W. F. SULLIVAN.

AUTOMATIC BALANCING MECHANISM FOR FLYING MACHINES.

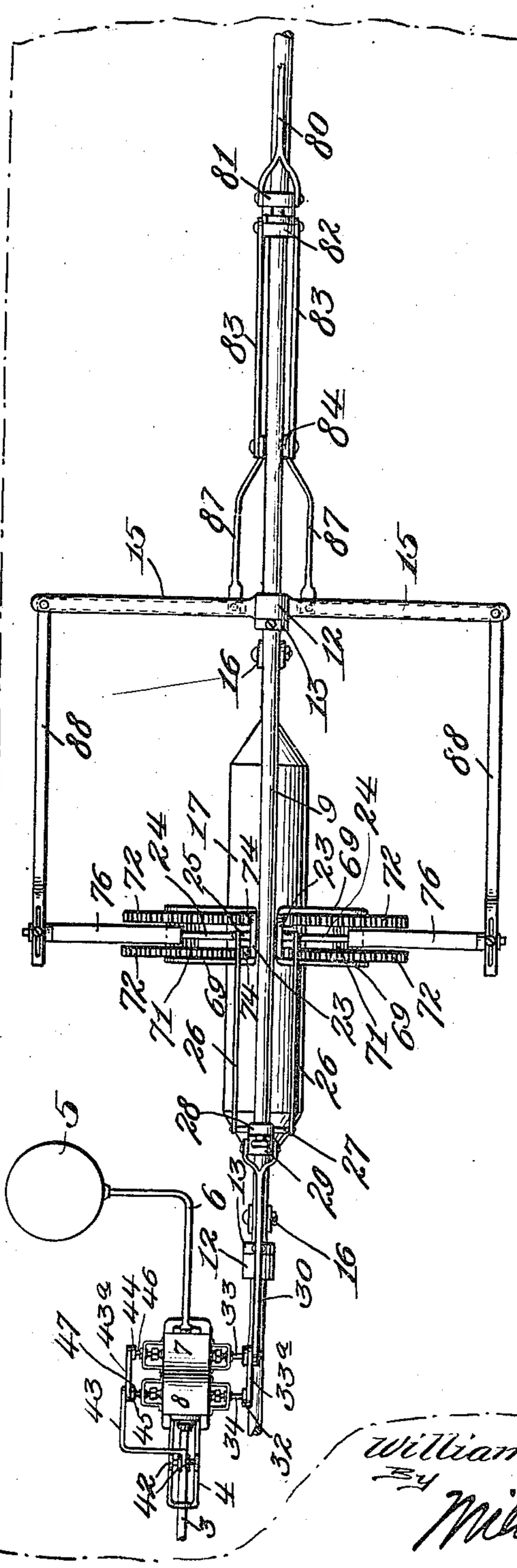
APPLICATION FILED SEPT. 13, 1909.

976,312.

Patented Nov. 22, 1910.

6 SHEETS—SHEET 1.

Fig. 1.



Witnesses:
A. R. Walton.
F. A. Barron.

Inventor
William F. Sullivan
By Wilson, Stevenson & Co.
Attys

W. F. SULLIVAN.

AUTOMATIC BALANCING MECHANISM FOR FLYING MACHINES.

APPLICATION FILED SEPT. 13, 1909.

976,312.

Patented Nov. 22, 1910.

6 SHEETS—SHEET 2.

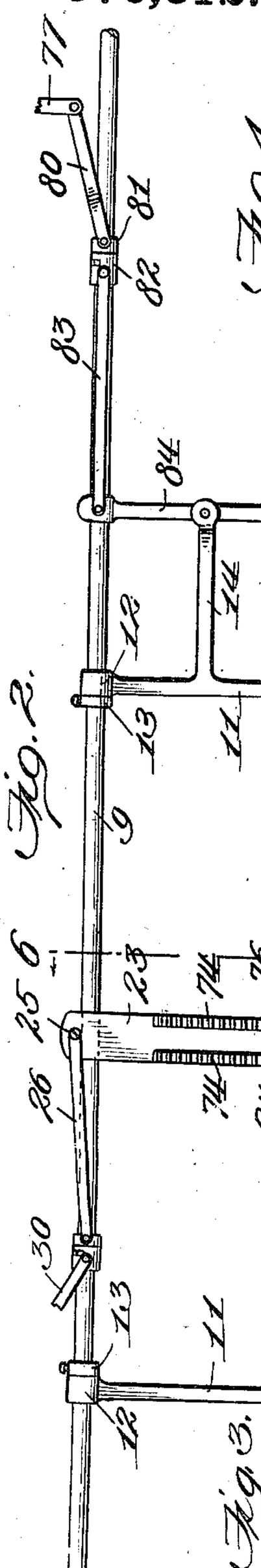


Fig. 2.

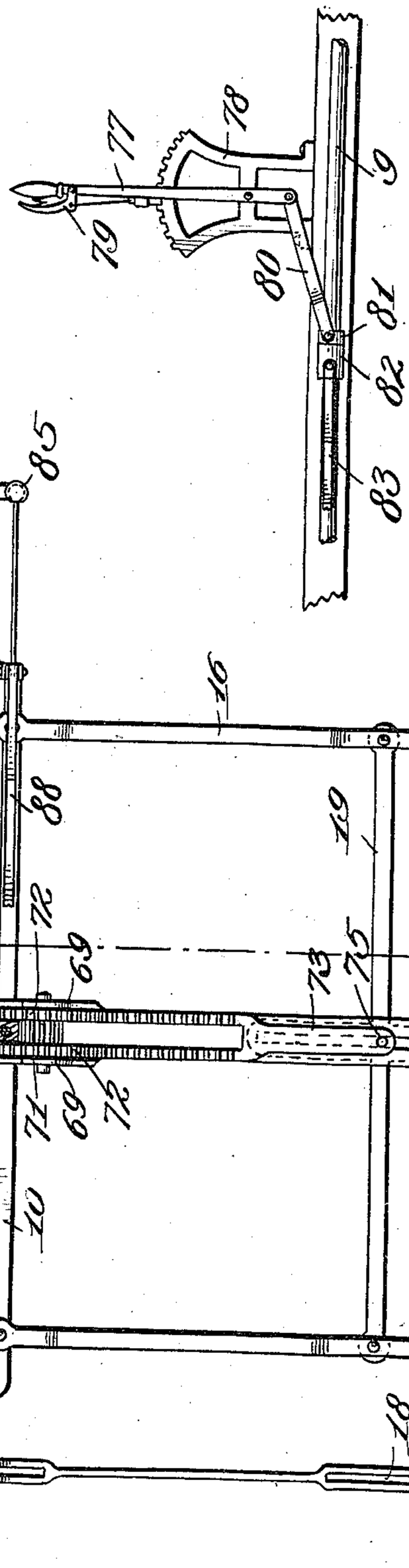


Fig. 3.

Fig. 4.

Fig. 5.

Witnesses:
A. R. Walton.
F. R. Barron.

Inventor
William F. Sullivan
By Miles B. Stevens & Co
Attys

W. F. SULLIVAN.

AUTOMATIC BALANCING MECHANISM FOR FLYING MACHINES.

APPLICATION FILED SEPT. 13, 1909.

976,312.

Patented Nov. 22, 1910.

6 SHEETS—SHEET 3.

Fig. 11.

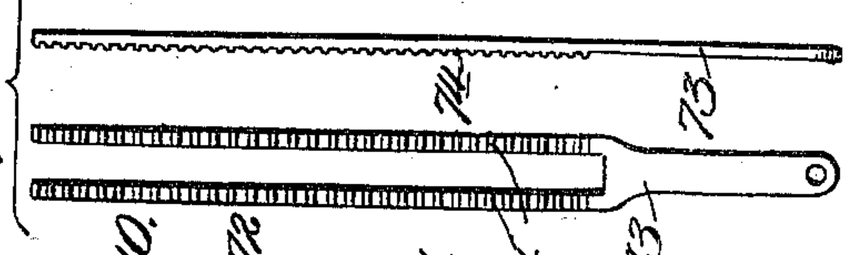


Fig. 10.

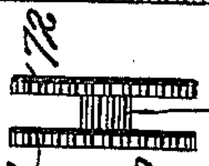


Fig. 9.

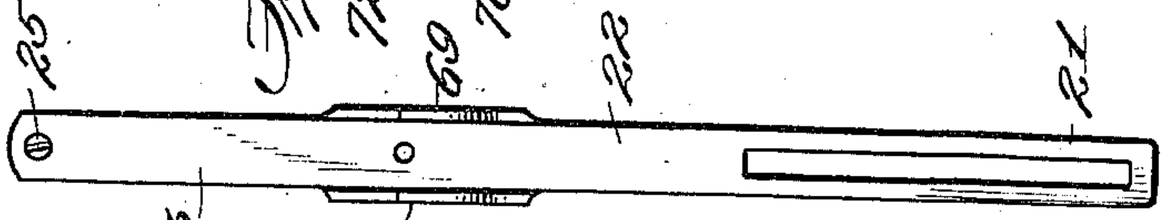


Fig. 8.

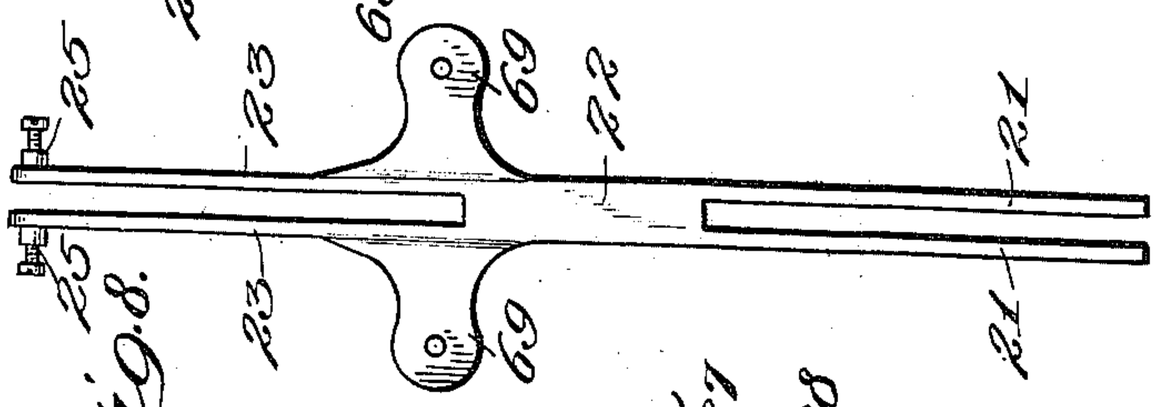


Fig. 12.

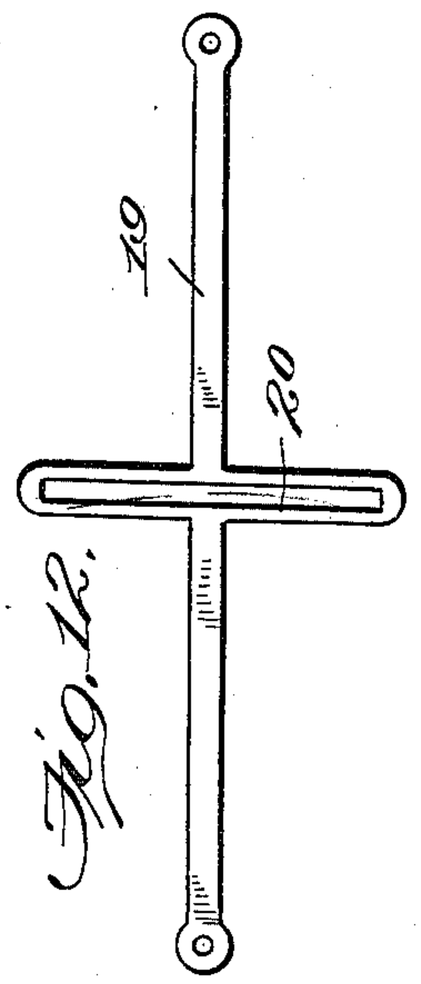


Fig. 6.

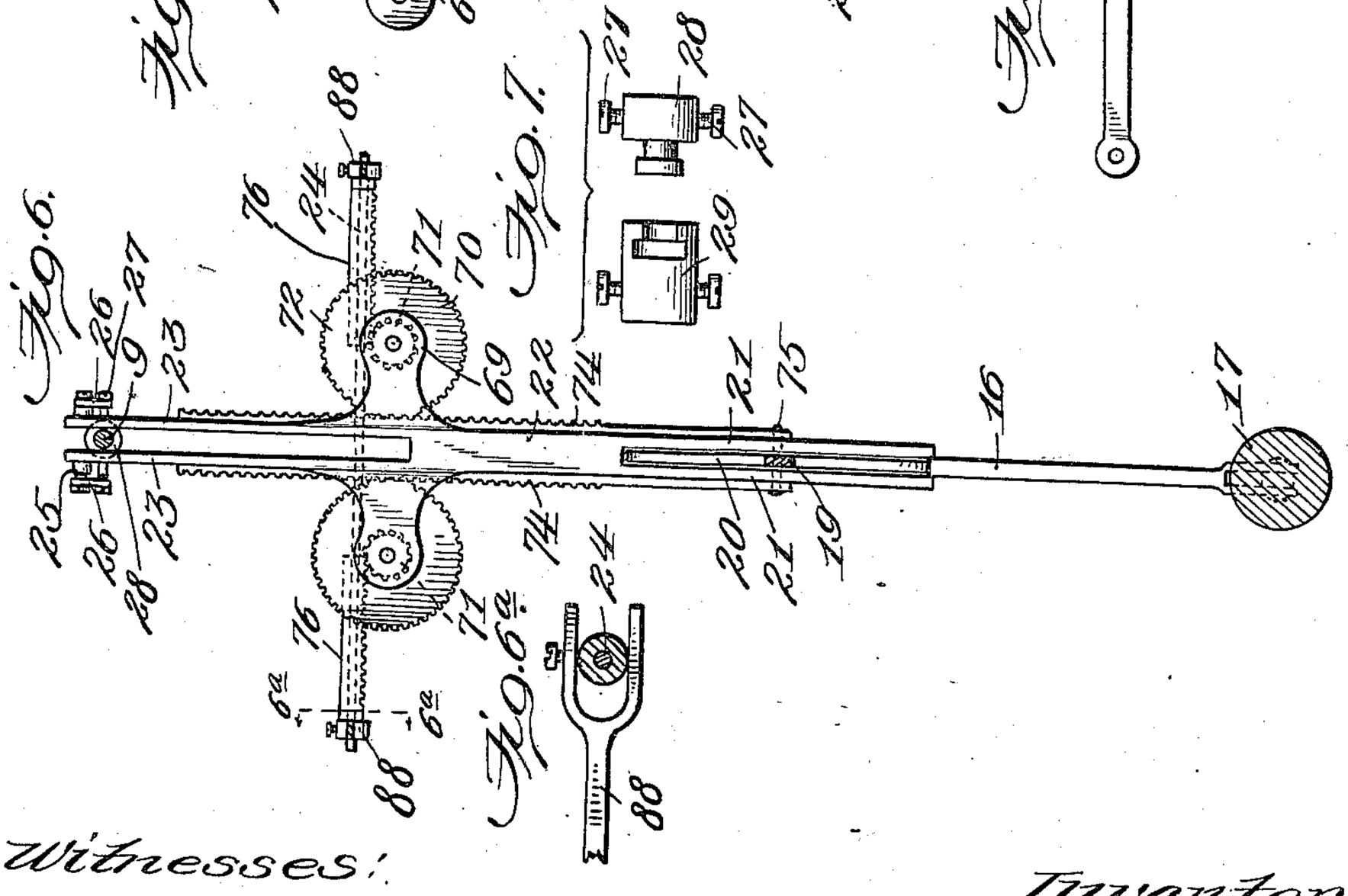


Fig. 7.

Witnesses:

A. R. Walton.

F. A. Barron.

Inventor

William F. Sullivan

By

Wilson, Stevens & Co.

Attys.

W. F. SULLIVAN.

AUTOMATIC BALANCING MECHANISM FOR FLYING MACHINES.

APPLICATION FILED SEPT. 13, 1909.

976,312.

Patented Nov. 22, 1910.

6 SHEETS—SHEET 4.

Fig. 13

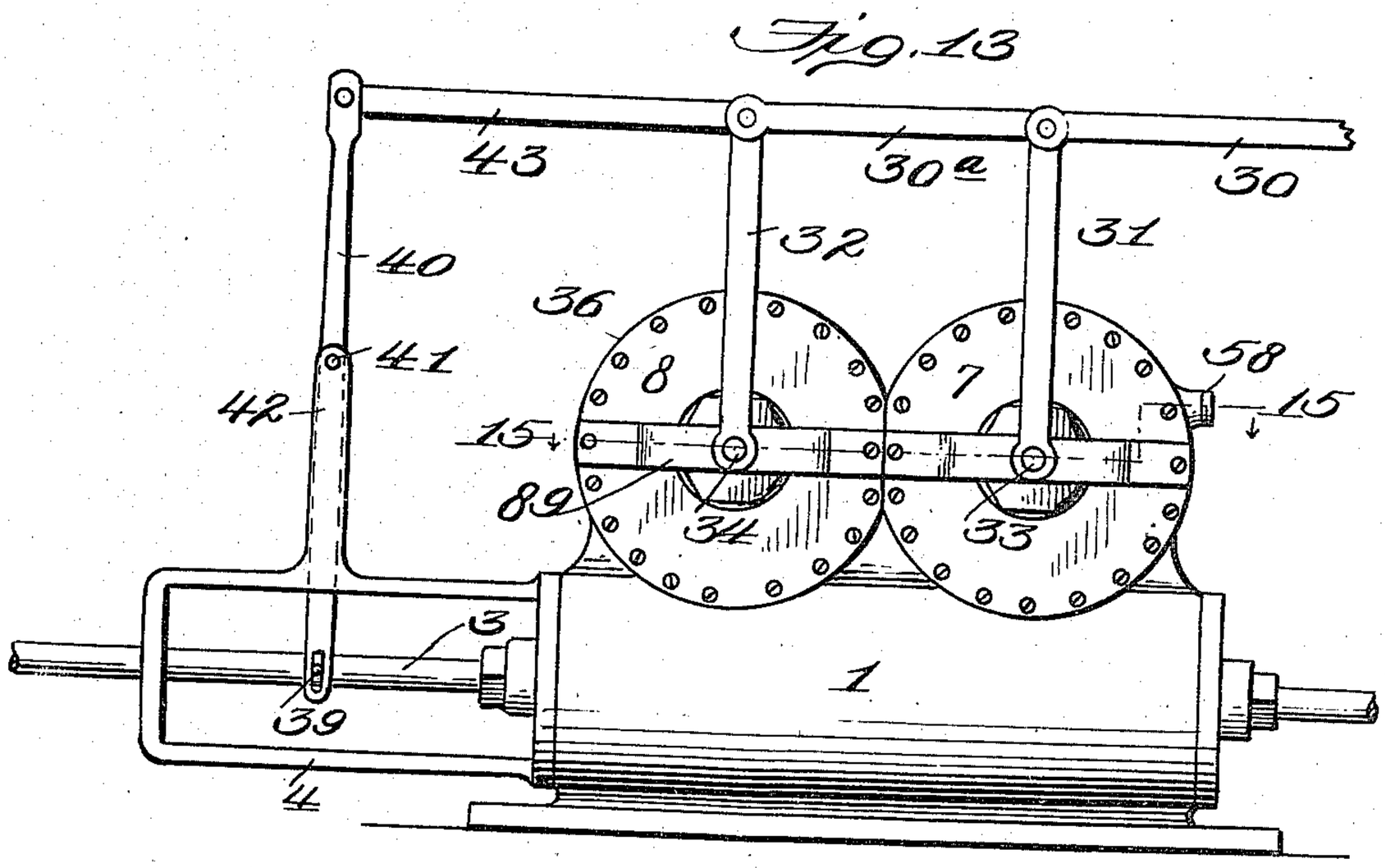
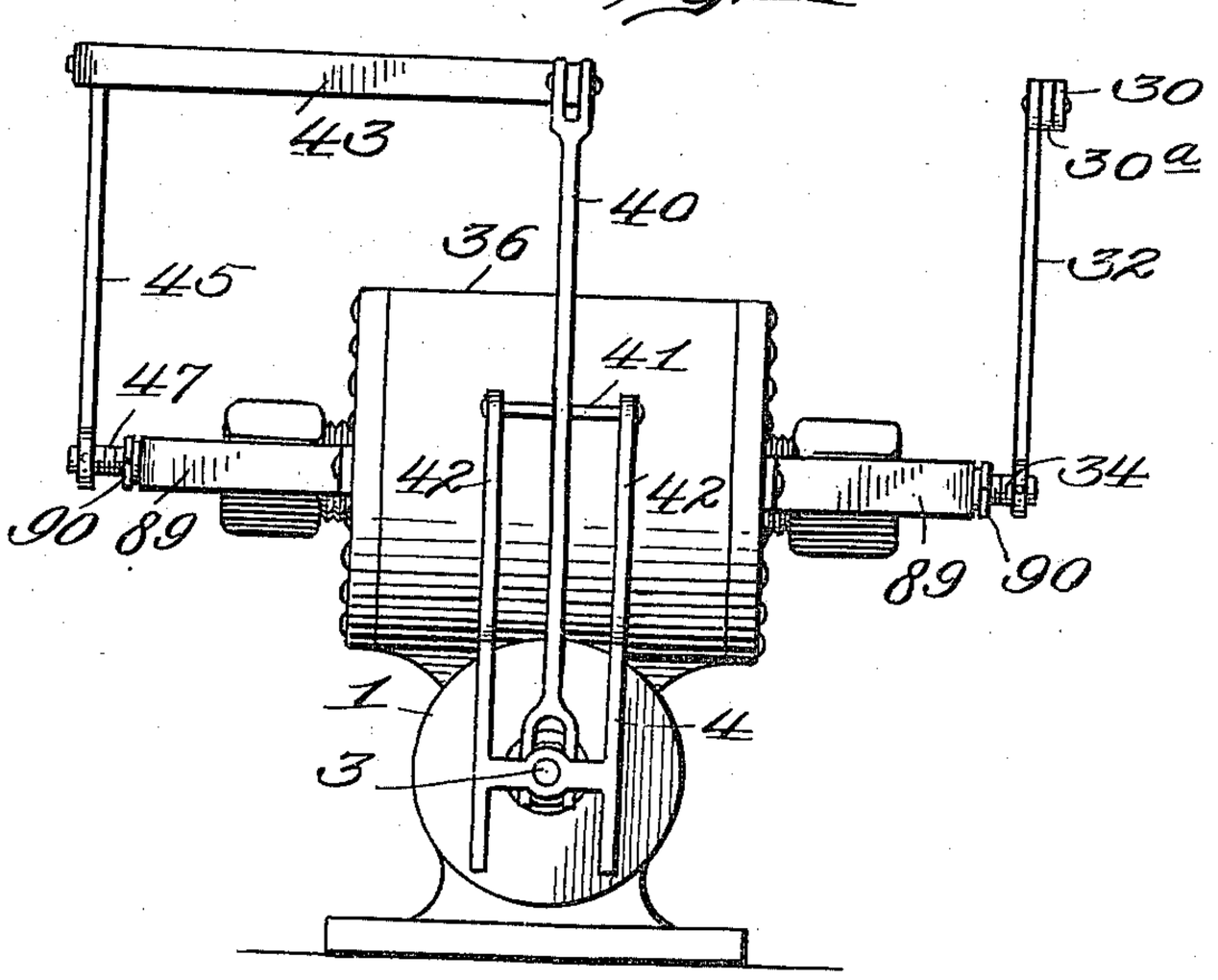


Fig. 14



Witnesses:
A. O. Walton.
F. A. Barron.

Inventor
William F. Sullivan
By Wilson Stevens & Co.
Attys

W. F. SULLIVAN.

AUTOMATIC BALANCING MECHANISM FOR FLYING MACHINES.

APPLICATION FILED SEPT. 13, 1909.

976,312.

Patented Nov. 22, 1910.

6 SHEETS—SHEET 5.

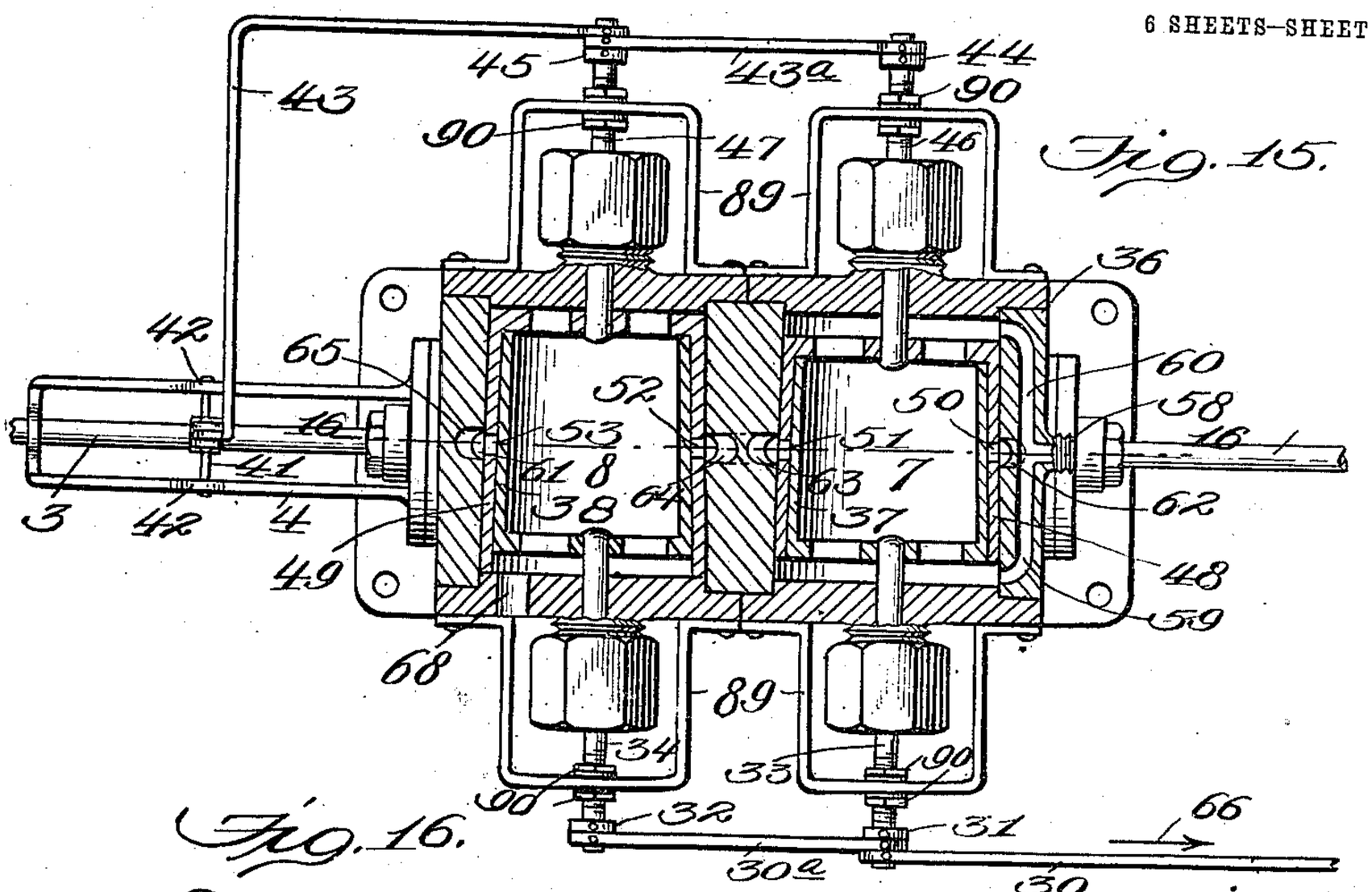


Fig. 15.

Fig. 16.

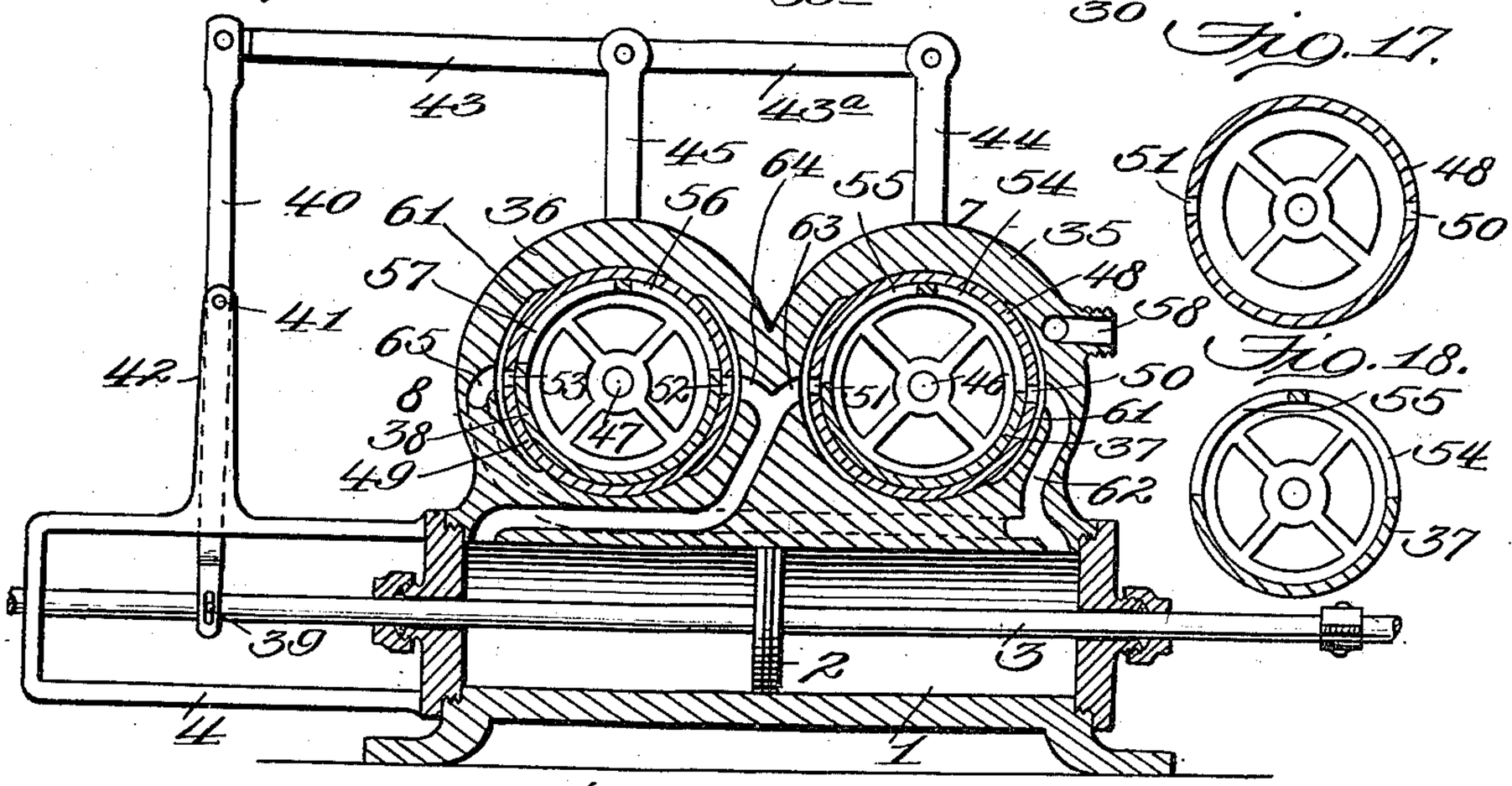


Fig. 17.

Fig. 18.

Fig. 19.

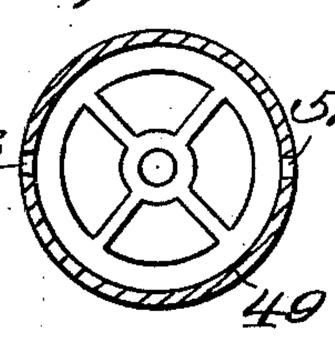


Fig. 20.

Witnesses:
A. R. Walton.
F. A. Barron.

Inventor
William F. Sullivan
By Miles B. Stevens & Co.
Attys

W. F. SULLIVAN.

AUTOMATIC BALANCING MECHANISM FOR FLYING MACHINES.

APPLICATION FILED SEPT. 13, 1909.

976,312.

Patented Nov. 22, 1910.

6 SHEETS—SHEET 6.

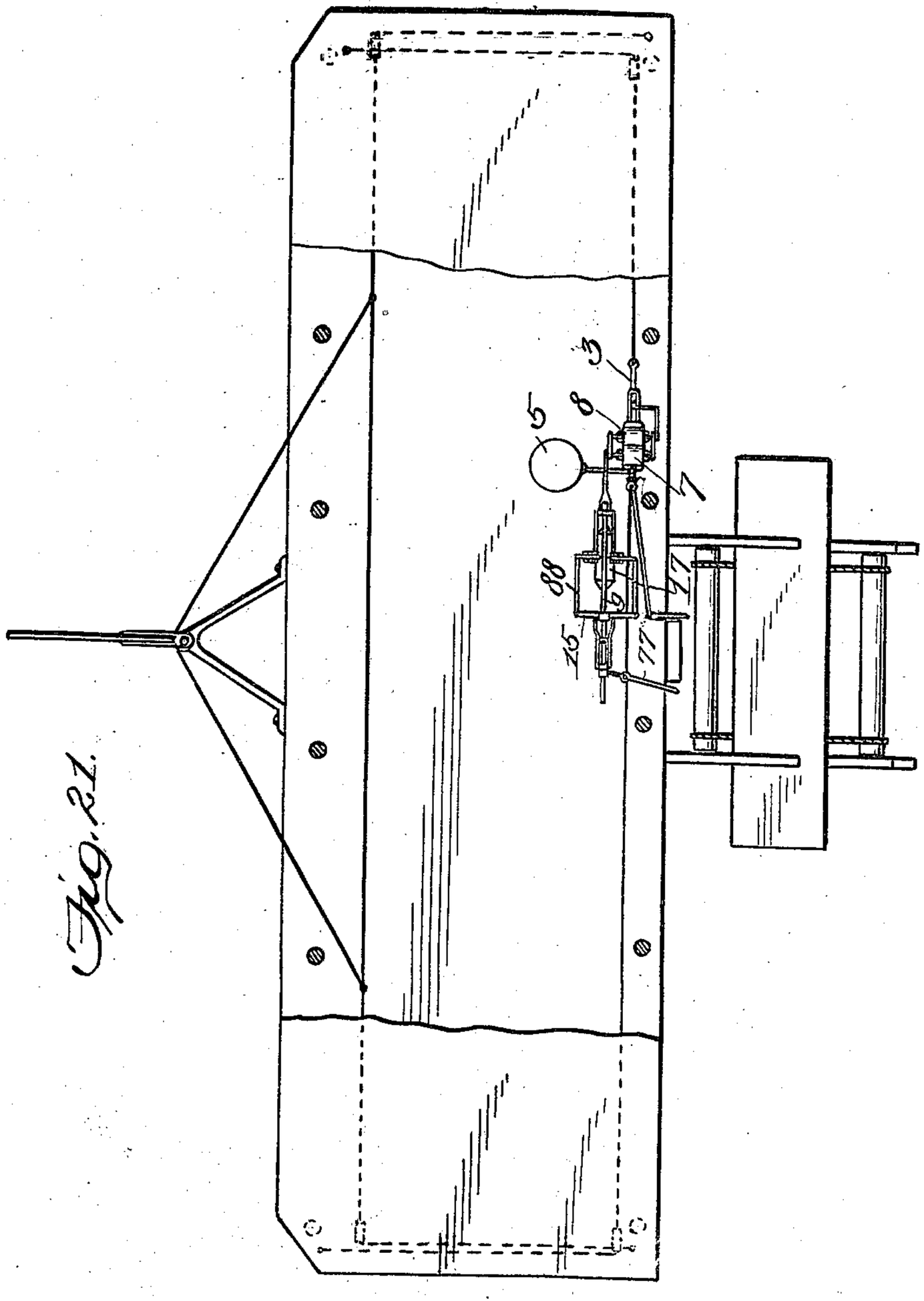


Fig. 21.

Witnesses:
F. A. Barron.
A. R. Walton.

Inventor
William F. Sullivan,
By Wilson B. Stevenson.
Attys

UNITED STATES PATENT OFFICE.

WILLIAM F. SULLIVAN, OF MOUNT VERNON, OHIO, ASSIGNOR OF ONE-HALF TO EDWIN LATIMER WEBER, OF BALTIMORE, MARYLAND.

AUTOMATIC BALANCING MECHANISM FOR FLYING-MACHINES.

976,312. Specification of Letters Patent. Patented Nov. 22, 1910.

Application filed September 13, 1909. Serial No. 517,371.

To all whom it may concern:

Be it known that I, WILLIAM F. SULLIVAN, a citizen of the United States, residing at Mount Vernon, in the county of Knox and State of Ohio, have invented certain new and useful Improvements in Automatic Balancing Mechanism for Flying-Machines, of which the following is a specification.

Up to the present time that class of aeroplanes embodying the mono-planes, biplanes and tri-planes, have depended upon hand-operated means to maintain their equilibrium or horizontal level. Usually such means have been in the form of horizontal plane-tips, or more particularly small horizontal, vertically swinging fins, hinged at each end of the planes and actuated angularly in opposite directions in the same degree of angle, by a single lever, which lever is mounted adjacent the operator. As stated, this is the usual method, and while there are others, namely, the "Wright" method of warping the ends of the planes, they all necessitate a hand or foot lever such as just named.

It is the object of my invention to accomplish this maintenance of equilibrium, or horizontal level, automatically, and to accomplish it by automatic means which may be connected to the ordinary hand lever above mentioned.

In any case the action of a means such as briefly outlined, is to force the machine back to its horizontal level after it has tipped to one side, and, of course, such movement must, of necessity, be faster in a high wind than in a calm.

Therefore, in my invention, a further object is to provide means by which the automatic means may be so controlled as to operate, or perform its function, faster or slower, as the case may be, than the tilting or tipping of the plane.

These and other objects, together with the advantages of my invention, will be apparent by careful consideration of the following description, in which reference is made, by numerals, to the several parts of the accompanying drawings, which form part of this specification, and in which—

Figure 1 is a plan view of my entire mechanism with the exception of the controlling lever; Fig. 2 is a side elevation of the swinging weight frame; Fig. 3 is a detail elevation of one of the swinging side bars removed; Fig. 4 is a side elevation of the controlling lever; Fig. 5 is a detail perspective view of one of the bell-crank levers, actuating a horizontal rack-bar, and its complementary ball-end connecting rod, removed; Fig. 6 is a detail vertical section through the swinging frame, taken on line 6—6 of Fig. 2, and looking in the direction of the arrows; Fig. 6ª is an enlarged detail view of one end of one of the horizontal rack-bars; Fig. 7 is a detail view of one of the slip-joint sleeve connections, the parts being detached for better illustration; Fig. 8 is a face view of the vertical pivot bar located in the center of the swinging frame; Fig. 9 is a side view thereof; Fig. 10 is an edge view of one of the pinions; Fig. 11 is a face and edge view of one of the vertical pivot carrying rack-bars; Fig. 12 is a detail elevation of the horizontal pivot bar of the swinging frame; Fig. 13 is a detail side elevation of the piston cylinder, valves, and connecting rods; Fig. 14 is an end elevation thereof; Fig. 15 is a horizontal section therethrough on line 15—15 of Fig. 13; Fig. 16 is a vertical section therethrough on line 16—16 of Fig. 15; Figs. 17 and 18 are detail sections through the piston and weight frame controlled intake valve cylinders, Figs. 19 and 20 are similar views through the piston and weight controlled exhaust valve cylinders, and Fig. 21 is a diagrammatic plan view of an aeroplane embodying level controlling planes and provided with my invention.

In the practical embodiment of my invention, as shown, I provide a piston cylinder 1, in which is arranged a piston head 2 upon a piston rod 3 extending longitudinally through the cylinder. One of the exteriorly projecting ends of the rod 3, extends through a guide frame 4 upon the adjacent end of the cylinder 1, while its opposite exteriorly projecting end, shown broken away in Figs. 13 and 16, is adapted for connection with a hand lever, to operate the same, upon movement of piston head 2, in the same manner that it is ordinarily operated by hand. The operating fluid, preferably compressed air, is supplied from a tank 5, which may be either the receiving tank for a compressor located upon the machine, or may be a tank charged before starting upon a trip. This operating fluid is led from tank 5 to cylinder 1 through a pipe 6 and supply valve 7, and exhausted from the latter through an

exhaust valve 8, and said valves are actuated both by the piston rod 3, and a mechanism which I will now proceed to describe.

Mounted upon a suitable portion of the machine, for instance one of the planes, and longitudinal and parallel with said plane, is a supporting rod 9, from which depends a U-shaped bracket, the lower cross-bar 10 of which is parallel with said rod 9, and the side bars 11 of which terminate in apertured ends 12 revolubly surrounding rod 9. The bracket may thus be oscillated with respect to rod 9 while it is held from sliding thereon by set collars 13 secured upon said rod within the bracket and against each of the apertured side bar ends 12. One of the side bars 11 of the bracket has an intermediate arm 14, outstanding beneath and parallel to the supporting rod 9, and said side bar further has, at its lower end, opposite laterally outstanding arms 15.

Pivotally secured at their upper ends to the lower bracket cross-bar 10 adjacent the side bars 11 thereof, are a pair of parallel depending bars 16, which are thus, in themselves, adapted to swing in the same plane with the rod 9, while adapted to move, through the U-shaped bracket, in a plane transverse to that of said rod without destroying their ability to accomplish their first-mentioned movement. These swinging bars 16 support, at their lower ends, a horizontal weight bar 17, pivotally connected, and adapted to maintain bars 16 in the perpendicular, no matter in which direction the machine tilts. The side bars 16 are also provided with intermediate opposing slots 18, to receive the ends of a horizontal pivot bar 19 parallel with the weight bar 17 and having its ends pivotally secured in said slots by transverse pins. The pivot bar 19, which is shown in detail in Fig. 12, has a central slotted cross-bar 20, which receives a pivot (to be hereinafter described) extending through the slotted forks 21 at the lower end of a vertical oscillatory lever 22, said forks 21 straddling said cross-bar 20, as shown in Figs. 2 and 6. The lever 22 has upper forks 23 which straddle both the cross-bar 10 of the swinging bracket, and the supporting rod 9, and extends slightly above the latter. The lever 22 is pivotally connected to the bracket cross-bar 10, by a rod 24 passing through alined openings in said cross-bar and the forks 23, and the said forks 23 thereof have, at their upper ends, outstanding studs 25 to which one end of connecting rods 26 are pivotally secured, the opposite ends of said rods being similarly connected to the studs 27 of part 28 of a connection sleeved upon the rod 9, the part 28 of which is slip-jointed to the part 29 in such manner that they are locked together with respect to sliding movment upon said rod, while permitted to independently rotate. This connection is shown in detail in Fig. 7. Thus the swinging frame including the side bars 16, weight bar 17 and the horizontal bar 19 and lever 22, will swing, as the machine tilts sidewise, whereby to remain perpendicular, and the upper end of the lever 22 will be forced, by this movement, in the opposite direction to the tilting of the machine. Thus also, by the connections described, the mechanism, as a whole, including the weight frame and the bracket, may swing freely when the machine tilts forwardly or backwardly, without interfering with the swinging of the weight frame when the machine tilts sidewise.

The part 29 of the sleeved connection previously referred to, is connected, by a connecting bar 30, to the upstanding arms 31 and 32 by a link 30ª between said arms, which arms are respectively upon the exterior ends of the valve stems 33 and 34 of the intake and exhaust valves 7 and 8. These valve stems lead inwardly through one of the ends of their respective valve shells 35 and 36, and carry the inner valve cylinders 37 and 38, which latter are thus rotated in their shells by the movement of the weight frame. The end of the piston rod 3, projecting through the guide frame 4, has an outstanding pin 39 engaging with the slotted lower end of a vertical rocker-arm 40, intermediately pivoted by a transverse pin 41 extending between the upper ends of upright bracket-arms 42 from frame 4, and connected at its upper end, by a connecting bar 43, to the upper ends of upright arms 44 and 45, in turn connected by a bar 43ª, said arms 44 and 45 being respectively, upon the exterior ends of the valve stems 46 and 47 of the intake and exhaust valves 7 and 8. These valve stems lead inwardly through the opposite ends of their respective valve shells 35 and 36, to the weight-valve stems 33 and 34, and carry valve cylinders 48 and 49, telescopingly engaging upon the weight valves 37 and 38, and which are thus rotated by movement of the piston rod 3 in either direction.

Each of the valve cylinders 37, 38, 48 and 49, are entirely open at one end, and have their opposite ends, to which their stems are secured, spidered as shown in Figs. 16 to 20. The cylinders 48 and 49, controlled by the piston rod 3, are provided with diametrically opposing central ports 50, 51, 52 and 53, while the cylinders 37 and 38, controlled by the weight frame, have slotted ports 54. 55, 56 and 57, those of the former being somewhat longer than those of the latter.

The operating fluid is led from pipe 6 into an inlet port 58 in the inlet valve shell 35, which has passages 59 and 60, diverging from the port 58 to the end of the cylinders 37 and 48, respectively. The shells 35 and 36 also have curved recesses 61, opposite to

one another, in their internal surfaces, and in line with the ports of the valve cylinders. and said shells also have passages 62, 63, 64 and 65 leading from their said recesses 61 to the piston cylinder 1, one passage of each shell, namely 62 and 65, leading to one end of the cylinder, and one passage of each shell, namely 63 and 64, leading to the opposite end.

The position in which the valves are shown in Fig. 16, is the one which they will assume when the machine is at equilibrium, or when it is horizontally level, and in this position it will be noted that the intake valve is partially open at both sides and that the exhaust valve is closed at both sides. Thus the fluid pressure is equalized on both sides of piston head 2. Suppose, however, that the machine had tipped to one side in such manner as to cause the weight frame to move connecting bar 30 in the direction of the arrow 66 (Fig. 15). Such movement will rotate valve cylinder 37 to more widely open its port 54 to the port 50 of valve cylinder 48 and passage 62 thus admitting more fluid to the right of the piston head 2, at the same time will close the opposite port 55 of cylinder 37 to the port 51 of cylinder 48 and passage 63. Valve 38 will also be rotated and will open its port 56 to the port 52 of valve 49, and to passage 64, thus permitting the fluid upon the left of this piston head 2, to exhaust through passage 64, ports 52 and 56, and through the spidered end of cylinder 38 and the exhaust passage 68 of shell 36. As soon as the piston rod 3 starts to move, it operates the ordinary hand lever to which it is, as before stated, connected, and also causes rotation of the valve cylinders 48 and 49 in the same direction as valve cylinders 37 and 38. The cylinders 48 and 49 thus follow the cylinders 37 and 38, the same relative registration of ports and passages being maintained owing to the recesses 61, and while cylinders 37 and 38 stop as soon as movement of the weight frame ceases, the piston continues to travel until pressure upon both sides thereof is equalized, which causes sufficient continued movement on the part of cylinders 48 and 49 to close the exhaust valve, and partially open the intake valve, as it is in Fig. 16, whereby to balance the piston head. By this means the plane-tips are not only automatically moved to a proper angular position to restore the machine to its horizontal level, but are automatically held in such position until the machine begins to right itself. From this, the operation of the valves, when the machine tilts in the opposite direction will, it is thought, be readily seen.

In order to control the weight frame in such manner that the lever may be moved faster or slower than the tilting movement of the machine, I provide means which I will now proceed to describe, by which the pivot, before referred to, between the horizontal bar 19 and lever 22, may be raised or lowered. To this end the lever 22 has pairs of apertured ears 69, outstanding from opposite sides thereof at right angles to the cross-bar 10, between the extremities of which ears are rotatively supported pinions 70. These pinions, one of which is shown in detail in Fig. 10, comprise a small central toothed portion 71, and enlarged circular toothed side flanges 72. Vertical forked rack-bars 73 are adapted to slide upon the opposite surfaces of the lever 22 between its ears 69, with the enlarged flanges 72 of the pinions in engagement with the racks 74 thereof. Between the lower ends of said rack-bars is secured a thrust pin 75 which, as shown, projects through the lower slotted forks 21 of lever 22 and through the slotted cross-bar 20 of bar 19. Mounted to slide upon the rod 24, extending through the lever 22 and the cross-bar 10, are a pair of horizontal rack sleeve bars 76, one upon each side of said lever 22, and in engagement with the small central toothed portions 71 of the pinions 70. Thus the horizontal rack bars 76 may be forced toward or away from one another to rotate the pinions 70 and move the vertical rack bars 73 down or up and consequently the thrust pin 75. A controlling lever 77 is intermediately pivoted upon a notched frame 78, and has a latch mechanism 79 to engage selected notches on said frame. The lower end of the lever 77 is connected, by connecting rods 80, to the part 81 of a slip-joint connection sleeved upon the supporting rod 9 and similar to the one shown in Fig. 7. The other part 82, of said connection, is connected by connecting rods 83 to the upper bifurcated end of a vertical rocker-arm 84, intermediately pivotally connected to the end of the arm 14 of bracket side bar 11. The lower end of rocker-arm 84 has twin sockets 85 to receive the ball ends 86 of connecting levers 87 having their opposite ends flattened to engage with the bifurcated inner ends of bell-crank levers 88 to which they are pivotally connected. The bell-crank levers 88 are pivoted at their knees beneath the outstanding arms 15 at the lower ends of the bracket side bars 15 and to the ends thereof, and their opposite forked ends are slotted, as shown in Fig. 5 to receive studs upon the outer swiveled ends of the horizontal rack-bars 76. Thus when the lever 77 is moved, the horizontal rack-bars 76 are moved inwardly or outwardly, dependent upon the direction of movement of such lever.

While I have described my invention in connection with side tilting of an aeroplane, wherein it is arranged transversely of the machine, it will be understood that the same

apparatus when arranged longitudinally of the machine will operate in a like manner to correct forward and rear tilting. Thus by the use of two such apparatus as I have shown, the aeroplane may be corrected of tilting in all four directions.

The valve members 37, 38, 48 and 49, while referred to as cylindrical, are preferably, and as illustrated, slightly conical, and the stems of the valves are threaded where they extend through U-shaped frames 89 projecting outwardly from the ends of shells 35 and 36. Thus by the use of nuts 90 on said stems, one upon each end of a sleeve projecting through the openings in said frames 89, the valves 37 and 38 may be forced inwardly, more tightly within valves 48 and 49 and the latter within the shells 35 and 36 to compensate for wear.

Claims:

1. In an aeroplane embodying level controlling planes, the combination of automatic means to actuate the planes, and a controlling lever and connections for regulating the speed of such actuation.

2. The combination in a mechanism of the character described, of means to actuate level controlling planes, means to automatically control said actuating means, and means to regulate the speed of such actuation.

3. The combination in a mechanism of the character described, of fluid-operated means to actuate level controlling planes, means to automatically control said fluid-operated means, and means to regulate said automatic means to vary the speed of such actuation.

4. The combination in a mechanism of the character described, of fluid-operated means to actuate level controlling planes, valves controlling said means, a weighted swinging frame adapted to maintain itself in the perpendicular and having connections for operating said valves, and a lever and connections for regulating the speed of movement of said frame.

5. The combination in an aeroplane embodying level controlling planes, of automatic means to actuate the planes, and hand-operated means to regulate the speed of such actuation.

6. The combination in a mechanism of the character described, of a weighted swinging frame, embodying a central pivotal lever, and means to change the pivot of said lever, with respect to that of said frame, for the purpose specified.

7. The combination in a mechanism of the character described, of a weighted swinging frame, embodying a pivoted lever projecting therefrom, racks sliding upon said lever and carrying a movable pivot therefor, pinions in engagement with said racks, other racks in engagement with said pinions, and means embodying a latch controlled lever, for moving said last named racks whereby to actuate the pivot carrying racks and thus vary the motion of the projecting end of said lever.

8. The combination in a mechanism of the character described, of a source of fluid supply, a piston cylinder, a piston therein adapted for connection to level controlling planes whereby to actuate the same, valves between said supply and said cylinder, connections between said piston and certain of said valves for actuating the same, and a weighted swinging frame adapted to maintain itself in the perpendicular, and having connections with the other valves to actuate the same.

In testimony whereof I affix my signature, in presence of two witnesses.

WILLIAM F. SULLIVAN.

Witnesses:
A. R. Walton,
F. A. Barron.