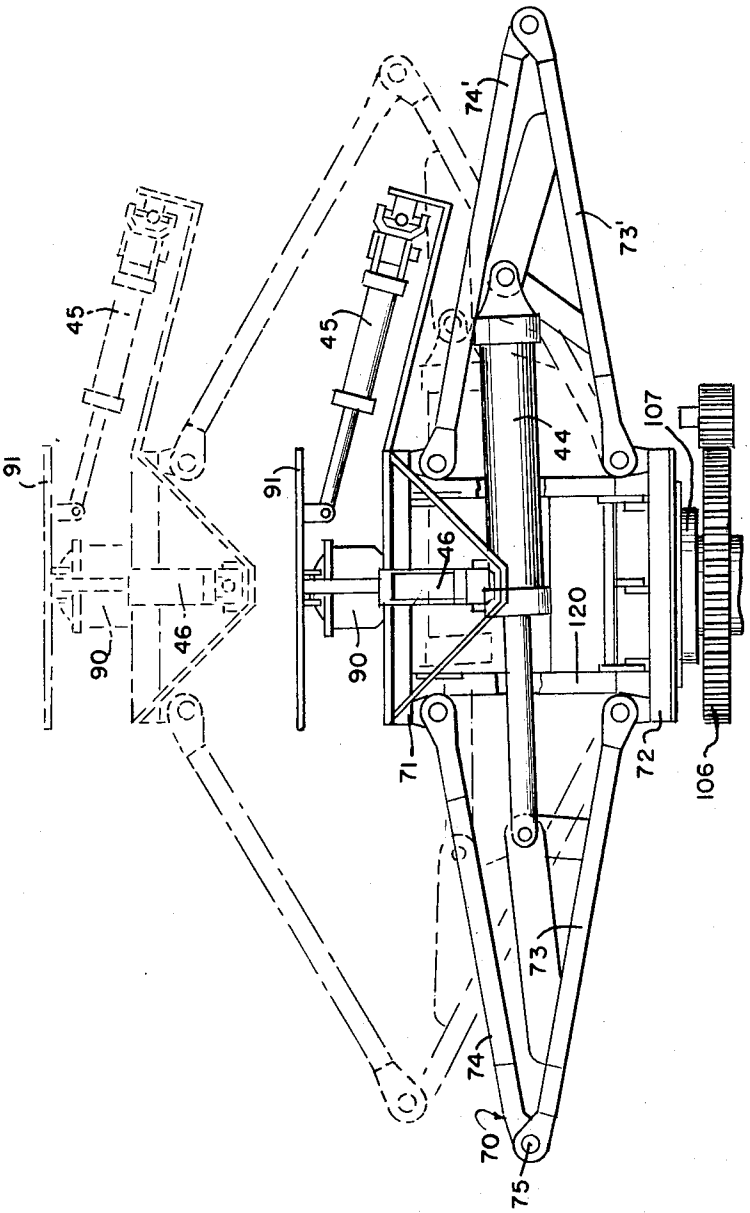

91
74
74'
70
73
44
72
73'
100
107
105
101
106
102
103
101

FIG. 4



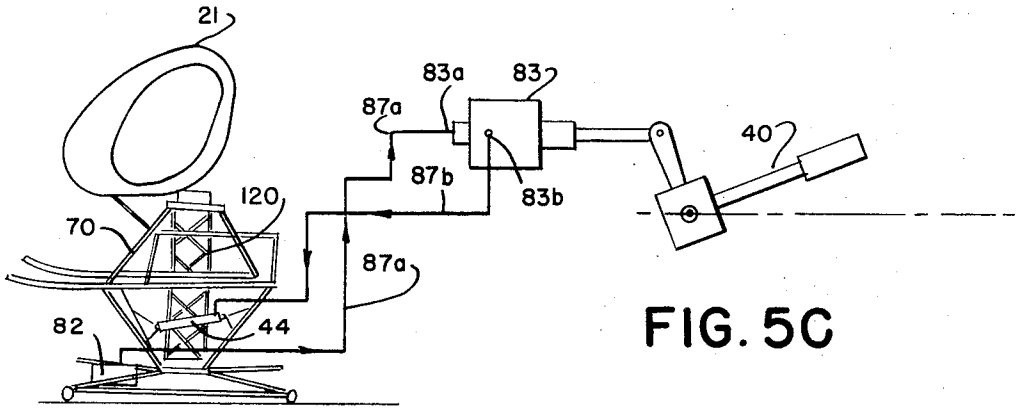



FIG. 5C

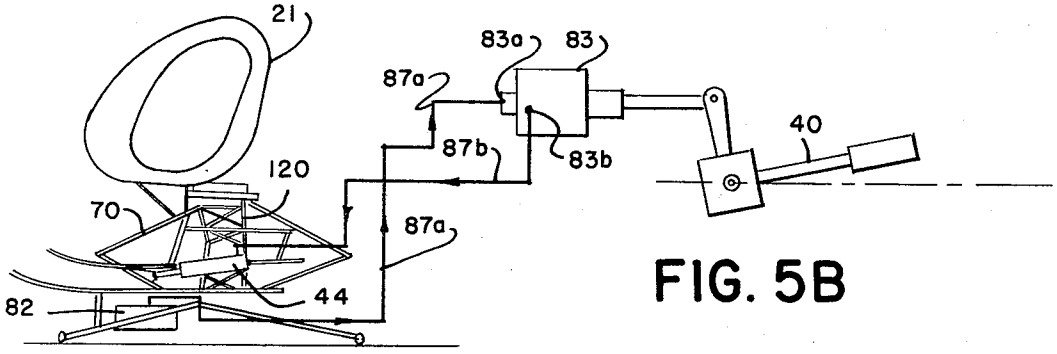



FIG. 5B

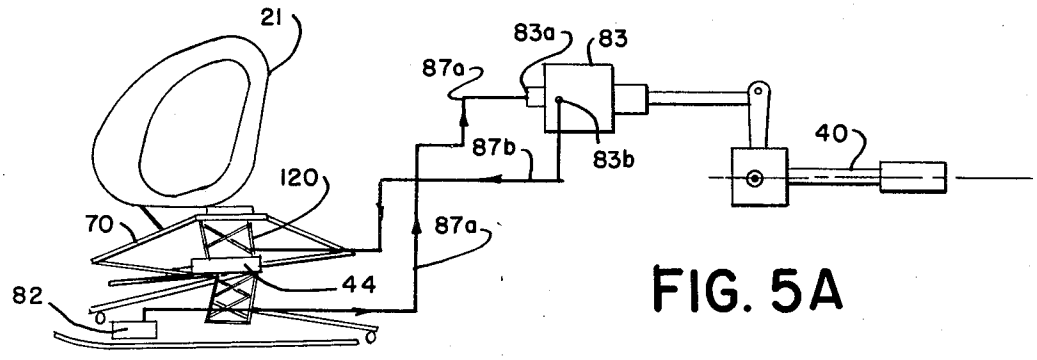



FIG. 5A

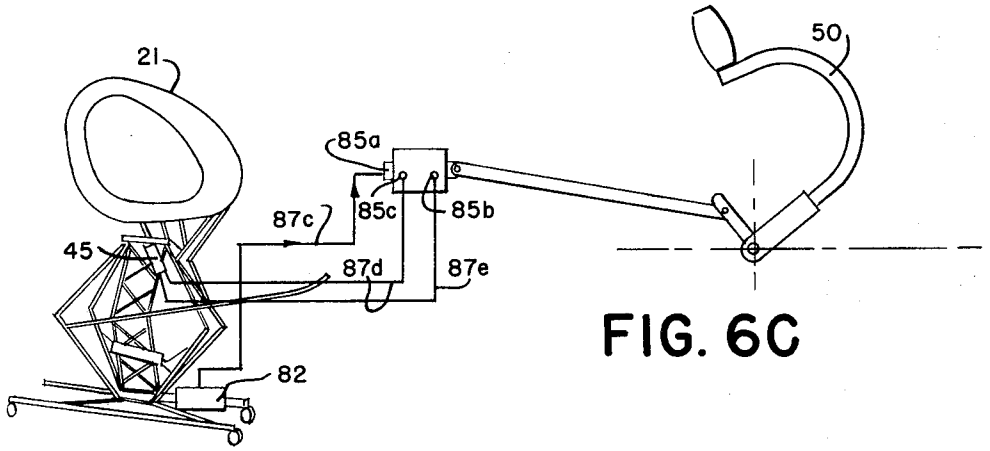



FIG. 6C

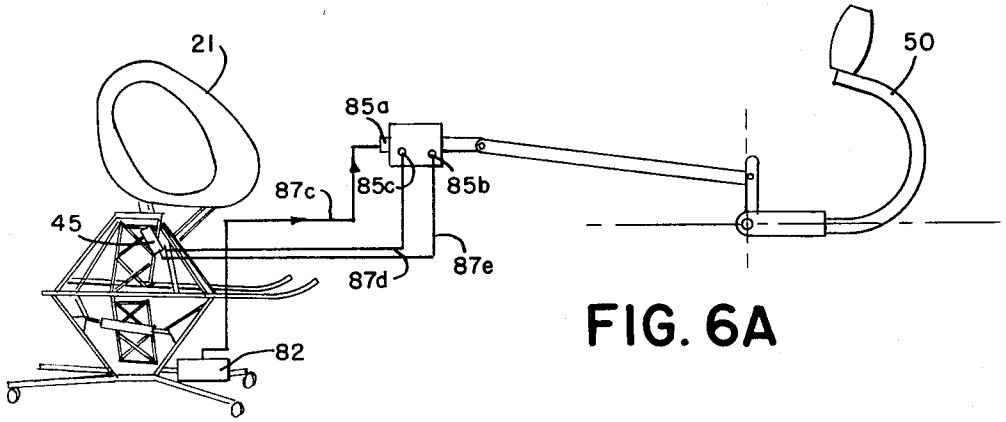



FIG. 6A

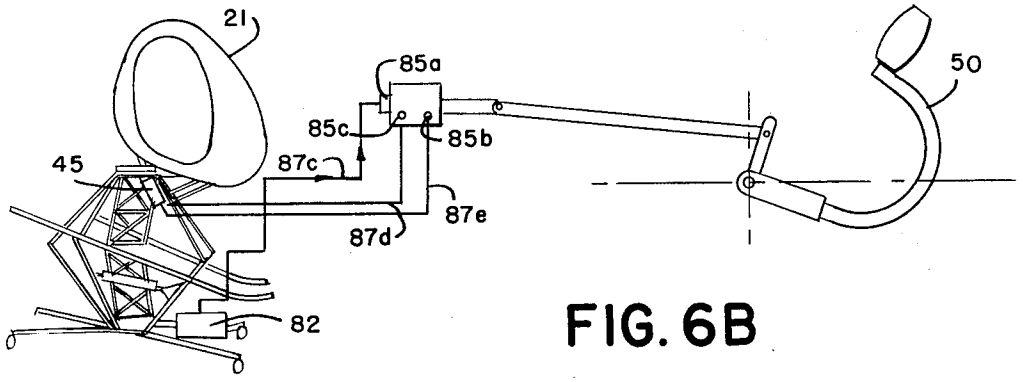



FIG. 6B

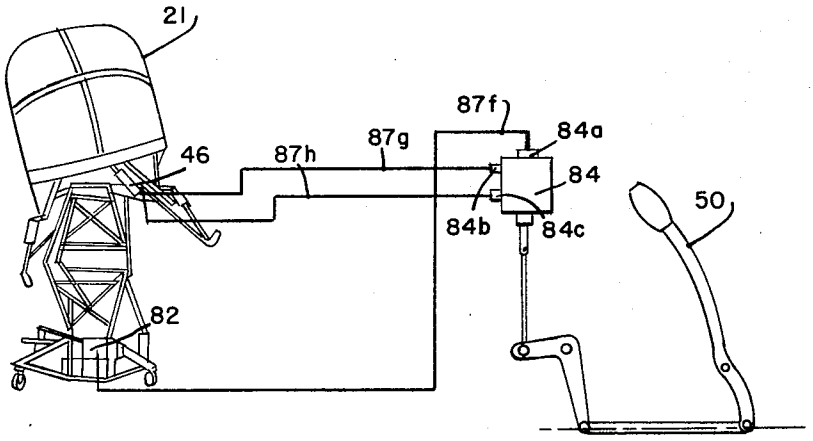

21
87f
84a
87g
87h
46
84
50
84b
84c
82

FIG. 7A

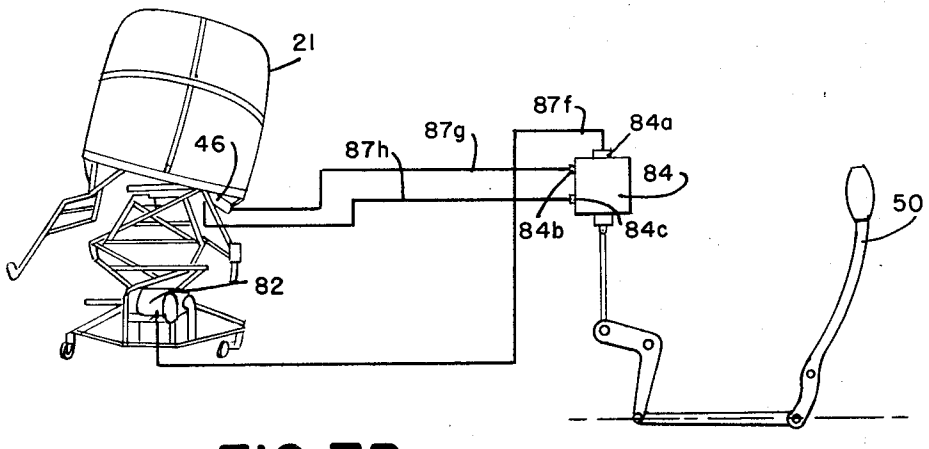

21
87f
84a
87g
87h
46
84
50
84b
84c
82

FIG. 7B

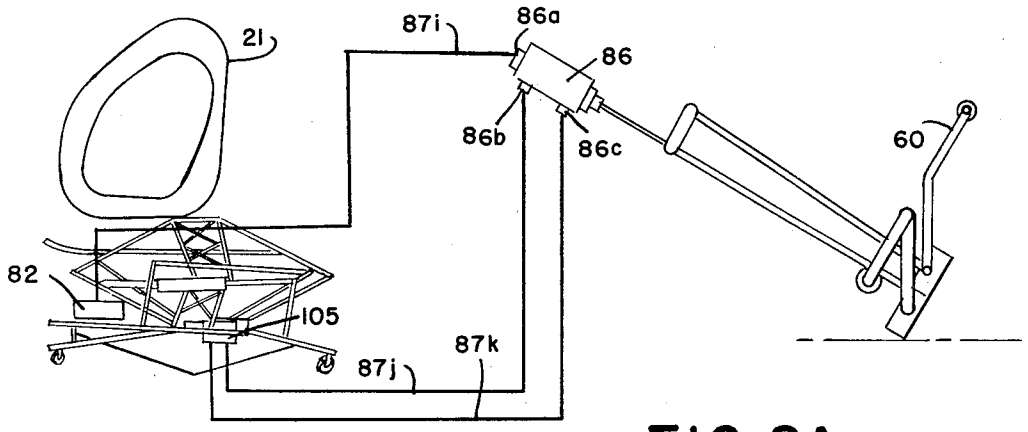

21
87i
86a
86
86b
86c
60
82
105
87k
87j

FIG. 8A

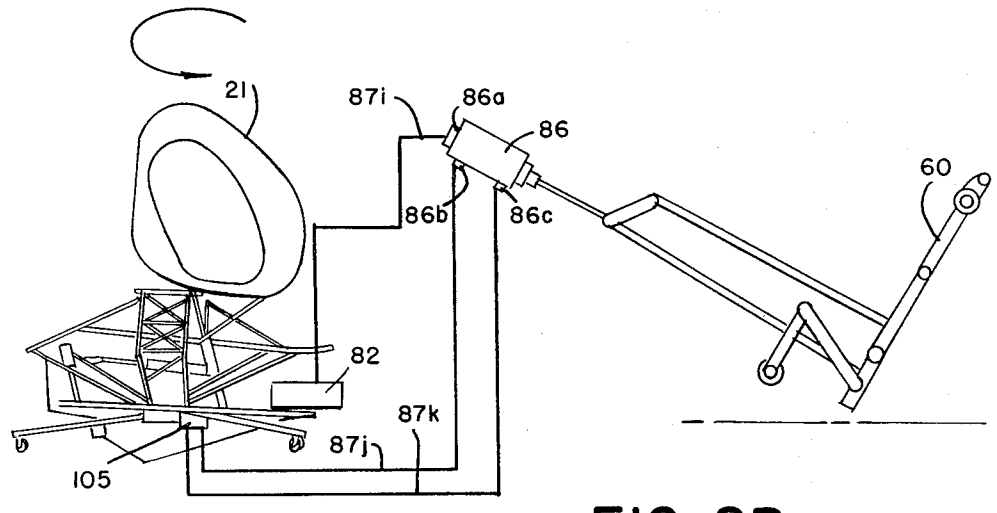

21
87i
86a
86
60
86b
86c
82
87k
87j
105

FIG. 8B

# HELICOPTER HOVER SIMULATOR

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to us of any royalty thereon.

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the field of helicopter hover simulators and helicopter training devices.

2. Description of the Prior Art

The prior art includes the following patents: U.S. Pat. No. 3,067,528 (Dec. 11, 1962) to D. Agusta which discloses a helicopter training apparatus comprising a conventional operative helicopter mounted on a float resting in a tank of water; U.S. Pat. 3,131,486 (May 5, 1964) to H. Derschmidt which discloses a helicopter training apparatus comprising a helicopter fuselage suspended by means of parallel levers; U.S. Pat. 3,164,911 (Jan. 12, 1965) to J. Vaughen which discloses an air cushion vehicle used as a helicopter flight trainer; and U.S. Pat. 3,176,413 (April 6, 1965) to P. Dornier et al. which discloses a flyable helicopter pilot training apparatus utilizing a compressed air jet driven rotor. In addition, HumRRO (The George Washington University Human Resources Research Office) and the Naval Training Device Center have studied various helicopter simulators since 1961.

The prior art patents, above, contain extensive discussions of the basic problems involved in helicopter flight trainers and the human factors involved in learning how to fly a helicopter. One of the most perplexing problems in teaching students how to fly helicopters is teaching the student how to hover. The difficulty is that the student must master all the controls at once, operating them in perfect coordination despite outside influences such as wind and weather and the inherent instability of rotary wing aircraft. Nothing in the student's previous experience has prepared him for hovering since nothing has developed the multiple motor skills and sensory responses required. Fixed wing pilots can learn to fly in small aircraft and then work up to multi-engine jets, but in the helicopter field it is as hard to learn to hover in a TH-55 light training helicopter as it is to hover in a large cargo helicopter. The first few hours of student flight training are usually filled with tension and apprehension for the student and the instructor pilot must "ride" the controls to avoid crashes.

## SUMMARY OF THE INVENTION

A helicopter hover simulator comprising a combination of the following elements:

A. a helicopter cabin including flight control means for regulating vertical movement, flight control means for regulating tilting movement, flight control means for regulating rotational movement, and flight control means for regulating rate of operation;

B. a first support means assembly supporting the helicopter cabin comprising a combination of the following sub-elements:

1. a tiltable base support means upon which the helicopter cabin is mounted;



2. a tilt drive means for tilting the tiltable base support means from a normal horizontal plane position;

3. connecting means for interconnecting the flight control means for regulating tilting movvement and the tilt drive means;

4. a vertically extendible pantograph support assembly comprising a combination of the following sub-elements:

a. an upper horizontal fixed base member connected to the tiltable base support means;

b. a lower horizontal fixed base member;

c. a vertically extendible pantograph frame connecting the upper horizontal fixed base member and the lower horizontal fixed base member;

d. a vertical drive means for vertically extending the upper horizontal fixed base member which in turn vertically raises or lowers the helicopter cabin; and

e. connecting means for interconnecting the flight control means for regulating vertical movement and the vertical drive means; and

C. a second support means assembly supporting the first support means assembly on the ground comprising a combination of the following sub-elements:

1. a ground support member in contact with the ground and in contact with the lower horizontal fixed base member of the pantograph support assembly above;

2. a rotational drive means for circular rotation of the simulator on the ground support member; and

3. connecting means for interconnecting the flight control means for regulating rotational movement and the rotational drive means.

More specifically, this invention is a helicopter hover simulator comprising a helicopter cabin with conventional flight controls, including a collective pitch stick (for controlling vertical ascent and descent), a cyclic pitch stick (for controlling attitude—the relationship of the helicopter cabin to the horizon—or, tilting movement of the cabin), antitorque pedals (for controlling rotational movement) and a throttle (for controlling rate of operation of the other control systems), the cabin being mounted on a tiltable base member, which in turn is mounted on a ball and socket universal joint, which in turn is mounted on the upper horizontal base member of a vertically extendible pantograph assembly (similar to the pantograph assembly seen on certain types of electrically-powered railroad locomotives). The pantograph assembly includes a vertical lift hydraulic cylinder for raising and lowering the helicopter cabin. The helicopter cabin is moved or tilted in a fore and aft direction by a fore and aft hydraulic cylinder, and the cabin is moved or tilted in a lateral direction by a lateral hydraulic cylinder, both of these hydraulic cylinders being connected to, and actuating, the tiltable base member. The pantograph assembly is supported on a central shaft resting on the ground. Rotational movement is accomplished by a hydraulic motor in geared engagement with central shaft. An electric motor drives a hydraulic pump which provides hydraulic pressure for the various hydraulic actuators.

Our helicopter hover simulator, which was first described in the July 23, 1971 issue of "The Fort Wolters

(Texas) Trumpet," is designed to teach the student how to use the various helicopter controls to accomplish hovering. The device lifts a standard helicopter cabin up as high as five feet, tilts in any direction and rotates; however, there is no forward, rearward or sideward travel. This is important because it isolates the hovering problem of up-and-down movement and turns. Thus, the student can limit his efforts to maintaining a single attitude and altitude.

Because the simulator is uncrashable, students do not exhibit the tensions and apprehension normally associated with the first few hours of flight, and the instructor pilots are not forced to "ride" the controls as they would in a real helicopter. Because the machine is made of actual helicopter parts and the controls work the same as in a real aircraft, we believe that the training time spent in the simulator will be more than 75 per cent transferrable—that is, "flying" in the simulator for five hours will eliminate about 3.5 hours of training time in the helicopter. And, since the simulator can be operated for 50 cents per hour as compared with $50 per hour (for operation and maintenance) in a helicopter, the savings will be considerable.

The intended purpose of our simulator is to teach the dynamic balancing of helicopter controls necessary to hover helicopters. Actual helicopter flight time is reduced by using the hover trainer. Students who have not received trainer instruction require 3 to 4 hours of actual flight time before they can manipulate the controls while test students have been able to manipulate the controls during their first hour of flight. Weak students may be identified early in the training program. Students who are marginal in our flight simulator normally will be marginal in actual flight training. The trainer will serve as an excellent inclement weather training device to maintain continuity during the critical pre-solo phase of training. The nature of the trainer makes it adaptable to any rotary wing aircraft, in that by adjustment of valves and change of instrument configuration, it will resemble and respond similar to any desired type.

While our invention utilizes a TH-55 cockpit, the "feel" of the controls closely simulates that of most light helicopters and can be adjusted to resemble any specific helicopter. By changing the cockpit and adjusting the controls, the device can be modified to support any basic helicopter.

## BRIEF DESCRIPTION OF THE DRAWINGS

The features which are considered characteristic of the invention are set forth with particularity in the appended claims. The invention may be best understood from the following description of the preferred embodiments when read in conjunction with the accompanying drawings, which are to be considered as illustrative of the best modes presently contemplated for carrying out the invention.

FIG. 1 is a persepctive view of the helicopter hover simulator in the down position.

FIG. 2 is a side elevational view of the tiltable base member, the ball and socket universal joint, the upper horizontal fixed base member of the pantograph assembly, and the fore and aft hydraulic cylinder. Also shown in FIG. 2 is fore and aft hydraulic cylinder with its ram in extended position whereby the tiltable base member is tilted forward.

FIG. 3 is a partial side elevational view of the helicopter hover simulator.

FIG. 4 is a side elevational view of the tiltable base member, ball and socket universal joint, the fore and aft hydraulic cylinder, the lateral hydraulic cylinder, the pantograph assembly, and the central support shaft resting on the ground.

FIG. 5A is a schematic drawing illustrating the operation of the simulator. The helicopter cabin is illustrated in the down position with the collective pitch stick in a down position.

FIG. 5B is a schematic drawing illustrating the helicopter cabin in an intermediate position with the collective pitch stick in an intermediate up position.

FIG. 5C is a schematic drawing illustrating the helicopter cabin in its uppermost position with the collective pitch stick in an uppermost position.

FIG. 6A is a schematic drawing illustrating the operation of the simulator. The helicopter cabin is illustrated in a level horizontal attitude with the cyclic pitch stick in the central point position.

FIG. 6B is a schematic drawing illustrating the helicopter cabin tilting forward with the cyclic pitch stick in a forward position.

FIG. 6C is a schematic drawing illustrating the helicopter cabin tilting backward with the cyclic pitch stick in an after position.

FIG. 7A is a schematic drawing illustrating the operation of the simulator. The helicopter cabin is illustrated tilting to the right (from the student pilot's point of view) with the cyclic pitch stick in a position to the right of the central point position.

FIG. 7B is a schematic drawing illustrating the helicopter cabin tilting to the left (from the student pilot's point of view) with the cyclic pitch stick in a position to the left of the central point position.

FIG. 8A is a schematic drawing illustrating rotational movement of the simulator. The simulator is illustrated in a forward heading, i.e.—not turning.

FIG. 8B is a schematic drawing illustrating the simulator after making a 180 degree turn to the left (from the student pilot's point of view) as compared to FIG. 8A.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

The flight control system of a helicopter includes three primary systems: the collective pitch control system which governs the rate of ascent or descent; the cyclic pitch control system that controls tilting movement; and the antitorque control system that varies the heading of the aircraft. In the present invention, the collective pitch stick raises or lowers the simulator; the cyclic pitch stick regulates fore and aft tilting movement and tilting movement to the right and left; and the antitorque control pedals, located on the cabin floor directly in front of the pilot's seat, control turns to the right and left. A more detailed description of helicopter flight controls may be found in Department of the Army Technical Manuals, such as TM 55-1520-214-10 (July 1969) which is entitled "Operator's Manual—Helicopter, Observation, OH-6A (Hughes)."

In the drawings, helicopter hover simulator **20** (FIG. 1) comprises a TH-55 helicopter cabin **21** tiltably mounted on a vertically extendible pantograph support assembly **70.** The student pilot **110** (FIG. 1) operates four standard helicopter controls: collective pitch stick

40; cyclic pitch stick 50; foot-operated antitorque control pedals 60 (see FIGS. 8A—8B); and handgrip throttle 40*a* (located on the end of collective pitch stick 40).

Pantograph support assembly 70 is connected to helicopter cabin 21 by means of tiltable base member 91 (see FIG. 2) which rests on ball and socket type universal joint 90 (FIG. 2). Universal joint 90 is mounted on upper horizontal fixed base member 71 of pantograph support assembly 70. Lower horizontal fixed base member 72 (FIG. 3) of pantograph support assembly 70 is supported by a support means comprising central shaft 102 (FIG. 3) extending perpendicularly from ground plate 103 in contact with the ground. Optionally, central shaft 102 may be positioned in the ground and secured in place by concrete, rather than utilizing ground plate 103. Arm members 100, which extend from lower horizontal fixed base member 72 contact the ground by means of wheels 101. The entire weight of simulator 20 rests on ball bearing ring 107 which is mounted on central shaft 102. Wheeled arm members 100 act only as stabilizers to prevent sway when simulator 20 is used in a windy environment; hence, wheeled arm members 100 are considered optional since central shaft 102 adequately supports simulator 20.

Movement of simulator 20 is accomplished hydraulically by fluid from hydraulic reservoir 82 which is pressurized by hydraulic pump 80 which in turn is powered by electric motor 81. Electric motor 81 is serviced from a source of electricity by means of conventional power cable on a swivel which will rotate with simulator 20 as it rotates on central shaft 102. A vertical drive means comprising vertical lift hydraulic cylinder 44 (see FIGS. 3 and 4) raises or lowers pantograph assembly 70, while fore and aft hydraulic cylinder 45 (see FIG. 2) tilts tiltable base member 91 fore and aft as shown in FIG. 2. Lateral hydraulic cylinder 46 (see FIG. 4) tilts base member 91 laterally from side to side. Fore and aft hydraulic cylinder 45 and lateral hydraulic cylinder 46, taken together, comprise a tilt drive means for tilting tiltable base member 91 in any direction. Rotation of simulator 20 on central shaft 102 is accomplished by a rotational drive means comprising reversible hydraulic motor 105 (see FIG. 3) which engages gear 106 on central shaft 102.

Hydraulic fluid is stored in reservoir 82. The flow of hydraulic fluid is controlled by a series of hydraulic valves actuated by the helicopter flight controls. Main pressure valve 87 (which controls the volume and pressure of hydraulic fluid fed into the hydraulic system), vertical lift control valve 83, lateral control valve 84, fore and aft control valve 85, and radial control valve 86 are located on the back side of cabin 21. Flexible hydraulic lines 87 connect the various control valves with the corresponding hydraulic cylinders or hydraulic motor. Radiator 88, cooled by a conventional electric fan (not shown), cools the hydraulic fluid.

Cabin 21 has landing gear consisting of a pair of tubular skid runners 22 attached to cabin 21 by means of shock dampers 22*a*, braces 22*b* and struts 22*c*. When simulator 20 is in the down position, the weight of cabin 21 rests on skid runners 22. Otherwise, when the simulator is elevated above ground, the weight of cabin 21 rests on central shaft 102. Skid runners 22 are optional since central shaft 102 can support simulator 20 in the down position.

As shown in FIG. 4, pantograph support assembly 70 comprises upper horizontal fixed base member 71, lower horizontal fixed base member 72 and tubular pantograph frame members 73, 73', 74, 74' hingedly connected at hinges 75. Pantograph support assembly 70 may be raised or lowered in a vertical plane by vertical lift hydraulic cylinder 44. Pantograph support assembly 70 is stabilized against fore and aft sway by vertical stabilizer 120 connected to upper horizontal fixed base member 71 and lower horizontal fixed base member 72. Vertical stabilizer 120 is hinged at its midpoint and it folds together when pantograph support assembly 70 is in the down position. (Vertical stabilizer 120 has been omitted from FIG. 3 to simplify the drawing, buy vertical stabilizer 120 may be seen in fully extended mode in FIG. 5C.)

The dynamic functions of the various systems comprising this invention will now be described with reference to FIGS. 5A–5C, 6A–6C, 7A–B, and 8A–8B.

Simulator 20 achieves vertical ascent and descent movement through raising or lowering collective pitch stick 40 as shown schematically in FIGS. 5A–5C. With collective pitch stick 40 in the down position shown in FIG. 5A, vertical lift control valve 83 is closed and cabin 21 is in the down position. Raising collective pitch stick 40 to an intermediate position as shown in FIG. 5B partially opens vertical lift control valve 83 and cabin 21 ascends approximately 2 ½ feet above ground. Raising collective pitch stick 40 to its uppermost position as shown in FIG. 5C opens vertical lift control valve 83 and cabin 21 ascends approximately 5 feet above ground. Collective pitch stick 40 actuates vertical lift control valve 83 when moved to any position between the down position (FIG. 5A) and the uppermost position (FIG. 5C) and cabin 21 is proportionately raised above ground. Control valve 83 has an inlet 83*a* which is fed from hydraulic reservoir 82 by hydraulic line 87*a*. Vertical lift control valve 83 has an outlet 83*b* which feeds vertical lift hydraulic cylinder 44 through hydraulic line 87*b*. Vertical lift hydraulic cylinder 44 actuates pantograph assembly 70 which raises and lowers cabin 21. Vertical lift hydraulic cylinder 44 is shown as a single acting hydraulic cylinder whereby the weight of cabin 21 causes extension of the hydraulic ram of vertical lift hydraulic cylinder 44 (lowering cabin 21). Optionally, vertical lift hydraulic cylinder may be a double acting hydraulic cylinder and accordingly, vertical lift control valve 83 would then have two outlets.

Simulator 20 may be tilted in any direction to an angle of approximately 30 degrees. This is accomplished through movement of cyclic pitch stick 50 as shown schematically in FIGS. 6A–6C and FIGS. 7A–7B. Cyclic pitch stick 50 may be moved in a conical (inverted cone) pattern. If cyclic pitch stick 50 is moved to the maximum forward position as shown in FIG. 6B, cabin 21 tilts forward approximately 30 degrees. If cyclic pitch stick 50 is moved to the maximum rear position as shown in FIG. 6C, cabin 21 tilts backward approximately 30 degrees. The same is true when the cyclic pitch stick 50 is moved to the maximum right (FIG. 7A) or maximum left (FIG. 7B) position; cabin 21 will tilt approximately 30 degrees to the right (FIG. 7A) or to the left (FIG. 7B). By moving cyclic pitch stick 50 to its maximum position at a point between the maximum forward and the maximum right position, cabin 21 will tilt approximately 30 degrees in that di-

rection. Cabin **21** may be stabilized in a particular attitude by moving cyclic pitch stick **50** to a central point position midway between maximum forward and rear, and left and right, as shown in FIG. **6A**. Cabin **21** may be tilted in any direction from 0 degrees to 30 degrees by moving the cyclic pitch stick between the central point position and the maximum position in the desired direction. When moved fore and aft of the central point position, cyclic pitch stick **50** actuates, through the linkage system shown schematically in FIGS. **6A–6C**, the fore and aft control valve **85** which controls fore and aft hydraulic cylinder **85**. Fore and aft hydraulic cylinder **45** is a double acting hydraulic cylinder connected to tiltable base member **71**. Tiltable base member **91** tilts cabin **21** fore and aft in response to fore and aft hydraulic cylinder **45**. Fore and aft control valve **85** has an inlet **85***a* which is fed from hydraulic reservoir **82** by hydraulic line **87***c*. Fore and aft control valve **85** has two outlets **85***b*, **85***c* which feed double acting fore and aft hydraulic cylinder **45** through hydraulic lines **87***d*, **87***e*.

When moved left to right of the central point, cyclic pitch stick **50** actuates, through a linkage system shown schematically in FIGS. **7A–7B**, lateral control valve **84** which controls lateraly hydraulic cylincer **46**. Lateral hydraulic cylinder **46** is a double acting hydraulic cylinder connected to tiltable base member **71** which tilts cabin **21** laterally in response to lateral hydraulic cylinder **46**. Lateral control valve **84** has an inlet **84***a* which is fed from hydraulic reservoir **82** by hydraulic line **87***f*. Lateral control valve **84** has two outlets **84***b*, **84***c* which feed double acting lateral hydraulic cylinder **46** through hydraulic lines **87***g*, **87***h*. It should be noted that when the student pilot actuates a flight control, the corresponding hydraulic valve will remain open, and in response the hydraulic cylinder ram will continue to move until the student pilot acts to stop the movement. Hence, hovering is the result of a dynamic balance of the flight controls and this dynamic balance must be maintained by the student pilot.

Simulator **20** accomplishes right and left turns through actuation of antitorque pedals **60** (the student pilot's left antitorque pedal is shown in FIGS. **8A–8B**). Pushing forward on the left pedal changes the cabin heading toward the left, and pushing forward on the right pedal changes the cabin heading toward the right. Antitorque pedal **60** is linked to radial control valve **86** as shown schematically in FIGS. **8A–8B**. Actuation of antitorque pedal **60** opens or closes radial control valve **86** which has inlet **86***a* fed by hydraulic reservoir **82** through hydraulic line **87***i*. Radial control valve **86** has two outlets which feed reversible hydraulic motor **105** through hydraulic lines **87***j*, **87***k*. Hydraulic motor **105** turns simulator **20** through gear **106** (FIG. **3**) attached to central shaft **102**. FIG. **8B** schematically illustrates a left turn of simulator **20** in relation to the heading shown in FIG. **8A**. The left turn illustrated in FIG. **8B** was accomplished by pushing forward on left antitorque pedal **60**. Simulator **20** will continue to circularly rotate to the left as long as left antitorque pedal **60** is depressed.

Throttle control **40***a* (FIG. **1**) is on the end of collective pitch stick **40** and throttle control **40***a* operates similar to that of a motorcycle as the handlegrip is rotated to increase or decrease power. Throttle control **40***a* regulates main pressure valve **87** which controls the volume and pressure of hydraulic fluid fed into the hydraulic system from hydraulic reservoir **82**. Throttle control **40***a* also regulates an electrical rheostat (not shown in the drawings) which controls the electrical power to a variable speed electric motor which drives an instrument panel tachometer (not shown). Throttle **40***a* is optional, but it does add realism to the training situation.

We claim:

**1.** A helicopter hover simulator comprising:

a. a helicopter cabin, said cabin including control means for regulating movement of said cabin;

b. a vertically extensible pantograph support assembly connected between an upper fixed horizontal member and a lower fixed horizontal member, said upper fixed horizontal member movable vertically relative to said lower fixed horizontal member and a tiltable base member supporting said cabin and universally connected to said upper fixed horizontal member for tilting movement relative thereto;

c. means for rotating said cabin connected to said lower fixed horizontal member;

d. fluid actuated drive means connected to each of said pantograph support assembly, said tiltable base member and said means for rotating said cabin; and

e. valve controlled fluid means interconnecting said control means and said fluid actuated drive means whereby upon operation of said control means the movement of said cabin may be controlled.

**2.** The helicopter hover simulator as defined in claim **1** wherein the fluid actuated drive means connected to said pantograph support assembly is attached between opposed parallel members of said pantograph support assembly.

**3.** A helicopter hover simulator comprising:

a. a helicopter cabin, said cabin including control means for regulating vertical movement, control means for regulating tilting movement, and control means for regulating rotational movement of said cabin;

b. first support means supporting said cabin comprising:

1. tiltable base means upon which said cabin is mounted;

2. tilt drive means for tilting said tiltable base means from a normal horizontal position;

3. valve controlled fluid means for interconnecting said control means for regulating tilting movement and said tilt drive means; and

4. a vertically extendible pantograph support assembly comprising:

a. an upper horizontal fixed base member universally connected to said tiltable base means;

b. a lower horizontal fixed base member;

c. a vertically extendible pantograph frame connecting said upper horizontal fixed base member and said lower horizontal fixed base member;

d. vertical drive means for vertically extending said upper horizontal fixed base member; and

e. valve controlled fluid means for interconnecting said control means for regulating vertical movement and said vertical drive means; and

c. second support means supporting said first support means on the ground comprising:
1. ground support means in contact with the ground and with said lower horizontal fixed base member;
2. rotational drive means connected to said second support means for circular rotation of said simulator;
3. valve controlled fluid means for interconnecting said control means for regulating rotational movement and said rotational drive means; and
4. said tiltable base means tilting relative to said upper and lower horizontal fixed base members.

**4.** The helicopter hover simulator defined by claim **3** wherein:
a. said tilt drive means comprises a first hydraulic cylinder;
b. said vertical drive means comprises a second hydraulic cylinder; and
c. said rotational drive means comprises a hydraulic motor.

**5.** The helicopter hover simulator defined in claim **3** wherein said ground support member comprises a central shaft resting on the ground and extending perpendicularly therefrom.

**6.** The helicopter hover simulator defined in claim **3** wherein:
a. said control means for regulating vertical movement comprises a first hydraulic valve;
b. said control means for regulating tilting movement comprises a second hydraulic valve;
c. said control means for regulating rotational movement comprises a third hydraulic valve;
d. said vertical drive means comprises a first hydraulic cylinder;
e. said tilt drive means comprises a second hydraulic cylinder;
f. said rotational drive means comprises a hydraulic motor;
g. said means for interconnecting said control means for regulating vertical movement and said vertical drive means comprises a first hydraulic line;
h. said means for interconnecting said control means for regulating tilting movement and said tilt drive means comprises a second hydraulic line;
i. said means for interconnecting said control means for regulating rotational movement and said rotational drive means comprises a third hydraulic line; and
j. said ground support member comprises a central shaft resting on the ground and extending perpendicularly therefrom.

**7.** A helicopter hover simulator comprising:
a. a helicopter cabin, said cabin including control means for regulating vertical movement, control means for regulating tilting movement and control means for regulating rotational movement;
b. first support means supporting said cabin comprising:
1. a tiltable base member on which said cabin is mounted;
2. tilt drive means for tilting said tiltable base member from a normal horizontal position;
3. valve controlled fluid means for interconnecting said control means for regulating vertical movement; and
4. a vertically extendible pantograph support assembly comprising:
a. an upper horizontal fixed base member connected to said tiltable base member, said tiltable base member tiltable relative to said upper horizontal fixed base member;
b. a lower horizontal fixed base member;
c. a first set of pantograph frame members interconnecting a first side of said upper horizontal fixed base member and a first side of said lower horizontal fixed base member;
d. a second set of pantograph frame members interconnecting a second side of said upper horizontal fixed base member and a second side of said lower horizontal fixed base member;
e. vertical drive means for vertically extending said upper horizontal fixed base member comprising a first hydraulic cylinder interconnecting one branch of said pantograph frame members and an opposed parallel branch of said pantograph frame members;
f. means for vertically stabilizing said pantograph frame members when extended; and
g. valve controlled fluid means for interconnecting said control means for regulating vertical movement and said vertical drive means; and

c. second support means supporting said first support means on the ground comprising:
1. a central shaft resting on the ground and extending perpendicularly therefrom;
2. a rotational drive means connected to said central shaft for circular rotation of said simulator; and
3. valve controlled fluid means for interconnecting said control means for regulating rotational movement and said rotational drive means.

**8.** The helicopter hover simulator defined in claim **7** wherein:
a. said tilt drive means comprises a second hydraulic cylinder; and
b. said rotational drive means comprises a hydraulic motor.

**9.** The helicopter hover simulator defined in claim **7** wherein said tilt drive means further comprises:
a. a second hydraulic cylinder for accomplishing tilting movement in a fore and aft direction; and
b. a third hydraulic cylinder for accomplishing tilting movement in a lateral direction.

**10.** The helicopter hover simulator defined in claim **7** wherein:
a. said second support means further includes four mutually spaced, arm members radially extending from said lower horizontal fixed base member, said arm members being in movable contact with the ground; and
b. said rotational drive means comprises a hydraulic motor in geared engagement with said central shaft.

**11.** The helicopter hover simulator defined in claim **7** wherein:
a. said control means for regulating vertical movement comprises a first hydraulic valve;

b. said control means for regulating tilting movement comprises:
1. a second hydraulic valve for regulating tilting movement in a fore and aft direction; and
2. a third hydraulic valve for regulating tilting movement in a lateral direction; and

c. said tilt drive means comprises:
1. a second hydraulic cylinder for accomplishing tilting movement in a fore and aft direction, said second hydraulic cylinder regulated by said second hydraulic valve; and
2. a third hydraulic cylinder for accomplishing tilting movement laterally, said third hydraulic cylinder regulated by said third hydraulic valve.

**12.** The helicopter hover simulator defined in claim 7 wherein:

a. said control means for regulating vertical movement comprises a first hydraulic valve;

b. said control means for regulating tilting movement comprises:
1. a second hydraulic valve for regulating tilting movement in a fore and aft direction; and
2. a third hydraulic valve for regulating tilting movement in a lateral direction;

c. said control means for regulating rotational movement comprises a fourth hydraulic valve;

d. said tilt drive means comprises:
1. a second hydraulic cylinder for accomplishing tilting movement in a fore and aft direction, said second hydraulic cylinder regulated by said second hydraulic valve; and
2. a third hydraulic cylinder for accomplishing tilting movement laterally, said third hydraulic cylinder regulated by said third hydraulic valve;

e. said means for interconnecting said control means for regulating vertical movement and said vertical drive means comprises a first hydraulic line;

f. said means for interconnecting said control means for regulating tilting movement and said tilt drive means comprises a second hydraulic line and a third hydraulic line;

g. said means for interconnecting said control means for regulating rotational movement and said rotational drive means comprises a fourth hydraulic line; and

h. said second support means further comprises four mutually spaced radially extending arm members extending from said lower horizontal fixed base member, said arm members being in movable contact with the ground; and

i. said rotational drive means comprises a hydraulic motor in geared engagement with said central shaft.

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