

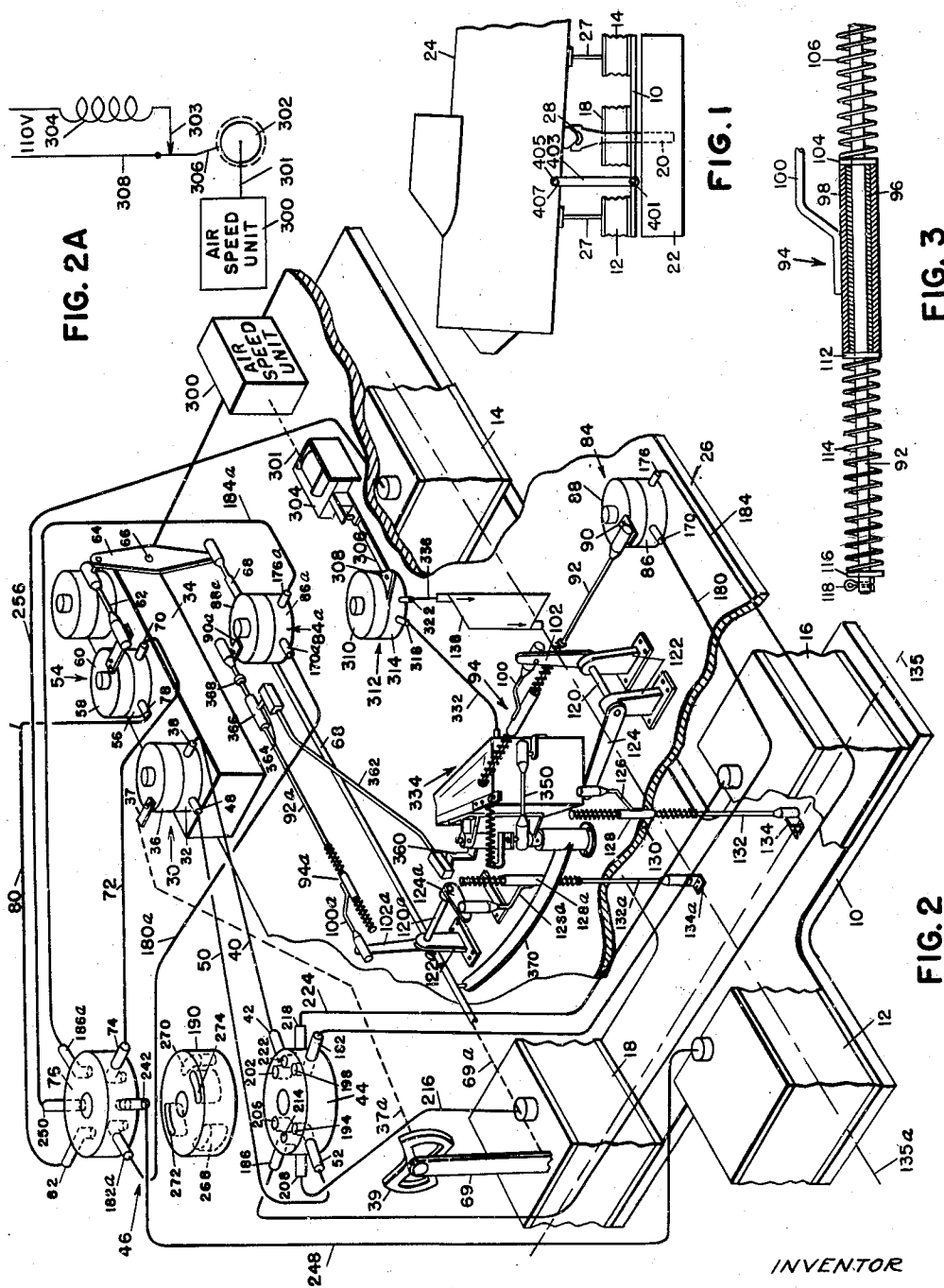
Oct. 18, 1949.

R. H. LEWIS
TAKE-OFF AND LANDING SIMULATING MEANS FOR
GROUNDED AVIATION TRAINERS

2,485,499

Filed Nov. 7, 1947

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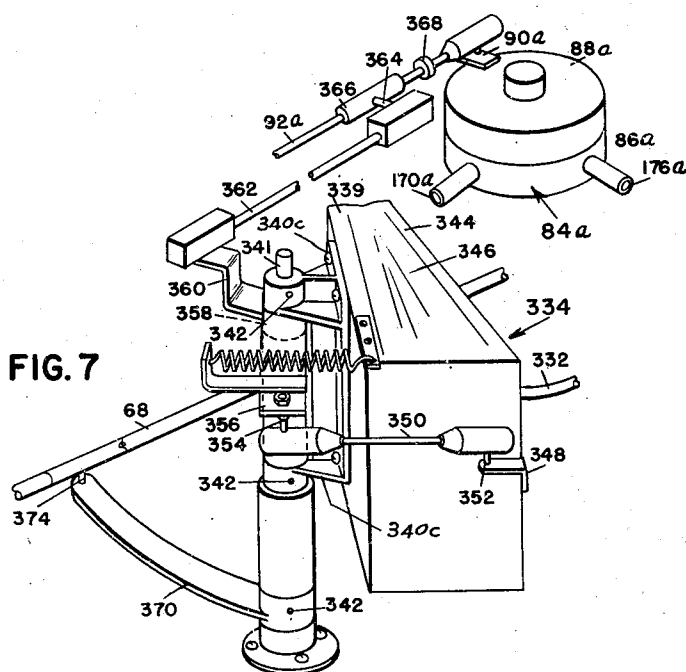
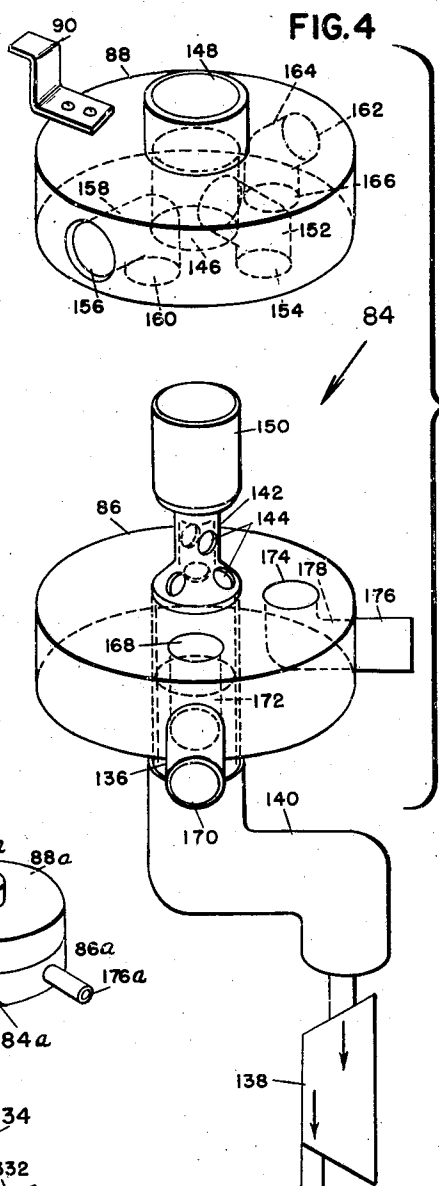
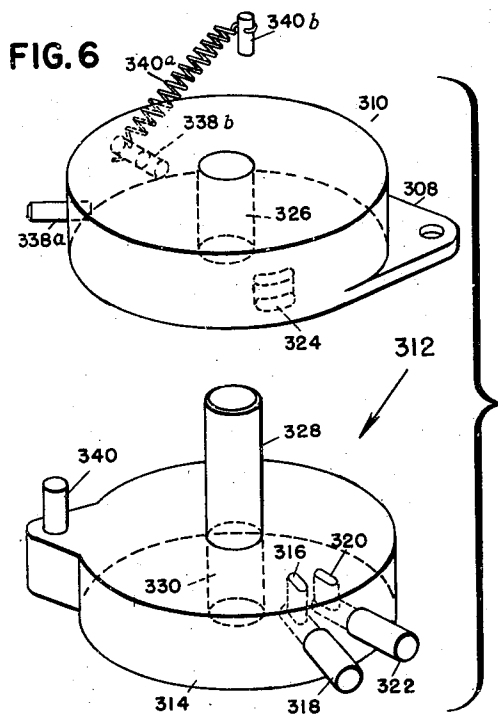
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FIG. 5

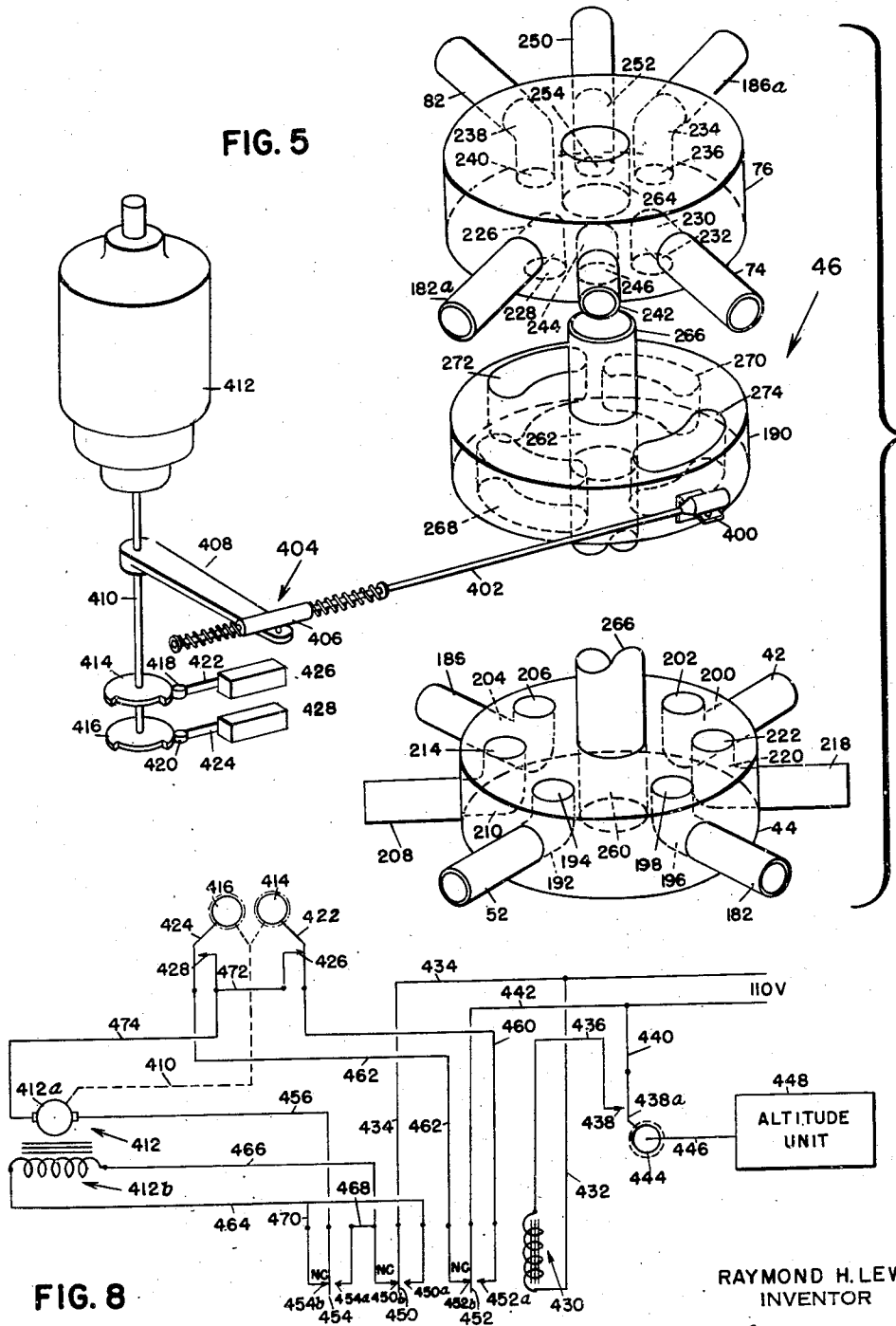


FIG. 8

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UNITED STATES PATENT OFFICE

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TAKE-OFF AND LANDING SIMULATING
MEANS FOR GROUNDED AVIATION
TRAINERSRaymond H. Lewis, Binghamton, N. Y., assignor
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Application November 7, 1947, Serial No. 784,616

8 Claims. (Cl. 35—12)

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This invention relates to grounded aviation trainers, and more particularly to means for simulating the take-off and landing of airplanes by such trainers.

In the case of an airplane, during the initial phase of its take-off run, i. e., until a certain air speed is reached, any movement of the controls of the plane and resulting movement of the control surfaces will not substantially affect the climbing, diving or banking position of the plane. However, when the critical air speed is reached, e. g., 25 knots, the relative motion between the elevators of the plane and the air through which the plane is traveling, even though the plane is still on the ground, is sufficient that when the pilot presses the control column ahead the co-
action between the elevators of the plane and the air is sufficient that the nose of the plane will be lowered and the tail of the plane will be raised from the ground. However, at the air speed being considered it still is not possible to substantially bank the plane. Return of the control column to its neutral position results in a lowering of the tail of the plane.

As the air speed of the plane increases and another critical air speed is reached, e. g., 75 knots, the coaction of the lift surfaces of the plane with the air through which the plane is moving is such that the plane has enough lift to become airborne, and the plane leaves the ground. Having left the ground, the plane can of course be moved about any of its three axes by the pilot's operation of the controls of the plane.

When the plane later returns to the ground, the pilot is able to keep the tail of the plane off the ground until the air speed has been reduced to a certain amount, e. g., 25 knots, but the pilot is not able to cause the plane to bank. When air speed has been reduced to 25 knots, the tail of the plane drops to the ground, and any diving, climbing, or banking of the plane is impossible.

This invention relates to means for simulating the aforescribed landing and take-off characteristics of a real plane, and will be described in conjunction with a trainer of the type including a fuselage universally mounted upon a stationary base for pitching and banking in response to movements of the controls within the fuselage which simulate the pitch and bank controls of a real plane, to simulate the pitching and banking of a real plane in response to the movements of its controls. Such trainers are well known to the prior art, and for a disclosure of one such type of trainer reference may be made to United States Patent 1,825,462 dated September 29, 1931, and

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issued to Edwin A. Link, Jr., for Combination training device for student aviators and entertainment apparatus.

In order that the preferred embodiment of my invention may be thoroughly understood, reference is made to the accompanying drawings wherein,

Fig. 1 is an exterior side view of a trainer of the type with which my invention will be illustrated.

Fig. 2 is a general schematic view of the essential parts of my invention.

Fig. 2A is a schematic view of the nose down solenoid control arrangement.

Fig. 3 is a detailed view, partly in cross section, of a double acting spring compensator assembly which is used in conjunction with the form of my invention disclosed herein.

Fig. 4 is an exploded perspective view of the bank leveling valve which forms an important part of my invention.

Fig. 5 is an exploded perspective view of the switching valve and control motor which form an important part of my invention.

Fig. 6 is an exploded perspective view of the nose-down control valve which forms a part of my invention.

Fig. 7 is a perspective view of the nose-down control bellows and associated apparatus.

Fig. 8 is a diagram of the electrical circuit which controls the motor shown in Fig. 5.

Reference is now made to Figs. 1 and 2 wherein there is disclosed the well known rotatable platform 10 which carries the forward pitching or dive bellows 12, the rear pitching or climb bellows 14, the left banking bellows 16 and the right banking bellows 18. The rotatable platform 10 is supported by the vertical spindle 20 which is suitably rotatably mounted in the stationary base 22. Above the rotatable platform 10 and the four mentioned bellows is carried the fuselage 24, the bottom of which is designated 26 and to which the upper edge of each of the four bellows is connected by members 27. Mounted upon the top of vertical spindle 20 is the universal joint 28 which supports the fuselage 24 to permit pitching and banking movements of the fuselage to simulate the climbing, diving and banking of a plane in actual flight.

Reference is now made to Fig. 2 where the conventional aileron valve is designated generally by 30, this valve comprising the lower fixed portion 32 which is mounted upon the main vacuum manifold 34 which is affixed to the bottom 26 of fuselage 24 and the upper rotatable leaf 36 which carries the arm 37. This arm is connected by the

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schematically shown connection 37a to the control wheel 39 in the fuselage 24 so that when the student turns the control wheel 39 counterclockwise to produce a left banking of the fuselage the upper leaf 36 is rotated counterclockwise in Fig. 2, and when the student rotates the control wheel clockwise leaf 36 is similarly rotated clockwise. The construction of the aileron valve 30 and the connection between this valve and the control wheel 39 is well known to the prior art, and consequently a detailed disclosure of the same is not deemed necessary in this application. It is sufficient to know that the lower fixed leaf 32 of the aileron valve 30 carries a port 38 which is connected through the pneumatic line 40 to the port 42 carried by the lower fixed leaf 44 of the main switching valve of this invention which is designated generally by 46. The lower leaf 32 of the aileron valve 30 also carries a second exterior port 48 which is connected through the pneumatic line 50 to the exterior port 52 of the lower fixed leaf 44 of valve 46.

The conventional elevator valve of trainers of the type being considered is designated generally in Fig. 2 by 54 and includes the lower fixed leaf 56 which is carried by the main vacuum manifold 34 and the upper rotatable leaf 58 which carries the arm 60 to the outer end of which is pivotally attached the forward end of link 62. The rear end of link 62 is pivotally attached to the upper end of lever 64 which is pivoted upon the fixed pivot 66, and the rear end of another link 68 is pivotally attached to the lower end of lever 64. Link 68 is connected to the control column 69 in the trainer through the schematically shown connection 69a to be responsive to fore and aft movements of the control column 69 so that when the control column is pushed ahead the link 68 moves to the rear, resulting in a counterclockwise rotation of the lever 64 and in a forward movement of link 62. The upper leaf of the elevator valve 54 rotates clockwise. On the other hand, a rearward movement of the control column results in movement of the just mentioned parts in opposite directions.

The lower fixed leaf 56 of the elevator valve 54 carries the exterior port 70 which is connected through the pneumatic line 72 to the exterior port 74 carried by the upper fixed leaf 76 of the switching valve 46. The lower leaf 56 of valve 58 also carries a second exterior port 78 which is connected through the pneumatic line 80 with the exterior port 82 carried by the upper leaf 76 of valve 46.

The bank leveling valve of this invention is shown in Fig. 2 and is designated generally by 84, this valve including a lower fixed leaf 86 which is affixed to the bottom 26 of the trainer fuselage, as well as an upper rotatable leaf 88 which carries the arm 90 to which is affixed one end of the link 92 which extends transversely of the trainer fuselage. The other end of link 92 carries the double acting compensator assembly designated generally by 94, a detailed disclosure of which is shown in Fig. 3, to which reference is now made. It will be seen that the assembly 94 includes a sleeve 96 which is affixed upon the link 92, and around the fixed sleeve 96 is a movable sleeve 98 to which is attached the lower end of the bent link 100. A washer 104 bears against the right end of the sleeves 96 and 98, as seen in Fig. 3, and the left end of the compression spring 106 bears against the washer 104. The right end of spring 106 bears against another washer 108 which is placed upon link 92, and the cotter pin 110 passes through

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link 92 to limit the movement of washer 108 therealong.

The left ends of the sleeves 96 and 98 are engaged by the washer 112 which in turn bears against the right end of the second spring 114 which encircles the link 92, the left end of this spring 114 being held in place by the washer 116 and cotter pin 118.

Referring back to Fig. 2, the upper end of bent link 100 is pivoted to the upper end of arm 102, the lower end of which is affixed upon the horizontal shaft 120 carried by the brackets 122 which are affixed to the bottom 26 of the trainer fuselage. Attached to the forward end of the horizontal shaft 120 is the inner end of arm 124, the outer end of which pivotally carries the upper end of the bent link 126, the lower end of which is fixedly attached to the outer sleeve 128 of a spring compensator assembly designated generally by 130 and which is carried by the upper end of the vertical link 132. Link 132 passes through the bottom 26 of the fuselage by means of a suitable clearance hole (not shown) and the lower end of link 132 is pivotally attached to the bracket 134 which is affixed to the platform 10 to the left of the universal joint 28 and on the transverse axis 135 which is below the universal joint. As seen in Fig. 2, this axis passes through the centers of the bank bellows 16 and 18. The spring compensating assembly designated generally by 130 is constructed exactly like the assembly shown in detail in Fig. 3.

Reference is now made to Fig. 4 for a detailed disclosure of the bank leveling valve designated generally by 84. The lower fixed leaf 86 carries a central stem 136 which is connected to a suitable vacuum source 138 by means of the pneumatic line 140. The upper end of stem 136 is of reduced diameter, as indicated at 142, and has a plurality of perforations 144. The upper leaf 88 includes a central chamber 146 and a cap 148, the enlarged upper portion 150 of stem 136 fitting inside cap 148 and the portion of smaller diameter 142 being within chamber 146. The chamber 146 is connected through the interior duct 152 to the port 154 in the lower face of leaf 88. The upper leaf 88 also includes an atmosphere port 156 which is connected through the interior duct 158 with the port 160 in the lower face of leaf 88, and leaf 88 also has a second atmosphere port 162 which connects by means of the interior duct 164 with the port 166 in the lower face of leaf 88.

The lower leaf 86 of the bank leveling valve 84 includes the port 168 in the upper face of the leaf, which port connects with the exterior coupling 170 by means of the interior duct 172. The upper face of leaf 86 has the second port 174 which is connected through the interior duct 178 with the exterior coupling 176. Referring now to Fig. 2, it will be seen that the exterior coupling 170 is connected through the pneumatic line 180 with the exterior coupling 182 of the lower leaf 44 of switching valve 46. The exterior coupling 176 of valve 84 is connected through pneumatic line 184 with the exterior coupling 186 of the leaf 44 of valve 46.

Referring back to Fig. 4, it should be understood that when the upper leaf 88 is in neutral rotatable position with respect to the lower leaf 86, the vacuum port 154 lies between the ports 168 and 174 in the lower leaf, the diameter of port 154 being substantially equal to the distance between the adjacent edges of ports 168 and 174. Under the same conditions, the port 160 lies just clock-

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wise of port 168, while port 166 lies just counter-clockwise of port 174.

Also shown in Fig. 2 is the pitch leveling valve designated generally by 84a. This valve is identical in construction with the bank leveling valve 84 which has been described in detail, and the upper rotatable leaf 88a of the pitch leveling valve 84a is connected through a series of linkages, compensator springs, etc., to the rotatable platform 10 exactly like the corresponding series which interconnects the platform 10 and the valve 84. Accordingly, the elements interconnecting the leaf 88a of valve 84a with the base 10 are given the same numbers as the corresponding elements interconnecting the valve 84 and base 10, with the exception that the suffix "a" is added to the reference characters to distinguish the two systems. Consequently, a detailed description of the system interconnecting the valve 84a and the base 10 is deemed unnecessary, but it should be pointed out that the bracket 134a is affixed to the platform 10 at a point to the rear of the universal joint 28 and on the longitudinal axis 135a which is below the universal joint and passes through the centers of the dive bellows 12 and climb bellows 14.

Inasmuch as the pitch leveling valve 84a is identical in construction with the bank leveling valve 84, a detailed description of the construction of valve 84a is deemed unnecessary. In Fig. 2, the shown parts of valve 84a are given the same numbers as the shown parts of the valve 84, with the exception that the suffix "a" is added to the reference characters of valve 84a. The exterior port 170a of valve 84a is connected through the pneumatic line 180a to the exterior port 182a of the upper fixed leaf 76 of the switching valve 46, while the exterior port 176a of valve 84a is connected through the pneumatic line 184a to the exterior port 186a of leaf 76 of the switching valve 46.

Reference is now made to Fig. 5 which is an exploded view of the switching valve designated generally by 46. The previously mentioned parts of valve 46 are numbered in Fig. 5 according to the numbers previously assigned, and it will be seen that in addition to the lower fixed leaf 44 and the upper fixed leaf 76, the switching valve 46 also includes the rotatable middle leaf 190. The exterior coupling 52 of the lower leaf 44 is connected through the interior duct 192 to the port 194 in the upper face of the lower leaf; the exterior coupling 182 is connected through the interior duct 196 with the port 198 in the upper face of the lower leaf 44; the exterior coupling 42 is connected through the interior duct 200 with the port 202 in the upper face of leaf 44; and the exterior coupling 186 is connected through the interior duct 204 with the port 206 in the upper face of leaf 44. A first additional exterior coupling 208 is attached to the lower leaf 44 and is connected through the interior duct 210 with the port 214 in the upper surface of the lower leaf 44. As seen in Fig. 2, exterior coupling 208 is connected through the pneumatic line 216 with the right banking bellows 18. The second additional exterior fitting 218 is carried by the lower leaf 44 of the switching valve 46, and this exterior coupling is connected through the interior duct 220 with the port 222 in the upper surface of leaf 44. Referring to Fig. 2, it will be seen that the exterior coupling 218 is connected through the pneumatic line 224 to the left banking bellows 16.

Considering now the detailed construction of the upper leaf 76 of the switching valve 46, it

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will be seen in Fig. 5 that the exterior coupling 182a of leaf 76 is connected through the interior duct 226 with the port 228 in the lower face of leaf 76; that the exterior coupling 74 is connected through interior duct 230 with the port 232 in the lower face of leaf 76; that exterior coupling 186a is connected through interior duct 234 with the port 236 in the lower face of leaf 76; and that the exterior coupling 82 is connected through the interior duct 238 with the port 240 in the lower face of leaf 76. Leaf 76 also carries the first additional exterior coupling 242 which is connected through the interior duct 244 with the port 246 in the lower face of leaf 76, and referring to Fig. 2 it will be seen that coupling 242 is connected through the pneumatic line 248 with the dive bellows 12. The upper leaf 76 also carries the second additional exterior coupling 250 which is connected through the interior duct 252 with the port 254 in the lower face of leaf 76. As seen in Fig. 2, exterior coupling 250 is connected by means of pneumatic line 256 with the climb bellows 14.

The lower fixed leaf 44 has a hollow center 260, the central rotatable leaf 190 has a hollow center 262, and the upper fixed leaf 76 has a hollow center 264. The central stem 266 fits in the hollow centers of each of the three leaves to concentrically position the same with respect to one another.

The central leaf 190 of the switching valve 46 has two diametrically opposed kidney-shaped counterbores 268 and 270 in the lower face of leaf 190, and has another pair of diametrically opposed kidney-shaped counterbores 272 and 274 in the upper face of the leaf.

In Fig. 5 it will be seen that the center leaf 190 of the switching valve 46 carries the extension 490 to which is pivotally attached one end of the link 402, the other end of which carries the spring compensating arrangement designated generally by 404 and which is constructed like the arrangement shown in Fig. 3. The outer sleeve of the spring compensating arrangement 494 is numbered 406 and is attached to the outer end of arm 408 which in turn is fixed upon the vertical shaft 410 which is positioned by the motor 412. Also affixed upon the shaft 410 are the cams 414 and 416 and upon which ride the rollers 418 and 420 respectively carried by the movable arms 422 and 424 of the microswitches 426 and 428.

Reference is now also made to Fig. 8 which is an electrical wiring diagram of the circuit controlling the operation of the motor 412. In Fig. 8 it will be seen that the relay 430 is provided, one side of this relay being connected to one side of the 110 volt source through the conductors 432 and 434 while the other side of this relay is connected through the conductor 436, fixed switch element 438, movable switch element 438a, conductor 440 and conductor 442 to the other side of the 110 volt source. Switch element 438a is under the control of the cam 444 which is affixed upon the shaft 446 positioned by the altitude unit 448 which is shown in block form. It is sufficient to know that the shaft 446 is always positioned according to the instant assumed altitude of the trainer, the cam 444 being positioned upon the shaft 446 and arranged relative to the movable switch element 438a to bring the same into engagement with the fixed switch element 438 to energize relay 430 at all times when the assumed altitude is above zero. The conductor 434 which connects with one side of the 110 volt source is

connected to the movable switch element 450 while the conductor 442 which connects with the other side of the 110 volt source is connected to the movable switch element 452. A third movable switch element 454 is shown and is connected through the conductor 456 to the right side of the armature 412a of motor 412. Associated with the movable switch element 452 are the fixed contacts 452a and 452b, the former contact being connected through the conductor 460 with the microswitch element 422 under the control of cam 414, and the latter being connected through the conductor 462 with the movable microswitch element 424 which is controlled by cam 416. Fixed switch elements 450a and 450b are associated with the movable switch element 450, the former being connected through conductor 464 with one side of the field winding 412b of motor 412, and the latter being connected through the conductor 466 with the other side of field winding 412b. The fixed switch elements 454a and 454b are associated with the movable contact 454, the former being connected through the jumper 468 with the previously mentioned fixed switch element 450b, and the latter being connected through the conductor 470 with conductor 464.

The fixed switch elements 426 and 428 are interconnected by the conductor 472, and one end of conductor 472 is connected through conductor 474 with the left side of the armature 412a of motor 412.

It has been stated that the cam 444 closes switch elements 438, 438a at assumed altitudes above zero. The elements are open at all other times. Relay 430 is energized whenever switch elements 438, 438a are closed, and the movable switch elements 452, 450 and 454 are controlled by relay 430. The positions of the three just mentioned movable switch elements when the relay 430 is de-energized are shown in Fig. 8. The cam 414 and the cam 416 are arranged and the switches controlled thereby are of the type that one of the switches controlled by these cams is closed at all times and one of the switches controlled by the cams is open at all times. As will become more clearly understood, the movable switch element 424 controlled by cam 416 is positioned by the cam to contact the fixed switch element 428 when assumed altitude is above zero, but when assumed altitude is zero or below, the movable contact 424 is disengaged from fixed contact 428. On the other hand, cam 414 controls the movable switch element 422 so that the movable switch element engages the fixed switch element 426 only when the trainer is at an assumed altitude of zero, and when the trainer is air-borne, the movable switch element 422 is displaced from the fixed switch element 426.

The detailed description of the operation of the electrical circuit of Fig. 8 will be later given, it being deemed sufficient to state at this time that the unit 448 controls relay 430 to energize the motor 412 to position the central leaf 190 of the switching valve 46 according to whether it is assumed the plane represented by the trainer is airborne or grounded.

The kidney shaped counterbores 268 and 270 are shaped and positioned so that when the central rotatable leaf 190 is in its clockwise position, as is the case when the trainer is assumed to be grounded, the kidney shaped counterbore 268 in the bottom of leaf 190 connects the port 206 in the top face of bottom leaf 44 with the

adjacent port 214, and port 194 is disconnected from the port 214. At the same time, the kidney shaped counterbore 270 in the bottom face of leaf 190 connects the port 198 with the port 222, but port 202 is disconnected from port 222. Consequently, the bank leveling valve 84 is connected with the bank bellows 16 and 18, but the main aileron or bank valve 30 is disconnected from the bank bellows 16 and 18.

The kidney shaped counterbores 272 and 274 in the upper face of the central leaf 190 are shaped and positioned so that when center leaf 190 is in its clockwise position, the kidney shaped counterbore 272 connects the port 236 with the port 254 in the lower face of the upper fixed leaf 76, and port 240 is cut off from the port 254. At the same time the kidney shaped counterbore 274 in the upper face of the middle leaf 190 connects the ports 228 and 246 in the lower face of the upper leaf, but port 232 in the same surface is cut off from the port 244. Consequently, when the middle leaf 190 is rotated into its clockwise position, as is the case when the trainer is assumed to be grounded, the main aileron valve 30 is disconnected from the bank bellows 16 and 18, the main elevator valve 54 is disconnected from the dive and climb bellows 12 and 14, the bank leveling valve 84 is connected to the banking bellows 16 and 18, and the auxiliary pitch valve 84a is connected to the dive bellows 12 and climb bellows 14.

It will be appreciated without a detailed explanation that when the central leaf 190 is rotated into its counterclockwise position, as is the case when the trainer is assumed to be air-borne, the kidney shaped counterbores in the upper and lower surfaces of the middle leaf 190 will be moved out of positions overlapping the ports in the upper leaf 76 and lower leaf 44 which connect with the auxiliary valves 84 and 84a, and will instead be moved into positions overlapping the ports which lead to the main aileron valve 30 and main elevator valve 54, at the same time continuing to overlap the ports which go to the bellows 12, 14, 16 and 18. Consequently, when the middle leaf 190 is in the counterclockwise position, the auxiliary valves 84 and 84a will be disconnected from the main bellows, but the conventional main aileron valve 30 and elevator valve 54 will be connected to the four main bellows which control the attitude of the fuselage upon the universal joint.

Referring again to Fig. 2A the air speed unit of the trainer is shown in block form and designated by 300. The output shaft 301 of the air speed unit 300 is positioned according to the instant assumed air speed and cam 302 which is affixed upon shaft 301 is arranged to close the switch 303 to energize the solenoid when the assumed air speed is the predetermined amount, e. g., 25 knots, or higher, and to open the switch when the assumed air speed is lower than the predetermined amount. The plunger of the solenoid 304, as seen in Fig. 2, is numbered 306. This plunger is pivotally connected to the arm 308 integral with the upper leaf 310 of the nose-down control valve 312, which valve also comprises a lower fixed leaf 314. Reference is now made to Fig. 6 which is an exploded view of the valve 312. The lower leaf 314 of this valve is suitably affixed to the bottom 26 of the trainer fuselage, and this valve includes the port 316 in the upper face of the lower leaf which connects with the exterior fitting 318, as well as the port 320 beside the port 316, port 320 being connected to the exterior fit-

ting 322. The upper leaf 310 includes a counter-bore 324 in the lower face of the upper leaf, the upper leaf being hollow at the center 326 for the reception of the central stem 328. The lower leaf 314 is also hollow at 330 to receive this central stem. The exterior coupling 318 is connected by means of pneumatic line 332 with the nose-down control bellows shown in Fig. 2 and designated generally by 334. The exterior coupling 322 is connected through the pneumatic line 336 with the turbine 138 which provides a source of reduced air pressure. The lower leaf 314 carries the vertical stud 340 while the upper leaf 310 carries the two horizontal studs 338a and 338b which coact with the vertical stud 340 to limit the rotation of the upper leaf 310. The spring 340a has one end connected to the horizontal stud 338a and the other end to the member 340b which may be suitably affixed within the trainer fuselage. When solenoid 304 is energized, the upper leaf 310 is rotated counterclockwise until stop 338b engages stop 340, and when the solenoid 304 is de-energized the spring 340a rotates the upper leaf 310 clockwise until stop 338a engages stop 340.

Reference is now made to Fig. 7 where the nose-down control bellows 334 is shown. This bellows includes a fixed side 339 which is mounted upon the two brackets 340c which in turn are pinned upon the vertical shaft 341 by means of set screws 342. The bellows 334 also includes the movable side 344 having one end pivoted to the fixed side 339 and the usual fabric covering 345 which renders this bellows air-tight. Affixed to the movable side 344 is the bracket 348 to which the right end of link 350 is connected by means of pivot 352. The left end of link 350 is carried by pivot 354 which in turn is carried by the outer end of the arm 356 which together with the hub 358 and arm 360 forms a bellcrank, this bellcrank being freely mounted upon the vertical shaft 341. Pivotaly connected to the outer end of arm 360 is the forward end of link 362, the rear end of which, as also shown in Fig. 2, is pivotaly connected by means of pivot 364 to the slider 366 which is mounted upon the link 92a. Link 92a also carries the collar 368 which is affixed upon the link 92a somewhat to the rear of slider 366.

It will be seen that the arm 370 is affixed upon the vertical shaft 341 by means of set screw 342, the outer end of arm 370 being connected to the previously mentioned link 68 by means of pivot 374. The forward end of link 68, it will be recalled, is connected to the control column 69 by means of connection 69a, and the rear end of link 68 is connected to the lower end of lever 64, which lever is connected to the upper leaf 58 of the elevator valve 54 by the intermediate link 62.

Referring now to Fig. 1 only, it will be seen that there is affixed to the lower platform 10 the stud 401 upon which the locking arm 403 is pivotaly mounted. A stud 405 is carried by the bottom 26 of the fuselage, this stud being arranged to project into the hole 407 in the top of the locking arm 403. A similar arrangement may be provided upon the opposite side of the trainer, as is well known to those skilled in the art, in order that the fuselage may be in the locked level position when the arms 403 are positioned to engage the studs 405.

Considering now the operation of the apparatus of this invention, before the student in the trainer starts his simulated take-off run, the well known "ignition" switch (not shown) in the trainer is turned on to energize the turbine 138 and the

instructor then disengages the locking straps 402, thus leaving the position of the fuselage 24 on the universal joint 28 to be controlled by the four main bellows 12, 14, 16 and 18. As the student starts his simulated take-off run, the assumed air speed will of course be below the amount required for the pilot flying the plane represented by the trainer to raise the tail of the plane off the ground, and also the air speed will be insufficient for the pilot to bank the plane. This phase of the take-off run is hereinafter referred to as the "initial phase." Accordingly, the air speed unit 300 is arranged so that during the initial phase of the take-off run the solenoid 304 is de-energized resulting in a forward positioning of the plunger 306 under the control of spring 340a and in the positioning of the upper leaf 310 of the valve 312 in its clockwise position. The kidney shaped counterbore 324 in the bottom face of the upper leaf 310 of valve 312 is positioned clockwise of the ports 316 and 320 in the upper face of the lower leaf 314. Consequently, the port 316 is not connected with the port 320, and therefore vacuum is not admitted into the interior of the bellows 334. This bellows will therefore be expanded. Such being the case, the link 350, as best seen in Fig. 7, will be positioned to the rear, and the bellcrank including the arms 356 and 360 and hub 358 will be positioned in its counterclockwise position, moving the link 362 and the slider 366 into its foremost position. Consequently, when the student in the trainer moves the control column 69 ahead or to the rear, the resulting fore and aft movement of the link 68 results in a movement of the arm 370 and of the vertical shaft 341 upon which arm 370 is affixed. Inasmuch as the bellows 334 is also fixed to shaft 341, this bellows will move with the shaft 341, and by means of link 350, bellcrank arm 356, hub 358 and bellcrank arm 360, the link 362 will be moved fore and aft by fore and aft movements of the control column 69 and of the link 68. However, the fore and aft movements of link 362 merely result in a sliding of slider 366 along the link 92a, and slider 366 does not engage the collar 368 which is affixed upon link 92a. Consequently, the upper leaf 88a of the pitch level valve 84a is not affected by fore and aft movements of the control column 69 during the initial phase of the take-off run.

Also, during the initial phase of the take-off run, inasmuch as the assumed air speed will be below the amount required to make the plane represented by the trainer become air-borne, the central leaf 190 of the switching valve 46 will be positioned in its clockwise position, in which case the vacuum lines 180 and 184 connected to the bank leveling valve 84 will be connected to the vacuum lines 224 and 216 respectively, which lines run to the left banking bellows 16 and right banking bellows 18, respectively. At the same time, the vacuum lines 40 and 50 which connect the main aileron valve 30 to the lower leaf 44 of the switching valve 46 will not be connected to the vacuum lines 216 and 224 which run to the banking bellows 16 and 18. Consequently, the main aileron valve 30 is disconnected from the banking bellows 16 and 18, and any movement of the upper leaf 36 of the aileron valve in response to movements of the control wheel 39 do not produce any operation of the banking bellows 16 and 18. However, inasmuch as the bank leveling valve 84 is connected through the described vacuum lines and switching valve 46 to the banking bellows 16 and 18, it will be appreciated that the bank leveling valve 84 is effective

to control the lateral position of the trainer fuselage.

However, assuming that at any time during the initial phase of the simulated take-off run the fuselage 24 is displaced from the level horizontal position in that one side of the fuselage, e. g., the left side, becomes somewhat lower than the other, inasmuch as bracket 134 seen in Fig. 2 is affixed upon the horizontal platform 10 and the brackets 122 are carried by the bottom 26 of fuselage 24, when the left side of the fuselage becomes lower than the right, the intermediate connecting link 132 will cause the arm 124 to rotate clockwise as seen in Fig. 2, and the shaft 120 and arm 102 will be rotated in the same direction. By means of link 100 and the compensating spring arrangement 94, link 92 will be moved to the right in Fig. 2, resulting in a counterclockwise rotation of the upper leaf 88 of the bank leveling valve 84. Referring to Fig. 4, it will be appreciated that when the upper leaf 88 is rotated counterclockwise of its neutral position in response to the lowering of the left side of fuselage 24, the vacuum port 154 which is normally positioned between the ports 168 and 174 in the lower leaf 86 will be moved into an overlapping position with respect to the port 174 and will apply vacuum to the pneumatic line 184. At the same time, the atmosphere port 160 in the upper leaf 88 which normally lies just clockwise of the port 168 will also be placed into an overlapping position with the port 168, and atmosphere will be applied to the pneumatic line 180. Inasmuch as the central leaf 190 of the switching valve 46 is positioned in its clockwise position, the vacuum applied to line 184 is applied through the switching valve 46 to the pneumatic line 216 which runs to the right banking bellows 18, and this bellows is collapsed. At the same time, the atmosphere applied to the pneumatic line 180 is applied through the switching valve 46 to the vacuum line 224 which runs to the left banking bellows 16, and that bellows is expanded. The collapsing of the right banking bellows 18 and the expanding of the left banking bellows 16 will result in a raising of the left side of the fuselage. Consequently, during the initial phase of the simulated take-off run the apparatus of this invention is arranged so that a lowering of the left side of the fuselage automatically causes the apparatus to function to produce a raising of the left side of the fuselage.

It will be appreciated without a detailed explanation that if during the initial phase of the take-off run the right side of the fuselage should become positioned below the level position, the apparatus interconnecting the upper leaf 88 of the bank leveling valve 84 with the bracket 134 which is affixed to the platform 10 will be operated to rotate the upper leaf 88 of the bank leveling valve 84 clockwise of its neutral position. Referring to Fig. 4, a clockwise rotation of the upper leaf 88 will result in the application of vacuum to the pneumatic line 180 which is connected to the left banking bellows 16 through the switching valve 46, and in an application of atmosphere to the pneumatic line 184 which is connected to the right banking bellows 18 through the switching valve 46. Accordingly, the left banking bellows 16 will be collapsed and the right banking bellows 18 will be expanded, and the right side of the fuselage will be raised.

It will therefore be appreciated that the apparatus of this invention is arranged so that during the initial phase of the take-off run, any displacement of the trainer fuselage 24 from the level

horizontal position will result in an operation of the bank leveling valve 86 and in a resulting operation of the bellows 16 and 18 to return the fuselage to the level transverse position. The apparatus of this invention for accomplishing the preceding described result will maintain the fuselage 24 in the level transverse position with great accuracy and sensitivity. (Also, during the initial phase of the take-off run, the main aileron valve 30 and main elevator valve 54 are disconnected from the bellows 12, 14, 16 and 18 so that the student in the trainer cannot produce banking and pitching movements of the fuselage. These conditions accurately simulate the performance of a real plane during the initial phase of the take-off where the pilot cannot cause the plane to pitch or bank.)

Also, during the initial phase of the simulated take-off run, the clockwise position of the center leaf 190 of the switching valve 46 disconnects the vacuum line 80 which runs from the main elevator valve 54 to the upper leaf 76 of the switching valve from the vacuum line 256 which runs from the switching valve upper leaf to the climb bellows 14, and also the position of the central leaf 190 disconnects the vacuum line 72 which runs from the main elevator valve 54 to the upper leaf 76 of the switching valve 46 from the vacuum line 248 which runs from the same upper leaf to the dive bellows 12. Accordingly, any movement of the upper leaf 58 of the main elevator valve in response to a fore and aft movement of the control column 69 will not produce any operation of the dive bellows 12 and climb bellows 14, and consequently the control column 69 is rendered ineffective to control the pitch attitude of the fuselage 24.

At the same time, the clockwise position of the central leaf 190 of the switching valve 46 connects the vacuum line 184a from the pitch leveling valve 84a with the vacuum line 256 which runs to the climb bellows 14, and also connects the vacuum line 180a which runs from the valve 84a to the upper leaf 76 of the switching valve 46 with the pneumatic line 248 which connects with the dive bellows 12. Consequently, the pitch leveling valve 84a is rendered operative to control the bellows 12 and 14 to affect the pitch attitude of the fuselage 24.

Assuming that during the initial phase of the simulated take-off run the pitch attitude of the fuselage 24 departs from the normal preselected position of the fuselage 24 about its transverse axis for the said initial phase, as by a lowering of the front end of the fuselage 24 below the position in question, by virtue of the fact that bracket 134a is affixed to the platform 10 behind the position of the universal joint 28, and that the brackets 122a are carried by the base 26 which is mounted upon the universal joint, when the nose of the fuselage 24 is lowered the arm 124a, shaft 120a and arm 102a in Fig. 2 will all be rotated counterclockwise, and the link 92a will move ahead, resulting in a counterclockwise rotation of the upper leaf 88a of the pitch leveling valve 84a. Referring to Fig. 4 which shows the construction of the pitch leveling valve 84a (albeit the reference characters used in Fig. 4 are those of the bank leveling valve 84), when the upper leaf 88a is rotated counterclockwise in response to the lowering of the nose of fuselage 24, the vacuum port of the upper leaf will apply vacuum to the pneumatic line 184a which connects with the upper leaf 76 of the switching valve and through the switching valve to the vacuum line 256 which

connects with the climb bellows 14. At the same time, the counterclockwise rotation of the upper leaf 88a applies atmosphere to the pneumatic line 180a which runs to the upper leaf 76 of the switching valve and which is connected through the switching valve to the pneumatic line 248 which runs to the dive bellows 12.

The application of vacuum to the climb bellows 14 and of atmosphere to the dive bellows 12 will result in a raising of the nose of fuselage 24. Consequently, the lowering of the nose of fuselage 24 immediately operates the apparatus of this invention to produce a raising of the nose of the fuselage.

On the other hand, should the rear of the fuselage 23 become displaced downwardly from its normal position during the initial phase of the simulated take-off run, it will be appreciated that the apparatus interconnecting the bracket 134a and the upper leaf 88a of the pitch leveling valve 84a will produce a clockwise rotation of the upper leaf 88a, and vacuum will be applied to the pneumatic line 180a which is connected through the switching valve 46 and pneumatic line 248 with the dive bellows 12, while atmosphere will be applied to the pneumatic line 184a which is connected through the switching valve and pneumatic line 256 with the climb bellows 14. The dive bellows 12 will be contracted and the climb bellows 14 expanded, and the rear of the fuselage will be raised. Accordingly, the lowering of the rear of the fuselage results in an application of vacuum to the dive bellows 12 and of atmosphere to the climb bellows 14, and the rear of the fuselage is raised.

Consequently, during the initial phase of the take-off run, the apparatus of this invention operates to maintain the fuselage 24 at the desired pitch attitude for the early phase of the take-off run, and the apparatus of this invention maintains the fore and aft position of the fuselage 24 in the desired position within a very small tolerance. It will be appreciated that the fore and aft position of the fuselage during the initial phase of the take-off run may be selected as truly level, or any arbitrary position of the fuselage 24 may be selected. For example, it may be desired to tilt the longitudinal axis of the fuselage so that the nose of the fuselage is higher than the tail, to simulate the corresponding situation in the case of a plane during its initial phase of the take-off run where the nose of the plane is considerably higher than the tail.

Consequently, during the initial phase of the take-off run, i. e., until the assumed air speed is such that the plane represented by the trainer could get its tail off the ground in response to a pressing forward of the control column, the apparatus of this invention maintains the fuselage horizontally level and longitudinally stable at the desired angle, which angle may or may not be horizontal. Any movement of the control column or wheel to produce a change in the pitch attitude of the fuselage or in the banking position of the fuselage is without effect.

The preceding described conditions prevail until the second phase of the take-off run is reached, i. e., when the assumed air speed of the trainer reaches the predetermined amount required to enable the pilot to raise the tail of the plane represented by the trainer from the ground by pressing forward of the control column. When that predetermined amount, e. g., 25 knots, is reached, the apparatus of Fig. 2A energizes the solenoid 304 and the plunger 306 is moved to the rear,

rotating the upper leaf 310 of the valve 312 counterclockwise and, referring to Fig. 6, it will be seen that the kidney shaped counterbore 324 in the lower surface of the upper leaf 310 will connect the ports 316 and 320 in the upper face of the lower leaf 314. Such being the case, the vacuum line 336 which connects with the turbine 138 will be connected to the vacuum line 332 which runs to the bellows 334, and this bellows will be collapsed by the application of vacuum to its interior. The collapsing of the bellows 334 results in a movement ahead of the link 350 and in a clockwise rotation of the bellcrank arms 356 and 360 as seen from above, and in a rearward positioning of the link 362, the forward end of which is pivotally attached to the outer end of arm 360. Consequently, the slider 366 is moved to the rear, the apparatus being adjusted so that when the control column 69 is in its neutral fore and aft position, and the bellows 334 is collapsed, link 362 is positioned so that the rear end of sleeve 366 just engages the forward edge of the collar 368 which is affixed upon the link 92a.

Consequently, upon the reaching of an assumed air speed of the predetermined amount of 25 knots, when the student in the trainer fuselage presses the control wheel 39 and control column 69 ahead to simulate the raising of the tail of the plane represented by the trainer from the ground, the link 68 moves to the rear rotating the arm 370 clockwise, as seen in Fig. 7, which rotation results in a similar rotation of the vertical shaft 341, bellows 334, link 350, and the bellcrank arms 356 and 360, and the link 362 similarly moves to the rear. As best seen in Fig. 2, the rearward movement of link 362 results in a rearward movement of the slider 366 upon the link 92a, and this slider engages the fixed collar 368 to move the entire link 92a to the rear. The upper leaf 88a of the pitch leveling valve 84a will be rotated clockwise, applying vacuum to the pneumatic line 180a and atmosphere to the pneumatic line 184a. Through the upper leaf 76 of the switching valve 46, the vacuum applied to pneumatic line 180a will be applied to the pneumatic line 248 leading to the dive bellows 12, while the atmosphere applied to the pneumatic line 184a will be applied to the pneumatic line 256 leading to the climb bellows 14. The application of vacuum to the dive bellows 12 and of atmosphere to the climb bellows 14 will result in a lowering of the nose of fuselage 24 and in a raising of the tail of the fuselage, thus simulating the raising of the tail of the plane represented by the trainer from the ground. It will be appreciated that the rearward movement of link 92a is permitted by virtue of the provision of the spring compensating arrangement 94a.

Having lowered the nose of the fuselage 24, should the student release the pressure applied to the control column 69, the well known mechanical centering arrangement incorporated in trainers of the type being considered returns the control column 69 to the neutral position, resulting in a returning of the arm 370 and the mechanism interconnecting that arm and the slider 366 to their neutral positions. The spring compensating arrangement 94a will return the link 92a and the upper leaf 88a of the pitch leveling valve 84a to their neutral positions, and the previously described functioning of the pitch leveling valve 84a to keep the fuselage 24 in the predetermined pitch attitude will again take place.

It will be noted that when the predetermined

assumed air speed is reached which will permit the student to raise the tail of the fuselage 24, the student is not able to raise the nose of the fuselage because any rearward movement of the control column 69 will merely result in a movement of the slider 366 ahead along link 92a, and the main elevator valve 58 is cut off from the climb and dive bellows 12 and 14 by the position of the center leaf 190 of valve 46. Also, any rotation of the control wheel 39 to produce a banking of the fuselage 24 will be ineffective, because the position of the middle leaf 190 of the switching valve 46 cuts off the main aileron valve 33 from the banking bellows 16 and 18.

Consequently, during the second phase of the simulated take-off run, the student in the trainer may by pressing the control column 69 ahead lower the nose of the trainer fuselage and raise the rear end thereof to simulate the raising of the tail of the plane represented by the fuselage from the ground when the required air speed is reached. However, the student cannot raise the nose of the fuselage, nor can he produce a banking thereof.

The just described conditions of operation continue until such time as the assumed air speed reaches the predetermined amount required to render the airplane represented by the trainer air-borne, and a positive assumed altitude is obtained, as previously explained. At that moment, as seen in Fig. 8, the cam 444 moves the movable switch contact 438 into engagement with the fixed contact 438a and relay 430 becomes energized, resulting in a movement of the movable switch elements 452, 450, and 454 to the right in Fig. 8, into positions engaging the fixed elements 452a, 450a, and 454a respectively. The electrical circuit comprising the conductor 434, movable switch element 450, fixed element 450a, conductor 464, field coil 412b, conductor 466, jumper 468, fixed switch element 454a, movable switch element 454, conductor 456, armature 412a, conductor 474, conductor 472, fixed switch element 426, movable switch element 422, conductor 460, fixed contact 452a, movable contact 452 and conductor 442 will be completed. (Movable contact 424 will be displaced from fixed contact 428 because as previously stated, cam 416 engages elements 424, 428 only when the trainer is assumed to be air-borne.) Consequently, the motor 412 is energized to rotate its output shaft 410 to move the arm 408 and connecting link 402 so that the center leaf 190 of the switching valve 46 is rotated counterclockwise. This energization of motor 412 continues until the center leaf 190 has been rotated into its counterclockwise position, at which instant the cam 414 is positioned to displace the movable switch contact 422 from the fixed switch element 426, and motor 412 stops. At the same instant, cam 416 moves the movable switch element 424 into engagement with the fixed switch contact 428.

The moving of the center leaf 190 of the switching valve 46 into its counterclockwise position, as previously explained, breaks the pneumatic connection between the bank leveling valve 84 and the bank bellows 16 and 18, and breaks the pneumatic connection between the pitch leveling valve 84a and the dive and climb bellows 12 and 14. Consequently, the bank leveling valve 84 and pitch leveling valve 84a are no longer effective to maintain the fuselage 24 in the predetermined take-off position. The counterclockwise positioning of the center leaf 190 of the switching valve 46 establishes pneumatic con-

nection between the pneumatic lines connecting with the main aileron valve 30 and main elevator valve 54 with the pneumatic lines which connect the switching valve with the four main bellows 12, 14, 16 and 18. Consequently, the main aileron valve 30 and main elevator valve 54 are rendered effective to control the pitch and banking position of the fuselage 24, under the control of the control wheel 39 and control column 69. Consequently, the student regulates the pitch and banking position of the fuselage 24 by a manipulation of the control wheel 39 and control column 69 in the same manner that a pilot controls the pitch and banking position of a plane in actual flight.

The simulated air-borne condition just mentioned prevails until the assumed altitude again reaches zero or ground level, at which time the landing gear of the plane represented by the trainer will be assumed to touch the ground. When this condition is reached, the cam 444 seen in Fig. 8 is positioned by the altitude unit 448 to displace the movable switch contact 438a from the fixed contact 438, and relay 430 becomes de-energized, resulting in a movement of the movable switch contacts 452, 450, and 454 into the positions shown in Fig. 8. Current then flows from conductor 434 to the movable contact 450 and then along the fixed contact 450b to conductor 466 and through the field winding 412b to the conductor 464, then along conductor 470 to the fixed contact 454b to the contact 454, thence along conductor 456 through the armature 412a and by means of conductor 474 to the fixed contact 428. From contact 428 the circuit is completed along the movable contact 424 to the conductor 452 and fixed contact 452b, and by means of movable contact 452 and conductor 442 back to the other side of the 110 volt source. It will be noted that in this instance current flows in the opposite direction through the field winding 412b and in the same direction through the armature 412a from the previously cited instance when the simulated take-off took place. Consequently, the motor 412 is energized to rotate its output shaft 410 in the opposite direction from the previously described instance, and the center leaf 190 of the switching valve 46 is rotated from its counterclockwise position to its clockwise position. When the clockwise position of this leaf is reached, the cam 416 displaces the movable switch element 424 from the fixed contact 428, and motor 412 stops. At the same instant, cam 414 places the movable switch element 418 in contact with the fixed contact 426.

The return of the center leaf 190 to its clockwise position renders the main aileron valve 30 and main elevator valve 54 ineffective to control the banking and pitching attitude of the fuselage 24, but reconnects the bank leveling valve 84 and pitch leveling valve 84a with the main bellows 12, 14, 16 and 18. Consequently, the functioning of the bank leveling valve 84 is reestablished, and the fuselage 24 is kept transversely level, while the functioning of the pitch leveling valve 84a is re-established to keep the longitudinal position of the fuselage 24 in the predetermined take-off position, modified only by the fact that the student in the trainer can lower the nose of the fuselage 24 by pressing the control column 69 ahead until such time as the assumed air speed drops below the predetermined amount, e. g., 25 knots, because the bellows 334 continues to be collapsed until the assumed air speed drops to that predetermined amount.

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When assumed air speed drops to 25 knots, the predetermined amount, the arrangement shown in Fig. 2A opens the switch 303 and the solenoid 304 becomes deenergized. Spring 340a of Fig. 6 rotates the upper leaf 310 of valve 312 clockwise, and the counterbore 324 is moved clockwise of the ports 316 and 320, and the supply of vacuum in port 320 is disconnected from port 316. Bellows 334 expands, displacing the slider 366 from the collar 368 upon the link 92a so that a forward movement of the control column 69 no longer causes slider 366 to engage the collar 368 to operate the upper leaf 88a of the pitch leveling valve.

Consequently, when the assumed air speed drops to the predetermined amount of 25 knots, the fore and aft movement of the control column 69 and the rotation of the control wheel 39 is ineffective to control the pitch and banking of the fuselage 24. This condition prevails until the assumed air speed drops to zero, at which time it is assumed that the plane represented by the trainer is at a stop.

In view of the preceding disclosure of the preferred embodiment of my invention, it will be appreciated that this invention provides means for simulating, in conjunction with a trainer having a fuselage mounted for pitching and banking movements, the various degrees of maneuverability of a plane during the various phases of its take-off run and air-borne flight, as set forth in detail hereinbefore. It will be appreciated by those skilled in the art that many changes may be made from the disclosed embodiment of my invention without departing from the substance thereof. All such changes are intended to be covered by the following claims.

I claim:

1. The combination of a grounded aviation trainer comprising a fuselage universally mounted with respect to a stationary base, manually operable means in the fuselage simulating the pitching and banking control means of a real plane, motive means for changing the pitching and banking position of said fuselage and a first control means connected to said manually operable means and to said motive means for actuating said motive means under predetermined conditions to universally pitch and bank said fuselage in response to movements of said manually operable means, a second control means connected to said manually operable means and to said motive means for actuating said motive means under different predetermined conditions to raise one end of said fuselage in response to movements of said manually operable means, an altitude unit and an air speed unit forming a part of the trainer and respectively operable in response to changes in the assumed altitude and assumed air speed of said trainer, means interconnecting said air speed unit and said second control means for rendering said manually operable means operable to raise one end of the fuselage upon the reaching of a predetermined assumed air speed, and means interconnecting said altitude unit and said first control means for rendering said manually operable means operable to universally pitch and bank said fuselage upon the reaching of a predetermined assumed altitude.

2. The combination of a grounded aviation trainer comprising a fuselage universally mounted with respect to a stationary base, manually operable means in the fuselage simulating the pitching and banking control means of a real

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plane, motive means for changing the pitching and banking position of said fuselage and a first control means connected to said manually operable means and to said motive means for actuating said motive means under predetermined conditions to universally pitch and bank said fuselage in response to movements of said manually operable means, a second control means connected to said manually operable means and to said motive means for actuating said motive means under different predetermined conditions to raise one end of said fuselage in response to movements of said manually operable means, an altitude unit and an air speed unit forming a part of the trainer and respectively operable in response to changes in the assumed altitude and assumed air speed of said trainer, means interconnecting said air speed unit and said second control means for rendering said manually operable means operable to raise one end of the fuselage upon the reaching of a predetermined assumed air speed, means interconnecting said altitude unit and said first control means for rendering said manually operable means operable to universally pitch and bank said fuselage upon the reaching of a predetermined assumed altitude, and means forming a part of said trainer for maintaining said fuselage in the level transverse position until both said predetermined assumed air speed and altitude are reached.

3. The combination of a grounded aviation trainer comprising a fuselage universally mounted with respect to a stationary base, manually operable means in the fuselage simulating the pitching and banking control means of a real plane, motive means for changing the pitching and banking position of said fuselage and a first control means connected to said manually operable means and to said motive means for actuating said motive means under predetermined conditions to universally pitch and bank said fuselage in response to movements of said manually operable means, a second control means connected to said manually operable means and to said motive means for actuating said motive means under different predetermined conditions to raise one end of said fuselage in response to movements of said manually operable means, an altitude unit and an air speed unit forming a part of the trainer and respectively operable in response to changes in the assumed altitude and assumed air speed of said trainer, means interconnecting said air speed unit and said second control means for rendering said manually operable means operable to raise one end of the fuselage upon the reaching of a predetermined assumed air speed, means interconnecting said altitude unit and said first control means for rendering said manually operable means operable to universally pitch and bank said fuselage upon the reaching of a predetermined assumed altitude, means forming a part of said trainer for maintaining said fuselage in the level transverse position until both said predetermined assumed air speed and altitude are reached, and means forming a part of said trainer for maintaining said fuselage in a predetermined position about an axis transverse thereof until said predetermined assumed air speed is reached.

4. The combination of a grounded aviation trainer comprising a fuselage universally mounted with respect to a stationary base, manually operable means in the fuselage simulating the pitching and banking control means of a real

plane, pneumatically operated motive means for changing the pitching and banking position of said fuselage, a switching valve connected to said motive means, a first valve means connected to said manually operable means and to said switching valve, a second valve means arranged to be operated by said manually operable means and connected to said switching valve, an altitude unit and an air speed unit forming a part of the trainer and respectively operable in response to changes in the assumed altitude and assumed air speed of said trainer, means operable in response to the operation of said air speed unit upon the reaching of a predetermined assumed air speed for rendering said manually operable control effective to raise one end of said fuselage by the operation of said second valve means, and means operable in response to the operation of said altitude unit upon the reaching of a predetermined assumed altitude for operating said switching valve to connect said first valve means to said motive means for rendering said manually operable control effective to universally pitch and bank said fuselage by the operation of said first valve means.

5. The combination of a grounded aviation trainer comprising a fuselage universally mounted with respect to a stationary base, manually operable means in the fuselage simulating the pitching and banking control means of a real plane, pneumatically operated motive means for changing the pitching and banking position of said fuselage, a switching valve connected to said motive means, a first valve means connected to said manually operable means and to said switching valve, a second valve means arranged to be operated by said manually operable means and connected to said switching valve, an altitude unit and an air speed unit forming a part of the trainer and respectively operable in response to changes in the assumed altitude and assumed air speed of said trainer, means operable in response to the operation of said air speed unit upon the reaching of a predetermined assumed air speed for rendering said manually operable control effective to raise one end of said fuselage by the operation of said second valve means, means operable in response to the operation of said altitude unit upon the reaching of a predetermined assumed altitude for operating said switching valve to connect said first valve means to said motive means for rendering said manually operable control effective to universally pitch and bank said fuselage by the operation of said first valve means, and valve means forming a part of said trainer and connected to said switching valve for maintaining said fuselage in the level transverse position until both said predetermined assumed air speed and altitude are reached.

6. The combination of a grounded aviation trainer comprising a fuselage universally mounted with respect to a stationary base, manually operable means in the fuselage simulating the pitching and banking control means of a real plane, pneumatically operated motive means for changing the pitching and banking position of said fuselage, a switching valve connected to said motive means, a first valve means connected to said manually operable means and to said switching valve, a second valve means arranged to be operated by said manually operable means and connected to said switching valve, an altitude unit and an air speed unit forming a part of the trainer and respectively operable in response to changes in the assumed altitude and assumed

air speed of said trainer, means operable in response to the operation of said air speed unit upon the reaching of a predetermined assumed air speed for rendering said manually operable control effective to raise one end of said fuselage by the operation of said second valve means, means operable in response to the operation of said altitude unit upon the reaching of a predetermined assumed altitude for operating said switching valve to connect said first valve means to said motive means for rendering said manually operable control effective to universally pitch and bank said fuselage by the operation of said first valve means, valve means forming a part of said trainer and connected to said switching valve for maintaining said fuselage in the level transverse position until both said predetermined assumed air speed and altitude are reached, and means comprising said second valve means for maintaining said fuselage in a predetermined position about an axis transverse thereof until said predetermined assumed air speed is reached.

7. The combination of a grounded aviation trainer comprising a fuselage universally mounted with respect to a stationary base, manually operable means in the fuselage simulating the pitching and banking control means of a real plane, pneumatically operated motive means for changing the pitching and banking position of said fuselage, a switching valve connected to said motive means, a first valve means connected to said manually operable means and to said switching valve, a second valve means arranged to be operated by said manually operable means and connected to said switching valve, an altitude unit and an air speed unit forming a part of the trainer and respectively operable in response to changes in the assumed altitude and assumed air speed of said trainer, means operable in response to the operation of said air speed unit upon the reaching of a predetermined assumed air speed for rendering said manually operable control effective to raise one end of said fuselage by the operation of said second valve means, means operable in response to the operation of said altitude unit upon the reaching of a predetermined assumed altitude for operating said switching valve to connect said first valve means to said motive means for rendering said manually operable control effective to universally pitch and bank said fuselage by the operation of said first valve means, and valve means operated by a displacement of said fuselage from the level transverse position and forming a part of said trainer and connected to said switching valve for maintaining said fuselage in the level transverse position until both said predetermined assumed air speed and altitude are reached.

8. The combination of a grounded aviation trainer comprising a fuselage universally mounted with respect to a stationary base, manually operable means in the fuselage simulating the pitching and banking control means of a real plane, pneumatically operated motive means for changing the pitching and banking position of said fuselage, a switching valve connected to said motive means, a first valve means connected to said manually operable means and to said switching valve, a second valve means arranged to be operated by said manually operable means and connected to said switching valve, an altitude unit and an air speed unit forming a part of the trainer and respectively operable in response to

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changes in the assumed altitude and assumed air speed of said trainer, means operable in response to the operation of said air speed unit upon the reaching of a predetermined assumed air speed for rendering said manually operable control effective to raise one end of said fuselage by the operation of said second valve means, means operable in response to the operation of said altitude unit upon the reaching of a predetermined assumed altitude for operating said switching valve to connect said first valve means to said motive means for rendering said manually operable control effective to universally pitch and bank said fuselage by the operation of said first valve means, valve means operated by a displacement of said fuselage from the level transverse position and connected to said switching valve for maintaining said fuselage in the level transverse position until both said predetermined as-

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sumed air speed and altitude are reached, and means for operating said second valve means upon a displacement of said fuselage from a predetermined position about an axis transverse thereof to return said fuselage to the predetermined position about the transverse axis until said predetermined assumed air speed is reached.

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