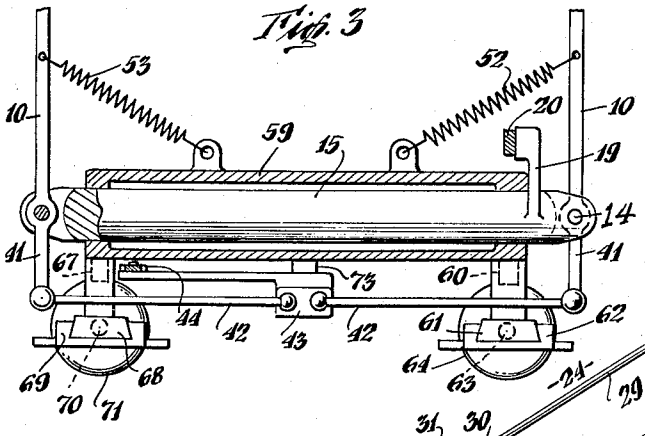
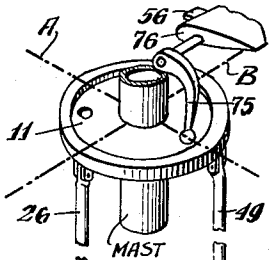
Nov. 8, 1960 G. S. DOMAN 2,959,230

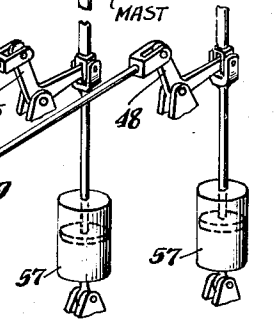
MECHANICAL DIRECTIONAL AND TRIM CONTROL FOR HELICOPTERS

Filed Aug. 16, 1951

Fig. 3







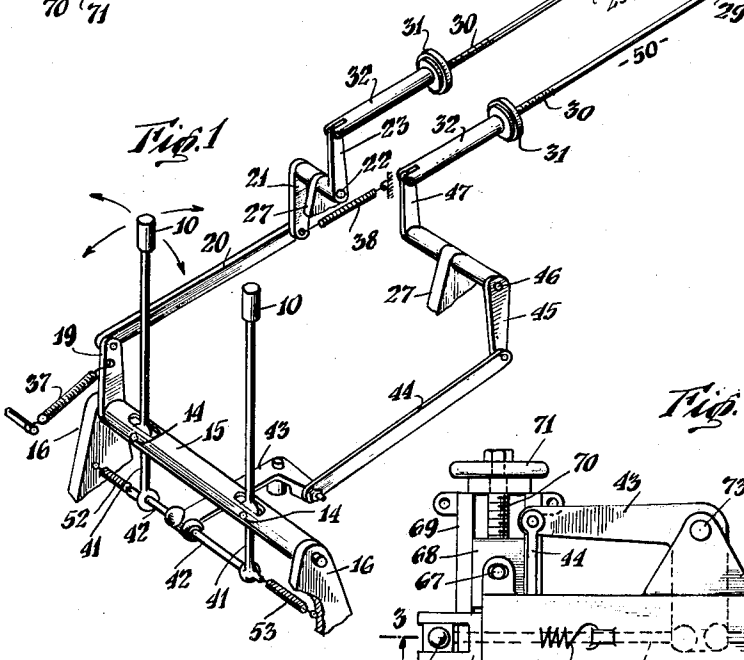
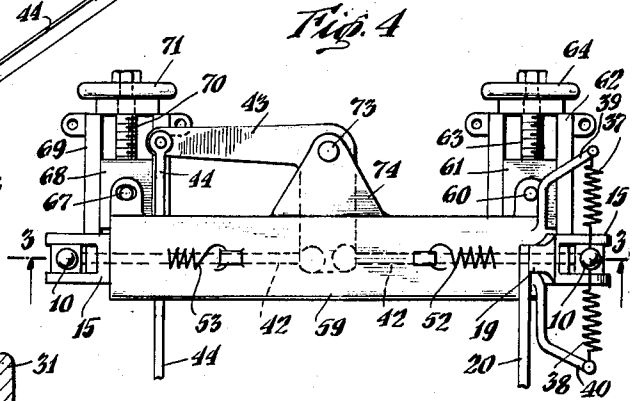


Fig. 1

Fig. 4



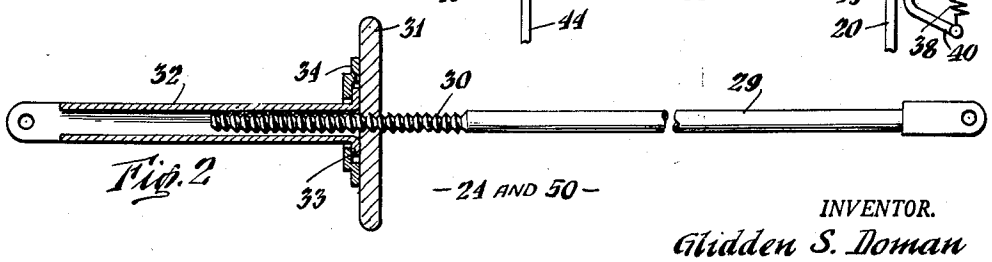


Fig. 2

—24 AND 50—

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MECHANICAL DIRECTIONAL AND TRIM CONTROL FOR HELICOPTERS

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18 Claims. (Cl. 170—160.25)

The invention relates to an improved directional and trim control for the rotor head of a self sustaining aircraft. Such rotor head includes a swash or azimuth plate which is universally mounted so that it can be tilted laterally and longitudinally, i.e. fore and aft for maneuvering and forward flight of the aircraft, the swash plate controlling the cyclic pitch of the blades of the rotor head and thus controlling the flight of the aircraft as is known. The invention relates to the connection between the control stick and the swash plate by which a lateral trim and a longitudinal trim of the swash plate and of the aircraft may be set into the control mechanism or connection.

It is an object of the invention to construct a new and novel directional and trim control mechanism so that the control stick is retained in center position by spring means and a desired amount of trim or azimuth plate adjustment either laterally or forwardly or both are set into the connection without change of the central position of the control stick.

Another object of the invention is to construct a new and novel directional and trim control mechanism in which the trim mechanism is located between the spring centering means for the pilot's control stick and the swash plate.

Another object is to construct a directional and trim control mechanism having a positive connection between the control stick and the swash plate yet with spring means aiding in restoring the control mechanism to its preset condition.

A still further object is to construct a mechanical directional and trim control of simplified construction.

Other objects of the invention will be more apparent from the following description when taken in connection with the accompanying drawings illustrating a preferred embodiment thereof in which:

Figure 1 is a perspective view of the directional and trim control mechanism;

Figure 2 is an enlarged view of the adjustable link;

Figure 3 is a partial section of a different form of mechanism taken on line 3—3 of Figure 4;

Figure 4 is a plan view of another form of direction and trim control.

The trim and control mechanism is located between the control stick 10 and the swash or azimuth plate 11. The swash plate may be any desired construction and is well known. It is mounted on the mast of the aircraft which carries the rotor head and mounted for universal inclination with respect to the mast. The swash plate is connected by means of horns with the blades of the rotor head to cyclically change the pitch of the blades upon the longitudinal axis of the blades. By tilting the swash plate the extent or amount of cyclic blade pitch change is controlled and by the direction of tilt the direction of flight or maneuvering is controlled. As is known the swash plate may be moved along the aircraft mast for collective pitch control. The control stick means particularly illustrated herein is a dual control in that it contains two control sticks 10. Each control stick is carried on a pivot 14 which extends longitudinally and permits side to side pivoting of the control stick. The two pivots 14 are carried by a pivoted member such as a tube or bar 15 which is pivotally mounted on a pivot means including the brackets 16 forming a frame which pivot means extends laterally so that the control stick means is universally mounted and may be pivoted fore and aft or longitudinally or both movements simultaneously. With this double pivot mounting means the control stick means has universal movement anywhere around a horizontal circle to control the position or tilt of the swash plate upon two axes or a combination movement on both axes.

The swash plate is tilted longitudinally with respect to the aircraft by means now to be described. Secured to tube 15 is an arm 19 to which a link 20 is connected which link is in turn connected with an arm 21 pivotally mounted upon a shaft 22 which also carries a second arm 23 which arm is connected with an adjustable link 24. The shaft 22 may be mounted in any suitable manner such as in bracket 27. The end of the adjustable link is connected with one arm of a bellcrank lever 25, the other arm of which is connected with a link 26 which is secured to the swash plate in a fore and aft position thereof. The various parts connecting the control stick means with the adjustable link 24 constitutes connecting means and may include any desired number of elements, those illustrated being the preferred construction. Each connecting means and the adjustable link connected therewith constitutes a connecting mechanism.

The adjustable link 24 is extendable and contractile and may take any form including an hydraulic means; however, the simpler form is a mechanical linkage as shown more clearly in Figure 2. The adjustable link includes a rod 29 having screw threads 30 upon which is threadedly mounted an adjusting hand wheel or plate 31. The adjusting hand wheel or plate is fixed to a tube 32 so that it is rotatable thereupon which construction may be any suitable form, that shown being a flange 33 carried by the tube 32 received in a suitable groove 34 carried by the adjusting plate. By turning the hand wheel or adjusting plate 31 the screw 30 is extended from or projected into the tube 32 thereby lengthening or shortening the adjustable link as desired.

Centering spring means are connected with the control mechanism to center the control stick means fore and aft and also from side to side. Preferably this spring means is in two units with one unit or spring means connected with the control mechanism to center the control stick means fore and aft. The spring means illustrated includes a spring 37 having one end anchored to the aircraft such as a bracket 39 and the other end connected with the arm 19. A second spring 38 has one end anchored to the aircraft such as a bracket 40 and the other end connected with the arm 21. These springs 37 and 38 may be connected at any point in the control connection so long as they are between the control stick 10 and the adjustable link 24 including attachment to the control stick if desired.

Means are provided for tilting the swash plate laterally or from side to side relatively to the mast which means includes an extension 41 of the control stick which is connected by link 42 to an arm of the bellcrank lever 43, the connection being by ball and socket joint for entire freedom of movement of the control stick. The links 42 are relatively long, because one control stick is in front of each pilot's seat, and hence fore and aft movement of the control stick means does not affect the connection between the control stick and the bellcrank 43. The other arm of the bellcrank is connected by link 44 to

an arm 45 carried by a pivotally mounted shaft 46 to which is secured a second arm 47. The arm 47 is connected with an adjustable link 50 the other end of which link is connected to one arm of the bellcrank 48 and the other arm thereof is connected by a link 49 to the swash plate at a side position thereof, that is 90° removed from the connection of the link 26 therewith. The adjustable link 50 is identical to the adjustable link 24. Again the connections between the control stick means including the extension of the control stick and the adjustable link 50 constitute connecting means and may include any number of parts as desired.

The centering spring means for the control stick means 10 as illustrated includes a second unit of spring means to center the same relatively to its side to side movement which means is shown as a spring 52 one end of which is anchored to the aircraft frame and the other end is connected with the extension 41 of the control stick means. With a dual control stick construction, the second spring 53 has one end anchored to the frame of the aircraft and the other end is secured to the extension 41 of the other control stick.

It will be noted that there is a positive connection between the control stick 10 or control stick means and the swash plate without any yieldable connection in the succession of elements. The spring means, however, are connected to the directional and trim control mechanism to center the control stick means, to exert its pressure to restore the control means to its present or neutral or center position, and requiring the pilot to overcome the spring means in any maneuver or movement of the control mechanism away from the preset condition. The spring means may be connected anywhere to the direction and trim control mechanism except at a point including the adjustable rods 29 and between it and the swash plate.

If the pilot wishes to tilt the swash plate longitudinally or on axis A of the universal mounting therefor, the control stick 10 is tilted longitudinally or fore and aft which pivots the mounting tube 15. This in turn swings the arm 19 as well as the arms 21 and 23 and moves the adjustable link means 24 to swing the bellcrank lever 25 which tilts the swash plate. If the swash plate is to be tilted in side to side plane of the aircraft or mast or such as on the axis B, the control stick 10 is pivoted on pivots 14 to the side which through extension 41, and link 42 swings the bellcrank lever 43 and through the link 44 swings the arms 45 and 47. The adjustable link means 50 is moved thereby which swings the bellcrank lever 48 which in turn tilts the swash plate through the link 49. It will be clear that any combination of these movements may take place so that the swash plate may be tilted on axes A and B simultaneously.

Suppose now that the pilot wishes to fly forward at a desired speed and to do this he would tilt the control stick 10 forward against the tension of the spring 38 and hold the stick in this position so long as he desires to fly at the selected speed. The pilot would be holding the control stick forward constantly against the tension of spring 38. Preferably, however, the pilot sets into the control mechanism a predetermined extent of tilt of the swash plate which gives the desired speed of forward flight. This is accomplished by rotating the adjusting wheel 31 while holding the control stick in central position. In this way the swash plate is tilted longitudinally until the aircraft is flying forward at the desired speed. A fixed or desired tilt has been inserted into the swash plate position. If now the pilot wishes to temporarily alter the speed of the aircraft either faster or slower he can accomplish that by tilting the control stick fore or aft respectively against the tension of the springs 38 or 37 respectively. With the directional control set into the control mechanism any reaction from the rotor head is transmitted through the swash plate to the control stick against the tension of springs 37 or 38 which resist any alteration in the set conditions of the rotor head. The pilot may resist them if he wishes and usually will automatically if the control stick moves excessively under these forces. Note further that the pilot retains full movement of the control stick fore and aft for maximum maneuverability with respect to the adjusted position of the swash plate.

In a like manner a fixed side to side tilt of the swash plate may be secured by shortening or lengthening the adjustable link 50. In other words, the cargo of the ship may introduce an unbalance so that the fuselage is not level and needs a trim adjustment. The pilot can adjust for this unbalance by adjusting the tilt of the swash plate while holding the control stick 10 in central position. Here again with a fixed trim set into the control mechanism, the pilot has full movement of the control stick to either side for maneuvering the aircraft. The hand wheels 31 are adjacent the pilot's seat so that they can easily be adjusted. Any forces on the rotor head which tend to cause it to change its relative position are transmitted to the swash plate and through the linkage is applied against the resistance of the springs 37, 38 and 52, 53 which tend to restore the swash plate and rotor head to its set position. The pilot also may assist through the control stick. Should the aircraft come to a port and unload cargo so that the center of gravity of the aircraft now assumes a different position and a different tilt is assumed by the fuselage, the pilot again adjusts the hand wheel for the trim control adjustable link 50 to set a different side by side tilt in the swash plate so that the aircraft flies level under this new location of center gravity or different unbalance of the aircraft.

In the event gyroscopic weights 56 are used projecting forwardly from the leading edge of the blades, dashpots 57 are connected to the swash plate or to the links 26 and 49 as particularly illustrated. Preferably they are connected as close to the swash plate as possible although they may be connected anywhere in the control mechanism.

Figures 3 and 4 illustrate another form of directional and trim control mechanism, which as in Figure 1, provides positive connections between the control stick means and the swash plate in that all connections therebetween are without a resilient connection. It is in many respects similar to the construction of Figure 1 and hence like parts are similarly numbered. The bar 15 which carries the control sticks 10, is pivotally mounted in a frame 59. The frame 59 has a pivot 60 at one end thereof adjacent to or in line or approximately in line with the connecting link 20. This pivot is carried by a slide 61 slidable longitudinally in a guide 62. A screw 63 having an end wheel 64 secured thereto threadedly engages the slide 61 and longitudinally adjusts the position thereof and pivot 60 and hence the right hand end of the frame 59. Movement of the right hand end of the frame longitudinally adjusts the position of the whole control mechanism relatively to the aircraft and hence is the equivalent of lengthening or shortening the link 29 without the use of this extensible or contractible link which would be a solid link with the construction of Figures 3 and 4. This adjustment constitutes directional control which may be preset into the control mechanism and swash plate without altering the central position of the control stick 10.

A similar adjustment may be provided for the trim control connections through the connecting link 44. The left hand end of the frame 59 is pivotally mounted upon a pivot 67 which may have a slotted bearing to receive the pivot for relative endwise movement therebetween. The pivot is carried by a slide 68 movable longitudinally in a guide 69. The position of the slide and pivot and hence the left hand end of the frame is adjusted by a screw 70 carrying a hand wheel 71 and threadedly engaging the slide. Adjustment of the left hand end of the frame 59 moves the connecting link 44 longitudinally and thereby adjusts the side by side tilt of the swash plate without

the use of an extensible and contractible link **50** and hence this link would be a single or solid link. Movement of the left hand end of the frame **59** does not alter the longitudinal position of the right hand end and its link **20**.

The bellcrank lever **43** is shown as extending forwardly and illustrates that this link may extend forwardly as shown in Figure 4 or rearwardly as shown in Figure 1 as desired. The bellcrank lever **43** in Figure 4 is carried upon a pivot **73** mounted in a bracket **74** forming a part of the frame **59** so that the bellcrank lever moves with the movement of the frame. The pivot **67** is at or approximately in line with the link **44** at the left hand end of the frame so that any longitudinal movement of the right hand end with respect to the aircraft does not result in any longitudinal movement or substantially no longitudinal movement of the connecting link **44**.

The operation of the mechanism of Figures 3 and 4 is very similar with that of Figure 1. If the trim of the aircraft is unbalanced then hand wheel **71** is rotated to provide a lateral tilt in the swash plate sufficiently to put vertical trim into the aircraft. If it is desired to fly forward at a certain rate of speed the hand wheel **64** is adjusted to put a longitudinal tilt in the swash plate until the desired speed is reached. It is to be noted that the adjustment of hand wheel **64** and/or **71** does not alter the center location or relative pivotal position of the control sticks **10** which are retained in central position by their springs **37, 38** and **52, 53**. Thereafter any temporary increase or decrease in speed is secured by moving the control sticks forwardly or rearwardly against the springs or spring means and flight to the left or right is secured by moving the control stick means to the left or right against the tension of the spring means **53, 52**. Similarly any forces affecting or occurring at the rotor head are transmitted through the swash plate to the control stick against the tension of the spring means which tend to restore conditions to the preset condition. The spring means in other words aids the pilot in restoring or without pilot aid restores the preset flight condition. Also any pilot instigated change from preset flight conditions is against the spring means so that he is constantly aware of any change made. The hand wheels are adjacent the pilot's seat so that they may be changed at will to change preset flight conditions such as an increase in preset speed or if the cargo should shift in flight and require a change in the preset trim of the aircraft.

In both forms of control mechanism there is a positive mechanical connection between the control stick and the swash plate without any hydraulic connection or linkage therebetween which results in a simpler mechanism and one less costly to manufacture. In the form of control mechanism shown in Figure 1 the extensible link is located between the control stick means and the end of the connecting means or mechanism adapted to be connected with the swash plate. In the form shown in Figures 3 and 4, the entire control mechanism participates in the adjusting movement or what may be termed the extension and contraction of a link or member within the control mechanism. The adjusting means in both forms is therefore connected with one of the parts including the frame and the connecting means or mechanism. Means are provided in both constructions to change the position of the end of the connecting means which is adapted to be connected with the swash plate and hence adjusts the swash plate through the control mechanism without altering the central or neutral location of the control stick means. In Figures 1 and 2 this is accomplished by an extensible link or connection **24** and **50**. In Figures 3 and 4 the position of the control mechanism relatively to the aircraft is shifted by means **61, 62, 63** and **68, 69, 70** between the whole control mechanism and the aircraft to secure the same result as that secured by the extension or contraction of the links **24** and **50**. The frame **59** provides the laterally extending pivot means for the bar **15**. It is the adjustment of the position of the end of the connecting means adapted to be connected with the swash plate relatively to aircraft which secures the preset tilt of the swash plate either fore and aft or laterally. The adjustment of the left hand end of the bar **15** in a longitudinal direction is not the sole manner in which the adjustment of the second connecting means may be secured and such adjustment may be secured by movement of any link thereof in a direction to effect longitudinal movement of the link **44**.

The invention is presented to fill a need for improvements in a mechanical directional and trim control. It is understood that various modifications in structure, as well as changes in mode of operation, assembly, and manner of use, may and often do occur to those skilled in the art, especially after benefiting from the teachings of an invention. Hence, it will be understood that this disclosure is illustrative of preferred means of embodying the invention in useful form by explaining the construction, operation and advantages thereof.

What is claimed is:

1. A trim and directional control mechanism adapted to be connected with the swash plate of a self-sustaining aircraft having blades and the swash plate being universally inclinable for cyclic control of the pitch of the blades comprising a frame, control stick means, means mounting the control stick means on the frame for universal pivotal movement fore and aft and side to side, a first connecting mechanism connected with the control stick means so as to be movable solely upon any fore and aft movement thereof and having an end adapted to be connected with the swash plate at fore and aft position thereon, a second connecting mechanism connected with the control stick means so as to be movable solely upon any side to side movement thereof and having an end adapted to be connected with the swash plate at a lateral position thereon, the first and second connecting mechanisms being positive mechanical means, adjustable means connected with one of the parts including the frame and at least one of the connecting mechanisms to vary the position of the end of at least one of the connecting mechanisms to vary the position of the swash plate therethrough without varying the relative pivotal position of the control stick means with respect to the frame, and spring means connected to at least one of the parts including the control stick means and the connecting mechanisms where relatively unaffected by the adjustable means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means in fore and aft position and in side to side position.

2. A trim and directional control mechanism adapted to be connected with the swash plate of a self-sustaining aircraft having blades and the swash plate being universally inclinable for cyclic control of the pitch of the blades comprising a frame, control stick means, means mounting the control stick means on the frame for universal pivotal movement fore and aft and side to side, a first connecting mechanism connected with the control stick means so as to be movable solely upon any fore and aft movement thereof and having an end adapted to be connected with the swash plate at fore and aft position thereon, a second connecting mechanism connected with the control stick means so as to be movable solely upon any side to side movement thereof and having an end adapted to be connected with the swash plate at a lateral position thereon, the first and second connecting mechanisms being positive mechanical means, adjustable means connected with one of the parts including the frame and the first connecting mechanism to vary the position of the end of the first connecting mechanism to vary the position of the swash plate therethrough without varying the relative pivotal position of the control stick means with respect to the frame, and spring means connected to at least one of the parts including the control stick means and the connecting mechanisms where relatively unaffected

by the adjustable means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means in fore and aft position and in side to side position.

3. A trim and directional control mechanism adapted to be connected with the swash plate of a self-sustaining aircraft having blades and the swash plate being universally inclinable for cyclic control of the pitch of the blades comprising a frame, control stick means, means mounting the control stick means on the frame for universal pivotal movement fore and aft and side to side, a first connecting mechanism connected with the control stick means so as to be movable solely upon any fore and aft movement thereof and having an end adapted to be connected with the swash plate at fore and aft position thereon, a second connecting mechanism connected with the control stick means so as to be movable solely upon any side to side movement thereof and having an end adapted to be connected with the swash plate at a lateral position thereon, the first and second connecting mechanisms being positive mechanical means, adjustable means connected with one of the parts including the frame and the second connecting mechanism to vary the position of the end of the second connecting mechanism to vary the position of the swash plate therethrough without varying the relative pivotal position of the control stick means with respect to the frame, and spring means connected to at least one of the parts including the control stick means and the connecting mechanisms where relatively unaffected by the adjustable means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means in fore and aft position and in side to side position.

4. A trim and directional control mechanism adapted to be connected with the swash plate of a self-sustaining aircraft having blades and the swash plate being universally inclinable for cyclic control of the pitch of the blades comprising a frame, control stick means, means mounting the control stick means on the frame for universal pivotal movement fore and aft and side to side, a first connecting mechanism connected with the control stick means so as to be movable solely upon any fore and aft movement thereof and having an end adapted to be connected with the swash plate at a fore and aft position thereon, a second connecting mechanism connected with the control stick means so as to be movable solely upon any side to side movement thereof and having an end adapted to be connected with the swash plate at a lateral position thereon, the first and second connecting mechanism being positive mechanical means between control stick and swash plate, adjustable means connected with one of the parts including the frame and the first connecting mechanism to vary the position of the end of the first connecting mechanism to vary the position of the swash plate therethrough without varying the relative pivotal position of the control stick means with respect to the frame, adjustable means connected with one of the parts including the frame and the second connecting mechanism to vary the position of the end of the second connecting mechanism to vary the position of the swash plate therethrough without varying the relative pivotal position of the control stick means with respect to the frame, and spring means connected to at least one of the parts including the control stick means and the connecting mechanisms where relatively unaffected by the adjustable means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means in fore and aft position and in side to side position.

5. A trim and directional control mechanism adapted to be connected with the swash plate of a self-sustaining aircraft having blades and the swash plate being universally inclinable for cyclic control of the pitch of the blades comprising a frame, control stick means, means mounting the control stick means on the frame for universal pivotal movement fore and aft and side to side, a first connecting mechanism connected with the control stick means so as to be movable solely upon any fore and aft movement thereof and having an end adapted to be connected with the swash plate at a fore and aft position, a second connecting mechanism connected with the control stick means so as to be movable solely upon any side to side movement thereof and having an end adapted to be connected with the swash plate at a lateral position, mechanical extensible and contractile means included in at least one of the connecting mechanisms including adjustable means to change the length thereof, and spring means connected to at least one of the parts including the control stick means and the connecting mechanisms where relatively unaffected by the adjustable means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means with respect to the frame in fore and aft position and in side to side position.

6. A trim and directional control mechanism adapted to be connected with the swash plate of a self-sustaining aircraft having blades and the swash plate being universally inclinable for cyclic control of the pitch of the blades comprising a frame, control stick means, means mounting the control stick means on the frame for universal pivotal movement fore and aft and side to side, a first connecting mechanism connected with the control stick means so as to be movable solely upon any fore and aft movement thereof and having an end adapted to be connected with the swash plate at a fore and aft position, a second connecting mechanism connected with the control stick means so as to be movable solely upon any side to side movement thereof and having an end adapted to be connected with the swash plate at a lateral position, mechanical extensible and contractile means included in the first connecting mechanism including adjustable means to change the length thereof, and spring means connected to at least one of the parts including the control stick means and the connecting mechanisms where relatively unaffected by the adjustable means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means with respect to the frame in fore and aft position and in side to side position.

7. A trim and directional control mechanism adapted to be connected with the swash plate of a self-sustaining aircraft having blades and the swash plate being universally inclinable for cyclic control of the pitch of the blades comprising a frame, control stick means, means mounting the control stick means on the frame for universal pivotal movement fore and aft and side to side, a first connecting mechanism connected with the control stick means so as to be movable solely upon any fore and aft movement thereof and having an end adapted to be connected with the swash plate at a fore and aft position, a second connecting mechanism connected with the control stick means so as to be movable solely upon any side to side movement thereof and having an end adapted to be connected with the swash plate at a lateral position, mechanical extensible and contractile means included in the second connecting mechanism including adjustable means to change the length thereof, and spring means connected to at least one of the parts including the control stick means and the connecting mechanisms where relatively unaffected by the adjustable means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means with respect to the frame in fore and aft position and in side to side position.

8. A trim and directional control mechanism adapted to be connected with the swash plate of a self-sustaining aircraft having blades and the swash plate being universally inclinable for cyclic control of the pitch of the blades comprising a frame, control stick means, means mounting the control stick means for universal pivotal movement fore and aft and side to side, a first connecting mechanism connected with the control stick means so as to be movable solely upon any fore and aft movement

thereof and having an end adapted to be connected with the swash plate at a fore and aft position, a second connecting mechanism connected with the control stick means so as to be movable solely upon any side to side movement thereof and having an end adapted to be connected with the swash plate at a lateral position, mechanical extensible and contractile means included in the first connecting mechanism including adjustable means to change the length thereof, mechanical extensible and contractile means included in the second connecting mechanism including adjustable means to change the length thereof, and spring means connected to at least one of the parts including the control stick means and the connecting mechanisms where relatively unaffected by the adjustable means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means with respect to the frame in fore and aft position and in side to side position.

9. A trim and directional control mechanism adapted to be connected with the swash plate of a self-sustaining aircraft having blades and the swash plate being universally inclinable for cyclic control of the pitch of the blades comprising a frame, control stick means, means mounting the control stick means on the frame for universal pivotal movement fore and aft and side to side, a first connecting mechanism connected with the control stick means so as to be movable solely upon any fore and aft movement thereof and having an end adapted to be connected with the swash plate at a fore and aft position, a second connecting mechanism connected with the control stick means so as to be movable solely upon any side to side movement thereof and having an end adapted to be connected with the swash plate at a lateral position, mechanical extensible and contractile means included in the first connecting mechanism including adjustable means to change the length thereof, mechanical extensible and contractile means included in the second connecting mechanism including adjustable means to change the length thereof, spring means connected to at least one of the parts including the control stick means and the first connecting mechanism where relatively unaffected by the adjustable means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means with respect to the frame in fore and aft position, and spring means connected to at least one of the parts including the control stick means and the second connecting mechanism where relatively unaffected by the adjustable means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means with respect to the frame in side to side position.

10. A trim and directional control mechanism adapted to be connected with the swash plate of a self-sustaining aircraft having blades and the swash plate being universally inclinable for cyclic control of the pitch of the blades comprising a frame, control stick means, means mounting the control stick means on the frame for universal pivotal movement fore and aft and side to side, a first connecting mechanism connected with the control stick means so as to be movable solely upon any fore and aft movement thereof and having an end adapted to be connected with the swash plate at a fore and aft position, a second connecting mechanism connected with the control stick means so as to be movable solely upon any side to side movement thereof and having an end adapted to be connected with the swash plate at a lateral position, spring means connected to at least one of the parts including the control stick means and the first connecting mechanism where unaffected by the adjustable means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means with respect to the frame in fore and aft position, spring means connected to at least one of the parts including the control stick means and the second connecting mechanism where unaffected by the adjustable means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means with respect to the frame in side to side position, mechanical extensible and contractile means included in the first connecting mechanism including adjustable means to change the length thereof, and mechanical extensible and contractile means included in the second connecting mechanism including adjustable means to change the length thereof.

11. A trim and directional control mechanism adapted to be connected with the swash plate of a self-sustaining aircraft having blades and the swash plate being universally inclinable for cyclic control of the pitch of the blades comprising a frame, control stick means, means mounting the control stick means on the frame for universal pivotal movement fore and aft and side to side, a first mechanical connecting mechanism connected with the control stick means so as to be movable solely upon any fore and aft movement thereof and having an end adapted to be connected with the swash plate at a fore and aft position thereof, a second mechanical connecting mechanism connected with the control stick means so as to be movable solely upon any side to side movement thereof and having an end adapted to be connected with the swash plate at a lateral position, extensible and contractile means included in the first connecting mechanism including adjustable means to change the length thereof, extensible and contractile means included in the second connecting mechanism including adjustable means to change the length thereof, and spring means connected to at least one of the parts including the control stick means and the connecting mechanisms where relatively unaffected by the adjustable means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means with respect to the frame in fore and aft position and in side to side position.

12. A trim and directional control mechanism adapted to be connected with the swash plate of a self-sustaining aircraft having blades and the swash plate being universally inclinable for control of the pitch of the blades comprising a frame, control stick means, means mounting the control stick means on the frame for universal pivotal movement fore and aft and side to side, a first connecting means connected with the control stick means so as to be movable solely upon any fore and aft movement thereof, a second connecting means connected with the control stick means so as to be movable solely upon any side to side movement thereof, spring means connected to at least one of the parts including the control stick means and the first connecting means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means with respect to the frame in fore and aft position, spring means connected to at least one of the parts including the control stick means and the second connecting means where unaffected by the adjustable means and adapted to be connected to the aircraft to center the control stick means with respect to the frame in side to side position, an adjustable push rod means having an end connected with the first connecting means and having another end adapted to be connected with the swash plate at a fore and aft position thereof including a screw member and a threaded hand wheel member engaging the screw member to chage the length theerof, an adjustable push rod means having an end connected with the second connecting means and having another end adapted to be connected with the swash plate at a lateral position thereof including a screw member and a threaded hand wheel member engaging the screw member to change the length thereof.

13. A trim and directional control mechanism adapted to be connected with the swash plate of a self-sustaining aircraft having blades and the swash plate being uni-

versally inclinable for cyclic control of the pitch of the blades comprising a frame, control stick means, means mounting the control stick means upon a longitudinally extending pivot for pivotal movement of the control stick means side to side, means carrying the pivot and mounted on the frame for pivotal movement upon a laterally extending pivot for fore and aft movement of the control stick means, a first connecting means connected with the pivot carrying means so as to be movable solely upon any fore and aft movement of the control stick means, a second connecting means connected with the control stick means so as to be movable solely upon any side to side movement thereof, spring means connected to at least one of the parts including the control stick means and the first connecting means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means with respect to the frame in fore and aft position, spring means connected to the frame in fore and aft position, spring means connected to at least one of the parts including the control stick means and the second connecting means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means with respect to the frame in side to side position, extensible and contractile means having an end connected with the first connecting means and having its other end adapted to be connected with the swash plate at fore and aft position thereon including adjustable means to change the length thereof, and extensible and contractile means having an end connected with the second connecting means and having its other end adapted to be connected with the swash plate at a lateral position thereon including adjustable means to change the length thereof.

14. A trim and directional control mechanism adapted to be connected with the swash plate of a self-sustaining aircraft having blades and the swash plate being universally inclinable for cyclic control of the pitch of the blades comprising a frame, control stick means including at least one control stick, means mounting the control stick means on the frame including longitudinally extending pivot means mounting the control stick for movement side to side and laterally extending pivot means carrying the longitudinally extending pivot means for longitudinal movement of the control stick, and an extension on the control stick; a first connecting means connected with the laterally extending pivot means so as to be movable solely upon any fore and aft movement of the control stick, a second connecting means connected with the extension of the control stick so as to be movable solely upon any side to side movement thereof, spring means connected to at least one of the parts including the control stick and the first connecting means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means with respect to the frame in fore and aft position, spring means connected to the control stick extension and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means with respect to the frame in side to side position, extensible and contractile means having an end connected with the first connecting means and having its other end adapted to be connected with the swash plate at fore and aft position thereon including adjustable means to change the length thereof, and extensible and contractile means having an end connected with the second connecting means and having its other end adapted to be connected with the swash plate at a lateral position thereon including adjustable means to change the length thereof.

15. A trim and directional control mechanism as in claim 4 in which the means mounting the control stick means includes a bar pivotally mounted upon laterally extending pivot means for pivotal movement fore and aft of the control stick means and having ends; and the first connecting means is connected with the bar at one end thereof so as to be movable solely upon any fore and aft movement of the control stick means, the second connecting means being connected with the control stick means in a position adjacent the other end of the bar, one adjustable means being connected with the frame and bar to move the end thereof connected with the first connecting means longitudinally and independently of the other end, and the other adjustable means being connected with the frame and the other end of the bar to move the bar to adjust the position of the second connecting means independently of longitudinal adjustment of the other end.

16. A trim and directional control mechanism as in claim 1 in which the means mounting the control stick means includes a bar pivotally mounted upon laterally extending pivot means whereby the control stick means is mounted for pivotal movement fore and aft, the bar having ends, the first connecting means being connected with the bar at one end thereof so as to be movable solely upon any fore and aft movement of the control stick means, the second connecting means being connected with the control stick means with at least a part thereof located adjacent the other end of the bar, and the adjustable means being connected with the frame and at least at one end of the bar to move the same longitudinally and independently of the longitudinal movement of the other end.

17. A trim and directional control mechanism as in claim 15 in which one adjustable means includes a pivot at one end of the bar and the other adjustable means includes a pivot at the other end of the bar.

18. A rotor and trim and directional control mechanism combination for a self-sustaining aircraft comprising a plurality of blades mounted for oscillation upon their longitudinal axis, a gyroscopic weight projecting from the leading edge of each blade, a swash plate universally mounted for cyclic control of the pitch of the blades, a control mechanism including a frame, a control stick means, means mounting the control stick means on the frame for universal pivotal movement fore and aft and side to side, a first connecting mechanism connected with the control stick means so as to be movable solely upon any fore and aft movement thereof and connected with the swash plate at fore and aft position thereon, a second connecting mechanism connected with the control stick means so as to be movable solely upon any side to side movement thereof and connected with the swash plate at a lateral position thereon, the first and second connecting mechanisms being positive mechanical means, adjustable means connected with at least one of the parts including the frame and at least one of the connecting mechanisms to vary the position of the swash plate therethrough without varying the relative pivotal position of the control stick means with respect to the frame, and spring means connected to at least one of the parts including the control stick means and the connecting mechanisms where relatively unaffected by the adjustable means and adapted to be connected to a point fixed relatively to the mounting means, to center the control stick means in fore and aft position and in side to side position, and dashpot means connected with each connecting means.

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UNITED STATES PATENT OFFICE

CERTIFICATION OF CORRECTION

Patent No. 2,959,230 November 8, 1960

Glidden S. Doman

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 11, lines 18 and 19, strike out "spring means connected to the frame in fore and aft position,".

Signed and sealed this 25th day of April 1961.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents