Oct. 15, 1946. T. C. BARBER 2,409,238

AIRPLANE FLIGHT TRAINER

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Fig. 1

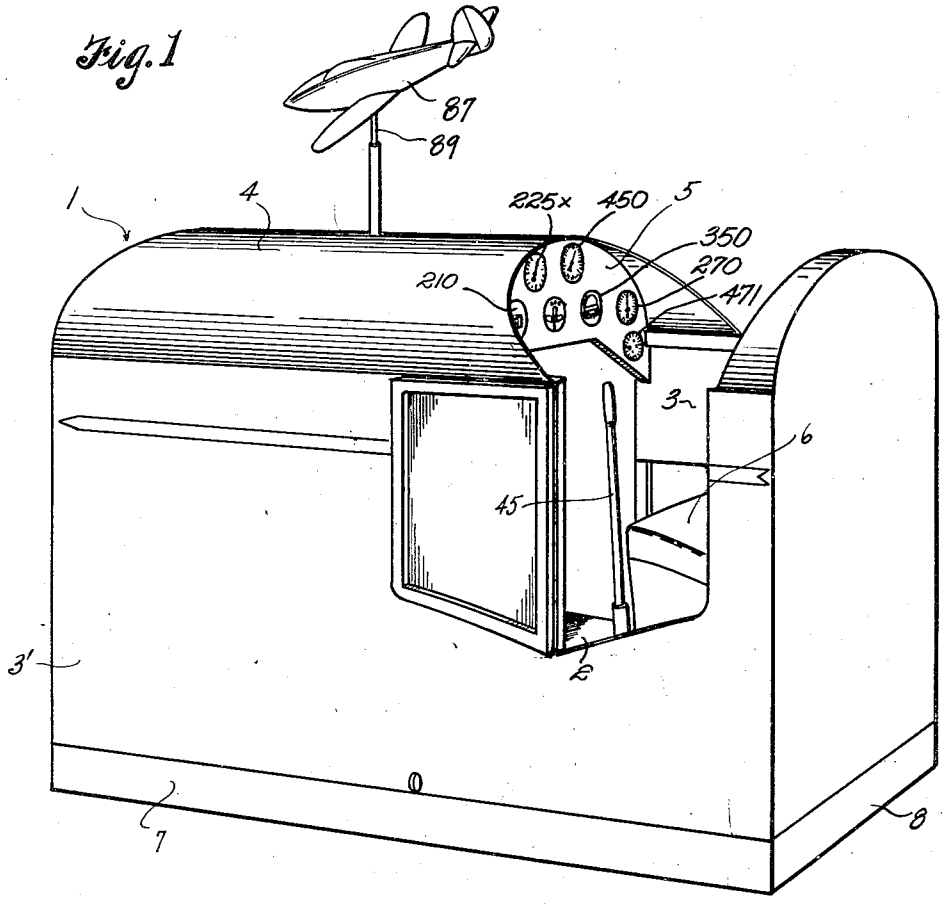
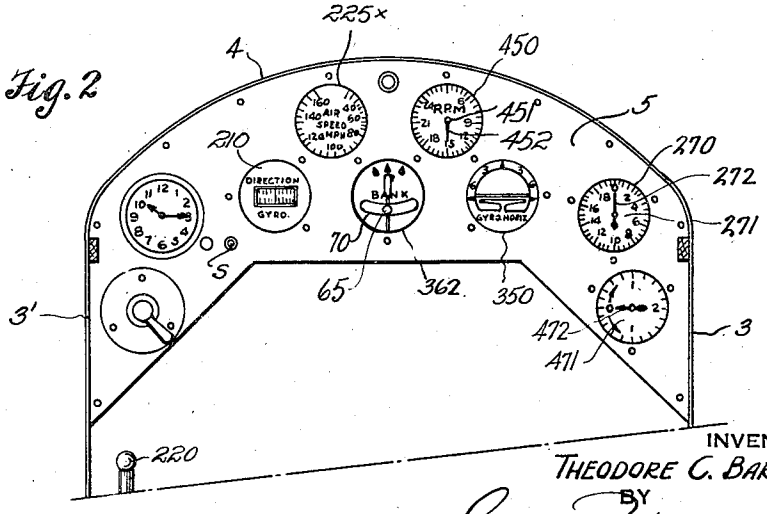


Fig. 2



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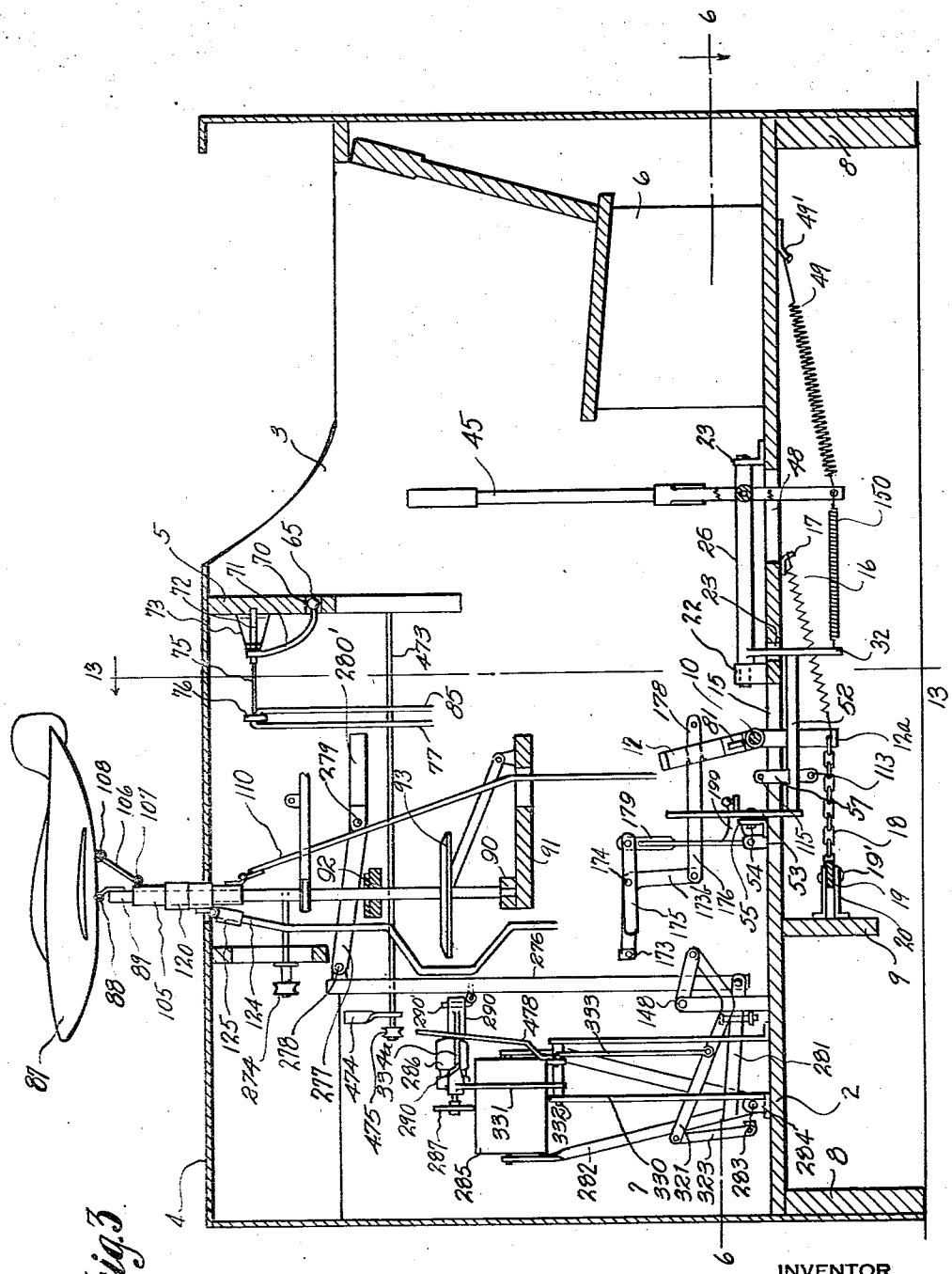


Fig. 3

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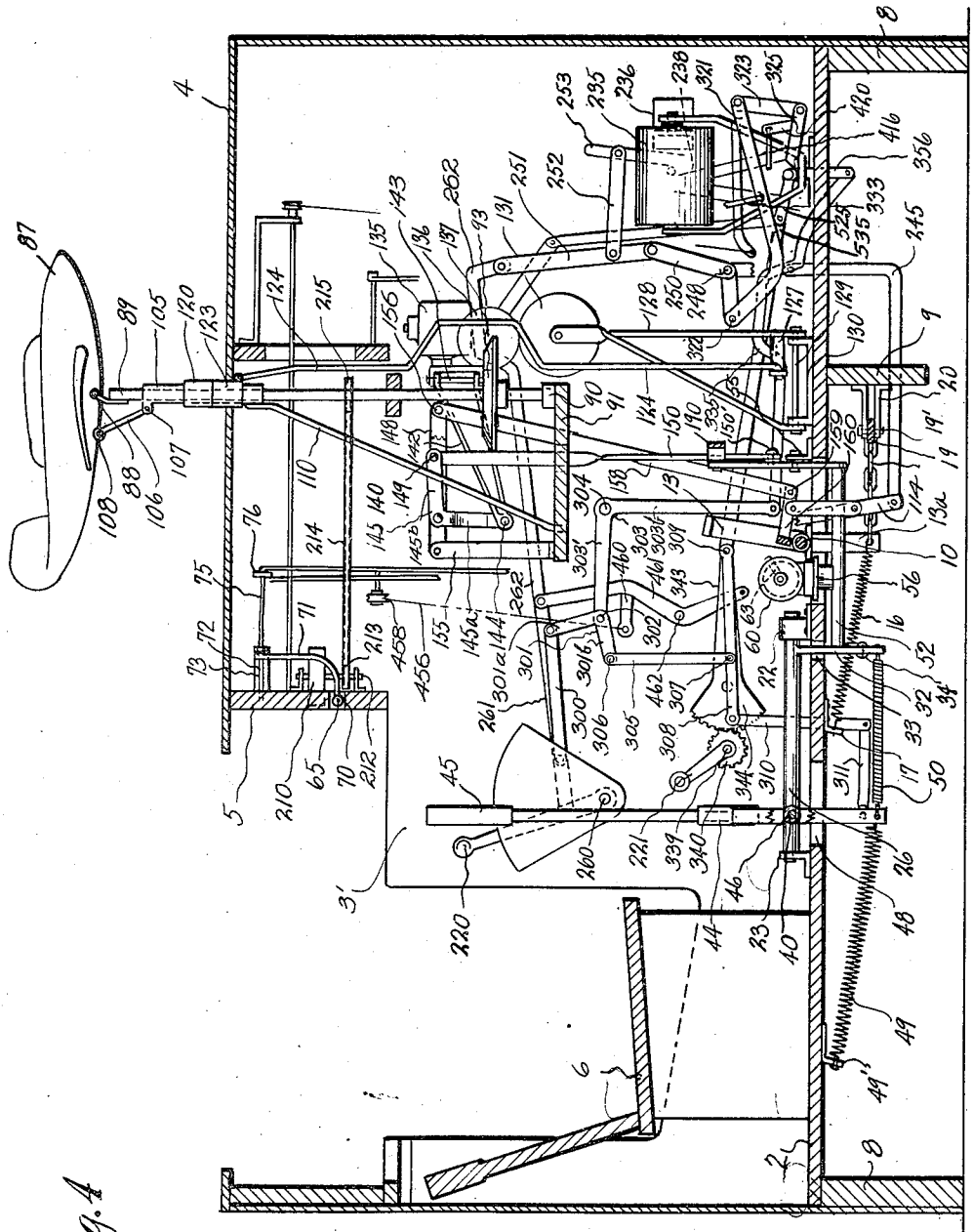


Fig. 4

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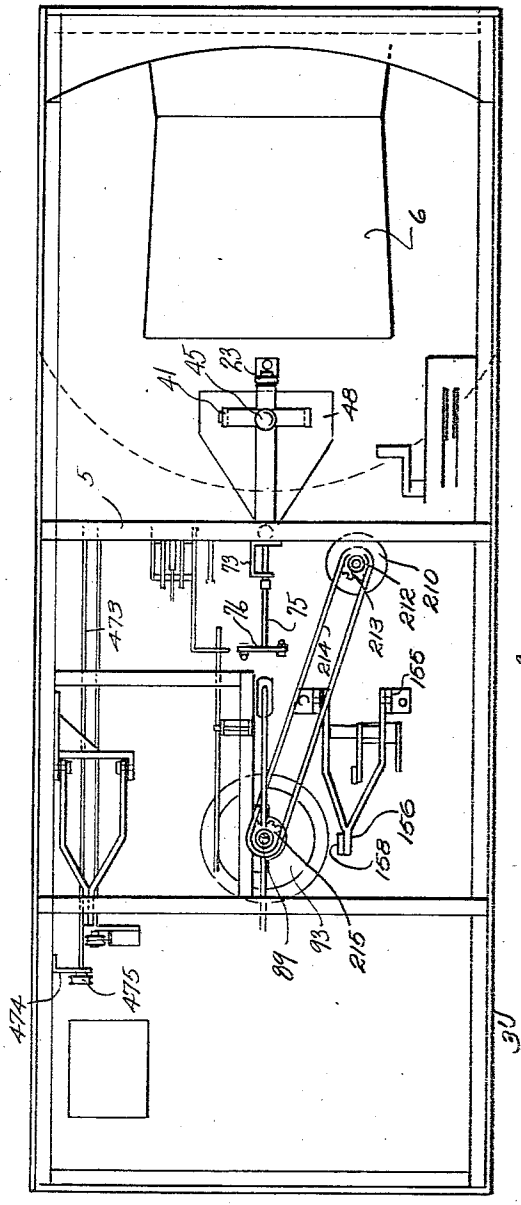


Fig. 5

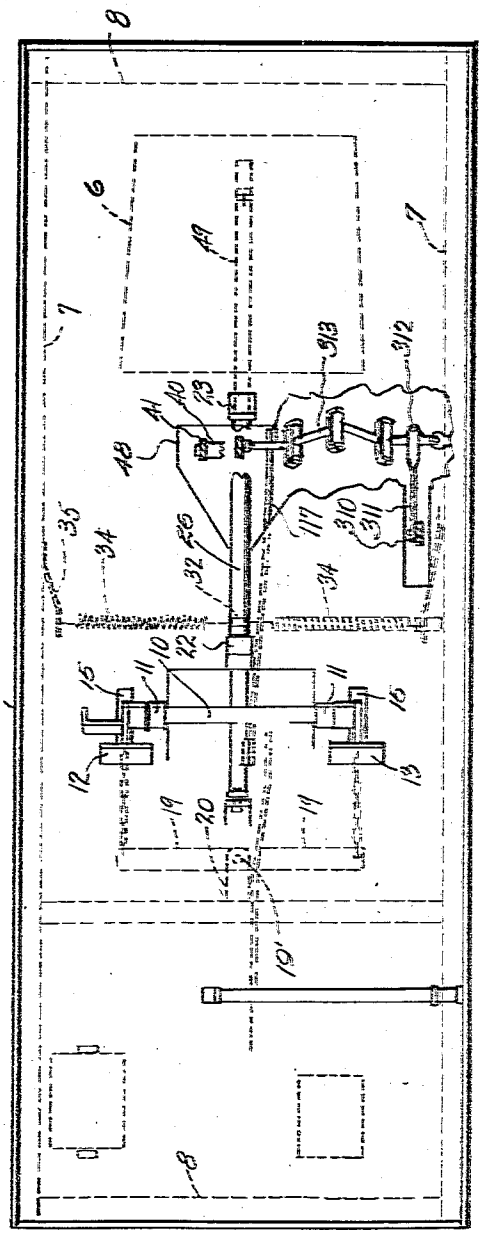


Fig. 6

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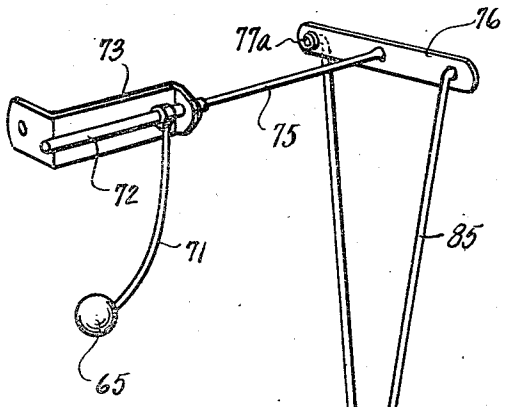


Fig. 7

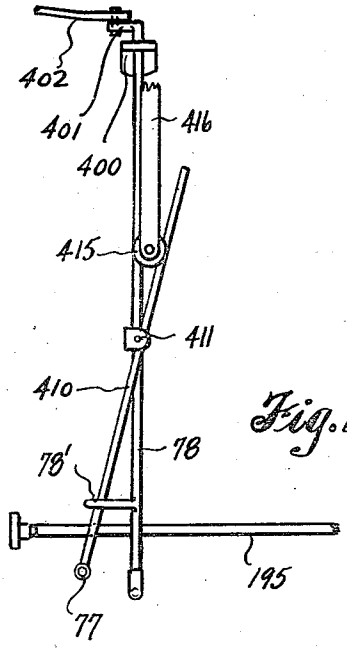
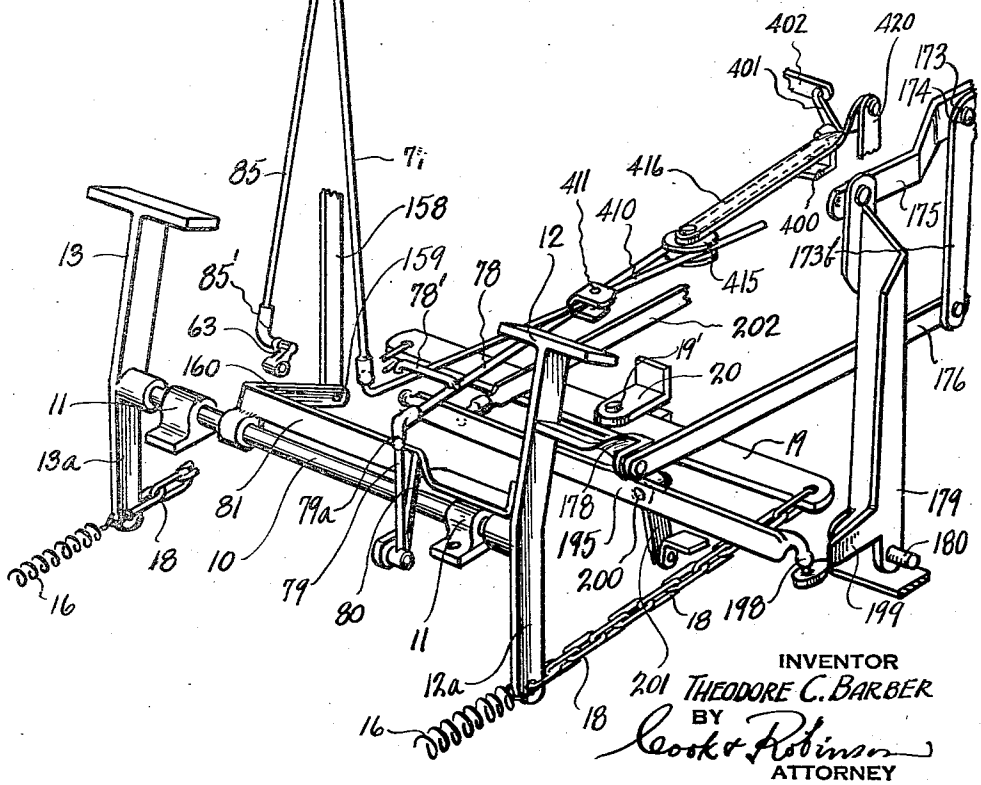


Fig. 7a

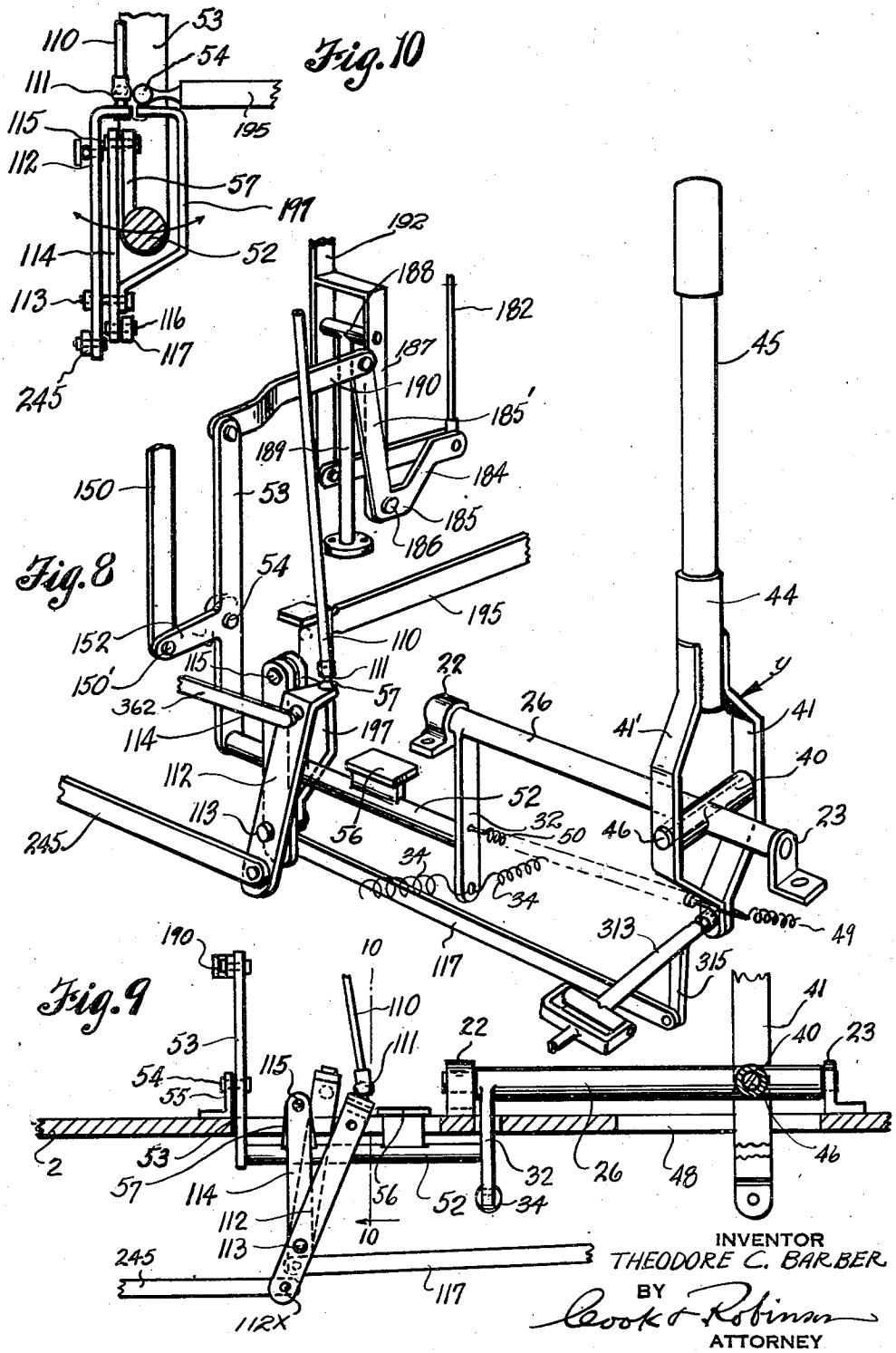


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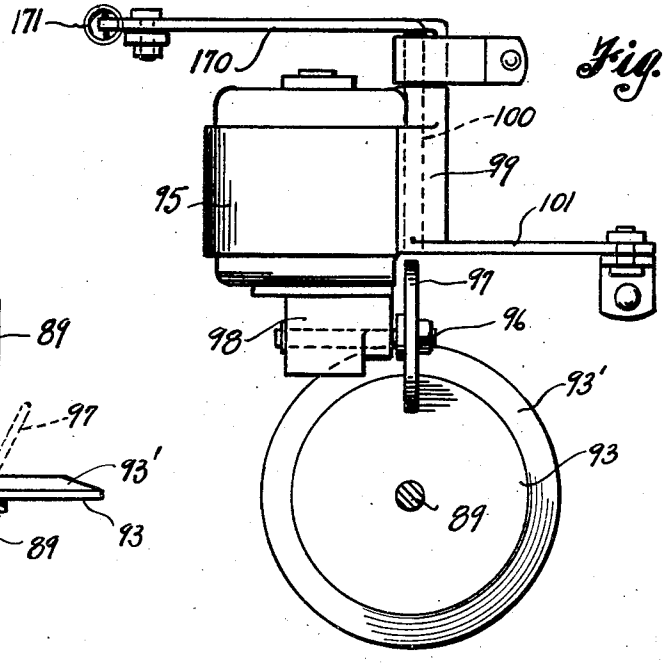


Fig. 11

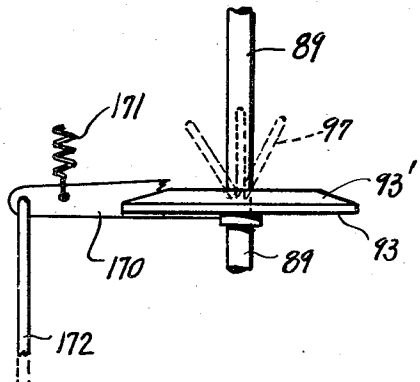


Fig. 12

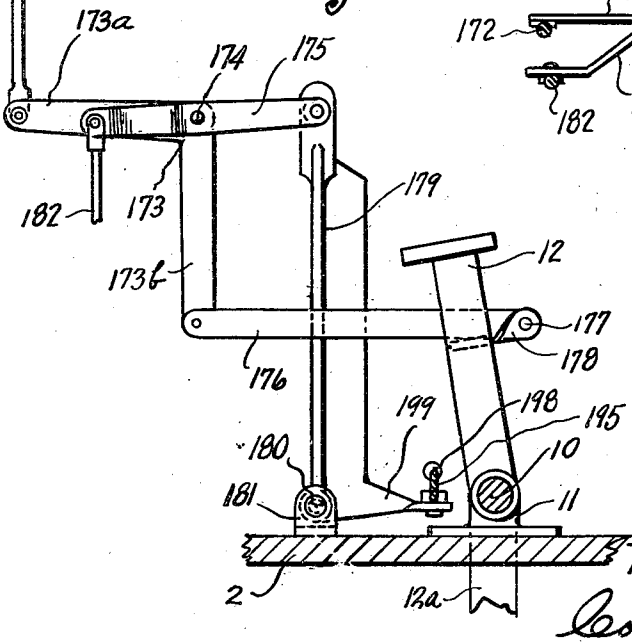
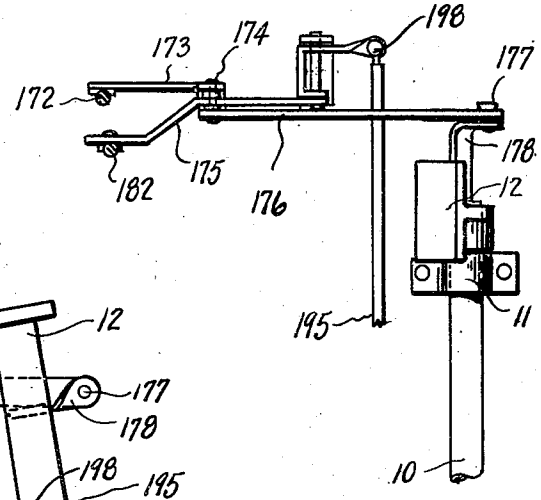


Fig. 12a



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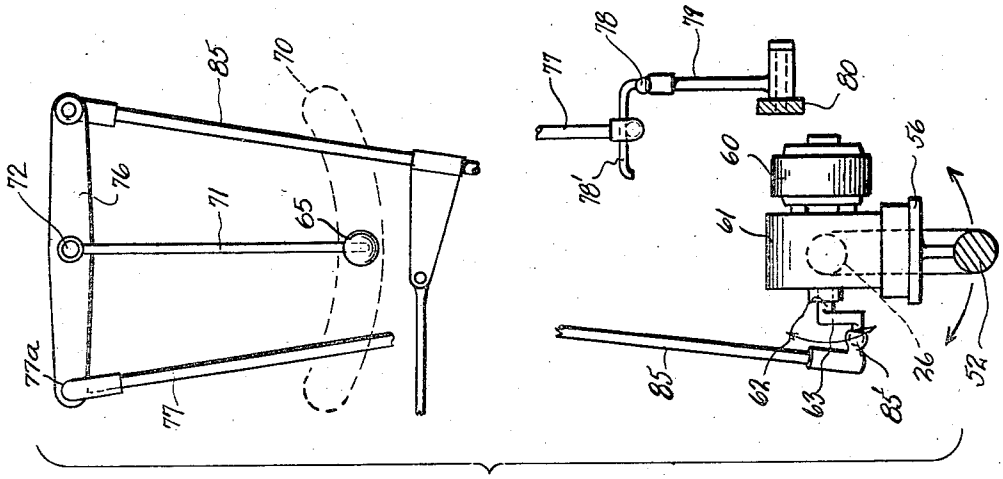


Fig. 14

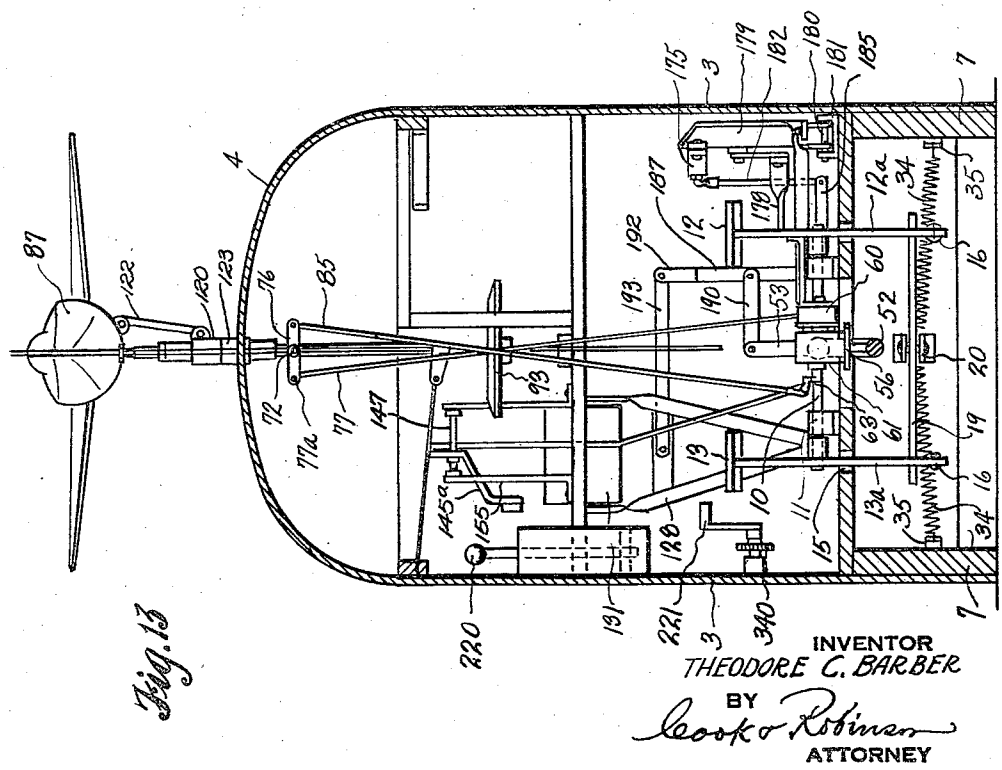


Fig. 13

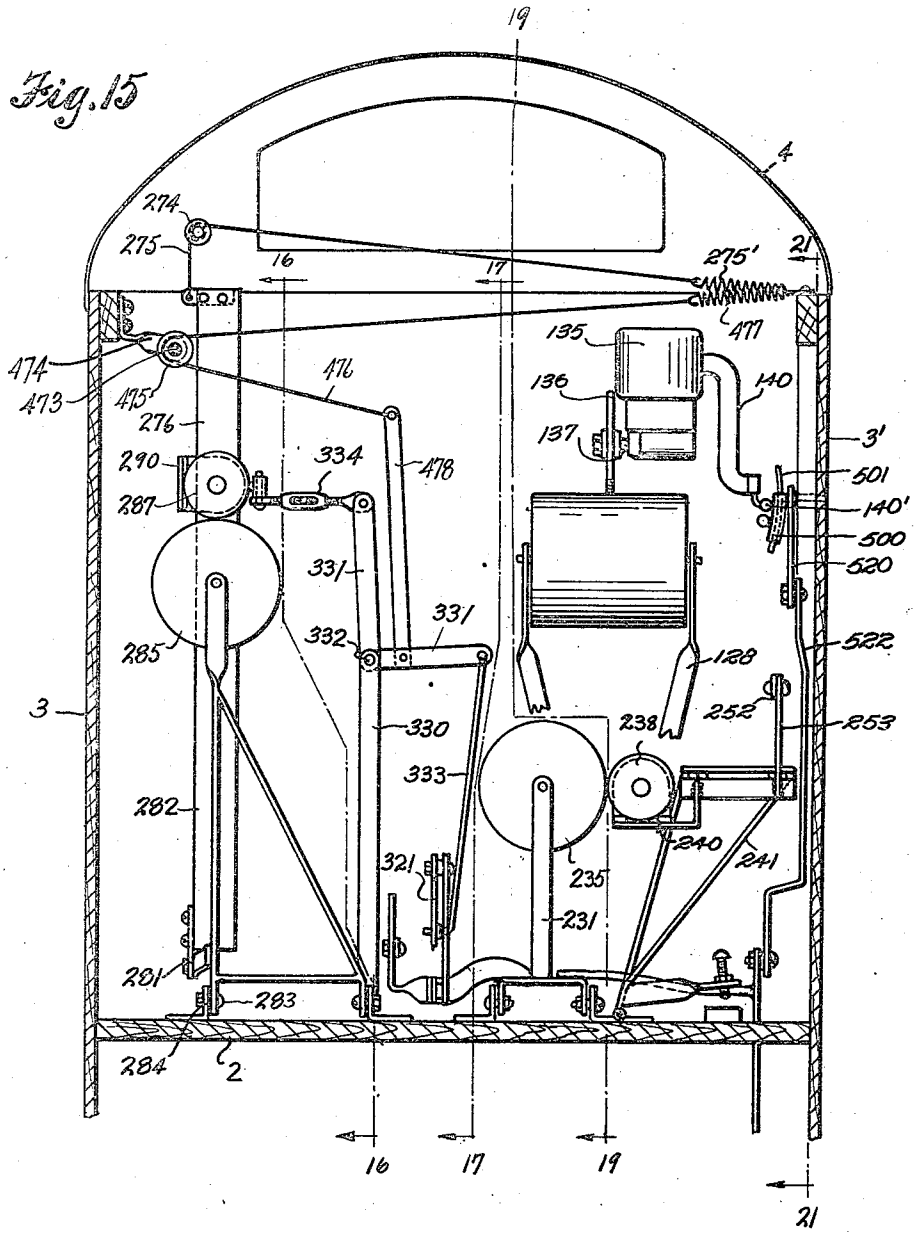
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Fig. 15



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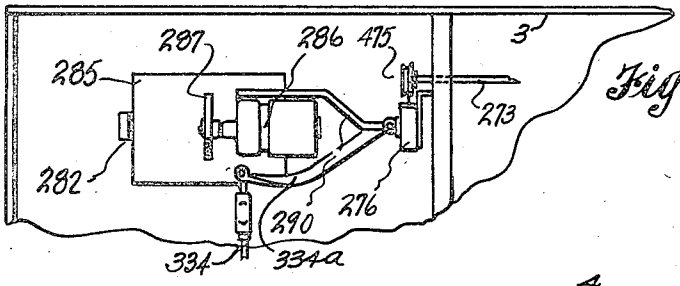


Fig. 18

Fig. 17

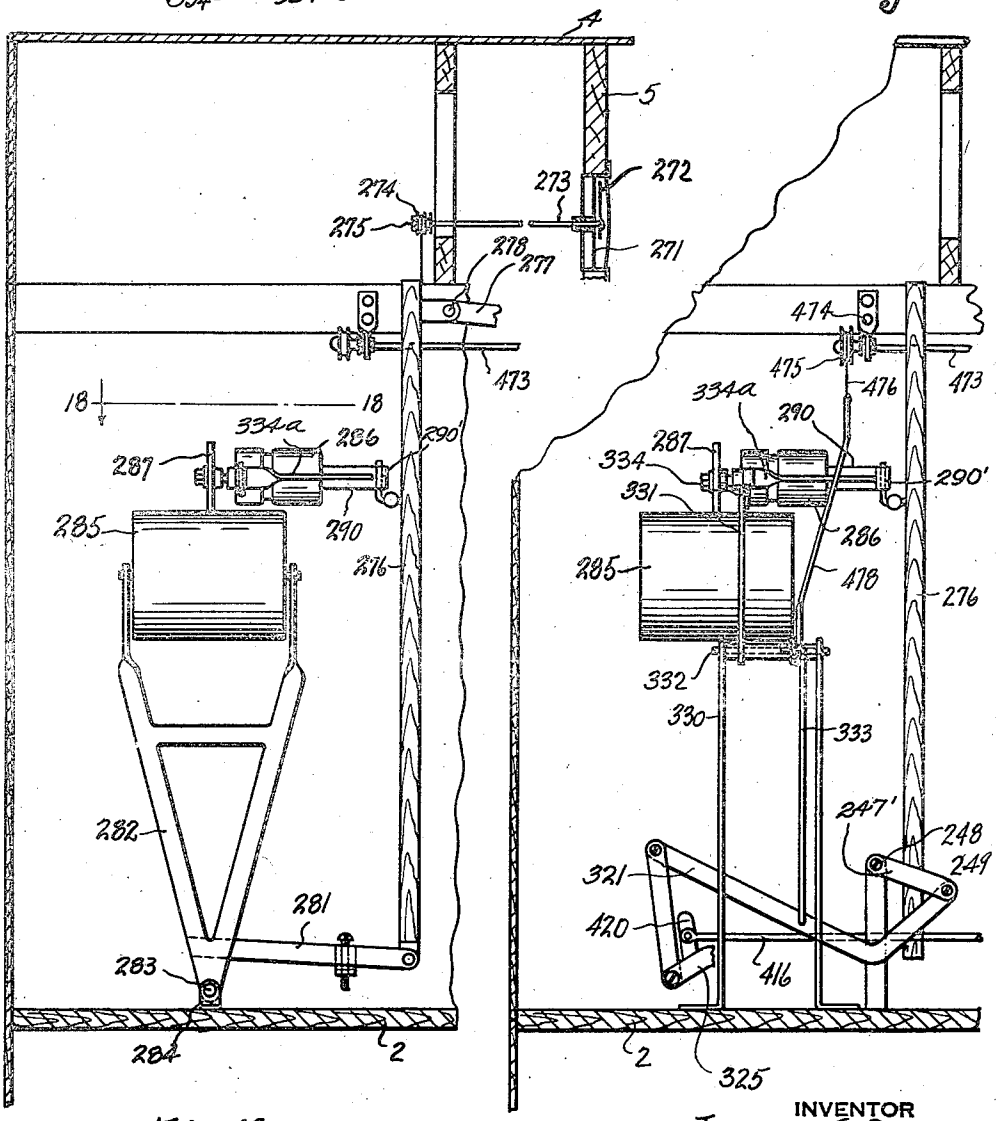


Fig. 16

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Fig. 19

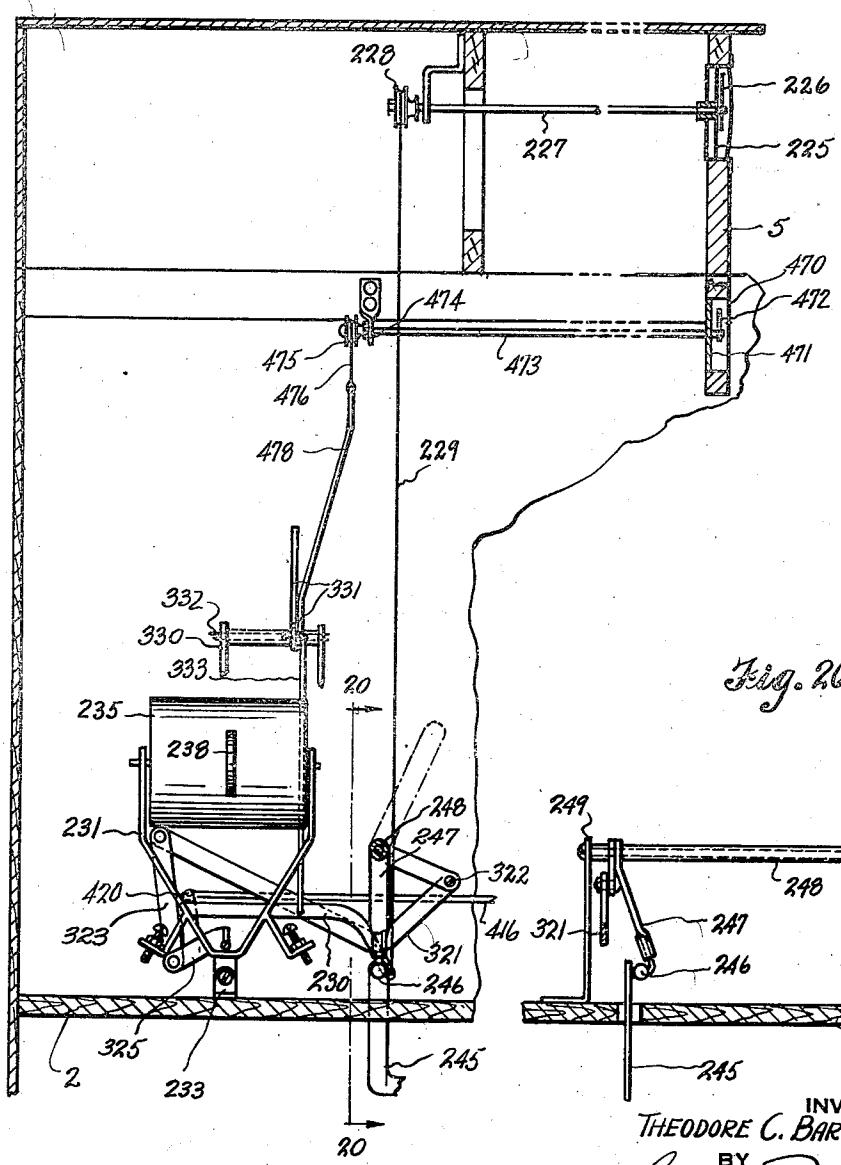


Fig. 20

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Fig. 22.

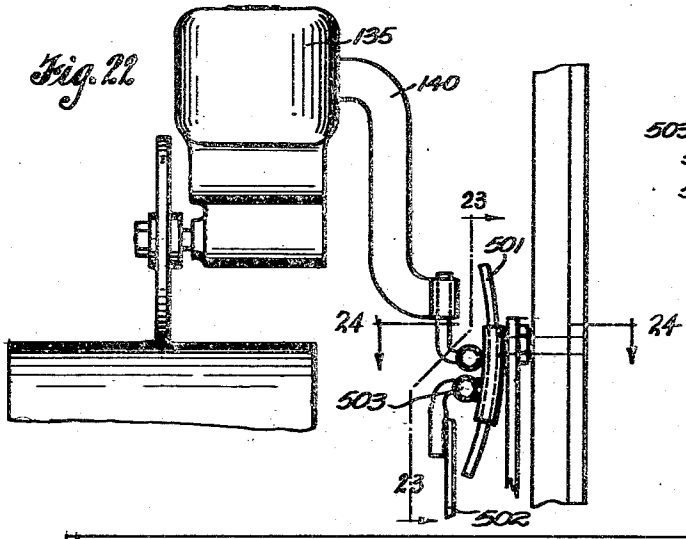


Fig. 24.

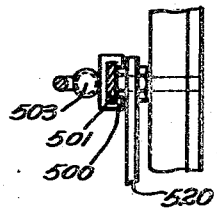
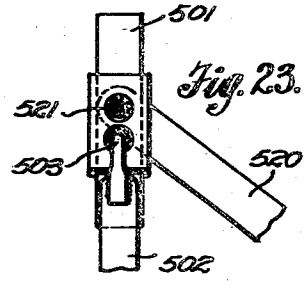


Fig. 23.



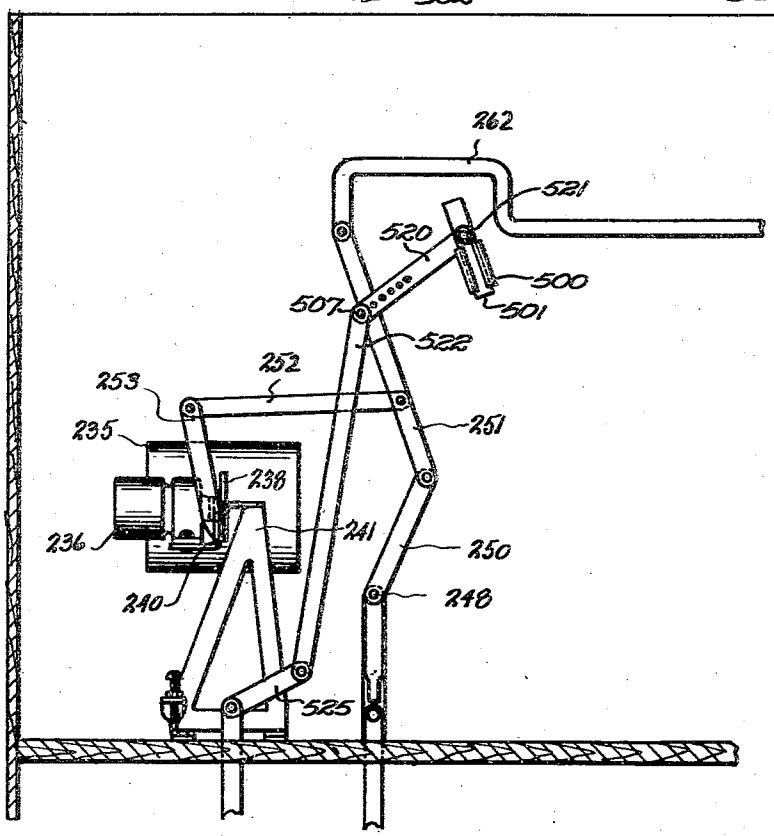


Fig. 21

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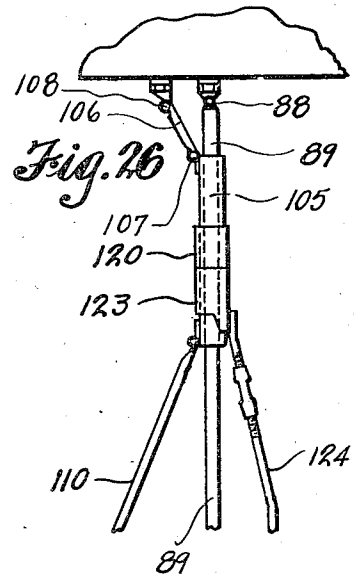


Fig. 26

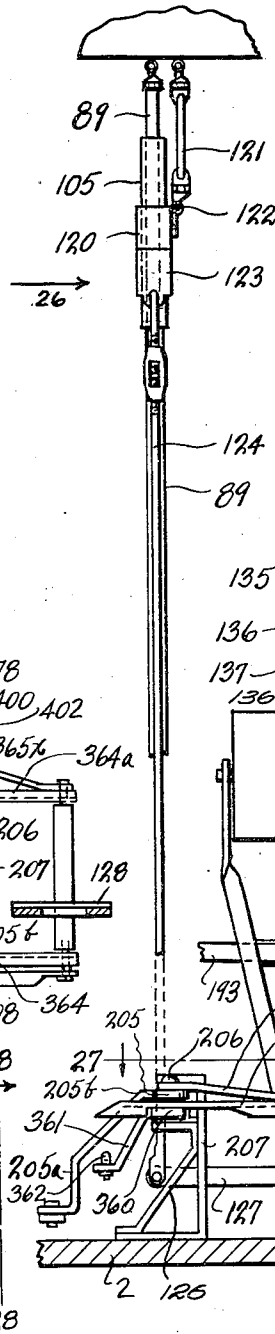


Fig. 25

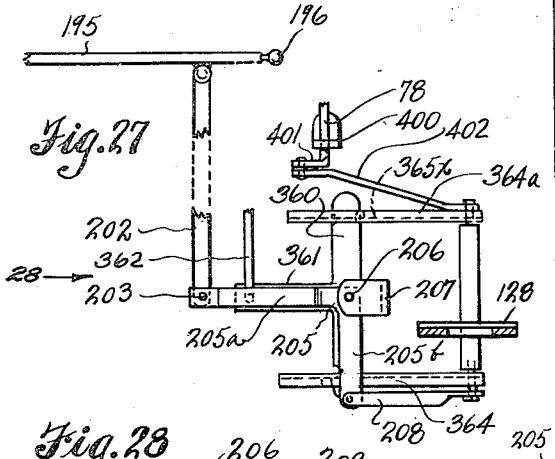


Fig. 27

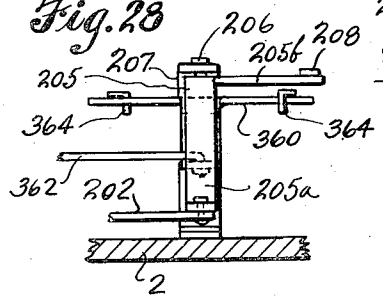
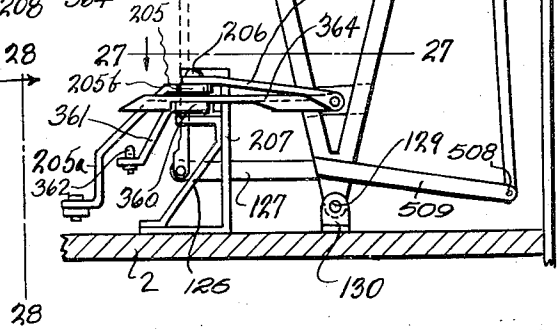


Fig. 28



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Fig. 29

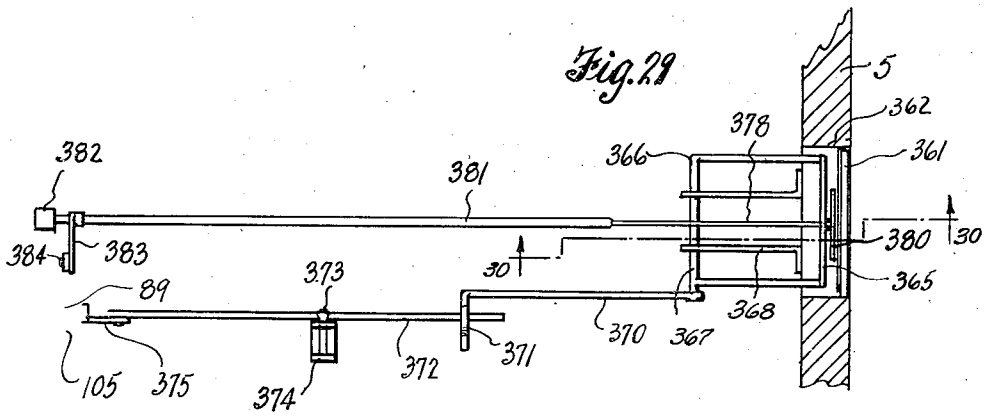


Fig. 30

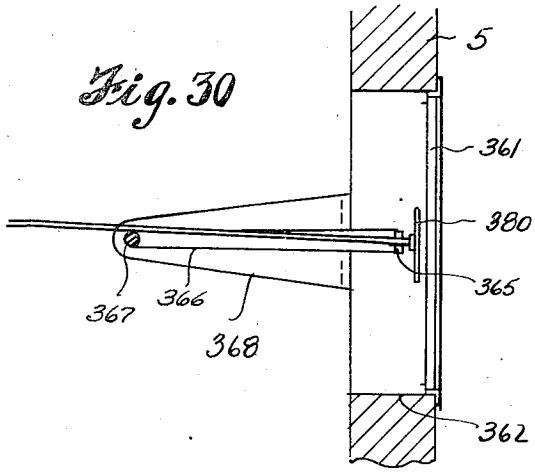
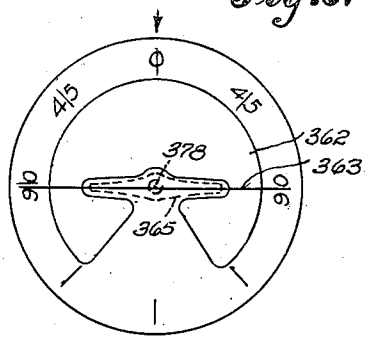


Fig. 31



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Patented Oct. 15, 1946 2,409,238

UNITED STATES PATENT OFFICE

2,409,238

AIRPLANE FLIGHT TRAINER

Theodore C. Barber, Seattle, Wash.

Application February 19, 1943, Serial No. 476,403

11 Claims. (Cl. 35—12)

1

This invention relates to apparatus designed for use in instructing and training student airplane pilots; the present device being in the nature of an improvement upon the Flight control coordinator that has been described and illustrated in my copending application filed on November 10, 1941, under Serial No. 418,579, now Patent Number 2,336,711, Dec. 14, 1943.

It is the object of this invention to provide a ground training apparatus whereby a student pilot may acquire a comprehensive understanding of the various controls and instruments as normally used in an airplane, their purpose and mode of use, the results accomplished through the manipulation of controls individually and the relationship and results of their functions when used conjointly or collectively.

It is also an object of this invention to provide means whereby to teach the student pilot the basic principles of airplane flying, involving the coordination of movements of foot and hand operated control devices; to better impart the proper understanding of the purpose and use of those instruments that are visually applied to the instrument panel; to enable the student to acquire the sense of proper feeling of the manually operated controls in stable flight and to develop the faculty in the student to act while thinking of more than one thing at a time.

Still another object of the invention is to equip the training cab with a model airplane, disposed in a position visible to the pilot while in training position at the controls and so connected with the controls and associated apparatus with which the training cab is equipped that it will maneuver, or change position in the same manner as would ordinarily be expected of an airplane in flight if its controls were similarly manipulated, thus to visually demonstrate to the student in training the action in flight of the plane due to his handling or movement of controls.

More specifically stated, the various objects of the present invention reside in the provision of a ground training apparatus that, for convenience, is herein referred to as a "training cab"; this cab being comparable in size, plan of construction, and in its instruments and accommodations, to the pilot's cockpit of the typical training plane, and having control equipment corresponding to the usual hand and foot controls, and having an instrument panel on which are arranged devices made to indicate readings or conditions that are to be obtained by the usually employed instruments such as the directional gyro, gyro turn and bank, artificial horizon, altimeter, air speed indicator, rate of climb indicator, tachometer, clock, etc., and in which cab, mechanisms have been provided for causing these instruments and devices to operate in accordance with movements of the present flight control devices and parts associated therewith, thus, by their readings, to indicate the conditions or situations which would normally result in actual flight under similar conditions of operation, and in this way to teach the student the fundamental principles of proper flight control and in so doing, to make it possible for him to more easily grasp an instructor's directions and teachings when flight training in air is undertaken, with less nervous strain and consequently with faster progress in mastering flying problems and in becoming efficient as an airplane pilot.

2

Still further objects of this invention are to be found in the construction of the various parts of the training device, in their operative relationship to each other, in their functions, and the relationship of their functions to each other.

In accomplishing the above mentioned and various other objects of the invention, I have provided the improved details of construction, the preferred forms of which are illustrated in the accompanying drawings, wherein—

Fig. 1 is a perspective view of the present flight training cab.

Fig. 2 is an elevation of the instrument panel showing the arrangement of instruments thereon.

Fig. 3 is a longitudinal section of the cab showing the mechanism at the right hand side of the central vertical plane.

Fig. 4 is a similar section showing parts at the left-hand side of the central vertical plane of the cab.

Fig. 5 is a plan, or top view of the cab with the cover removed to better show location of main parts of the apparatus; some of the parts being omitted to avoid confusion of illustration.

Fig. 6 is a horizontal section, substantially on line 6—6 in Fig. 3.

Fig. 7 is a perspective view illustrating the arrangement of foot controls and the operating connection with the ball bank indicator on the instrument panel.

Fig. 7a is a plan view of parts shown in Fig. 7.

Fig. 8 is a perspective view of the stick assembly and some of the directly associated parts.

Fig. 9 is a side view of parts associated with the stick and rocker shaft.

Fig. 10 is a cross sectional view on the line 10—10 in Fig. 9.

Fig. 11 is a top view of the motor and disk

assembly whereby the model airplane is rotated.

Fig. 12 is a detail showing linkage between the right foot pedal and the adjusting lever for the motor whereby the model plane is turned from side to side.

Fig. 12*a* is a top view of the linkage of Fig. 12.

Fig. 13 is a cross sectional view of the cab, substantially on the line 13—13 in Fig. 3, showing the ball bank indicator operating linkage and foot controls.

Fig. 14 is an enlarged view of connections of rods with the ball bank indicator and operating linkage.

Fig. 15 is a front elevation of the machine showing the mechanism that is adjacent the front end; parts farther back being omitted to avoid confusion.

Fig. 16 is a vertical section on line 16—16 in Fig. 15.

Fig. 17 is a vertical section on line 17—17 in Fig. 15.

Fig. 18 is a plan view of the motor and its mounting for operation of the altitude indicating means; this being a horizontal section substantially on line 18—18 in Fig. 16.

Fig. 19 is a vertical section on line 19—19 in Fig. 15, with some parts shown in Figs. 16 and 17 omitted.

Fig. 20 is a section on line 20—20 in Fig. 19.

Fig. 21 is a section on line 21—21 in Fig. 15.

Fig. 22 is a detailed view of the adjustable mounting of the aileron motor.

Fig. 23 is a cross section on line 23—23 in Fig. 22.

Fig. 24 is a section on line 24—24 in Fig. 22.

Fig. 25 is a front view of the motor and actuated parts for control of banking of the model plane.

Fig. 26 is a detail of the model plane supporting and operating linkage as seen looking in the direction of the arrow 26 in Fig. 25.

Fig. 27 is a horizontal section of the linkage as seen on line 27—27 in Fig. 25.

Fig. 28 is a side view of parts shown in Fig. 27, looking in the direction of the arrow 28.

Fig. 29 is a detail of the operating mechanism of the gyro-horizon.

Fig. 30 is a cross section on line 30—30 in Fig. 29.

Fig. 31 is a front view of the gyro-horizon dial.

Referring more in detail to the drawings—

First, it will be explained that in the description, the use of the words "forwardly" and "rearwardly," or "front" and "rear" has reference to the location of parts in the cab with reference to the front and rear ends thereof; the rear end being that back of the student's seat in the cab.

The present apparatus anticipates that it be used in the training of student pilots in the fundamentals of flight control, while on the ground, and in this connection, provision is made for stressing the importance of coordination of movements of hand and foot controls, as well as the necessity of observing the readings of the various flight indicating instruments and acting in accordance with the readings, as an aid in maintaining proper balance in gliding, turning, banking, climbing, landing, and in various other expected or unexpected maneuvers of the airplane. In the following description, various problems of flight control will be explained along with the description and explanation of use of the present apparatus.

In connection with one of the main objects of the present invention, it will here be explained

that the common types of airplanes used for training purposes, as well as many used in commercial flying, have their instrument panels equipped, at a location readily visible to the pilot, with an instrument known as a gyro-turn and bank indicator, or with an instrument for a similar purpose, which visibly indicates to the pilot whether or not the plane is in stable flight. One of such types of such instruments employs a ball that is movable under the influence of gravity, in an arcuately curved glass tube of liquid. The ball is so arranged that it will move from a neutral position toward opposite ends of the tube in accordance with the degree of bank of the plane except as those movements might be influenced by lateral forces that might be due to various causes. In the actual flight of an airplane, the operator normally endeavors to maintain the ball of the ball bank indicator at a neutral position while banked for turning as well as while in straight flight.

If the plane should be banked by the action of the ailerons alone, plane slipping normally results. If the plane is caused to turn by action of the rudder alone, skidding normally will result. The actuation of the stick to bring about banking of the plane, or the actuation of the rudder in either direction, will normally result in a certain unstable condition of the plane that will be indicated by movement of the ball of the bank and turn indicator to an off-center position in the instrument, and it now is accepted teaching that only by the proper coordinated and conjoint use of ailerons and rudder can the plane be brought to and maintained in stable flight and the ball maintained at that neutral position indicating stable flight. However, the exact manipulations of hand and foot controls may vary under different flying conditions and at different speeds. While in some unusual situations, a fair degree of stability in flight might be maintained by manipulation of either the hand or foot controls individually, it is in accordance with best principles of flight control and is the generally accepted procedure, that stability in flight shall be accomplished through the conjoint and properly coordinated action of both foot and hand controls, and this anticipates also the proper use of throttle and elevators.

The present training cab, preferably, is in accordance with the device shown in perspective in Fig. 1, and for most practical and obvious purposes, this is made to correspond in shape and size to the cockpit portion of the typical training plane.

The present training cab is designated in its entirety in Fig. 1 by numeral 1. In Figs. 3 and 4, the cab is shown as comprising a horizontal bottom floor 2, right and left side walls 3 and 3', respectively, and a hood or cowl 4. Below the cowl is an instrument panel 5 and rearwardly thereof is a seat 6 for occupancy by the student in training. The floor, as here shown, is supported on relatively deep longitudinal, opposite side sills 7 mainly for the purpose of providing a desired clearance space below the floor for certain operating parts of the mechanism, later described, and there are cross sills 8 at opposite ends of the cab and an intermediate cross sill or brace member 9.

Foot controls

In the provision of foot controls, simulating those employed in the usual airplane, there is here provided, transversely of the cockpit, at

suitable distance forwardly of the seat and closely adjacent the floor, as noted best in Figs. 3, 4 and 7, a horizontal shaft 10, rigidly fixed to the floor by brackets 11 attached thereto adjacent its ends. Revolubly supported by this shaft 10, at its opposite ends respectively, are upwardly extending right and left foot controls 12 and 13, hereinafter called foot pedals. These pedals are pivotally mounted for forward and rearward movements and each has a lever arm extending downwardly therefrom. These lever arms, designated respectively by numerals 12*a* and 13*a*, pass through floor openings 15, to some distance below the floor. It has been shown in Figs. 3 and 4 that two coiled springs 16, 16 have their forward ends attached to the lower ends of these lever arms, respectively, and their rearward ends attached to brackets 17—17 that are fixed to under side of the cab floor directly rearwardly of the levers. Also, short lengths of chain 18, 18 are attached to the lower ends of the lever arms and extend forwardly therefrom and at their forward ends are fixed, respectively, to the opposite ends of a horizontal cross lever 19. Lever 19 is pivotally mounted at its center point by a pivot bolt 19', held in a supporting bracket 20, which, in turn, is fixed to the cross sill 9 of the cab. The two coiled springs 16—16 are under equal tension and normally hold the foot pedals 12 and 13 evenly at the designated neutral position, as seen in Fig. 3. The connection of the foot pedals with the cross lever 19 provides that when either foot pedal is pressed forwardly, the connecting linkage will cause the other pedal to be moved rearwardly a corresponding distance, as is the case in the action of the foot controls provided in the usual airplane for the control of the rudder action.

Hand controls

Referring now more particularly to Figs. 3 and 4 it will be noted that bearings 22 and 23 are fixed on the floor 1, spaced apart on the central, longitudinal line of the cockpit, the bearing 22 being just rearward of cross shaft 10 and the bearing 23 being located just forward of the seat 5. Rotatably supported in the bearings 22 and 23 are the forward and rearward end portions of a horizontal shaft 26. The forward end portion of the shaft 26 is revolubly held in the bearing 22 while the rearward end portion is revolubly held in the bearing 23.

A lever arm 32 is fixed rigidly to and extends directly downward from the forward end portion of the shaft 26, passing with clearance through an opening 33 in the floor. Located below the floor, at opposite sides of the opening 33, and transversely directed, are coiled springs 34 and 34' shown in Fig. 6, which have inner ends fixed to the lower end portion of the lever arm 32 and their outer ends attached to brackets 35 that are adjustably fixed to the side sills of the base frame of the cab for equalizing spring tension. These springs are under balanced tension that results in the lever arm 32 being maintained normally in vertical position.

Fixed to the rear end portion of the shaft 26 and extending equally to opposite sides thereof, as shown best in Figs. 8 and 9, is a tubular cross bearing 40, and pivotally mounted by this bearing is a yoke *y* for mounting the joystick 45. This yoke comprises opposite side straps 41 and 41', spaced apart along their medial portions and joined together along their lower end portions, and with their upper end portions directed toward each other and fixed to the opposite sides of

a vertical socket member 44 in which the lower end of the joystick 45 is fitted. The two side straps 41 and 41' of the yoke pass across the opposite ends of the tubular cross bearing 40, and a pivot bolt 46 is extended therethrough and through the bearing thereby to pivotally mount the yoke for forward and rearward oscillation of the stick. It will be understood also that the stick may be oscillated laterally in opposite directions by reason of the rotatable mounting of the yoke supporting shaft 26 in the bearings 22 and 23.

The lower end portion of the stick mounting yoke extends to below the floor through an opening 48 therein, Figs. 4 and 9, and at the under side of the floor, coiled springs 49 and 50 have ends fixed thereto; these springs, respectively, extend rearwardly and forwardly from the yoke, as seen in Figs. 3 and 4 and have their other ends anchored, respectively to a bracket 49' that is attached to the cab floor and to the lower end portion of the previously mentioned lever arm 32. These two springs are under balanced tension and normally retain the joystick 45 in an upright and predetermined neutral position.

Fixed rigidly to the depending arm 32 and extending directly forward therefrom, axially parallel to shaft 26, as shown in Figs. 3, 4, 8 and 9, is a shaft 52, with an upright suspending lever 53 at its forward end. The lever 53 has a supporting pivot bolt 54 therethrough fixed in a bracket 55 mounted on the cab floor. This pivot 54 is axially alined with the pivot axis of shaft 26. The upper end of the lever 53 extends somewhat above the pivot 54 as seen in Fig. 4 for a purpose presently to be explained. Also, for a purpose later apparent, a motor base 57 is fixed to the shaft 52 near its forward end, this being shown in Figs. 9 and 10. The shaft 52, as swingingly suspended by the legs or levers 32 and 53, will be oscillated from side to side, as is indicated by the arcuate arrow placed thereon in Fig. 10, by the side to side action of the stick 45.

Ball bank indicator and rough air mechanism

It is one of the purposes of this training equipment to teach the student the use of the ball bank indicator and how, by reference to the ball bank indicator, to maintain stable flight in rough air and to learn proper methods of correcting mistakes he has made in control applications and to artificially simulate the results of improper control use and rough air. To artificially simulate rough air conditions, I employ a mechanism which is shown best in Figs. 13 and 14. This includes an electric motor 60 that is mounted on the previously mentioned motor base 56, supported upon the shaft 52 near its point of fixed connection with lever 32. The motor 60 as shown in Fig. 14 has its drive shaft extended into a gear reduction housing 61 fixed on the motor and from which housing a lateral shaft 62 extends. This shaft, which will be driven by the motor at a relatively slow speed due to the gear reduction, has a short crank arm 63 at its outer end and this crank arm is offset laterally from the vertical plane of the shaft 26. Electrical energy for the motor can be supplied from a source of supply under control of a switch located on the instrument panel 5, such a switch being designated in Fig. 2 by reference character S.

It will be understood then by reference to Figs. 8, 13 and 14 that axial oscillating movements imparted to the shaft 26 by movement of the stick 45 from side to side, will cause corresponding

oscillating action of the motor 60, and since the crank arm 63 is laterally offset from the vertical plane of shaft 26, this action will cause the crank arm mounting to be oscillated vertically to a corresponding degree, and this causes oscillating action of the crank arm as indicated by the double ended arrow adjacent thereto in Fig. 14. The purpose of this motion presently will be apparent.

The ball bank indicator of this training device as shown in Figs. 3, 4, 7 and 14 comprises a ball 65 movable in an arcuate slot 70 formed in a horizontal direction in the instrument panel 5 in the direct vision of the student pilot, when occupying the seat 6. This ball is fixed to the lower end of an arm 71 depending from a horizontal pivot shaft 72. Shaft 72 is held rotatably in a bracket 73 that is fixed to the forward side of the instrument panel directly above the arcuate slot. Fixed to the forward end of the pivot shaft 72, as an extension thereof, is a flexible steel shaft 75 which, at its forward end, is fixed to the central portion of a horizontal cross arm 76. Pivotally attached, as at 77*a* in Fig. 7, to one end of the cross arm 76, is a downwardly extending rod 77 which, at its lower end has an operating connection, later described in detail and shown best in Fig. 7 with a lateral crank arm 78' fixed to a rod 78 that extends in the longitudinal direction of the machine, and which at its rearward end has pivotal connection at 79*a* with the upper end of a vertically directed link 79 that is connected pivotally at its lower end to a lever arm 80 that is directed rearwardly from a rigid bar 81 that extends along the cross rod 10 and at one end, is fixed rigidly to the right foot pedal. This connection of bar 81 with the foot pedal, as observed in Fig. 7, provides that the lever arm 80 will be oscillated vertically with the forward and rearward movements of the foot pedals, and this oscillation, by reason of the above described connecting parts 78, 79 and 80 in connection with lever arm 78' and rod 77, can be employed to effect an oscillating action of the cross arm 76 about its opposite end support, whereby to rotate shaft 75 and, through the arm 71, to impart oscillating movement to the ball bank indicator in slot 70.

The rod 78, through which connection of rod 77 is made with lever arm 80, is axially rotatably supported for a purpose that later will be explained in connection with the air speed indicator, but for the purpose of affording an operating connection between the foot pedal system and the ball bank indicator, it is normally held against rotation by means later to be disclosed.

Fixed pivotally to that end of cross arm 76 opposite that to which the upper end of rod 77 is attached, is a downwardly extending rod 85 which, at its lower end is fixed pivotally as indicated in Figs. 7 and 14, at 85', to the end of the motor crank arm 63. Thus, with the stick and foot controls held stable and the motor 60 running, it will be understood that the crank arm 63 will, in its rotation, move rod 85 upwardly and downwardly, thus oscillating the cross arm 76 about its connection with rod 77, and by this oscillation, will turn shaft 75 in such manner as to produce back and forth movement of the ball of the bank and turn indicator that would simulate conditions of unstable flight of the plane. This motor connection is what has been referred to as the means for artificially creating rough air conditions and conditions of improper use of the controls.

Assuming that the ball 65 is being actuated by the motor 60 to stimulate conditions of rough air and unstable flight, it is the problem of the student pilot, in accordance with the objects of this invention, by properly coordinated action of the foot and hand controls, to nullify these mechanically produced movements of the ball in such manner as to retain it centered in the slot or in what will be referred to as a neutral position.

It is possible also to stabilize the movements of the ball that are mechanically produced by the motor 60 and the crank arm 63, through foot pedal action; it being understood that by the foot pedal connections made through rod 77, a corresponding raising and lowering of the opposite end of the cross arm 76 may be accomplished. When the two rods 77 and 85 which support opposite ends of the cross arm, are moved up and down in unison by the proper coordination of hand and foot controls, the cross bar 76 will be moved accordingly and there will be no turning action of the shaft 75 and consequently no ball movement. Likewise, it is possible to nullify the up and down movements of the end of cross arm 76 that might be produced through the rotating crank arm 63 when the motor is in operation, by actuation of the stick from side to side in synchronism with the crank arm rotation whereby to oscillate the motor supporting table to such extent that the point of crank arm connection with the lower end of rod 85 will remain at a constant horizontal level during rotation of the crank arm 63, and no oscillating action of shaft 75 will be produced and the ball will remain at a set position.

It will be mentioned here that the up and down movement of the cross arm 76 is here made possible without interference with rotation of shaft 72 by reason of the use of the short length of flexible shaft 75 that connects with the pivot shaft 72.

It is generally accepted as good flying practice that the flight of a plane should be so controlled by coordinated action of foot and hand controls, that the ball bank indicator will be maintained in a neutral position. The connections above described make this possible in this training device.

Assuming that the ball is being momentarily moved by the "rough air" simulating action of motor 60 from its neutral position to a position toward the right, or left, as observed by the pilot, it can be returned to its neutral position by depressing the corresponding foot pedal and at the same time moving the stick toward the opposite side. If the movement of either, or both of these controls should be made toward the wrong direction, the travel of the ball away from neutral will be accentuated, but when movement of both controls is correctly made, return of the ball to neutral is possible and will be accomplished by relatively short movements of the controls.

When it is desired merely to teach the student coordination of foot and hand action, for turning or banking, it is not necessary that the artificially produced movement of the ball by the action of the motor 60 and its crank arm be employed, for, by reason of the operating connections previously described, it is possible for the student to move the ball from side to side in the slot, either by the foot pedal action or by lateral stick action, and it is possible to correct the movement of the ball, as produced by the action of either, by a properly coordinated movement of the other. For example, if the right foot pedal is depressed as in banking to the right, the ball

will be moved accordingly to the left from neutral position. This movement can be corrected by moving the stick to the right, and according to present day teaching that is the proper movement, when in actual flight, to maintain a stable condition. Practice along this line, then, consists in moving the ball from neutral by action of one set of controls and correcting its position with the other set. When a student has mastered the coordination of foot and hand movements for stabilizing the ball bank indicator in the training plane, by this kind of practice, it will be easier, when actual flight is undertaken, for him to maintain the airplane in stable flight.

Model plane and its controls

In accordance with another object of the present invention, having to do with visually showing the student pilot what the attitude of a plane on actual flight will be as the various controls are manipulated, together or individually, I have mounted a model airplane above the cab, forwardly of the cockpit and in the student's direct line of vision. This plane, shown in Figs. 3, 4, and 13, is designated by numeral 87, and is hingedly mounted, as at 88, upon the upper end of a vertical supporting shaft 89. At its lower end, the shaft 89 is supported rotatably in a bearing 90 that is mounted on a horizontal, transverse shelf or platform 91 fixed in the frame structure. Somewhat above the bearing 90 the shaft is rotatably contained in a guide bearing 92 fixed to a frame member as noted in Fig. 4.

Fixed on the lower end portion of the shaft 89, just above shelf 91, is a horizontal friction disk 93 formed with a bevel peripheral edge surface 93'. Located at one side of the disk 93 (see Figs. 5 and 11) is an electric motor 95 having its shaft connected through suitable reduction gears with the drive shaft 96 of a friction wheel 97. The shaft 96 is carried in a gear housing 98 which is fixed to the motor, and the wheel 97, has contact at its periphery with the beveled edge surface of the disk 93. When the wheel 97, by reason of adjustment in position of the motor 95, is disposed in that upright position at which its plane coincides with the vertical plane of shaft 89, its rotation will have no turning influence on the disk 93, and it will operate by reason of its contact with the disk to hold the shaft 89 against rotation and thus retain the model plane in a set position indicating its direction of flight. However, tilting the motor on its mounting, to one side or the other, will cause the wheel 97 to be tilted accordingly, and its rotation will then impart turning movement to the disk 93 in the direction of tilt of the wheel and at a faster or slower rate of speed depending on the degree of the angle of tilt.

In connection with Fig. 12, I have designated by the dotted lines back of shaft 89 the normal position of friction wheel 97 with respect to the disk 93, and in dotted lines at the sides of shaft 89 have shown it tilted as for causing the disk 93 to rotate in opposite directions.

In order that the tilting or adjusting of the motor may be accomplished for the purpose stated, it is shown in Fig. 11 to be fixed on a base 99 hingedly pivoted by a shaft 100 to a supporting bracket 101 that is mounted upon the shelf 91; the hinge axis being axially alined with the point of contact of disk 97 with the beveled edge surface of disk 93. The means provided for tilting the motor to effect turning of the model plane will be described in detail later in the specification.

In view of the object that the model airplane shall be caused to maneuver to various positions, such as different banked positions, and different angles of flight in upwardly or downwardly nosed positions, in accordance with action of the controls and corresponding to results to be expected in similar action of the controls of a plane in actual flight, I have provided a certain connection with the stick whereby the forward and rearward actions thereof will cause downward or upward nosing of the model plane accordingly. Other connections with the hand and foot controls provide for banking, and for effecting change in banking angle of the model plane, and turning of this model plane, as in the modern airplane, is a result of banking when produced by proper coordination of movement of ailerons and rudder controls. The first mentioned connection for nosing the plane up or down, as seen in Figs. 2, 5 and 26 comprises a sleeve 105 of substantial length that is slidable and rotatable on the upper portion of shaft 89. This sleeve is in two sections, an upper and a lower section, that are independently rotatable, but which move up and down together. A link 106 is hingedly attached at its lower end, as at 107, to the upper end of the upper section of sleeve 105 and at its upper end has a hinge connection, as at 108, with the model plane body somewhat rearwardly of the hinge 88. A rod 110 is fixed hingedly at its upper end to the lower end of the lower section of the sleeve 105 and it extends in a downwardly and rearwardly inclined direction, then is directed downward and at its lower end, is pivotally fixed, as seen at 111 in Fig. 8, to the upper end of a swingingly supported link 112. The link 114 is one of an assembly of links through which the movements of various controls will effect the position of the model plane. This linkage is best shown in Figs. 8, 9 and 10, wherein it is to be observed that the link 112 is attached by a pivot bolt 113 to the lower end of a link 114 which, in turn, is pivotally attached by a cross bolt 115 through its upper end to the upper end of the previously mentioned post 57 that is fixed on the shaft 52, and it is to be remembered that shaft 52 is suspended for oscillation by the lateral or side to side action of the stick. The lower end portion of link 114, which extends somewhat below the level of shaft 52, has pivotal connection, as at 116, with the forward end of a horizontally directed rod or link 117 which, at its rearward end, has an operating connecting, later to be described, with the lower end of the mounting yoke for the stick 45, whereby forward and rearward action of the stick will cause forward and rearward swinging of the lower end of the link 114.

It is to be observed by reference to Figs. 8 and 10, which show the assembly of links in a normal position, that the link 114 is vertically suspended from the pivot 115, and that link 112 has a pivotal connection 112x at its lower end with a link 245, later described. Also, the link 112 is inclined rearwardly to a substantial degree from its lower end supporting pivot 113, placing the pivot point of connection 111 with rod 110, rearward of the line of bolt 115. Therefore, any forward or rearward action of the stick, whereby in the usual operation of an airplane, the elevators are adjusted for nosing down or up, will, through the connecting link 117, cause link 114 to swing likewise, and by the resultant pivotal

movement of the link 112, on bolt 113, to tilt the model plane accordingly, to visually demonstrate the normal effects on the airplane of such operation of the stick.

It will here be mentioned, for later reference, that the nosing action of the model plane produced in banking, is modified by making adjustments of the link 112 which places its upper end connection 111 with rod 110 closer or farther from the line of pivot 115; it being understood that when pivot 111 is alined with pivot bolt 115, swinging of the linkage on pivot 115 will have no moving effect on rod 110. The reasons for such adjustments will later be apparent.

In order to bank the model plane in accordance with the results that might be produced in actual flight by lateral actions or side to side movements of the stick, I have provided a sliding collar 120, shown in Figs. 4 and 25 rotatable about the upper portion of sleeve 105, and this has a link 121 pivotally attached thereto, as at 122, and to the body of the model plane at one side of its hinge mounting on shaft 89. Also, there is a supporting sleeve 123 for the collar 120, and this latter sleeve, which is freely fitted about the lower portion of the sleeve 105, has the upper end of a rod 124 pivotally attached thereto. The lower end of rod 124 connects pivotally, at 126, with the end of an arm 127 that is rigidly fixed to and extends in a horizontal direction from the base portion of an upright rocker frame structure, designated generally by numeral 128, this being seen best in Fig. 25.

The frame structure 128 has a mounting hinge shaft 129 through its base. This shaft is held in brackets 130 attached to the floor 1, and is disposed in the longitudinal direction of the apparatus. At the upper end of the frame structure 128, is a rotatably mounted friction cylinder 131 disposed with its axial line directed transversely of the machine and lying in a plane at a right angle to the direction of the hinge shaft 129, that is, in a vertical plane transversely of the machine.

Swingingly mounted, as presently described, more in detail, above the friction cylinder 131 is an electric motor 135 adapted to drive a friction disk 136 fixed on a shaft 137 that extends in the general direction of the friction cylinder axis, and is carried in a gear case 136' attached to the motor. The disk edge rests upon the top edge of the friction cylinder, and it is so arranged that by swinging the motor mounting about its vertical hinge axis, the friction disk will be caused to move accordingly, thus to change the angle of its plane relative to the vertical axial plane of the cylinder, so that, incident to its angular position and rotation of the disk, to cause the friction cylinder to travel in an endwise direction, one way or the other, depending on the direction of inclination of the friction disk. The rate of such endwise travel of the cylinder would be dependent upon the extent of the angle to which the disk is thus adjusted.

The motor 135, as seen in Fig. 25 has a mounting bracket 140 fixed thereto, and this has a ball and socket mounting 140' with a support 141, later described in detail. Also as seen in Figs. 4 and 5, there is a triangular bracket 142 lying in a vertical plane, and fastened hingedly at its base and by a vertical hinge pin 143, to the motor.

Fig. 4 shows that bracket 142 extends from the motor in a direction toward the rear of the cab and at its vertex has pivotal connection, at 144, with the lower end of a vertical leg 145a of a bell crank lever 145. The bell crank lever has pivotal mounting on a cross shaft 147 in a horizontally disposed supporting frame 148 and has a horizontally directed arm 145b extended along but terminating short of the forward end of frame 148, this arm being connected at its forward end, as at 149, with the upper end of a link 150 which extends downwardly and has a pivoted connection 150' at its lower end with a lever arm 152 fixed rigidly to the previously mentioned leg 53 and extended laterally therefrom, as in Fig. 8, at the level of the pivot 54. Thus, when the stick is actuated from side to side, as for aileron adjustment and control, the linkage, above described, will actuate the bell crank 145 accordingly on its pivot 147, and this, through the bracket 142, will cause the motor 135 to be pushed forwardly or pulled rearwardly, according to the direction of movement of the stick, and this, by reason of the resultant change of the angular position of the friction disk 136 relative to the line of the cylinder 131 will cause the latter to be moved endwise accordingly.

The frame 148 is hingedly mounted at its rearward end by supporting brackets 155 mounted on shelf 91 so that its forward end may oscillate vertically, and at its forward end, the frame has pivotal connection at 156, with the upper end of a link 158 which, at its lower end as seen in Fig. 7, has pivotal connection at 159 with a lever arm 160 that extends forwardly from the bar 81 previously described as being extended along the cross rod 10 and having fixed connection with the right foot pedal; this being seen in Fig. 7. Thus, this connection provides that the action of foot pedals, which in the airplane would normally cause rudder action as employed with banking for turning, will cause an additional angular adjustment of the motor 135 beyond that provided by the stick action, whereby travel of the cylinder 131 will be speeded up.

It is the accepted practise that for best flight control in making a turn, banking of the plane by the aileron action should be accompanied by a corresponding rudder movement to avoid skidding or slipping. Therefore, in this trainer, the student should, in practising the making of a turn, conjointly use the stick and foot controls, and in watching the manuevering of the model plane, should also pay due attention to the position of the ball of the bank and turn indicator, to see that it is maintained in neutral position during the turning operation by properly coordinated movements of the controls used.

It is to be pointed out that, by the mechanisms previously described, the banking of the model plane can be caused by stick action alone, and to some extent, by action of the foot controls alone, although in actual flight of a plane, this latter would be undesirable as it might easily result in unstable flight. It has been explained that in the airplane, the extent of movement of these two controls to produce a given result will be materially shortened and more stable flight will be possible when they are properly used conjointly.

In the mechanism herein illustrated, for demonstrating the shortened travel of the controls, when used conjointly to produce a desired banking and turning action of the model plane, is due to the fact that the supporting pivot 147 of the bell crank lever 145, through which the control of position of motor 135 and friction disk is obtained by action of the stick, changes with any

coincident action of the foot controls so that the angular change in position of the motor and its friction disk is equal to the sum of the movements that are produced individually by the stick and foot controls; this change in position of the bell crank lever being due to its mounting on the frame structure 148, and the connection of frame 148 with the foot controls through link 158 as above explained.

Turning of a plane in flight is a function of proper banking by aileron and a rudder action. In this training device, when the foot and hand controls are conjointly adjusted to produce proper banking for a turn, the model plane will be caused to turn on its supporting shaft 89 accordingly by reason of the fact that this action of the controls changes the normal position of the motor 95, and its driven friction wheel 97 in such direction and to such angle relative to the axis of the disk 93, that the disk will be rotated accordingly in direction and at a rate determined by the angular position of the disk. This rotation of the disk 93 continues as long as the motor is held in angular position, and this is in accordance with the understanding that a plane in flight will continue to turn as long as it is held in a banked position by reason of a proper aileron and rudder setting. The angular adjustment of the motor 95 to produce the turning action of the model plane, is accomplished by devices and mechanism which will now be described.

Fixed to the hingedly mounted supporting base 99 for the motor 95 as seen in Fig. 11 is a horizontally and forwardly directed rocker lever 170. To this arm there is attached a coiled spring 171 held under tension and having a fixed connection to the cab frame so that it acts to pull upward on the lever to balance the weight of the motor. Also fixed to the rocker lever, and extended downwardly, is a rod 172 which, at its lower end, as seen in Fig. 12 has pivotal connection with the horizontally directed arm 173a of a bell crank lever 173 that is pivotally supported, as at 174 on a horizontally directed supporting lever 175 to be used as later described. The bell crank 173 has a downwardly directed arm 173b connected pivotally at its end with a link 176 extended rearwardly therefrom and pivotally attached, at 177, to a lever arm 178 extended laterally from the right foot pedal.

The lever 175 is pivotally supported at its rear end from the upper end of a vertical standard 179 which has a hinge mounting 180 at its lower end in a bracket 181 for forward or rearward movement at its upper end. At its forward end the lever 175 (see Fig. 12) has pivotal connection with a link 182 that extends downwardly and is pivotally attached at its lower end to the horizontal leg 184 of a bell crank frame 185 that is mounted as seen best in Figs. 3 and 8 by pivots 186 on the lower end of another frame 187 that is suspended to swing hingedly on a cross head support 188 at the upper end of a post 189 that is fixed to the floor. The bell crank frame 185 has an upwardly directed leg 185' pivotally connected by a link 190 with the upper end portion of the previously mentioned leg 53 which carries the forward end of rocker shaft 52. Thus, by rocking the stick from side to side, the arm 53 and link 190 will cause frame 185 to be rocked accordingly, as understood by reference to Fig. 8.

The frame 187 has a leg 192 extended above the support 188 and this is shown in Figs. 13 and 25 to be pivotally connected to one end of a horizontal link 193 which has pivotal connection at its other end with the rocker frame 128 whereby the friction cylinder 131 is mounted.

Now, with all parts in neutral setting, as in level flight, assuming that the stick is moved to the right, for example, to bank for turning, the friction cylinder 131, by the means previously described, including the bracket 142, crank 145 and link 159, will position disk 136 on cylinder 131 and cause the latter to travel endwise, and this travel, transmitted to frame 128, will, through the linkage just described, including link 182, bell crank 173 and link 172, cause the motor 95 to be tilted in such manner as to cause its friction wheel 97 to rotate the disk 93 and turn the shaft 89 and model plane to the right. Likewise, movement of the stick to the left from a neutral setting, operates through the same linkage to effect that angle of tilting of the motor 95 and wheel 97 which results in turning the disk 93 to cause turning of the model plane to the left. The rate of turn is dependent upon the angle of adjustment of friction wheel 97, and this is determined by the control adjustment.

In the proper use of the controls for turning a plane in actual flight, for example, for turning to the right, this can be accomplished by a relatively short movement of the stick to the right to give the required aileron setting, if accompanied by that coincident, relatively slight depression of the right foot pedal required to produce a desirable adjustment of the rudder. In this training device, the actuation of the stick and foot controls moves the bell crank 173, and this, through link 172 and lever 170, will impart tilting action to the motor 95 and its friction disk 97, and the results of this operation of controls is made apparent by the turning of the model plane.

In actual flight of an airplane, after a turn has been started by reason of having brought the plane to a banked position, the stick may be brought back to neutral position without throwing the plane out of its banked position. In the present training device, the sharpening of a turn is readily apparent in the speeding up of the rate of turning of the model plane, and this speeding up is by reason of the fact that when the devices are in position to bank the model plane, movement of the stick rearward as for nosing up, will cause an increase of the driving angle of the wheel 97 on disk 93 and this increases the rate of turning of the disk accordingly. This increased angularity of the wheel 97 relative to the disk 93 is by reason of the following mechanism:

Extending in a horizontal direction, and transversely of the device, just back of cross rod 10, as shown in Fig. 7, is a lever 195 which at its inner end has a pivotal connection 196 as seen in Fig. 10 with the upper end of an upright link 197 which, at its lower end, has pivotal attachment to the lower end of the link 114 by bolt 113. At its outer end, as seen in Fig. 7, the lever 195 has pivotal connection at 198 with an arm 199 that is fixed rigidly to the hinged standard 179 to rock the latter forwardly or rearwardly. Intermediate its ends, the lever 195 has a pivotal support 200 in the form of a short upright post 201 that is hinged at its lower end to the floor so that its upper end has slight swinging movement in the longitudinal direction of the cab.

Attached pivotally to the lever 195 near its inner end, is a rod 202 which extends forwardly (Figs. 7 and 27) therefrom and at its forward end has pivotal connection, at 203, with one leg 205a of a bell crank lever 205 supported by a vertical

pivot bolt 206 fixed in a bracket 207 attached to the floor. The other leg of the bell crank lever 205b has connection through the mediacy of a link 208 with the rocker frame 128 which supports the friction cylinder 131. This linkage with the rocker frame provides that when the cylinder 131 is in neutral position, as in level flight of the model plane, the pivot point of connection of lever 195 with the upper end of link 197 is held in axial alinement with the pivot bolt 115. However, when the cylinder 131 moves to the right or to the left, this linkage will cause the alinement with pivot bolt 115 to move forward or rearward, then when the stick is pulled back, the connection provided by link 197 with link 114, will rock the transverse lever 195 on pivot 200 and in so doing will cause the hinged standard 179 to be oscillated rearwardly or forwardly and in so doing, will move the point of support of the bell crank 173 accordingly and incidentally will actuate the bell crank to increase the angle of the motor 95 and its disk to speed up the turning of disk 92 and the turning of the model plane accordingly.

Gyro compass

In order that the student pilot may observe the extent of turning of the model plane, I have shown the instrument panel in Figs. 2 and 5 as being equipped with a cylindrical indicator 210 in an opening 211. This is located in the panel and it simulates the function of the gyro compass. Fig. 4 shows that the cylinder is fixed on a vertical shaft 212 that is rotatably supported from the panel and on which shaft a sprocket wheel 213 is fixed. A chain belt 214 extends about the wheel 213 and about a sprocket wheel of the same diameter, 215, fixed on the shaft 89 and thus, as the model plane is turned from side to side by turning action of disk 93, the indicator 210 is caused to rotate accordingly. The indicator is marked in degrees so that the student may observe the angle of any turn made with reference to a zero mark on a glass overlying the opening.

Instruments

In order to familiarize the student with the effects on flight due to changes in throttle and stabilizer adjustments, and the object of making adjustments of these parts, I have equipped the present training cab at locations therein of their normal uses, with a throttle lever 220 and a stabilizer adjusting crank 221. The intent is that, through the use of certain instruments located on the instrument panel, such, for example, devices simulating the functions of the altimeter, air speed indicator and tachometer, and the like, the normal effects on flight or speed due to nosing the plane up, or nosing it down, and the effects of opening and closing the throttle and up or down adjustment of the stabilizers, may be visually observed.

First, describing the air speed indicator. The purpose of this device is to indicate to the student the effects on speed that result from banking, nosing up or down, throttle and stabilizer adjustment. This instrument as seen in Fig. 19, comprises a dial 225 that is fixed in the instrument panel and is marked with graduations which would designate air speed per hour. With the dial, there is associated a pointer 226 fixed on a shaft 227 that extends forwardly from the panel, and at its forward end is equipped with a turning wheel 228 about which a wire cable 229 is wound. This cable extends downwardly from the wheel and is attached to a horizontally directed lever arm 230 that is fixed to and extends rearwardly from a rocker frame structure 231 hingedly mounted in a base bracket 233 in a manner permitting forward and rearward swinging of the upper end of the frame. At its upper end, the rocker frame mounts a horizontally disposed friction cylinder 235 disposed with its axis longitudinally of the machine and in a plane that is at a right angle to the line of the hinge axis. At one side of the cylinder, is an electric motor 236 shown in Fig. 21 having its drive shaft connected through suitable reduction gearing, to drive a friction disk 238 which engages in frictional contact with the side of the cylinder. The motor is affixed to a base 240 that is hinged to a fixed support 241 and this base may be adjusted to change the plane of the friction disk, which normally is perpendicular to the cylinder axis, to such angle that, in rotation, the disk will impart endwise travel to the cylinder and this travel will, through the frame 231, lever 230 and the cable connection 229, cause turning of the shaft 227 and thereby indicate change of air speed on the dial reading. The speed indication will be as determined by the extent of endwise travel of the friction cylinder from a starting point. It will be understood that endwise travel of the cylinder 235 will stop whenever its axis assumes a position perpendicular to the plane of the friction disk.

The flying speed of an airplane is determined to some extent by stabilizer and throttle adjustment as well as by adjustment of foot and hand controls, and it is understood that changes in adjustments of these parts during flight will cause a change in flying speed. Therefore, in this equipment, I have provided various connections with the mounting of motor 236, whereby its position will be altered in accordance with these adjustments, to thereby change the position of the friction cylinder to indicate the change of speed by reference to the dial 225. First, with reference to stick adjustment:

Attached pivotally to the lower end of the suspended link 112, as noted in Figs. 8 and 9, is a forwardly directed link 245 which at its forward end has an upturned portion passing upwardly through the floor opening, and pivotally attached, as at 246, see Figs. 19 and 20, to the depending arm of a bell crank lever 247 that is fixed on a transversely directed supporting shaft 248. This shaft is rotatably carried by suitable supports 249, 249' at its ends. On this shaft is an upwardly directed lever arm 250 pivotally connected at its upper end to the lower end of an upwardly directed and pivotally suspended link 251, later to be more fully described. Pivotally attached to the link 251, slightly above its connection with lever 250, as seen in Fig. 4, is a horizontally and forwardly directed link 252 which connects pivotally with the upper end of a lever arm 253 fixed rigidly to the hinged supporting base 240 of the motor 236. This linkage is shown in Fig. 21.

Through the linkage just described, any forward or rearward action of the stick 45, as for nosing up or down, will cause the motor 236 to be adjusted accordingly to different positions, and thus to result in that change in the angular position of the friction disk 238 relative to the friction cylinder 235 that produces longitudinal travel of the cylinder, and this travel, which continues until the axial line of the cylinder again assumes a position directly perpendicular to the plane of the disk, will indicate on the dial reading, the increase or decrease of speed, due

to nosing up or down, as determined by extent of movement of the stick. Thus, by nosing down with the stick, the motor 236 and its friction disk 238 are tilted to cause that travel of the cylinder 235 that will cause increase of air speed on the instrument. Likewise, in nosing up on the stick, the friction disk rotation and inclination causes the cylinder 235 to travel in the opposite direction and this will operate to adjust the pointer 226 to indicate a reduction of air speed.

Changes in throttle setting likewise have an effect on flying speed and this change is herein indicated by reference to the dial 225*x* through the following mechanism:

It is shown in Fig. 4 that the throttle lever 220 is pivotally mounted for forward and rearward adjustment on a pivot 260, and a link 261 pivotally joins the lever 220 to a link 262 which, in turn, connects with the upper end of link 251. Therefore, when the throttle 220 is pushed forward, it will operate through the linkage 261, 262, and 251 as described to change the position of the motor 236 accordingly and cause the friction disk 238 to impart movement to the cylinder 235 that will operate to indicate, on the dial 225*x*, an increase in air speed.

Due to the fact that both the stick and throttle lever connect to the motor base 240 through connection with the link 251, and this link is arranged to be actuated either by the throttle or stick connecting linkage alone or by both conjointly, it will be understood that the indicated change of speed that may be shown by the nosing up or down action resulting from action of the stick, can be altered by throttle adjustment; that is, it can be increased or decreased to some extent by throttle opening and closing. Likewise, increase or decrease of air speed that is the result of throttle adjustment alone, can be shown to be altered by stabilizer adjustment. However, in actual flight of an airplane, the opening and closing of the throttle causes comparatively little change in air speed, due to the fact that when it is opened to a greater extent, the plane will nose up and when closed down, the plane will nose down accordingly, thereby to some extent nullifying the added power, and this fact is made apparent in the present device by noting the slight change in reading that is made on the air speed indicator when the throttle is opened or closed; this slight change being due to the fact that on opening the throttle, the link 251 is caused to pivot about its point of connection with link 252 rather than about its lower end of connection with arm 250.

Due to inherent characteristics of an airplane, the opening and closing of the throttle in actual flight does, however, cause an increase or decrease in elevation or altitude, and this result is made apparent in the present training device by means now described.

Altimeter

In the present instance, the change in altitude or elevation that may be due to change in control devices, is indicated on an instrument simulating the functions of an altimeter, and which is located on the instrument panel and is designated in Fig. 2 by reference numeral 270. This instrument shown in Fig. 16 comprises a graduated dial 271 with which is associated a dial pointer 272 fixed on a rotatably supported shaft 273. Shaft 273 extends horizontally and to the front of the cab, where it is equipped with a wheel 274 about which a cable 275 is wound; one end of the cable being attached to a spring 275', see Fig. 15 that is anchored to the frame. The other end of the cable extends downwardly from the wheel and is attached to the upper end of a post 276 that is supported for vertical adjustment in accordance with change in condition of controls that would cause the plane to gain or lose altitude. These various connections and their effects will presently be explained.

It is to be understood that this instrument 270 referred to as the altimeter, does not show exact elevations, but rather, operates to indicate changes in reading that would result from the manipulation of various controls that ordinarily would cause a plane in flight to gain or to lose altitude. When a student steps into this training machine and takes over handling of the controls, he is assumed to be flying at whatever elevation then is indicated by the instrument. By manipulation of controls, he can then increase or decrease this reading.

In the flight of an airplane, change in altitude may be due to any of the following: first, to change in throttle adjustment; second, to nosing up or down of the plane; third, to stabilizer adjustment, as for the trimming of the ship; fourth, to banking; and fifth, to change in air speed.

In this training device, connections are provided with the vertically movable post 276 whereby any of the above actions will change its position, and thus effect change in the position of those parts that affect the reading of the altimeter.

As will be observed best by reference to Fig. 16, the post 276 is vertically disposed and is supported at its upper end by a horizontal frame 277 hinged at its forward end, as at 278, to the upper end of the post, and hinged at its other end by a horizontal hinge pin 279 to a bracket 280' (see Fig. 3), that is fixed to the cab wall. At its lower end, the post has pivoted connection with the rear end of an arm 281 as noted in Fig. 16 that is fixed rigidly to and extends rearwardly from the base portion of a rocker frame 282 that is pivoted by a horizontal hinge pin 283 through a mounting bracket 284 fixed to the floor; the hinge pin 283 being directed transversely of the cab so that the upper end of the rocker frame may be swung in the longitudinal direction of the cab.

Supported at the upper end of this frame 282 is a friction cylinder 285 and directly above the cylinder is an electric motor 286 equipped with a friction disk 287 disposed normally perpendicular to the disk axis to frictionally engage the cylinder at its top edge. This motor is supported by a bracket 290 that is pivoted at 290' on the post 276 to swing laterally in a manner whereby to change the angle of the disk in one direction or the other from normal relative to the axis of the cylinder, thereby to cause it to impart endwise travel to the cylinder and thus rock the frame 282 so that it operates through the arm 281 to raise or lower the post 276 and thus through the cable 275, wheel 274 and shaft 273, to move the dial pointer to show a change of indicated elevation on the altimeter.

The change in reading of the altimeter that is caused by change in throttle adjustment is by reason of the following connections, as noted best in Figs. 4, 15 and 17: Pivotally connected with the link 261 which connects pivotally with throttle lever 220, is a forwardly directed link 300 which connects with the vertical leg 301*a* of a bell crank lever 301 mounted by a pivot bolt 302

that is held in the rear end of a horizontal arm 303' of another bell crank lever 303 mounted by a pivot bolt 304 in the frame structure. The bell crank lever 301 has a horizontal leg 301b to which a link 305 is attached as at 306. Link 305 extends downwardly and has a pivoted connection as at 307 with the rear end portion of a horizontally directed lever 308, which in turn has a pivoted support 309 at its forward end, later explained in detail. Depending from the rear end of lever 308 is a link 310 which passes below the floor and is there connected with a rearwardly directed link 311 that has a vertical hinge connection 312 with a rotary cross shaft 313 that is supported at one end from the side sill 7 of the frame and at its other end from the lower end of the joy stick mounting yoke, as shown in Fig. 6. It is also shown in Fig. 8 that the rear end of the link 117 previously mentioned, connects with a crank lever arm 315 that extends downwardly from the cross shaft 313.

The rotary cross shaft 313, as observed in Fig. 6, is made up of a series of short lengths that are hingedly connected together in a manner whereby the oscillating action of the stick 45 will not be interfered with. The shaft 313 is in effect adjustable in length.

The connections just described are such that when the throttle lever 220 is moved forwardly or rearwardly, the cross shaft 313 is given a rotary motion, and this, as understood by reference to Fig. 8, through the link 117, causes a forward or rearward adjustment of the upper or swinging end of the link 112 that will, through linkage previously described, and including link 245, and bell crank 247, cause rotation of shaft 248. The bell crank 247 mounted by the cross shaft 248, as observed in Fig. 4, has a rearwardly extended arm 247' to which the rear end of an angular link 321 is pivoted as at 322; the link 321 has pivoted support at its forward end on the upper end of a link 323 mounted at its lower end on arm 325 laterally extended from the rocker frame 231. Supported from the floor of the cab near its forward end, as seen in Figs. 15 and 16 is a vertical frame 330 which, at its upper end mounts a bell crank 331 by a pivot bolt 332. This bell crank has a horizontal arm connected by link 333 with the medial portion of link 321, and it has a vertical arm connected by a link 334 with a lever arm 334A which in turn is fixed to the motor base frame 290, as noted in Fig. 18.

The action of the throttle lever 220 that imparts slight rotary motion to cross rod 248 causes the linkage above described to effect an adjustment of the motor base 290 that changes position of the friction disk 287 relative to the cylinder 285, thus by movement of the cylinder, to cause the frame 282 to swing forwardly or rearwardly, and thus effect vertical adjustment of post 276 and incidentally through cable connection 275 with shaft 273 to effect change in the altitude reading.

In the flying of an airplane, stabilizer adjustment is frequently made in order to change altitude or maintain flying altitude. In other words, the stabilizer adjustment will affect the altitude of the flying plane. This is demonstrated in the present mechanism by the following means:

It is shown in Fig. 4 that the stabilizer adjusting crank 221 is fixed to a mounting shaft 339 having a gear 340 thereon meshing with a gear segment 344 from which a horizontally and forwardly directed arm 343 extends. The lever 308 previously mentioned, is pivoted at its forward end at 309 to the forward end of this segment arm. Therefore, when the crank 221 is rotated, the segment 341 is adjusted accordingly and through the connection of lever arm 343 with lever 308, and the linkage 310 and 311 with the cross shaft 313, will rotate the latter to effect the change in altitude adjustment through the same linkage as accomplished by the throttle adjustment. Thus, it is provided for in this device that regardless of throttle position, or stick position at any time, the trimming of the plane in flight by a stabilizer adjusting operation simulated by rotative movement of crank arm 221, will have an effect on altitude reading just the same as in actual flight.

Change in air speed in the airplane also affects altitude. In the present machine, air speed at any time is indicated by that instrument on the instrument panel which I refer to as the "air speed indicator," designated at 225x, and which is operable under control of the friction cylinder 235. An increase in air speed operates to lift the nose of the plane in actual flight, and this same result is made apparent in the present machine by the raising of the nose of the model plane. Likewise, decrease in speed permits the nose of a plane in flight to lower and this is also demonstrated by reference to the model plane when the various controls affecting speed are manipulated.

Whenever the air speed motor 236 is adjusted through the manipulation of any of the controls which have been described to effect a change in position of the air speed friction cylinder 235, the rocker motion of frame 231 is transmitted through linkage already described to the cross shaft 313 to operate through link 117, see Fig. 9, to change the position of the link 112 from rearwardly inclined position toward a vertical position, and thus to lift rod 110 as previously described, thus to change the position of the model plane and also through the cable connection 229 to change the altitude reading. The bell crank 330 shown in Fig. 4, has a downwardly directed leg 303b connected at its lower end to a forwardly directed link 355 which at its forward end is connected pivotally with an arm 356 extended from the base of the rocker frame 231. Thus, rocker action of frame 231, causes the bell crank 303 to be rocked accordingly. This action of bell crank 303 lifts or lowers bell crank 301 and this, through links 305, 308 and 310, and 311 rotates cross shaft 313.

Due to inherent characteristics of an airplane in flight, banking to right or left causes the plane to nose down. This result is demonstrated in the present mechanism. Mechanism has already been described providing that whenever the stick is moved to either side for banking, the motor 136 is adjusted accordingly and the rocker frame 128 swings laterally to operate through rod 124 to bank the plane accordingly.

To obtain the nosing down action of the model plane that is due to banking, I have fixed on the cab floor, adjacent the frame 128, as shown in Fig. 25, the bracket 207 in which bell crank 205 is mounted. Also mounted in the bracket, by the pivot pin 206, is a lever 360, shown best in Figs. 27 and 28, having a downwardly and laterally directed lever arm 361 to which the forward end of a horizontal link 362 is pivotally attached. The rear end of this link is pivotally connected to the link 112. The ends of lever 360 extend equally to front and rear of pivot 226. Overlying the opposite ends of lever 360 and slidable thereon,

are bars 364—364a, each pivoted on the frame 128. Bar 364 has a hook 365 at its end adapted to engage with the lever 360 to pull it with the frame 128 when the latter rocks outwardly. Bar 364a has a stop 365x at its end to engage the other end of the bar 360 to push it with the frame 128 when it swings inwardly from neutral position. Thus, regardless of the direction of swing of frame 128, the lever 360 will be actuated in the same direction to pull the link 112 forwardly and thereby, due to the forward and upward swinging of the link, to lift rod 110 and thus cause the model plane to be nosed down accordingly.

Naturally the stick adjustment forward or rearward for nosing down or up will change the altitude of the plane. In this mechanism, when the stick is moved forwardly or rearwardly, the assembly of links including links 114 and link 112 connected to link 117 by pivot bolts 113 and 116 moves up or down accordingly with the swing of link 114 and by reason of connections made with the altitude motor through link 245, adjusts it accordingly, to change the reading of the altimeter.

It will be here mentioned also that in the flight of an airplane at normal speed, banking to the right or left will change the position of the ball bank indicator. If the plane should be banked to the right, the ball will move to the right unless more right rudder or left stick is applied. At a slower air speed, this is more pronounced. Therefore, in order that this training device will simulate this particular item, I have provided the means shown best in Figs. 7 and 25 whereby change in air speed will affect the position of the ball bank indicator, making it more or less pronounced with increase or decrease of speed.

Rod 78 is seen in Fig. 7 and Fig. 7a to be equipped at near its rear end portion with a lever arm 78' and to be rotatably mounted by a bracket 400 near its forward end, where it is equipped with a crank arm 401 connected by link 402 (see Fig. 27) with the rocker frame 128. When frame 128 rocks, it causes shaft 78 to be rotatably adjusted, and thus to cause lever arm 78' to swing up or down accordingly. Rod 77 connects at its lower end to a rod 410 that extends along rod 78 and is pivoted thereon at 411. The rear end of rod 410 engages the under side of arm 78' and therefore the extent of movement of rod 77 that may be due to rotation of rod 78 is increased or decreased in accordance with the position of rod 410 relative to the radial center of arm 78'. The position of rod 410 is determined by the adjustment of a roller 415, between the portions of rods 78 and 410 forward of the pivot 411. This roller is carried on a link 416 that extends forwardly and as seen in Fig. 19 is connected to an arm 420 that extends up from the outer end portion of the lever arm 325 that is fixed to the base of the pivoted frame 231 that carries the friction roller 235. Thus, when frame 231 is rocked toward front or rear of the machine in accordance with a change of speed, the roller 415 is adjusted accordingly toward or from the pivot 411 to increase or decrease the effective radial length of the lever arm 78' so that in the rotation of shaft 78 the movement of ball 65 as produced through the control devices, will be more or less pronounced in accordance with change of speed.

Gyro-horizon

In order that the student in training in the present cab may visually ascertain the position of the plane relative to a normal position of horizontal flight by reference to instruments on the instrument panel 5, there is provided thereon an instrument designated at 350 in Fig. 2 to stimulate the actions and functions of the gyro-horizon. As shown in Figs. 29, 30 and 31, this device includes a transparent plate 361 that is set in an opening 362 in the panel and on which plate a horizon line 363 is marked, and about the dial is an arc that is graduated in degrees. Back of the plate is a movably mounted horizontal bar 365 and this is supported for upward or downward movement from one end of a rocker frame 366 fixed to a horizontal cross shaft 367 rotatably carried in a mounting bracket 368 on the back of the panel 5. Fixed to the shaft, and extending forwardly, is an arm 370 with a lateral bend 371 that rests upon the rearward end portion of a rod 372, pivotally mounted, as at 373, by a support 374. A link 375 operatively connects this bar with the sleeve 105 so that the adjustments of this sleeve that moves the model plane from horizontal to an upwardly or downwardly nosed position, will likewise cause action of the rocker frame 366 that will shift the horizonal bar 365 above or below the horizon mark on the dial. Extending through the bar 365, at its center, and rotatable therein, is a flexible wire shaft 378. At its end that is adjacent the dial, this wire has a horizontal cross arm 380 fixed thereon. At its other end the wire shaft connects with a forwardly extending rod 381, rotatable in a support 382. On the rod is a lateral arm 383 and to this is pivotally attached a rod 384 that extends downward and at its lower end is pivotally attached to an arm or lever 385 extended from the frame structure 128 which supports the friction cylinder 131. When the cylinder is in neutral position that would show the plane not to be banked in either direction, the cross arm 380 will be held in a horizontal position, but should the controls be so operated as to cause banking, this action, as transmitted to the model plane through the travel of the friction cylinder 131 will cause the rod 381 to rotate accordingly and thus tilt the cross arm relative to the horizon line to show the relative angle of bank. Also, it will be understood that the movements of the model plane in a nosing up or down action will be made apparent by the resultant relative adjustment of the bar to position above or below the horizon line on the dial.

Tachometer

To designate revolutions per minute, or more particularly, to designate a change in revolutions per minute, I have provided a tachometer simulating device designated in Fig. 2 at 450 located on the instrument panel 5. This device has a marked dial 451 with which a pointer 452 is associated. The pointer is fixed on a shaft 453 that extends forwardly from the panel and is rotatably mounted in a supporting bracket 454. Fixed on the shaft, is a wheel 455 about which a cable 456 is wound; the cable being anchored at one end by a spring 457, and extended at its other end across the frame downwardly about a guide roller 458, and is attached to an arm 460 that extends from a lever 461 mounted on the side of the cab frame, as is shown in Fig. 4. The lever 461 is mounted by a pivot 462 through its lower end portion and is connected pivotally at its upper end to the link 261 so that, with the adjustment of the throttle lever 220 it will be moved and through the cable 456, the tachometer reading is caused to change accordingly. It is desirable also that any change

in air speed indication should be reflected in the tachometer reading, and I have accomplished this by connecting the lower end of lever 461 with the rear end of a link 535 which, at its forward end, connects with the lever 525 that is fixed to the frame 231 that supports the roller 235 which shifts in accordance with changes in air speed indication.

I have also provided an instrument on the panel 5 for indicating the rate of change of altitude. This is designated in Fig. 2 by reference numeral 470, and as shown in Fig. 19 comprises a graduated dial 471 with which a pointer 472 is associated. The pointer is mounted by a rod 473 which extends forwardly therefrom and is rotatably supported at its forward end in a bracket 474 fixed to the frame structure; this being shown in Figs. 15 and 19. On the forward end of the shaft is a wheel 475 about which a wire cable 476 is wound; one end of the cable being fixed by a spring 477 to the frame structure, and the other end being attached to a lever arm 478 that is fixed rigidly to the bell crank 331. As has been explained, the position of the bell crank changes with the rate of change in altitude as influenced, among other things, by throttle adjustment and stabilizer setting. Therefore, the position of the pointer 472 with respect to the dial 471 will be in accordance with the angular position of the disk 287 with respect to the cylinder 285, and the direction of inclination of the disk with respect to one side or the other side of the cylinder, will determine whether the pointer designates decreasing or increasing altitude.

With reference to the motor mountings and linkage shown in Figs. 21 to 24 inclusive: Explanatory to this, it may be said that in the normal flight of an airplane, once a bank has been started to make a turn, there is a natural tendency for the bank to get steeper because the wing on the outside of the turn has a greater distance to travel and therefore it will travel faster and thus has a greater lift. This result requires some stick adjustment in the opposition direction to which the plane is banked in order to overcome this tendency of the bank to get steeper. It is shown in Fig. 22 that the motor 135 is supported by an arm 140 from a slide 500 that is normally supported in an inclined position on a guide 501, as observed in Fig. 21. To this slide, a strap 502 is pivotally fixed as at 503, whereby the slide may be caused to move up or down when a change in the bank is effected; this movement being by reason of a connection shown in Fig. 25 wherein a link 506 is shown as pivotally connected at its upper end, as at 507, to the slide, and at its lower end, as at 508, to a lever arm 509 that is fixed to the rocker frame 128.

Disregarding air speed, and remembering that the slide is normally held at an incline as seen in Fig. 21, it will be understood that if the model airplane should bank in either direction, the slide will move accordingly to move the motor mounting forward or rearward to give an overbanking tendency which requires opposite stick to prevent the bank from getting steeper. In actual flight, this overbanking tendency is greater at the slower speeds, and in this flight trainer, this is taken care of through the linkage shown in Fig. 21, wherein a lever arm 520 connects with the guide bar 501 which is supported by a pivot bolt 521, and at its end has a link 522 connecting it with a lever arm 525 on the frame 231. It is to this lever arm 525 that the link 535, previously mentioned, is attached as a means through which change in air speed will effect movement of the lever 461 and arm 460 to effect a change in tachometer reading.

Having thus described my invention, what I claim as new therein and desire to secure by Letters Patent is:

1. A stationary airplane flight trainer comprising conventional type hand and foot controls, and a movable ball bank indicator element simulating parts of an airplane; separate operating connections between the ball bank indicator element and the foot and hand controls whereby the indicator element will be moved to various positions indicating unstable flight by functional movements of either the foot controls or the hand control, said connections being interconnected in a manner whereby the moving influence on the indicator element, as produced individually by either one of the controls, may be nullified by movement of the other.

2. A stationary airplane flight trainer comprising conventional type joystick and foot controls, and a ball bank indicator element simulating an airplane, devices operatively connecting the stick with the ball bank indicator element whereby movement of the stick simulating that for aileron adjustment, will cause the ball bank indicator to move accordingly, and means operatively connecting the foot controls with the said devices whereby their moving influences on the ball bank indicator element will be nullified by that movement of the foot controls that in actual flight would be required to maintain the plane in stable flight.

3. A stationary airplane flight trainer comprising, independently operable hand and foot controls, and a ball bank indicator element simulating parts of an airplane, devices operatively connecting the ball bank indicator element with the hand control and foot controls and through which functional action of the foot controls as for producing rudder adjustment, will cause the ball bank indicator to move accordingly, and through which the moving influences on the indicator element as produced by the foot controls may be nullified by a stabilizing adjustment of the hand controls that in actual flight would stabilize the plane.

4. A stationary airplane flight trainer comprising, hand and foot controls and a movable bank indicator element in simulation of an airplane; a motorized means connected to move the bank indicator element to indicate conditions of unstable flight, and means connecting the hand and foot controls with the indicator element through which movements of the said hand and foot controls, made as required for stabilization of an airplane when flying under the conditions indicated, by the ball bank indicator element, will nullify the moving influence on the bank indicator element as imparted thereto by said motorized means.

5. In a flight trainer of the character described, a hand control lever operable laterally in opposite directions from a neutral setting as for aileron adjustment to effect banking, a movable bank indicator element, a motor driven crank connected with said element to move it back and forth through its neutral position, a movable support for the motor driven crank, means connecting the support with the hand control lever whereby it may be held stationary, thereby to cause the crank to impart movement to the indicator element, or whereby it may be

moved in synchronism with the turning of the crank to nullify the moving influence of the crank on the indicator element.

6. A stationary airplane flight trainer, comprising a frame, hand and foot controls, in simulation of an airplane, a model airplane supported from the frame for the various flight movements and motorized means operable under control of action of the hand and foot controls to cause turning, banking and up or down nosing of the model plane on its support in accordance with the movement of the said hand and foot controls.

7. In a stationary airplane flight trainer comprising a cockpit frame, hand and foot controls, and seat, in simulation of an airplane, a model airplane and means supporting said model airplane for universal movement thereon, a motorized means for causing said model airplane to turn on its support, motorized means for causing the model to bank to either side, means actuated by the movements of these said hand and foot controls to govern the said motorized means, to cause turning and banking of the model airplane in accordance with their extent and direction of movement, and to simulate the action in flight of an airplane operated under similar conditions of control.

8. A stationary airplane flight trainer comprising conventional type hand and foot controls and a ball bank indicator element simulating parts of an airplane, an operating connection between the hand control and the ball bank indicator element whereby movement of the hand control from a neutral position as for banking in either direction, will cause the ball bank indicator to move to a position indicating an unstable condition of flight, and an operating connection between the foot controls and the indicator element, whereby that movement of the foot controls that in ordinary flight would be required to place the plane in stable flight, will return the indicator element to its neutral position.

9. A stationary airplane flight trainer comprising conventional type joystick, a rotatably mounted shaft, a model airplane mounted on the shaft to be turned in opposite directions thereby, a motorized means for rotating the shaft in opposite directions, and means operable under control of the joystick by its movement from a neutral position toward either side to cause the said motorized means to turn the shaft accordingly.

10. A stationary airplane flight trainer comprising conventional type joystick, a rotatably mounted shaft, a turning disk for the shaft fixed coaxially thereof, a model airplane mounted on the shaft to be turned thereby in opposite directions, an electric motor, a friction disk fixed to the motor shaft and engaged at its periphery with the shaft turning disk and normally positioned in the axial plane of the shaft, means operatively connecting the joystick with the motor whereby movement of the stick toward either side will tilt the friction disk accordingly to cause it to drive the shaft turning disk in a direction as determined by the direction of tilt and at a speed that increases or decreases with the change in degree of tilt.

11. A stationary airplane flight trainer comprising conventional type stick and foot controls, a rotatably mounted shaft, a model airplane mounted on the shaft to be turned in opposite directions from a neutral position thereby, and pivoted on the shaft for banking to either side, motorized means for turning the shaft in either direction, motorized means for banking the plane in either direction, and devices operated by the stick to control the first mentioned motorized means to turn the shaft and plane in accordance with the direction of movement of the stick, and means operated by the action of the foot controls to modify the turning action produced by the action of the stick.

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