June 6, 1950 K. A. KAIL 2,510,579

WEATHERCOCKING SIMULATING MEANS FOR GROUNDED AVIATION TRAINERS

Filed May 31, 1946 4 Sheets-Sheet 1

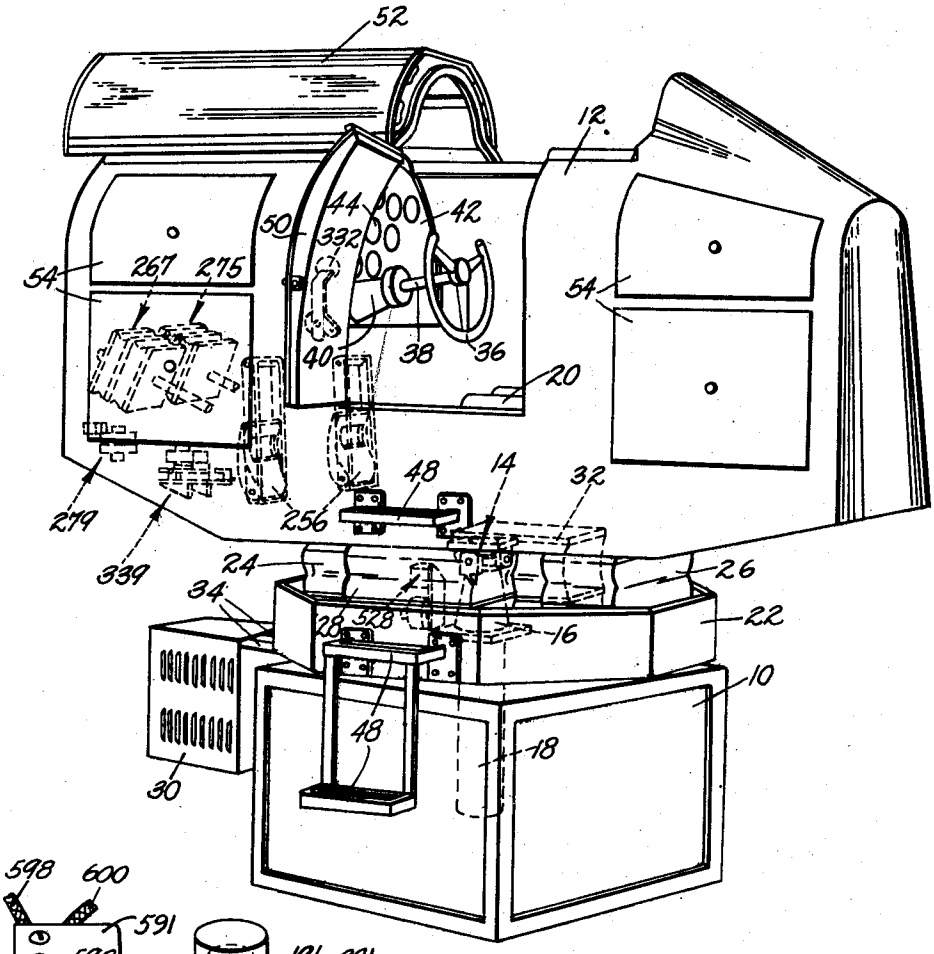



FIG. 1

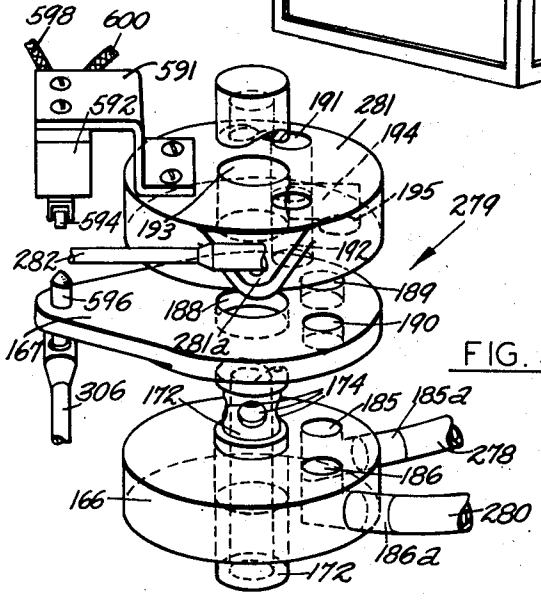



FIG. 3

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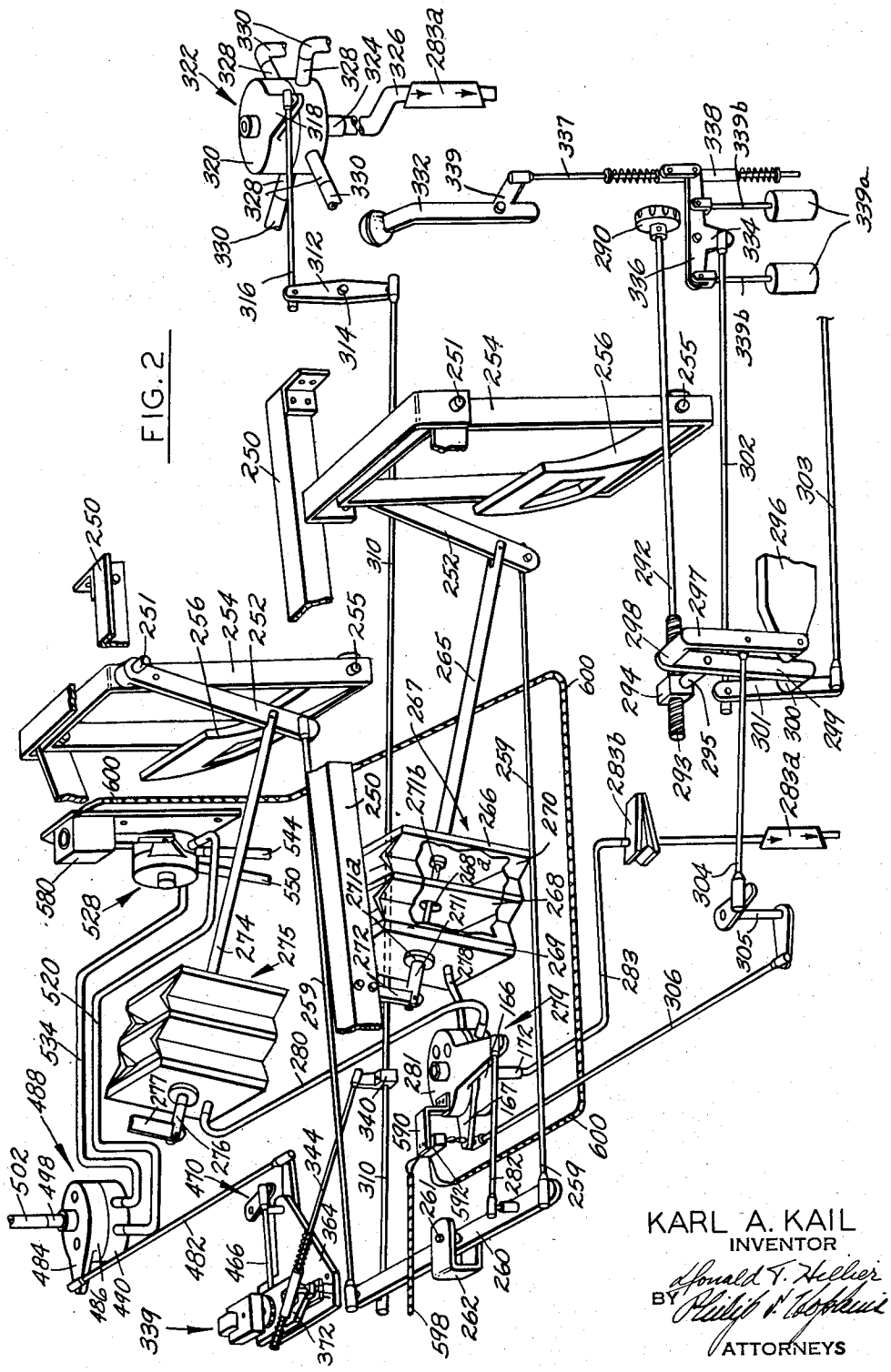
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WEATHERCOCKING SIMULATING MEANS FOR GROUNDED AVIATION TRAINERS

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FIG. 2



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WEATHERCOCKING SIMULATING MEANS FOR GROUNDED AVIATION TRAINERS

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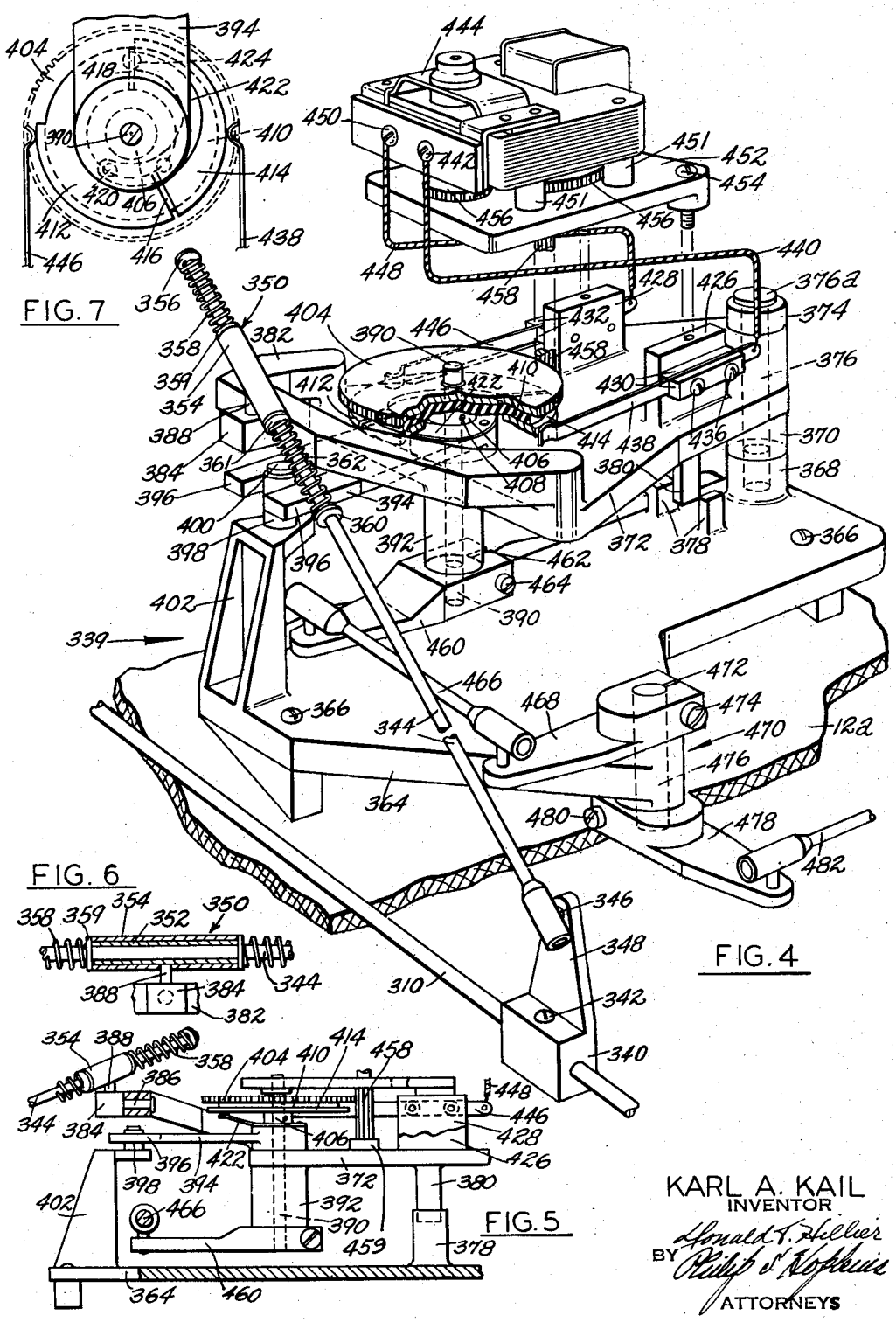



FIG. 7

FIG. 4




FIG. 6

FIG. 5

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WEATHERCOCKING SIMULATING MEANS FOR GROUNDED AVIATION TRAINERS

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FIG. 9

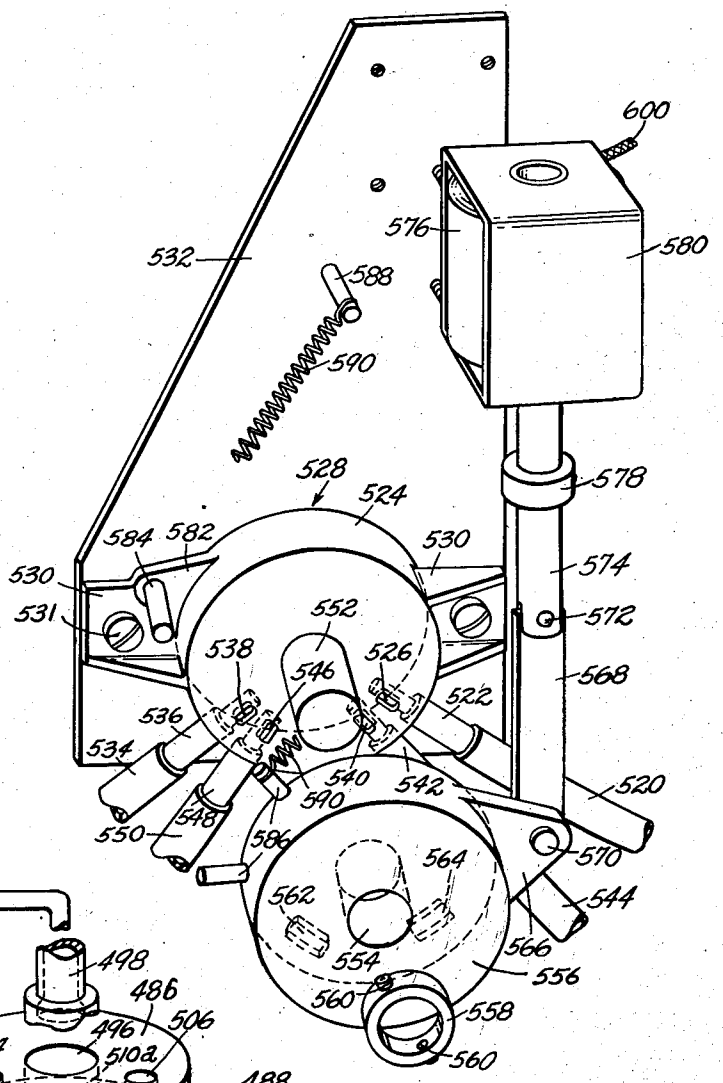
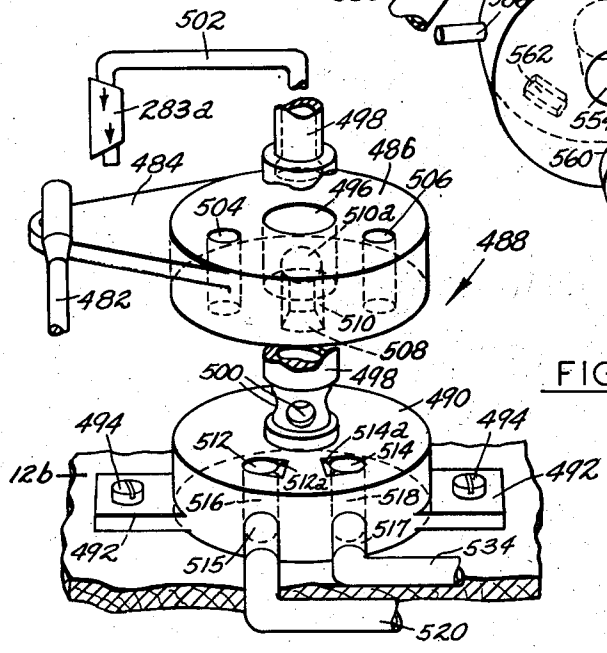



FIG. 8




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# UNITED STATES PATENT OFFICE

2,510,579

## WEATHERCOCKING SIMULATING MEANS FOR GROUNDED AVIATION TRAINERS

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Application May 31, 1946, Serial No. 673,593

4 Claims. (Cl. 35—12)

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This application relates to grounded aviation trainers, and more particularly to means for simulating in such trainers the weathercocking of a plane in actual flight. My invention will be disclosed in conjunction with trainers of the type covered by U. S. Patents 1,825,462 and 2,099,857. However, it will be appreciated by those skilled in the art that many parts of my invention may be adapted for use in conjunction with other types of trainers.

In order that my invention may be better understood it is believed that it would be helpful to explain what is meant by weathercocking, and when it occurs in the flying of a real plane. In the flying of a real plane, a correct turn is manipulated by coordinated movements of the aileron control and rudder pedals. To start the turn, aileron is first applied and then a very small amount of rudder pedal is used, and when the plane is in the turn, it may be necessary to neutralize the controls or even to apply a small amount of opposite aileron and rudder. In a properly executed turn, the center line of the plane coincides at each instant with the flight path of the plane. In taking the plane out of the turn, opposite rudder and aileron are applied gradually, and then the controls are gradually recentered. The center line of the plane at all times should coincide, in a properly executed turn, and in properly coming out of the turn, or very nearly so, with the flight path.

However, when a turn in a plane is made by the use of rudder pedals only, or an insufficiency of coordinated aileron, the plane "skids," and the center line of the plane is not pointed along the flight path. Accordingly, the plane is moving along at an angle to the flight path, and if the rudder pedals are released too rapidly, the airstream effect upon the tail surfaces of the plane cause the plane to turn momentarily in a direction opposite the direction of the turn, so that the center line of the plane aligns itself with the flight path of the faulty turn. This adverse turning of the plane is referred to as weathercocking.

It should be particularly noted that weathercocking occurs only in the faulty execution of a turn or the faulty manipulation of the plane to take it out of the turn, and occurs only when inordinately large amount of rudder pedal is being used.

It is a principal object of this invention to provide means in a grounded aviation trainer for simulating the weathercocking effect of a real plane in actual flight. In order that the

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nature of my invention may be better understood, reference is made to the accompanying drawings, wherein,

Fig. 1 is a general exterior view of trainers of the type covered by the two above mentioned U. S. patents.

Fig. 2 is a general perspective view showing the arrangement within the trainer of the essential parts of this invention.

Fig. 3 is an exploded perspective view of the rudder control valve.

Fig. 4 is a general perspective view of the weathercocking control unit.

Fig. 5 is an elevation view of a portion of the apparatus seen in Fig. 4, certain parts being cut away for purposes of illustration.

Fig. 6 is a cross sectional view of the compensating spring assembly.

Fig. 7 is a view of the weathercocking motor control assembly.

Fig. 8 is an exploded perspective view of the weathercocking control valve.

Fig. 9 is an exploded perspective view of the weathercocking shutoff valve and associated apparatus.

Referring now to Fig. 1, it will be seen that the stationary base of the trainer is designated 10 and the fuselage 12. The floor of the fuselage rests upon the top of the universal joint designated generally by 14, this joint being in turn supported by the pedestal 16 which rests upon the main spindle 18. Spindle 18 is in turn rotatably mounted in base 10. The conventional octagon 22 is shown as are the forward pitching bellows 24, the rearward pitching bellows 26, the left banking bellows 28 and the right banking bellows 32. The turning motor is designated 30, and the arms supporting this motor by 34. The rudder pedals within fuselage 12 are numbered 256, and the control wheel is 36, this control wheel being held by the shaft 38 which is slidably and rotatably mounted within the pedestal 40 positioned to the rear of the instrument panel 42 upon which are mounted a plurality of instruments 44. As is well known to those skilled in the art, upon a pressing forward of the left rudder pedal 256, the turning motor 30 is energized to rotate the main spindle 18, octagon 22, the pitching and banking bellows, the pedestal 16, universal joint 14 and fuselage 12, as well as the turning motor itself, to the left about a vertical axis. Forward movement of the right rudder pedal 256 results in an opposite rotation of the same parts. Forward movement of the wheel 36 results in a collapsing of bellows 24 and

in an expansion of bellows 26, and the front end of fuselage 12 is lowered. Opposite movement of wheel 36 results in opposite functioning of the bellows 24 and 26, and the nose of fuselage 12 is raised. A counterclockwise rotation of wheel 36 results in a collapsing of bellows 28 and in an expansion of bellows 32, and the fuselage 12 banks to the left. Opposite movement of wheel 36 results in a contraction of bellows 32 and in an expansion of bellows 28, and fuselage 12 banks to the right. A plurality of steps 48 are provided to enable easy entry to and exit from the fuselage 12, and a seat 20 is provided in the fuselage for the student. A door 50 is provided as is a sliding hood 52, and upon closing of the door and hood, instrument flying conditions may be realistically simulated. A plurality of inspection ports 54 are provided in order that access to the apparatus within the trainer may be easily had. The instruments 44 upon the instrument panel 42, as is well known, correspond to the flight instruments of a plane in actual flight, and these instruments properly respond to all fuselage movements as well as to movements of the simulated throttle lever 332 in a manner to simulate the functioning of the instruments of a real plane in response to corresponding plane and throttle lever control movements.

*Simulated rudder loading and trimming means*

Reference is now made to Fig. 2 which discloses in detail the simulated rudder loading means which may be combined with the novel apparatus of this application. In Fig. 2 it will be seen that there is provided a pair of brackets 250, these brackets being affixed to the inside of the fuselage 12 a substantial distance above the floor at a point ahead of the student's seat 20, as seen in Fig. 1, and a pair of rods 251 are held by the brackets 250. Also pivotally carried by each of the rods 251 is a depending square-shaped bracket 254 having mounted in the lower portion thereof a transverse shaft 255 upon each of which is fixedly mounted one of the rudder pedals 256. An arm 252 is affixed to each of the brackets 254, as shown, and pivotally attached to the bottom end of each of the arms 252 is a forwardly extending link 259, the forward end of each of which is pivotally connected to one end of the rudder bar 260 which is pivotally mounted upon the stud 261 carried by the bracket 262 which is fixed to the bottom of the fuselage floor.

Affixed to the left depending arm 252 is the rear end of the forwardly extending rod 265 which is affixed to the rear portion 266 of the left rudder control loading bellows designated generally by 267. It will be seen that this bellows comprises a central member 268 and a forward member 269 as well as the suitable air-tight covering material 270. A hole 268*a* is drilled through member 268, as shown.

The rod 271 has an enlarged forward end and is fixed to the forward end 269 of bellows 267 by flange 271*a*. The forward end of this rod is pivotally attached to the lower end of the arm 272 carried by the fixed bracket 250. It should be noted that the rear end 271*b* of the rod 271 passes through the central member 268 of the bellows 267 and telescopes inside the rod 265.

A rod 274, bellows designated generally 275, rod 276 and arm 277 are provided, these parts being constructed exactly like the corresponding members just described. The left rudder control loading bellows 267 is connected by means of the pneumatic line 278 to the rudder centering valve designated generally by 279, and the right rudder control loading bellows 275 is connected by means of the pneumatic line 280 to centering valve 279. It will be noted that the upper rotatable leaf 281 of valve 279 has attached thereto the rear end of the link 282, the forward end of which is pivotally connected to the rudder bar 260.



Reference is now made to Fig. 3 which is a detailed exploded view of the rudder pedal control loading valve designated generally by 279. It will be seen that this valve comprises an upper rotatable leaf or section 281, a middle rotatable leaf or section 167, and a fixed bottom leaf or section 166.

Fixedly mounted in the center of the lower leaf 166 is the vertical hollow stem 172 having a plurality of ports 174 in its side walls. Referring now to Fig. 2 it will be seen that the lower end of the hollow stem 172 is connected by means of the vacuum line 283 to the source of vacuum 283*a* through a conventional step-down regulator bellows 283*b*. The vacuum within bellows 283*b* manifests itself at all times in the central stem 172.

In Fig. 3 it will be seen that a pair of vertical ducts 185 and 186 extend from the upper face of leaf 166 downwardly and partly through the leaf 166. Connecting with the duct 185 is the exterior connector 185*a* which connects with the line 278 which, as seen in Fig. 2, connects with the left bellows 267. Similarly, connecting with the duct 186 is the connector 186*a* which connects with the line 280 which connects with the interior of the right bellows 275.

It will be seen that the movable center leaf 167 has a central bore 188 adapted to receive the vertical stem 172 and that two ports 189 and 190 extend completely through the leaf 167. When the leaf 167 is neutrally positioned relative to the lower fixed leaf 166, the port 189 coincides exactly with the port 185 and the port 190 coincides exactly with the port 186.

In the upper movable leaf 281 are a pair of vertical ducts 191 and 192 which extend completely through the leaf 281. It will be appreciated that the upper ends of both of the ducts 191 and 192 are at all times in communication with the atmosphere. Centrally located within the leaf 281 is the vertical bore 193 extending completely through leaf 281 and adapted to receive the upper end of stem 172 of the lower leaf. Communicating with the vertical bore 193 of leaf 281 is the transverse duct 194 which communicates with the vertical duct 195 drilled in the lower face of the leaf 281.

When the three leaves of the valve shown in Fig. 3 are in the neutral position, it will be appreciated that the vacuum in the stem 172 passes through the ports 174 in the stem into the ducts 194 and 195. In the neutral position there is no overlap between the port 195 in leaf 281 and the ports 189 and 190 in leaf 167, but the port 195 is tangent to the ports 189 and 190 so that a slight amount of vacuum leaks through the two latter ports. At the same time, in the neutral position, the atmosphere which is always present in the ports 191 and 192 cannot pass into either of the ports 189 or 190 because there is no overlap between the ports 191 and 189 on the one hand and ports 192 and 190 on the other. Consequently, when the leaves of the valve 279 are all in their neutral position, a slight amount of vacuum passes through the lines 278 and 280 into

the bellows 267 and 275, and the bellows are neutralized.

However, assuming that the upper leaf 281 is rotated counterclockwise from its neutral position as a result of a forward movement of the right rudder pedal 256, it will be appreciated that the vacuum port 195 will engage the port 189 which in the neutral position engages the port 185 of the lower leaf 166. At the same time the atmosphere port 192 will engage the port 190 which in the neutral position engages the port 186. Consequently, an increased amount of vacuum will be applied to the line 278 which connects with the interior of the bellows 267 and simultaneously atmosphere will be applied through the line 280 to the bellows 275. The bellows 267 will therefore be contracted and the bellows 275 will expand. The resultant expansion of bellows 275 and contraction of bellows 267 will exert a force tending to oppose the forward movement of the right rudder pedal, simulating the effect of the slipstream of an actual plane upon its rudder. If the student's foot is removed from the right rudder pedal, the bellows 267 and 275 quickly returns both rudder pedals to their neutral trimmed positions.

On the other hand, it should be understood without a detailed explanation that when the three leaves of the valve are in the neutral position, a clockwise movement of the upper leaf 281 in response to a pressing forward of the left rudder pedal will apply increased vacuum to the bellows 275 and atmosphere to the bellows 267. Both of the bellows will resist the movement of the rudder pedals, simulating the slipstream effect, and upon releasing of the student's foot from the left rudder pedals, both pedals will be quickly returned to their neutral trimmed positions.

A capillary is placed in both of the lines 278 and 280 to prevent a sudden over-application of vacuum to the bellows 267 and 275.

It will be appreciated that whenever the rudder pedals 256 are displaced from their neutral positions, the fuselage 12 should rotate with respect to the stationary base 10—to the left when the left rudder pedal is forward and to the right when the right rudder pedal is forward. In Fig. 2 it will be seen that the fore end of link 310 is pivotally connected to the rudder bar 260 while the rear end of link 310 is pivotally connected to the lower end of the lever 312 which is pivotally mounted upon the horizontal stub shaft 314. To the upper end of lever 312 is pivotally connected the fore end of link 316, the rear end of which is pivotally attached to the outer end of arm 318 which is fixedly attached to the upper leaf 320 of the rudder valve designated generally by 322.

The rudder valve may be constructed as disclosed in my above mentioned application Serial Number 619,361 or in the manner of the prior art rudder valves. For the purposes of this application it is sufficient to know that this valve has a central stem 324 connected through vacuum line 326 to the vacuum source 283a as well as a pair of ports 328 connected to the turning motor 30 through vacuum lines 330. This valve also has atmosphere ports (not shown) in the side of the upper leaf 320. Upon a movement ahead of the right rudder pedal 256 through the members 259, 260, 310, 312, 316 and 318 the upper leaf 320 is rotated counterclockwise, admitting air and vacuum to the turning motor 30 which responds to rotate fuselage 12 to the right. On



the other hand, when the left rudder pedal 256 is pressed forward the upper leaf is rotated clockwise admitting air and vacuum to the turning motor 30 in a reverse manner, causing the motor to rotate the fuselage to the left.

With the apparatus thus far disclosed, when the rudder pedals are released they will be returned by bellows 267 and 275 to their neutral positions, the upper leaf 320 will also be returned to its neutral position, and the rotation of the fuselage will stop.

Under most flying conditions, most planes will not fly perfectly straight with the rudder pedals in the dead center position. If the plane is not equipped with rudder trimming means it is necessary for the pilot to hold the rudder pedals in the correct position in order to keep the plane flying a straight course. Different pressures will have to be applied under different circumstances. For example, on the take-off it may be necessary to apply a great deal of right rudder in order to keep the plane flying straight down the runway. In cruising, left rudder may be necessary. Changes in engine power and air speed also affect the turning of the plane. In order to render it unnecessary for the pilot to apply a given amount of rudder over a long period of time, in order to keep the plane flying the desired course, aircraft of the type being simulated generally are equipped with rudder trimming means whereby the plane may be trimmed in order to keep it flying the desired course without the pilot's constantly applying a corrective pressure to the rudder pedals.

In order that this invention may be better understood, simulated rudder trimming means are also disclosed herein. Referring to Fig. 2, the manual rotation of the rudder trim knob 290 causes a rotation of the shaft 292 upon the forward end of which is affixed the screw 293. A nut 294 coacts with screw 293 to travel longitudinally thereof upon a rotation of the screw, and stud 295 travels with the nut 294. A bracket 296 is affixed to the interior of the fuselage 12 and the lower end of arm 297 is pivotally mounted upon this bracket. A horizontal extension 298 is integral with arm 297 and pivotally connected to extension 298 is the upper end of the walking beam 299. Walking beam 299 is pivotally mounted on stud 295 as shown. Integral with the lower end of walking beam 299 is the horizontal extension 300, and pivotally mounted upon the right end of this extension is the arm 301. A pair of links 302 and 303 are pivotally attached to arm 301 as shown. Link 302 is connected to the simulated throttle lever 332 in the trainer through the arm 334, lever 336, compensating assembly 338, link 337 and arm 339. A pair of dash pots 339a are connected to lever 336 through their plungers 339b to operate with spring assembly 338 to delay movements of link 302 in response to movements of lever 332. The rear end of link 303 is connected to other apparatus in the trainer responsive to the factor of assumed air speed. For present purposes the links 302 and 303 may be considered stationary, thus providing a fixed pivot for the lower end of the walking beam 299.

Affixed to the arm 297 is the rear end of link 304, the forward end of which is affixed to the upper arm of bell crank 305. The left end of link 306 is pivotally attached to the lower arm of bell crank 305 and the right end of this link is pivotally attached to the center leaf 167 of the rudder control loading valve 279.

Whenever the student in the fuselage finds that he must apply a constant pressure to one of the rudder pedals in order to maintain the fuselage upon the desired heading, it seems clear that the upper leaf 281 of the valve 279 will be displaced from its neutral position and consequently that the bellows 267 and 275 will exert a constant force tending to return the rudder pedals to their neutral positions. The rudder valve 322 will be positioned so that the fuselage maintains the desired heading.

Instead of so positioning the rudder pedals by means of his feet, the student may by rotating the simulated rudder trim control 290 move the nut 294 in the desired direction. Movement of this nut results in a pivoting of the walking beam 299 about its lower end and the arm 297 is pivoted about its lower end. Link 304 moves in the correct direction, as does link 306, the center leaf 167 of the valve 279 rotates in the correct direction until it is centered with respect to the upper leaf 281. When this point is reached the pressures within the bellows 267 and 275 become quickly neutralized, relieving the pressure upon the rudder pedals, but neither of the bellows is returned to its neutral position. Consequently, the positions of the rudder pedals 256 are not changed and neither are the relative positions of the leaves of the rudder valve 322. Accordingly, the trainer maintains the desired heading.

Specifically, let us assume that the student in order to maintain the fuselage upon the correct heading finds that he must exert a constant pressure upon the left rudder pedal 256. The upper leaf 281 of the control valve 279 will be rotated clockwise a given distance from its neutral position while the upper leaf 320 of the rudder valve 322 will be rotated a given distance clockwise from its neutral position. Atmosphere will be admitted to the bellows 267 and vacuum to the bellows 275. The student will then rotate the simulated rudder trim control 290 counterclockwise as seen from above and the nut 294 moves toward the head of the fuselage. The middle leaf 167 of the valve 279 will be rotated clockwise and when this leaf is centered with respect to the upper leaf 281 the pressure within the two bellows 267 and 275 will become quickly neutralized. The position of the rudder pedals 256 and of the upper leaf 320 of the rudder valve 322 will be undisturbed with the releasing of the pressure caused by the bellows upon the rudder pedals.

If the student finds he must apply constant right pedal pressure to maintain the fuselage 12 on a constant heading, opposite rotation of the trim control 290 will render the pressure unnecessary.

Reference is now made to Figs. 2, 4 and 5 for a disclosure of the weathercocking control unit. In Fig. 2 it will be seen that a block 340 is shown mounted upon the link 310 and in Fig. 4 it will be seen that screw 342 holds block 340 upon link 310. A forwardly extending link 344 is provided, this link being pivotally held by the pin 346 which in turn is held by the upper integral extension 348 of block 340. Upon the forward end of link 344 is mounted the compensating assembly designated generally by 350, and referring to Fig. 6 it will be seen that this compensating assembly includes an inner sleeve 352 affixed upon link 344, and also the outer sleeve 354 which is free to slide with respect to the inner sleeve 352. A stop 356 is mounted upon the foremost end of link 344, and spring 358 is provided, this spring encircling the forward end of link 344 and positioned so that



one end bears against the stop 356 while its other end bears against the washer 359 placed upon link 344 between sleeve 354 and the rear end of spring 358. A second stop 360 is affixed upon the link 344 and a second spring 362 is provided, spring 362 also encircling link 344 and arranged so that its front end bears against the washer 361 adjacent the rear end of sleeve 354, while its rear end bears against stop 360. This compensating spring arrangement will be recognized by those skilled in the art as conventional in nature.

The floor of the fuselage 12 is designated 12*a*, and a base plate 364 is provided, this plate being affixed to the floor 12*a* by means of screws 366. Integral with plate 364 is the boss 268 and upon which rests the boss 370 integral with the movable motor carrier 372. Integral with the rear end of member 372 is a second boss 374 positioned vertically above boss 370, and a suitable pivot pin 376 having a head 376*a* engaging the upper surface of boss 374 passes through the two bosses integral with carrier 372 and into the boss 368 integral with the base member 364, in order that the carrier 372 may pivot with respect to the stationary base member 364 about a vertical axis through pin 376. However, a pair of stops 378 are integral with the base member 364 and limit the angular movement of carrier 372 by engagement with the stop 380 which depends from the lower side of carrier 372.

Integral with the carrier 372 is the raised extension 382. The block 384 is rotatably carried by the forward end of extension 382 by means of the pin 386. The exterior sleeve 354 of the compensating assembly 350 is connected to the rotatable block 384 by means of pin 386.

A vertical shaft 390 is rotatably mounted in the boss 392 which depends from the lower side of carrier 372, and the right end of arm 394 is freely mounted upon shaft 390, the right end of arm 394 resting upon the top of member 372. The left end of arm 394 is in the form of a fork 396 between the fingers of which is positioned the roller 398 held in place by pin 400 which in turn is held by the bracket 402 integral with the base member 364.

The hub 406 of gear 404 is fixed upon shaft 390 by means of pin 408. Referring now also to Fig. 7, it will be seen that the lower surface of gear 404 carries the insulating disc 410 which in turn carries the two contact segments 412 and 414. It will be noted in Fig. 7 that the contact segments 412 and 414 are separated at 416 and 418. Affixed upon the right end of arm 394 by means of pin 420 is the contact button arm 422 integral with which is the contact button 424 which always engages the lower surface of one or both of the contact segments 412 and 414 depending upon their relative rotational positions, as will be later more fully explained.

Integral with the movable motor carrier 372 are the two bosses 426 and 428 which respectively carry the insulating blocks 430 and 432 which are affixed thereto by means of screws 436. The insulating blocks 430 carry the brush 438 which is connected through conductor 440 to the terminal 442 of motor 444. Insulating blocks 432 carry the brush 446 which is connected through conductor 448 to the terminal 450 of motor 444. The brushes 438 and 446 are held in the same horizontal plane as the contact segments 412 and 414, brush 438 against the periphery of contact segment 414 and brush 446 against the periphery of contact segment 412. The motor 444 is supported upon the posts 451 which are held by the

motor base 452 which in turn is attached by screws 454 to the bosses 426 and 428 of the motor carrier 372. The output shaft of motor 444 drives the reduction gears 456 which in turn drive the pinion 458, the lower end of this pinion being rotatably mounted in the boss 459 integral with the upper surface of the movable motor carrier 372. Pinion 458 meshes with the gear 404 to drive the same, as well as the elements carried thereby.

The previously described motor and contact control assembly therefor may be arranged so that when the contact button 424 engages both of the contact segments 412 and 414 the motor 444 is de-energized; when the contact button 424 engages only the contact segment 412, motor 444 will be energized to rotate the gear 404, insulating disc 410 and contact segments clockwise as seen from above to again bring both of the contact segments into engagement with the contact button 424; and when any relative movement between the contact button and contact segments occurs so that the contact button engages only contact segment 414, motor 444 is energized to rotate the gear 404, insulating disc 410 and contact segments counterclockwise as seen from above until the contact button again engages both of the contact segments.

Referring now more particularly to Figs. 2 and 4, it will be seen that there is affixed upon the lower end of shaft 390 the arm 460, this arm being slotted at 462 and held upon shaft 390 by set screw 464. Upon the unpivoted end of arm 460 is pivotally mounted the forward end of link 466, the rear end of which is pivotally attached to the upper arm 468 of the bellcrank designated generally by 470. The right end of arm 468 is slotted at 472 and is held by means of set screw 474 upon the upper end of shaft 476 which is held by the base plate 364. Upon the lower end of shaft 476 is affixed the forward end of arm 478 by means of set screw 480. The right end of link 482 is pivotally attached to the rear end of arm 478, and the right end of this link is pivotally attached to the arm 434 integral with the upper leaf 486 of the weathercocking control valve designated generally by 488.

Reference is now made to Fig. 8 for a detailed disclosure of the construction of the weathercocking control valve. It will be seen that this valve comprises an upper rotatable section or leaf 486 and a lower section or leaf 490 which has two integral extensions 492 through which the screws 494 pass in order to affix the leaf to any suitable part 12*b* of the fuselage 12. The upper leaf has a central bore 496 which passes completely therethrough and in which the stem 498 having the radial ports 500 is placed. Stem 498 is connected through pneumatic line 502 to the vacuum source 283*a*. Two atmosphere ports 504 and 506 pass completely through the leaf 486, as shown. The port 508 in the bottom face of leaf 486 is in communication with the ports 500 by means of the channel 510 and port 510*a* in leaf 486.

A pair of ports 512 and 514 in the upper face of lower section 490 communicate with the couplings 515 and 517 carried by the lower section by means of the internal channels 516 and 518. Recesses 512*a* and 514*a* are also placed in the upper face of section 490, as shown. Coupling 515 is connected to one end of the pneumatic line 520, the other end of which, as seen in Fig. 9, is connected to coupling 522 which connects with the port 526 in the front face of the rear section or leaf 524 of the weathercocking shutoff valve designated generally by 528. The section 524 has two integral ears 530 through which the screws 531 pass in order to affix this section to the plate 532 which may be suitably affixed to the trainer fuselage 12. The coupling 517 in Fig. 8 is connected through pneumatic line 534 with the coupling 536 in Fig. 9 which communicates with the port 538 placed in the front surface of section 524. Port 540 is placed in the front face of section 524 beside port 526 and is in communication with coupling 542 which in turn connects through the pneumatic line 544 with the turning motor 30 in Fig. 1. At the same time, port 546 is placed in the face of section 524 and communicates with the coupling 548 which in turn is connected through pneumatic line 550 with the turning motor.

A central vertical post 552 is formed integrally with section 524, and this post is adapted to fit inside the bore 554 in the rotatable leaf or section 556 of the weathercocking shutoff valve. A collar 558 having set screws 560 may be employed to hold section 556 against the fixed section 524.

In the rear face of the movable section 556 are placed the channel 562 and the channel 564. When outer section 556 assumes the open position as shown in Fig. 9, channel 562 connects the ports 538 and 546 in section 524, and channel 564 connects the ports 526 and 540 in section 524. However, when section 556 is rotated counterclockwise into a different position, it will be appreciated that the flat rear face of this section will prevent communication between ports 538 and 546 on the one hand, and ports 526 and 540 on the other.

Integral with the section 556 is the extension 566 to which the lower end of link 568 is pivotally attached by means of pin 570. Pin 572 connects the upper end of link 568 with the lower end of the plunger 574 of the solenoid 576. Guide 578 may be affixed to the plate 532, and the solenoid housing 580 may similarly be affixed to member 532. An extension 582 carrying the pin 584 is provided integral with section 524, and a pair of pins 586 are mounted upon the rotatable section 556. It will be appreciated that this pin arrangement limits the rotation of section 556. A pin 588 is carried by member 532, and the upper end of spring 590 is attached to this pin, the lower end of this spring being attached to one of the stops 596, as shown. This spring arrangement rotates leaf 556 clockwise to the open position when the solenoid is de-energized, and the solenoid rotates the leaf counterclockwise to the closed position when the solenoid is energized.

Referring now back to Figs. 2 and 3, it will be seen that a bracket 591 is affixed upon the upper rotatable leaf 281 of the control valve 279, and that this bracket carries the micro-switch 592, the movable contact of which carries roller 594. Carried by the extension of the center leaf 167 is the pointed stud 596. The micro-switch may be connected through conductor 598 to a suitable source of power, and through the conductor 600 with the solenoid 576 shown in Fig. 9. When the center leaf 167 of valve 279 is in neutral position with respect to the upper leaf 281, the roller 594 engages the point of stud 596 and the micro-switch 592 is opened. Accordingly, solenoid 576 is de-energized, plunger 574 is in its down position, and section 556 is in its clockwise position. When section 556 is so positioned, channel 562 connects the ports 538 and 546, and channel 564 connects ports 526 and 540.

On the other hand, when the upper leaf 281 of the control valve 279 is moved out of neutral position with respect to the center leaf 167, the roller 594 moves out of engagement with the stud 596, micro-switch 592 is closed and solenoid 576 becomes energized. Plunger 574 and link 568 in Fig. 9 move upwardly, rotating section 556 counterclockwise, and shutting off port 538 from port 546 on the one hand, and port 526 from port 540 on the other.

Considering now the operation of the apparatus of this invention, when the rudder pedals 256 in Fig. 6 are in their neutral trimmed positions, leaf 281 of valve 279 will be centered with respect to leaf 167, and micro-switch 592 will be opened. Solenoid 576 in Fig. 9 will be de-energized and valve section 556 will be rotated in its clockwise position bringing ports 538 and 546 on the one hand and 526 and 540 on the other into communication. Assuming that the motor carrier 372 is in its neutral position with respect to base 364, as shown in Fig. 2, contact button 424 will engage both of the contact segments 412 and 414 as shown in Fig. 7, and motor 444 will be de-energized. Accordingly, arm 460, link 466, bellcrank 470 and link 482 will be in their neutral positions, as will the upper rotatable leaf 486 of the weathercocking control valve 488. Referring to Fig. 8, when the upper leaf 486 is in its neutral position, it will be appreciated that the port 504 will be offset from the port 512 and the port 506 will be offset from the port 514. Accordingly, atmosphere will not enter either of the two ports 512 or 514 in the lower section 490. Port 508 of the upper section 486 will lie between the two recesses 512*a* and 514*a* of the lower section 490, and a slight amount of vacuum will leak into each of these recesses, and by means of the pneumatic lines 520 and 534 will be applied to the ports 538 and 526 of section 524 of the weathercocking shutoff valve shown in Fig. 9. Accordingly, this slight leak of vacuum may be applied through the pneumatic lines 550 and 544 to the turning motor 30, but as is well understood by those skilled in the art, an equal application of vacuum to both sides of the turning motor will be of no consequence insofar as turning of the fuselage 12 is concerned.

Then, assuming that the student presses forward the right rudder pedal 256 to turn the fuselage 12 to the right, link 340 in Fig. 2 will be moved ahead, carrying block 340 and link 344 in the same direction. Spring 362 will be compressed and will move the sleeve 354 and stud 388, best seen in Figs. 4 and 5, ahead. By means of block 384 carried by the front end 382 of carrier 372, the entire carrier 372 will be rotated clockwise as seen from above, this rotation taking place about the axis of the vertical pin 376. Accordingly, the vertical shaft 390 is moved clockwise around pin 376, this shaft being kept from rotating by virtue of gear 404 affixed thereupon and which meshes with the pinion 458. Also the right end of arm 394 moves clockwise about the axis of pin 376, the entire arm sliding somewhat to the right. The entire arm 460 will be carried toward the head of fuselage 12, as will link 466. The movement of link 466 is transferred by means of bellcrank 470 to the link 482, and link 482 will move to the left, resulting in a counterclockwise rotation of the upper leaf 486 of the weathercocking control valve 488.

Referring to Fig. 8, it will be appreciated that the counterclockwise rotation of section 486 of the weathercocking control valve will bring the



atmosphere port 504 into engagement with port 512 in the lower leaf 490, and at the same time vacuum port 508 will be brought into engagement with the port 514 in section 490. Accordingly, atmosphere will be applied to the pneumatic line 520 and vacuum to the pneumatic line 534, and referring to Fig. 9, it will be appreciated that atmosphere will be applied to the port 526 in section 524 of the weathercocking shutoff valve 528, while vacuum will be applied to the port 538 in the same section.

However, inasmuch as when the right rudder pedal 256 was moved forward the link 282 in Fig. 2 moves to the rear, rotating the upper section 281 of control valve 279 counterclockwise, it will be appreciated that the roller 594 will move out of engagement with stud 596, resulting in a closing of the micro-switch 592. Accordingly, solenoid 576 in Fig. 9 is energized moving plunger 574 and link 568 upwardly, and rotating valve section 556 counterclockwise into the closed position so that the channels 562 and 564 do not connect the ports 538 and 546 and 526 and 540 respectively. Inasmuch as valve section 556 is placed in the closed position, it will be appreciated that the application of vacuum to the port 538 and of atmosphere to the port 526 will not affect the turning motor 30. Accordingly, the only response of the turning motor 30 to the pressing forward of the right rudder pedal 256 is the conventional response which occurs as a result of the rotation of the upper leaf 320 of the main rudder valve 322 in Fig. 2. Accordingly, the trainer turns to the right as though the apparatus of this invention were not included in the trainer.

Referring now to Figs. 4 and 7, it will be appreciated that when the link 344 moves ahead in response to the pressing forward of the right rudder pedal, and the carrier 372 is rotated clockwise about the pin 376, and the right end of arm 394 is moved in the same direction, as seen from above, the contact button 424 will be moved out of engagement with the contact segment 412, but will remain in engagement with the contact segment 414 because of the relative clockwise rotation of the contact segments with respect to the contact button 424. Accordingly, motor 444 will be energized to rotate the gear 404 counterclockwise as seen from above, and this energization of motor 444 will continue until the gear 404 and contact segments 412 and 414 have been rotated back into the position at which button 424 again engages both of them. At this instant motor 444 will stop. While motor 444 is rotating gear 404 counterclockwise as seen from above, it will be appreciated that the shaft 390 upon which gear 404 is affixed will be rotated in the same direction, and the outer end of arm 460 will be moved toward the rear of the trainer—in the opposite direction in which it was moved initially in response to the pressing forward of the right rudder pedal. The rearward movement of the outer end of arm 460 results in a similar movement of link 466, and by means of bellcrank 470 the link 482 is moved towards the right. Accordingly, the upper leaf 486 of the weathercocking control valve is rotated clockwise—the opposite direction in which it was rotated in response to the initial rudder pedal movement. At the instant the contact button engages both of the contact segments 412 and 414, thereby de-energizing motor 444, the upper leaf 486 of the weathercocking control valve 488 is re-centered, and an equal leak of vacuum will

be applied to the two pneumatic lines 520 and 534.

Accordingly, if the student merely presses forward the right rudder pedal and retains the rudder pedal in the forward position, the apparatus of this invention does not in any manner affect the rotation of the fuselage 12.

It should be particularly noted that the operation of motor 444 does not return the motor carrier 372 and the shaft 390 to their neutral positions—the motor carrier and shaft 390 are still positioned clockwise of their neutral positions.

Assuming now that the student too rapidly releases the pressure applied to the right rudder pedal 256 in order to bring the fuselage 12 out of the turn, as previously explained the bellows 267 and 275 will quickly return the rudder pedals 256 to their neutral trimmed positions. Accordingly, link 310 will move quickly to the rear, carrying block 340 and link 344 therewith. The compensator assembly 354 will through its previously described attachment to the motor carrier assembly 372 quickly return the motor carrier assembly to its neutral position, as shown in Fig. 2. Accordingly, shaft 390 will be quickly moved counterclockwise about the pin 376, and link 466 will be moved to the rear. By means of bellcrank 470 the link 482 will be moved to the right and the upper leaf 486 of the weathercocking control valve 488 will be rotated clockwise from its previously placed neutral position.

Referring to Fig. 3, the clockwise rotation of the upper leaf 486 will bring the atmosphere port 506 into engagement with port 514 and will bring the vacuum port 508 into engagement with port 512. Vacuum will be applied through the pneumatic line 528 and atmosphere through the pneumatic line 534 to the ports 526 and 538, respectively, in the fixed section 524 of the weathercocking shutoff valve 528. Inasmuch as when the rudder pedals 256 were released by the student the upper section 231 of the valve 279 assumes its neutral position, the roller 594 will engage stud 595 and the micro-switch 592 will be opened. Accordingly, solenoid 576 will be de-energized resulting in a clockwise movement of the rotatable section 556 of the weathercocking shutoff valve, under the tension of spring 590, and channel 562 will connect ports 538 and 546 while channel 564 will connect ports 526 and 540. Accordingly, the atmospheric pressure in line 534 will be applied to the port 546 and through the pneumatic connection 550 to the turning motor 30, while the reduced pressure in port 526 will be applied to the port 540 and thence along pneumatic connection 544 to the turning motor. The application of atmosphere to the turning motor through line 550 and the application of vacuum to the turning motor through line 544 will result in an operation of the turning motor 30 to turn the fuselage 12 toward the left.

In the absence of any intervening limiting arrangement, the fuselage would continue to turn to the left indefinitely. However, as soon as the pressure upon the right rudder pedal is released, and setting the just described apparatus into operation to cause a rotation of the fuselage to the left, the counterclockwise rotation of the motor carrier 372 in response to the releasing of the pressure upon the right rudder pedal results in a counterclockwise rotation of the contact segments 412 and 414 relative to the button contact 424. Accordingly, segment 414 moves out of engagement with the contact button 424,



but segment 412 remains in engagement with this button. Consequently, motor 444 is energized to rotate the gear 404 and the contact segments carried thereby clockwise as seen from above. This rotation of motor 444 will continue until the gear 404 and contact segments 412 and 414 have been moved so that both of the contact segments again engage the contact button 424. At this instant motor 444 stops.

While motor 444 is so energized, it will be appreciated that the shaft 390 is being rotated clockwise as seen from above, resulting in a movement clockwise of the outer end of arm 460, and in a forward movement of the link 466. By means of the bellcrank 470, the link 482 is moved toward the left, and the upper leaf 486 of the weathercocking control valve is rotated counterclockwise. At the instant the motor 444 is de-energized, the upper leaf 486 will be rotated back to its neutral position with respect to the bottom leaf 490. Accordingly, the application of atmosphere to the pneumatic line 534 is stopped as is the application of excess vacuum to the line 520. Consequently, the gradual returning of the upper section 486 to its neutral position gradually lessens the rate of turning of the fuselage 12 to the left, until, when motor 444 is de-energized and upper valve section 486 is returned to its neutral position, the turning of fuselage 12 to the left stops.

If on the other hand, instead of quickly releasing the pressure upon the right rudder pedal, the student in fuselage 12 gradually reduces the pressure thereupon, as is done when correctly taking a plane in actual flight out of a turn to the right, it will be appreciated that no sudden returning of the rudder bar 260, link 310, block 340 and link 344 to their neutral positions will occur, and accordingly, the motor carrier 374 will be gradually returned to its neutral position. Such being the case, the gradual counterclockwise rotation of motor carrier 372 toward its neutral position will slowly rotate the contact segments 412 and 414 counterclockwise about the pin 376, and contact segment 414 will become disengaged from contact button 424, resulting in an energization of motor 444 in such a direction as to rotate the gear 404 and contact segments 412 and 414 clockwise as seen from above. The gradual counterclockwise rotation of motor carrier 372 in response to the releasing of the pressure upon the right rudder pedal will gradually rotate the shaft 390 counterclockwise as seen from above about the pivot 376, and will tend to gradually move the arm 460 to the rear. However, this gradual movement of arm 460 to the rear will be offset by the clockwise rotation of gear 404 by motor 444, and the net motion imparted to the link 466 will be zero. Accordingly, link 482 will not move, and the upper leaf 486 of the weathercocking valve will not be displaced from its neutral position. Accordingly, no rotation of the trainer to the left, in simulation of the weathercocking effect in a real plane, will occur as long as the student in the trainer gradually releases the pressure upon the right rudder pedal.

It is believed unnecessary to explain in complete detail the operation of the apparatus of this invention when the left rudder pedal 256 is pressed forward by the student to turn the fuselage 12 to the left, and then either quickly releases the pressure upon the left rudder pedal, or gradually releases the pressure thereupon. However, an outline of the functioning of the apparatus under such conditions will be given.

When the student presses forward the left rudder pedal 256, the following operations take place:

1. The upper leaf 320 of the rudder valve 322 is rotated clockwise to produce a turning of fuselage 12 to the left.

2. The micro-switch 592 is closed, solenoid 576 is energized, and the weathercocking shutoff valve 528 is closed.

3. Link 310 moves to the rear carrying link 344 therewith, and rotating the motor carrier 372 and shaft 390 counterclockwise about the axis of pin 376, resulting in a movement to the rear of arm 460 and link 466, and through the action of bellcrank 470 a movement to the right of link 482 and a clockwise rotation of the upper leaf 486 of the weathercocking valve 488. Atmosphere is applied to pneumatic line 534 and vacuum to line 520, but inasmuch as the weathercocking shutoff valve 528 is closed, no auxiliary turning effect occurs.

4. The angular movement between the contact segments 412 and 414 with respect to contact button 424 energizes motor 444 to turn the gear 404 and contact segments clockwise as seen from above, resulting in a similar rotation of shaft 390 and a return movement of link 466 to its neutral position, thereby returning the upper leaf 486 of the weathercocking control valve 488 to its neutral position, and equalizing the pressure within the pneumatic lines 520 and 534 which go to the weathercocking shutoff valve 528. However, it should be noted that the motor carrier 372 and shaft 390 continue to be displaced counterclockwise of their neutral positions.

5. Assuming that after an elapse of a predetermined length of time, during which the fuselage 12 continues to rotate to the left, the student takes the fuselage out of the turn to the left by quickly releasing the left rudder pedal, the rudder pedals will be quickly returned to their neutral positions, and the motor carrier 372 and shaft 390 will be rotated clockwise so that the motor carrier and the axis of shaft 390 assume their neutral positions as seen in Fig. 2. Accordingly, arm 460 will move ahead and through the interconnecting linkage system the upper leaf 486 of the weathercocking control valve 488 will be rotated counterclockwise of its neutral position, applying atmosphere to line 534 and vacuum to line 520.

6. The micro-switch 592 will be opened, deenergizing solenoid 576, and the upper leaf 556 of the weathercocking shutoff valve will be rotated counterclockwise by spring 590 into the open position.

7. Atmosphere will be applied to the pneumatic line 550 and vacuum to the pneumatic line 544, and the turning motor 30 will respond to rotate the fuselage 12 toward the right.

8. The returning of motor carrier 372 to its neutral position will result in an angular movement between the contact segments 412 and 414 with respect to contact button 424, and motor 444 will be energized to rotate gear 404, the contact segments and shaft 390 counterclockwise as seen from above, shaft 390 will be rotated in the same direction and through the interconnecting linkages the upper leaf 486 of the weathercocking control valve will be gradually returned to its neutral position, gradually neutralizing the pressure within lines 520 and 534, and gradually reducing the rate of turning of fuselage 12 to the right. Motor 444 will continue to be energized until the entire apparatus is returned to its neutral position, whereupon the turning of fuselage 12 toward the right will cease.



If instead of quickly releasing the left rudder pedal, the student gradually releases the same, the micro-switch 590 will not be opened until the rudder pedals are returned to their neutral trimmed positions, at which time the motor 444, energized by the gradual return of carrier 372 to its neutral position, will have returned the upper leaf 486 of the weathercocking control valve to its neutral position, and consequently no auxiliary turning of the fuselage 12 to the right will occur.

It is believed unnecessary to further explain the operation of the apparatus of this invention when the student applies coordinated aileron and rudder to cause the fuselage to start to turn in a given direction, then slowly neutralizes the rudder (or even applies a slight amount of opposite rudder) to maintain the proper rate of turn, and then to bring the fuselage out of the turn, slowly applies opposite rudder or additional opposite rudder, as the case may be, and finally, slowly centers the rudder pedals. The previous explanation of the operation of the apparatus should suffice, because such a series of manipulations is merely combined right and left rudder movements, both of which have been explained.

In view of the above disclosure, it will be appreciated that the apparatus of this invention functions in a manner to reproduce the weathercocking effect of a plane in actual flight when the trainer is flown in a manner corresponding to the flying of a real plane which would produce a weathercocking effect. When the controls in the fuselage are properly manipulated in executing a turn of the fuselage, the rudder pedals 256 will only be displaced by a limited amount, and they will always be slowly displaced and slowly returned to their neutral positions. Accordingly, the apparatus of this invention will not produce any weathercocking effect. However, whenever a large amount of rudder is employed in executing a turn in the trainer, if the rudder is not very gradually released a weathercocking effect will occur, just as in the case of a plane in actual flight.

It will be appreciated that many changes may be made in the disclosed embodiment of my invention, and accordingly, the disclosed embodiment should be considered as illustrative rather than limiting in nature. The following claims are intended to include all such changes.

I claim:

1. In a grounded aviation trainer of the type including a fuselage rotatably mounted upon a stationary base, the combination of a motor arranged to rotate the fuselage, rudder pedal means in the fuselage, a first means interconnecting the rudder pedal means and the motor for actuating the motor to turn the fuselage in a predetermined direction in response to the application of pressure to the rudder pedal means, and additional means interconnecting said rudder pedal means and said motor and operable upon a relatively rapid releasing of the pressure upon the rudder pedal means to actuate the motor to cause the fuselage to turn in the opposite direction for a predetermined length of time, said additional means comprising a control operated by a releasing of the pressure upon the rudder pedal means for regulating the actuation of the motor, and follow-up means operated by a releasing of the pressure upon the

rudder pedal means for regulating the control.

2. In a grounded aviation trainer of the type including a fuselage rotatably mounted upon a stationary base, the combination of a motor arranged to rotate the fuselage, rudder pedal means in the fuselage, a first means interconnecting the rudder pedal means and the motor for actuating the motor to turn the fuselage in a predetermined direction in response to the application of pressure to the rudder pedal means, and additional means interconnecting said rudder pedal means and said motor and operable upon a relatively rapid releasing of the pressure upon the rudder pedal means to actuate the motor to cause the fuselage to turn in the opposite direction at a gradually reducing rate and for a predetermined length of time, said additional means comprising a control operated by a releasing of the pressure upon the rudder pedal means for regulating the actuation of the motor, and follow-up means operated by a releasing of the pressure upon the rudder pedal means for regulating the control.

3. In a grounded aviation trainer of the type including a fuselage rotatably mounted upon a stationary base, the combination of a motor arranged to rotate the fuselage, rudder pedal means in the fuselage, means for automatically returning said rudder pedal means to a predetermined neutral position upon the releasing of a manually applied pressure thereto, a first means interconnecting the rudder pedal means and the motor for actuating the motor to turn the fuselage in a predetermined direction in response to the application of pressure to the rudder pedal means, and additional means interconnecting said rudder pedal means and said motor and operable in response to the operation of said rudder pedal returning means as a result of a relatively rapid releasing of the manual pressure upon the rudder pedal means for actuating said motor to cause the fuselage to turn in the opposite direction for a predetermined length of time, said additional means comprising a control operated by the returning of the rudder pedal means to the neutral position for regulating the actuation of the motor, and follow-up means operated by the returning of the rudder pedal means to the neutral position for regulating the control.

4. In a grounded aviation trainer of the type including a fuselage rotatably mounted upon a stationary base, the combination of a pneumatically operated motor arranged to rotate the fuselage, rudder pedal means in the fuselage, means interconnecting the rudder pedal means and the motor for actuating the motor to turn the fuselage in a predetermined direction in response to a displacement of the rudder pedal means from the neutral position, and means operable upon a relatively rapid recentering of the rudder pedal means to cause the fuselage to turn in the opposite direction for a predetermined length of time, said last means comprising a valve connected to said pneumatically operated motor, a follow-up motor connected to the valve, control means for the follow-up motor, a connection from the rudder pedal means differentially combined with the connection between the follow-up motor and the valve for actuating the valve upon recentering of the rudder pedal means, and a connection between the rudder pedal means and follow-up motor control means for actuating the follow-up motor upon a recentering of the rudder pedal means.

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