

Dec. 14, 1943.

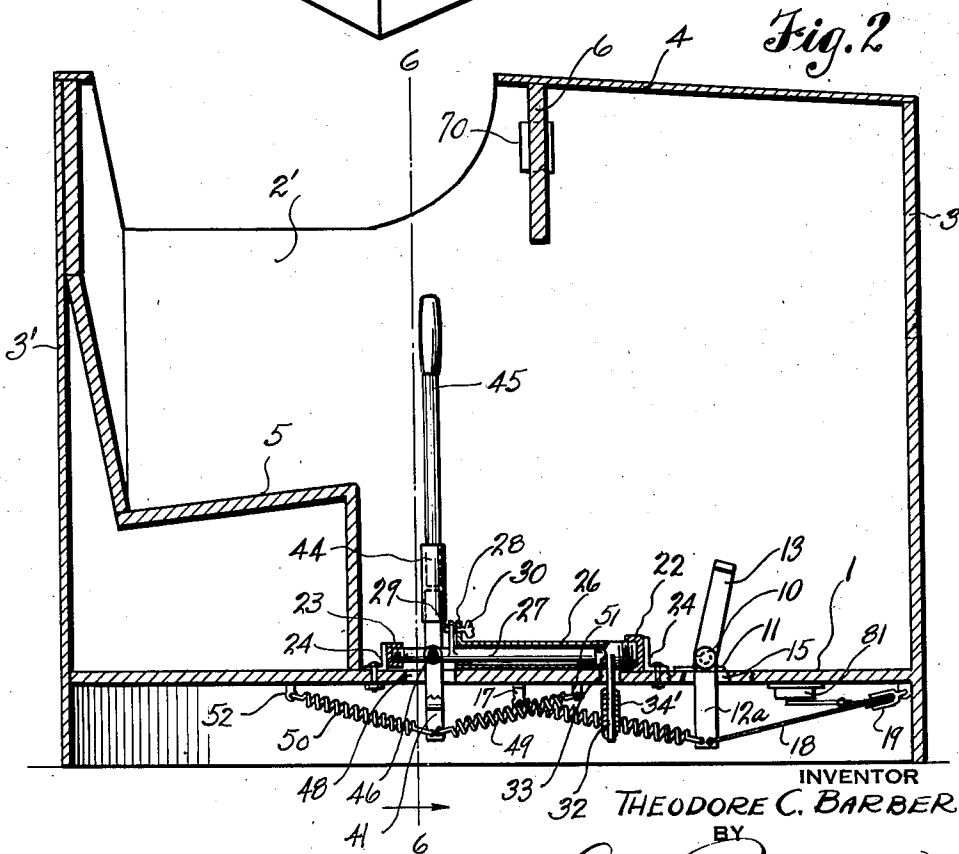
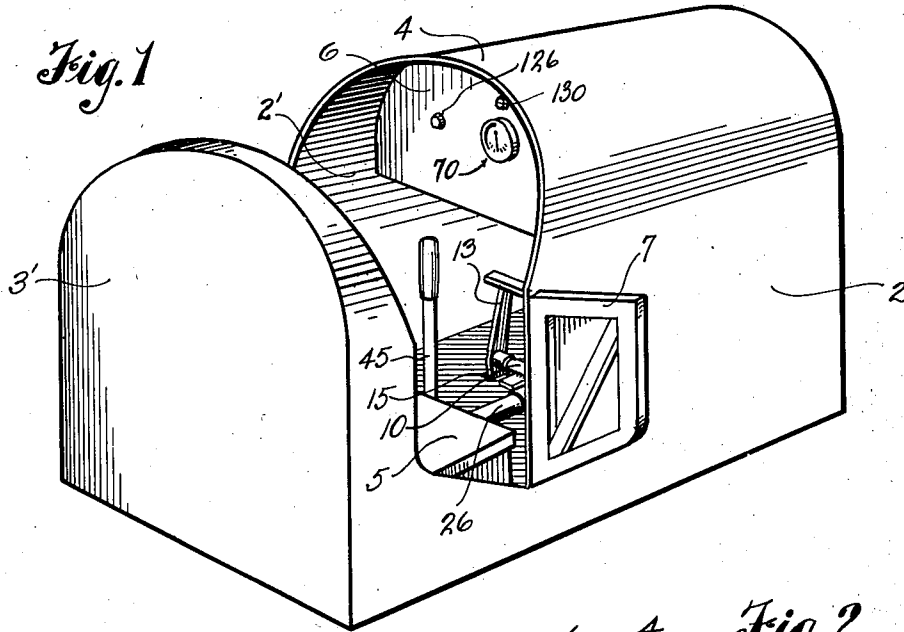
T. C. BARBER

2,336,711

FLIGHT CONTROL COORDINATOR

Filed Nov. 10, 1941

4 Sheets-Sheet 1



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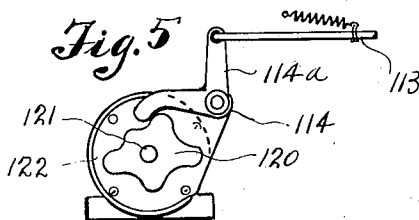
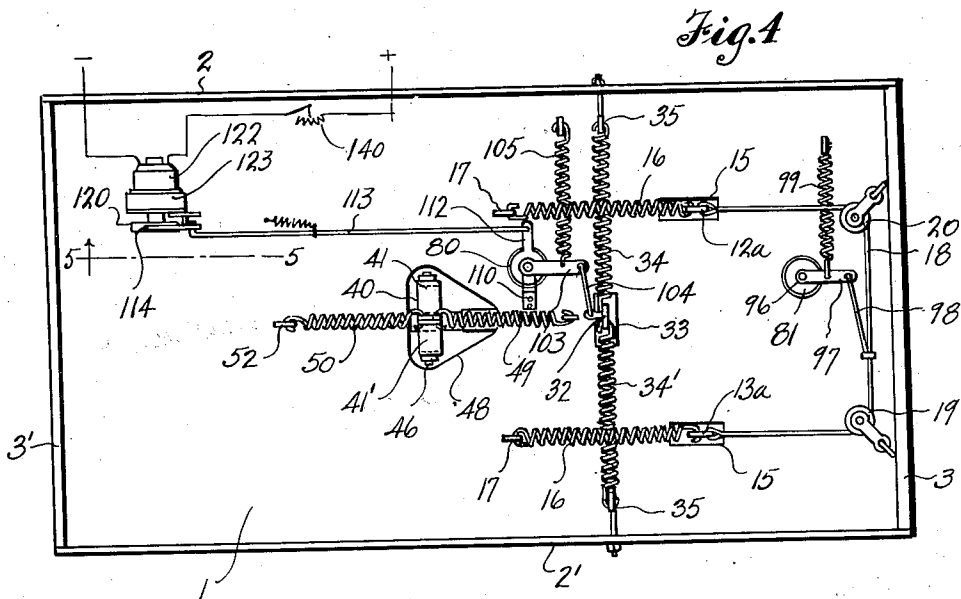
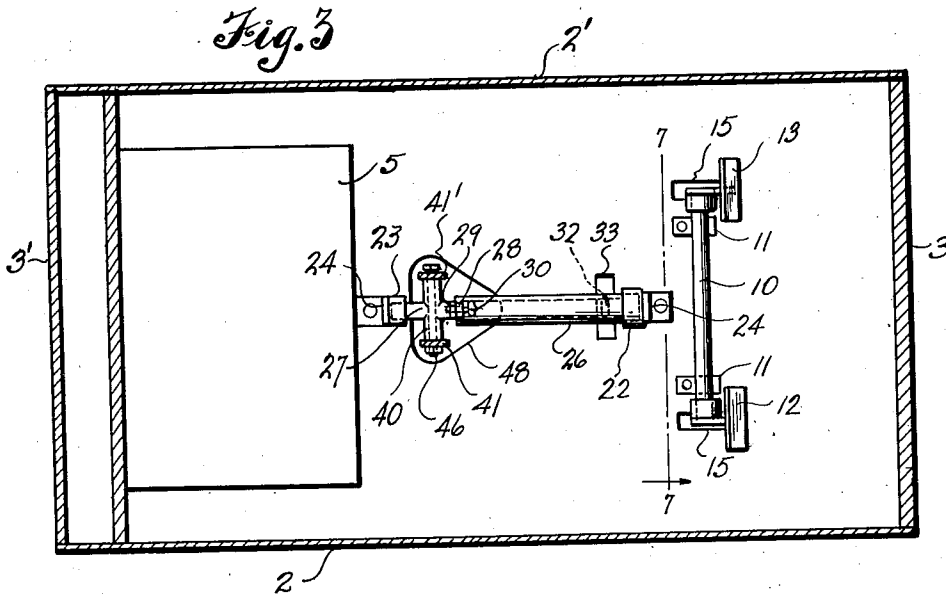
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4 Sheets-Sheet 2



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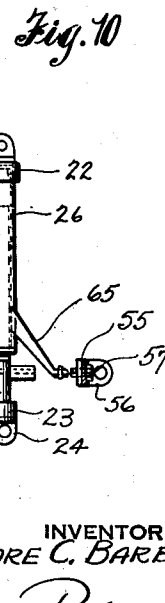
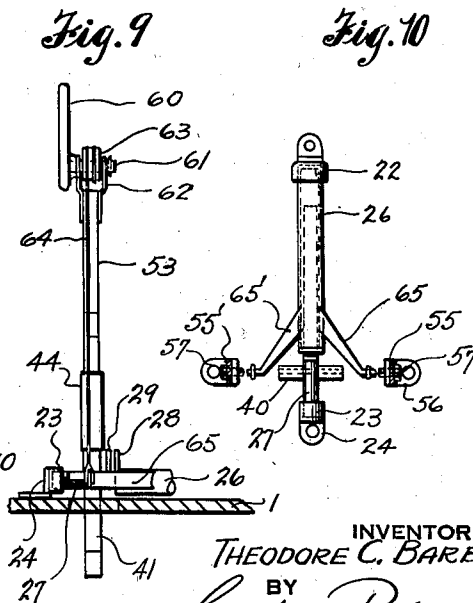
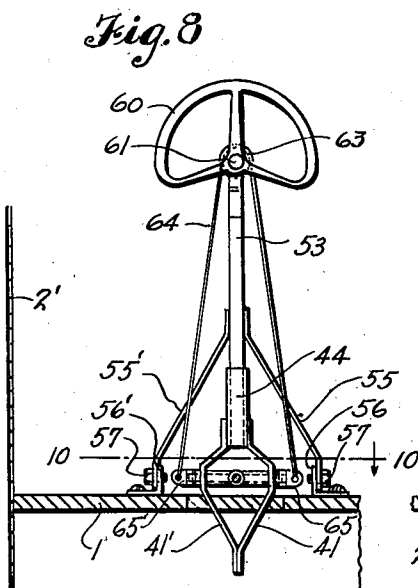
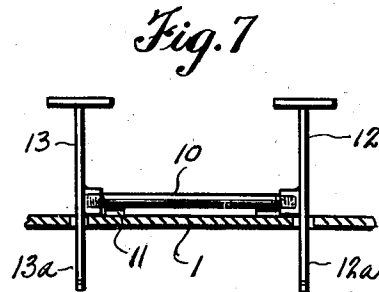
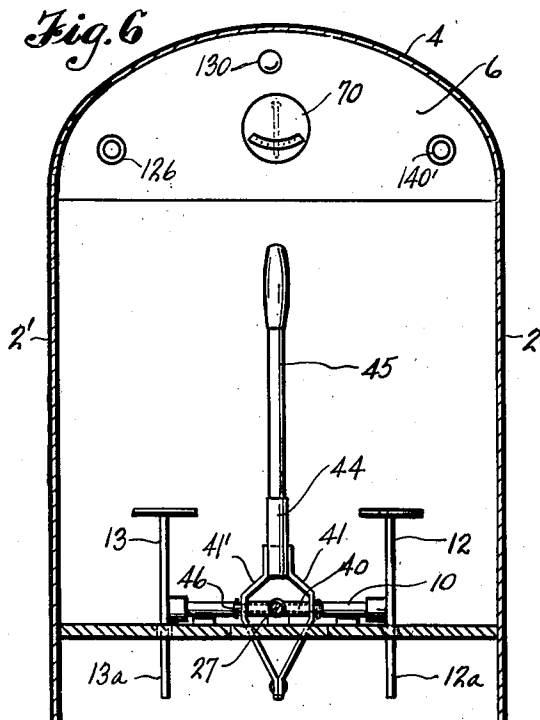
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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

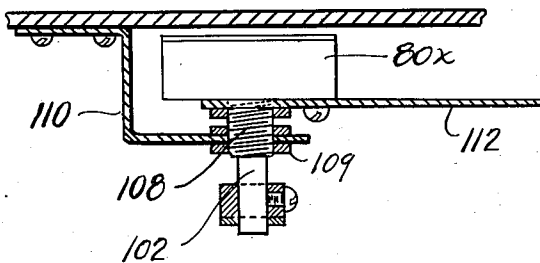
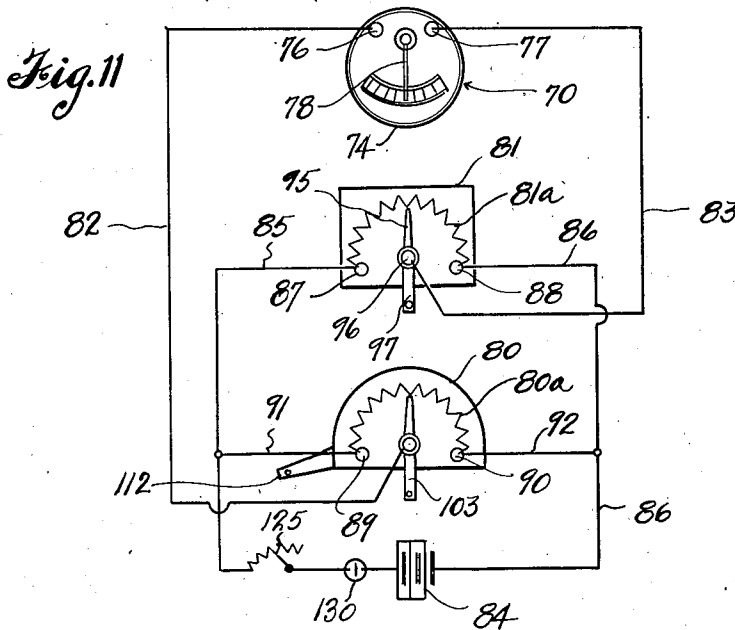


Fig. 12

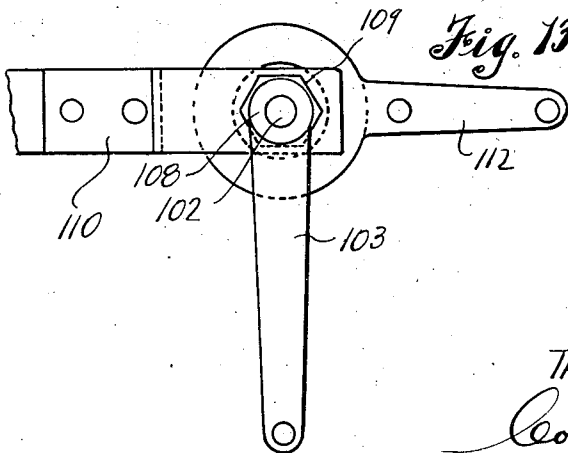


Fig. 13

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UNITED STATES PATENT OFFICE

2,336,711

FLIGHT CONTROL COORDINATOR

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Application November 10, 1941, Serial No. 418,579

5 Claims. (Cl. 35—12)

This invention relates to means designed to be used as an aid in the training of airplane pilots, and it has reference more particularly to the provision of means whereby student pilots may be taught, while on the ground, the proper coordination of the usual hand and foot controls, which, in the actual flight of an airplane, are operated conjointly to maintain the airplane in stable flight.

More specifically stated, the present invention resides in the provision of a training device for the purpose above stated, which for convenience will be referred to as a "training cab"; this cab being designed to rest upon the ground, or upon any suitable floor, and which is preferably similar in form and appearance to the pilot's cockpit or compartment in the typical training plane, and is equipped with an instrument panel on which a bank indicator is mounted, and an artificial means not under control of the student in training, is provided for causing movements of the bank indicator to take place, to simulate those of the bank indicator of a plane in flight. Also, there are hand and foot controls, like those in the typical airplane, operable by the student in the same manner and by the same coordination as would be required in actual flight, to counteract the artificially induced movements of the bank indicator and thus cause the return of the bank indicator to a stable or neutral indication.

Explanatory to the invention, it will here be stated that, generally speaking, the control and stability of an airplane in normal flight is maintained by the proper manipulation of ailerons, rudder and elevators. These controls are placed under control of the pilot through the mediacy of right and left foot controls or pedals, and a hand lever, referred to as the "stick" which lever is pivoted for forward and rearward, and also lateral oscillations; the direction of flight, or the control of flight being dependent upon the conjoint action of the rudder, elevators, and ailerons, as actuated by the above mentioned controls.

In the usual arrangement and connection of hand and foot controls, the pivoted "stick" has cable connections with the plane's elevators whereby direct forward and direct rearward oscillating movements of the stick will cause actuation of the elevators for directing the plane downwardly and upwardly. The stick also has cable connections with the ailerons of right and left wings whereby hinging actuation of the ailerons for banking toward one side or the other, according to the direction and extent of movement of the stick, may be effected.

The two foot pedals have cable connections with the rudder, and these connections provide that the pedals may be used selectively to effect actuation of the rudder for right or left turning. To those familiar with this art, it is understood that in making a turn to right, or left, under influence of the rudder movement, it is the accepted practise that the stick be actuated at the same time to move the ailerons to accomplish the proper banking of the plane to maintain it stable during the turning operations.

As an aid to flight control, airplanes are normally equipped on the instrument panel at a location conveniently visible to the pilot, with a gravity actuated bank indicator which visibly indicates whether or not the plane is in stable flight.

It is understood, furthermore, that for the proper or satisfactory control of a plane in flight, there must be proper coordination of the controls, as operated by hand and foot. In actual flight, the pilot endeavors to maintain the bank indicator at a neutral indication, in turning and banking, as well as in straight flight, and this may be accomplished through the proper coordination of the hand and foot controls, the exact manipulations of which might vary under different flying conditions and at different speeds, and while in some unusual situations, stability in flight might be maintained by the manipulation of hand or the foot controlled devices individually, it is the usual practise, and is the accepted procedure, that stability be accomplished through the conjoint and properly coordinated action of foot and hand controls.

In view of the foregoing, it has been the principal object of this invention to provide means for expediting the training of student pilots in the rudiments of handling and controlling an airplane in flight, and more particularly for expediting the teaching of proper coordination of movements of hand and foot controls, to maintain stable flight.

The invention also has for its object to provide improvements upon the device of my co-pending application, filed on February 11, 1941, under Serial No. 378,407, particularly in the simplification of means for causing the various movements of the bank indicator which are to simulate those indicating conditions of unstable flight, and also in the means and devices operable under control of the hand and foot actuated members, for causing the application of compensating influences, or counteracting forces on the bank indicator whereby to cause it to

return to its neutral position or to a position indicating the desired stability of flight.

Still another object of the invention is to simplify the structure of the device which is the subject of the above mentioned application, particularly by the elimination of the more or less complicated arrangement of cable connections between the hand and foot controls and the bank indicator, and to employ in their stead simple and practical electrical equipment and controls accomplishing the same results.

Still other objects of the invention reside in the details of construction of parts, in their relationship, and in their mode of operation, as will hereinafter be fully described.

In accomplishing these and 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 training cab.

Fig. 2 is an enlarged sectional view of the same, in the longitudinal vertical plane.

Fig. 3 is a horizontal section on line 2—3 in Fig. 2.

Fig. 4 is an underside view of the cab floor, showing the relationship of parts mounted thereby.

Fig. 5 is a detail of the motor driven means for effecting the artificial actuation of the bank indicator.

Fig. 6 is a cross section on line 6—3 in Fig. 3 showing the joy stick mounting.

Fig. 7 is a cross section on the line 7—7 in Fig. 3 showing the foot pedal mounting.

Fig. 8 is a view showing the manner of mounting the stick and wheel which may be used as an alternative in lieu of the stick as shown in Fig. 6.

Fig. 9 is a side view of the parts as seen in Fig. 8.

Fig. 10 is a horizontal section on line 10—10 in Fig. 8.

Fig. 11 is a wiring diagram and diagrammatic illustration of the electrical controls.

Fig. 12 is a detail of the mounting of one of the rheostats used.

Fig. 13 is a plan of the same.

In brief, the present invention comprises a training cab, resembling the cockpit section of an airplane, and equipped with a bank indicator and means whereby the bank indicator may be caused to move from side to side with rather irregular and varying movements. Also, wherein means is operable under control of hand and foot controls, like those of the typical airplane, whereby to counteract the moving influences artificially produced on the bank indicator and which cause its irregular movement, so that the indicator may be maintained at a neutral position. It is the intent that the coordinated movements of hand and foot controls must be substantially the same in this training cab, to maintain a stable indication of the bank indicator, as would be required in an actual flight under like action or indications of the bank indicator.

Referring more in detail to the drawings—

The training cab embodied by this invention preferably is in accordance with the showing of Fig. 1, and for most satisfactory results is made to resemble the cockpit portion of a typical airplane. Such cabs may be constructed in various dimensions and of different materials suitable

for its intended purpose. As here shown, the cab has a horizontal floor 1, right and left side walls 2 and 2', front and rear end walls 3 and 3', and a cowl 4. The construction of the cab resembles that found in an open cockpit airplane and there is a chair, or seat 5 for occupancy by a person in training, and forwardly of the chair, and directly below the cowl, is an instrument panel 6.

For convenience in use of the cab, the side wall 3 thereof is equipped with a hinged door 7 giving easy access to the cockpit. It is also to be observed that the horizontal floor 1 is supported somewhat above the level of the foundation on which the cab rests in order to give the necessary clearance for parts supported below the floor, as will presently be explained.

Disposed transversely of the cockpit, in its forward portion and closely adjacent the floor, is a horizontal tube or shaft 11, rigidly supported by brackets 11 that are welded thereto near its ends and which are bolted or otherwise secured to the floor 1. Revolvably supported by the tube, or shaft 11, at its opposite ends and adapted for independent oscillation, are upwardly directed, right and left foot pedals 12 and 13, each of which has a lever arm projecting downwardly therefrom, and extending somewhat below the floor through openings therein. The openings in this showing are designated by reference numerals 15, and the downwardly extending levers, for foot pedals 12 and 13, are designated respectively by numerals 12a and 13a.

By reference to Fig. 8, which shows the parts at the underside of the floor 1, it will be observed that a coiled spring 16 is associated with each of the levers 12a and 13a, and are attached under tension to the lower ends of these levers. Also, the springs have connection with posts 17 fixed in and extended downwardly from the floor. Also, there is a cable 18 attached at its opposite ends, respectively, to the lower end portions of the levers 12a and 13a, and extending forwardly therefrom and about laterally spaced guide sheaves 19 and 20, providing that a part of the cable extend transversely of the floor. The pull of the two springs 16 on the levers causes the cable 18 to be drawn taut and provides further that forward pressure on either one of the pedals will effect a corresponding rearward movement of the other pedal; this being a condition like that in training airplanes.

Referring now more particularly to Figs. 2 and 3, it is to be observed that bearings 22 and 23 are fixed in spaced relationship on floor 1 in the central, longitudinal line of the cockpit, rearwardly of the cross rod 10 and forwardly of the seat 5, each bearing member having an attaching bracket 24.

Rotatably supported by the bearings 22 and 23 are the forward and rearward ends of a horizontal shaft comprising a tubular outer portion 26 and a round rod 27 that has a part thereof telescopically and rigidly contained in the tube. The forward end portion of the tube 26 is revolvably threaded into the forward bearing 22 while the rearward end of the rod 27, which extends somewhat beyond the rear end of the tube, is revolvably threaded into the bearing 23. A lateral ear 28 is fixed on the rear end of tube 26, and coinciding with this and fixed on the rod 27 is a lateral ear 29, and a bolt 30 is threaded through the ears 28 and 29 to fix the tube and rod against relative rotation. This particular connection will

later be referred to in describing the use of the alternative stick shown in Figs. 6 and 7.

A lever arm 32 is fixed rigidly to and extends directly downward from the forward end portion of the tube 25, passing through an opening 33 in the floor. Located below the floor, at opposite sides of the opening, and transversely directed, are coiled springs 34—34' which have inner ends fixed to the lower end portion of the lever arm 32 and their outer ends fixed to posts or studs 35 in the floor. These springs extend laterally in opposite directions from the lever arm and are fixed under balanced tension whereby the lever arm is normally yieldingly held in vertical position.

Fixed to the rearward end portion of the rod 27 and extending equally to opposite sides thereof is a tubular cross rod 40, and pivotally mounted by the cross rod is the mounting means for the joystick. This, as best shown in Fig. 6, comprises a yoke having opposite side straps 41 and 41', spaced at the medial portions, then directed toward each other 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 socket member 44 in which the lower end of a lever, or stick 45 is fitted. The two side straps 41 and 41' of the yoke pass across the opposite ends of the tubular cross member 40, and a pivot bolt 46 is extended therethrough and through the tube to thereby pivotally mount the yoke for forward and rearward oscillation of the stick, and it will be understood also that the stick may be oscillated laterally in opposite directions by reason of the rotatable mounting of the longitudinal support in the bearings 22 and 23.

The lower end portion of the yoke that is formed by the uniting of the lower end portions of the straps 41—41', extends down through an opening 43 in the floor. At the under side of the floor, coiled springs 49 and 50 extend forwardly and rearwardly from the opening 43. These springs have adjacent ends fixed to the lower end portion of the yoke, and have their other ends fixed, respectively to posts 51 and 52 that are fixed in the floor. These two springs are under balanced tension and normally act to retain the stick in an upright, neutral position.

One of the features of this invention resides in the provision for an interchangeable use of two different types of hand controls; one being the usual joy stick already described, which may be oscillated from a neutral upright position, laterally from side to side, and also from front to rear, while the other type of control comprises a lever, or stick, that may be moved directly forwardly or rearwardly for control of the elevators but in lieu of the lateral movements for control of the ailerons, carries at its upper end a rotatable hand wheel with cable connections for the rotative action of the tube 26.

To use this alternative type of stick, it is required that the bolt 30 which fixed the parts 26 and 27 against relative rotation, be removed, the joy stick 45 withdrawn from its socket, the alternative stick applied to the socket, and parts attached to the floor as will now be described.

The alternative device has been illustrated in Figs. 8 to 10 where the joy stick 45, as previously used, has been replaced by a stick 53 which likewise is removably applied to the socket 44. This stick is provided with laterally extending and downwardly inclined brace rods 55 and 55' which, at their lower ends, have pivoted connection with brackets 56 and 56' that are fixed to the floor at

opposite sides of the floor opening 43. The pivotal connections are affixed by means of bolts 57 which extend through the lower ends of the brace rods and the corresponding brackets, and it is to be observed that the bolts 57 are aligned coaxially with the horizontal pivot bolt 46.

Rotatably mounted at the upper end of the lever 53, is a hand wheel 60 fixed on a supporting shaft 61 that revolves in a bearing 62 at the upper end of the stick. Fixed on the shaft is a pulley 63 about which a cable 64 is wound and secured, with the opposite end portions of the cable extended downwardly and laterally and attached, respectively, to the ends of laterally and rearwardly extended lever arms 65 and 65' fixed to the tubular member 26. These arms also extend to the axial line of the bolt 46 where the cable connections are made therewith.

In the use of this alternative control, with the bolt 30 removed from the ears 28 and 29, the tubular member 26 may be rotated by the turning of the hand wheel through the mediacy of the cable connections. The stick 53, however, still has a forward and rearward movement like that of the joy stick 45 previously described.

For the purpose of training the student pilot in control coordination, there is provided centrally, or at other location conveniently visible upon the instrument panel 6, a bank indicator 70. This indicator, in this instance, is an electrical instrument and is mechanically controlled to artificially produce certain movements of its indicator element which are intended to simulate those of a bank indicator in an airplane when flying in an unstable manner. Also, there are means controlled by the student pilot for counteracting and compensating for these artificially produced movements of the bank indicator; it being the intent that the pilot in training shall, by those certain coordinated movements of the hand and foot controls, as would be required in actual flight, cause the application of counter-acting forces which will maintain the bank indicator at, or return it to a stable indication.

The bank indicator 70 in this instance, is an instrument like an ordinary milliammeter operating as a galvanometer. This indicator comprises a housing 74 that is fixed to the panel 6. In the housing is the usual resistance coil, not shown, with terminal connections 76 and 77. Also, there is the bank indicator needle 70, normally vertically disposed at its zero or neutral position, and movable in opposite directions therefrom. The positive and negative poles 76 and 77 of the indicator are electrically connected, respectively, by circuit wire 82 and 83 as illustrated in Fig. 11, with the movable resistance varying elements of rheostats 80 and 81, as seen in Fig. 11.

A source of electrical current here provided by use of a storage battery indicated at 84, has circuit wires 85 and 86 leading from its positive and negative terminals to poles 87 and 88 of the rheostat 81, and as noted in Fig. 11, the rheostat 80 has its poles 89—90 electrically joined by wires 91 and 92 with the wires 85 and 86.

The two rheostats, 80 and 81, are associated with the mechanical equipment in the manner best illustrated in Fig. 4, wherein it is shown that the rheostat 81 is mounted on the under side of the floor 1 near the transverse run of cable 18. Each rheostat comprises a housing in which there is a resistance coil and a contact movable therealong by the movement of a lever arm extended from the housing. The resistance element of the rheostat 81 is designated diagrammatically in

Fig. 11 by numeral 81a and a movable resistance varying contact is designated at 95 and is fixed on a pivot shaft 95 which has an actuating lever arm 97. This arm 97 has a cable connection 93 with the cable 13, and a coiled spring 93 is attached under tension to the lever to keep the cable 93 taut. Thus, since the cable 13 will be moved in opposite directions in accordance with depression of the foot pedals 12 and 13, it can be seen that the lever 97 will be caused to move accordingly by reason of its connection with cable 13. This will actuate the contact member 95 along the resistance coil 81a.

The rheostat 80, likewise, has a housing 80x, a resistance element 80a, and a resistance varying contact member 101 on a pivot shaft 102 to which an actuating lever arm 103 is fixed. The arm 103 has a cable connection 104 with the lower end of the joy stick yoke and a coiled spring 105 is attached under tension to arm 103 to keep the cable taut.

In the use of the rheostat 80, its housing 80x is rotatably mounted by a pivot tube 106 carried by a bracket 110 fixed to the under side of floor 1. Fastened to the housing 80x is a lever arm 112, and the outer end of this arm has a link 113 pivotally connecting it with one arm, 114a of a bell crank lever 114, operable as presently described, to rotatably move the housing, thus to cause relative movements of the resistance element 80a and contact member 101.

It will now be understood, by referring to Fig. 11, that with both rheostats in neutral setting, the indicator needle 73 of the bank indicator 70 will be located at a neutral indication. However, should the contact element of rheostat 80 be moved toward either side by a relative movement of the resistance and contact element, this will cause movement of the bank indicator to one side or the other and the extent of movement and direction will be in accordance with the extent and direction of rotative movement of the housing. Thus, it is possible by this means to produce movements of the bank indicator to simulate those of the bank indicator of an airplane in unstable flight. These artificially produced movements can be made more or less erratic through actuation of the bell crank 114, and in this instance, I have shown it to be actuated by the rotation of a plural-lobed cam 120 that is fixed on a shaft 121 driven by an electric motor 122 through suitable gear reduction, as at 123, that may be fixed in any suitable manner to the under side of floor 1 or at any other suitable place.

Assuming the rheostats and bank indicator to be so arranged, and electrically connected, their use for training a student pilot in coordination of controls is as follows:

First, the electric motor 122 is energized and set in operation so that through the action of cam 120 and bell crank mechanism disclosed, the housing 80x of the rheostat 80 will be given rotative movements of various amounts in opposite directions. These rotative movements of housing 80x cause a relative adjustment of the contact element along the resistance coil of the rheostat, and in accordance with the well known principles, thus cause the needle of the bank indicator to move from neutral indication toward one side or the other to varying extent in accordance with the action of the housing 80x under influence of the cam 120.

Since the purpose of the present apparatus is to teach coordination of hand and foot controls, and since the student is taught as a fundamen-

tal principle that by proper coordination of their movements, the bank indicator can be brought back to show a neutral indication, it will be understood therefore that should the bank indicator needle swing to the left, indicating a high right wing, the proper correcting action of the joy stick is to press it to the right. This causes a compensating movement of the rheostat lever arm 103, tending thereby to counteract the movement of the resistance element which has been caused by the bell crank linkage. At the same time, the student depresses the corresponding foot pedal, thereby moving the cable 13 so that through the lever 97 and spring connection, the contact element of the rheostat 81 is moved accordingly; it being understood that is the contact element of the rheostat 80 is caused to move one direction, the contact element of the other rheostat should be moved correspondingly in the opposite direction, thus to effect a balance of resistances which will stabilize the needle of the indicator 70.

With the bank indicator thus being artificially moved from side to side to varying degrees, the student pilot may be taught the proper coordinated movements of the hand and foot controls and how to effect the bringing of the needle back to a neutral indication, and since these coordinated movements are the same in this training device as are required in the actual flying plane, the training period for this particular type of instruction can be materially shortened and all danger removed.

In order that the intensity of the movement of the needle 73 of the indicator may be somewhat controlled, I provide a variable resistance as at 125 interposed in the wire 25. This may be controlled by a button as at 126 located on the instrument panel. Also, there may be a suitable switch as at 130 for opening or closing the circuit.

The subject matter contained in this case covers a stationary or ground trainer for teaching coordination of hand and foot controls as used in an airplane in flight for maintaining stability in flight, and the invention features the use of a ball bank simulator element and an artificial means for causing typical flight movements thereof, in combination with means operable under control of the hand and foot controls, whereby the moving influence of the artificial means may be nullified, thus to cause the ball bank simulator element to assume a position that would indicate stable flight. In use of the term "typical flight movements," I mean movements from right to left of the bank indicator, such as are produced when an airplane is in unstable flight; it being understood that the ball bank indicator is in neutral position when the plane is stabilized.

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

1. In a coordinator of the character described, in combination, an electrically energized bank indicator simulator having a movable indicator element, means for causing the application of variable electric forces to said indicator to effect typical movements of the indicator element of varying degree and direction, movable right and left foot controls adapted to be selectively actuated by the user's feet, a hand control adapted to be actuated to right or left by the user's hands, and means operable under the conjoint control of the said hand and foot controls for producing

counteracting electrical influences in the bank indicator simulator, variable in direction and extent in accordance with the selection of controls and extent of their movement, and whereby the indicator moving forces may be nullified.

2. A coordinator of the character described comprising in combination, an electrically energized bank indicator simulator having an indicator element movable from a neutral indication to right or left according to direction of flow of current and potential on its terminals, selectively operable right and left foot controls, a hand control lever selectively movable from neutral position to right and left sides, an electrical resistance element associated with the hand control, a source of electrical energy with connections from its positive and negative poles to the opposite ends of each of the resistance elements, a contactor for each resistance element, means electrically connecting the contactors respectively with the terminals of the bank indicator, means for causing relative movement of one of the contactors along its resistance, and means operable by movements of said hand and foot controls to right or left to adjust the contactors along the resistance elements corresponding thereto accordingly to effect the neutralization of forces in the indicator.

3. A coordinator of the character described comprising, in combination, right and left foot pedals operable selectively by the user's feet, a hand control member operable selectively to right or left by the user's hands, an electrical resistance element associated with the foot control pedals having a contactor movable therealong, a resistance element associated with the hand control, and a contactor movable therealong, a bank indicator simulator comprising a galvanometer having its opposite poles electrically connected respectively to the contactors of said resistance elements, a source of electrical energy having electrical connections from its positive and negative poles, respectively, to the opposite ends of the said resistance elements, mechanically driven means for causing movement of one of the contactor elements in different direction and extent along its resistance coil to change potential on the galvanometer terminals and effect typical

movements of the galvanometer needle, and means movable with the foot pedals and other means movable by the hand control to cause a readjustment of the contact elements along their corresponding resistances to effect the neutralization of the needle moving influence in the galvanometer.

4. In a coordinator of the character described, a set of foot pedals adapted to be depressed respectively by the user's right and left feet, a joy stick operable to right and left from neutral by the user's hands, springs acting on the pedals and on the stick to yieldingly retain them at their neutral positions, a cable connection between the pedals and movable in opposite directions according to the depression of one or the other of the foot pedals, an electrical resistance coil associated with the pedals, a contactor for the coil, and means connecting the contactor and cable whereby the contactor will be moved in opposite directions along the resistance according to the pedal depressed, a resistance coil associated with the joy stick, a contactor for the coil, and means connecting the contactor and joy stick for moving the contactor along the coil in opposite directions and extent as determined by the direction and extent of movement of the stick, a source of electrical energy having positive and negative poles electrically joined with the opposite ends of said resistance coils, and a bank indicator simulator comprising a galvanometer having its opposite poles electrically connected with the said contactors, and mechanically operable means for effecting the movement of one of the resistance coils and its contactors to produce action of the bank indicator needle.

5. A stationary coordinator trainer for airplane flight training comprising a cockpit frame, hand and foot control devices, and a turn and bank indicator element simulating parts of an airplane; an auxiliary means operable to cause typical flight movements of the turn and bank indicator element, and means associated with the said auxiliary means and operable by the hand and foot control devices to counteract the movement producing action on the indicator element of the said auxiliary means.

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