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G. WUNSCH ET AL
RUDDER MACHINE FOR AUTOMATIC PILOTS
Filed Nov. 20, 1940

Serial No.
366,364
3 Sheets-Sheet 1

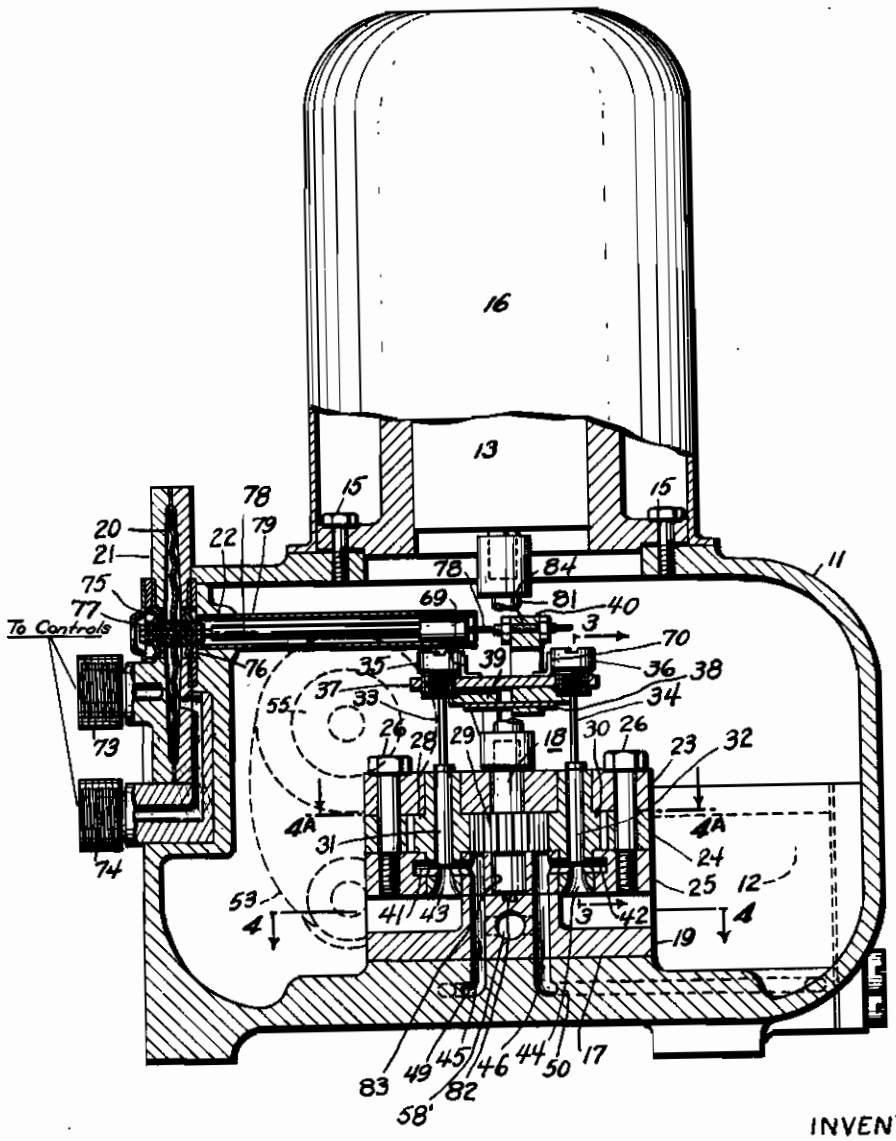

FIG. 1

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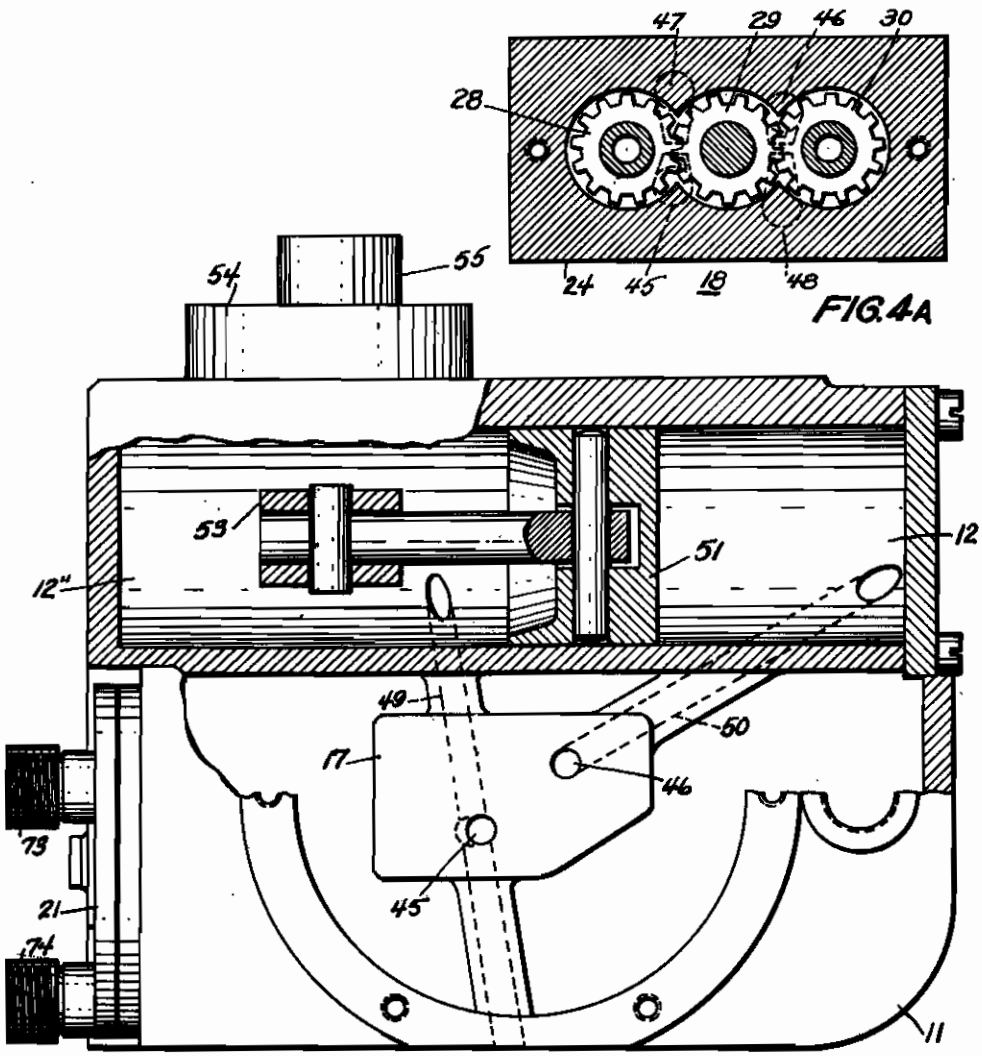

FIG. 4A

FIG. 2

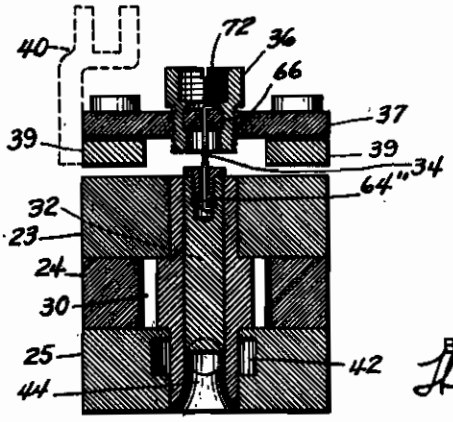

FIG. 3

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FIG. 6

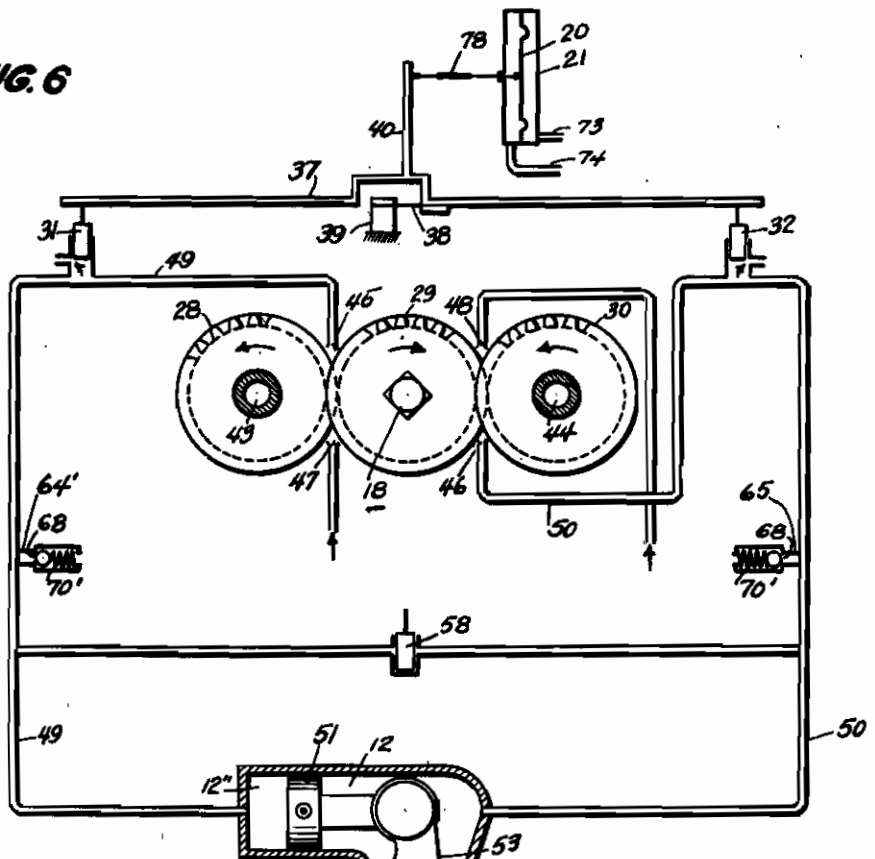


FIG. 4

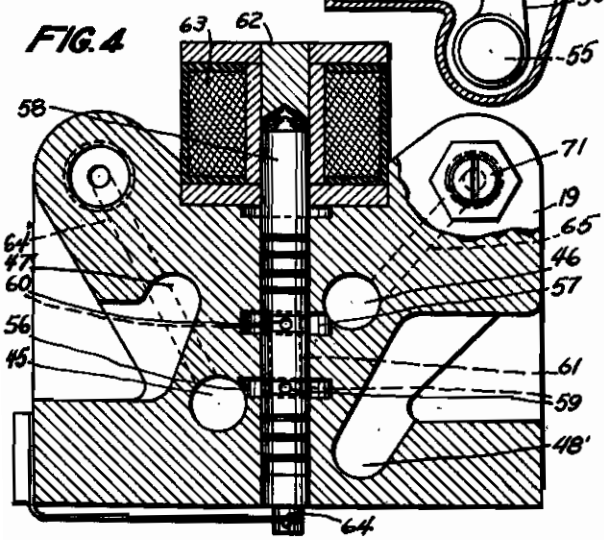
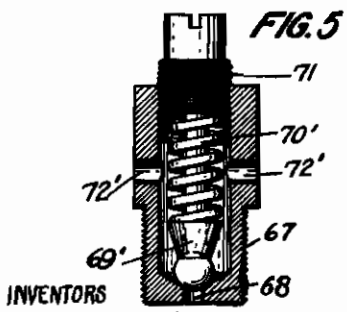


FIG. 5



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ALIEN PROPERTY CUSTODIAN

RUDDER MACHINE FOR AUTOMATIC PILOTS

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Application filed November 20, 1940

This invention relates to automatic pilots of the hydraulic type, especially adapted for aircraft. More especially, the invention relates to an improvement whereby a motor driven pump unit is directly combined with and built as a part of both the relay valve and the servo motor itself so that no hydraulic piping need be employed outside of the unit, and a separate unit of identical type may be employed for each axis of the aircraft. It is preferred to employ as the pump a double acting gear pump of known design which simultaneously circulates fluid in opposite directions through two lines leading to the servo motor, in which the pressure is varied on the servo motor by differentially and practically continuously bypassing a variable portion of the fluid in the two lines. The bypass valves are preferably located within the collared shafts of the gear pump itself, whereby friction is reduced to a minimum. It is also proposed to eliminate backlash in the connections by employing wire links connected to the stems of the valves and adjustably connected to a rock shaft or lever which is controlled from the governing impulses from the position maintaining device, such as a directional gyroscope or artificial horizon.

Further improvements accomplished by the invention will be apparent from the following description and claims.

Referring to the drawings, illustrating one form the invention may assume,

Fig. 1 is a side elevation, partly in section, of our improved combined motor driven pump, relay valve and servo motor.

Fig. 2 is a horizontal section through the bottom of the case, showing the servo piston.

Fig. 3 is a sectional detail of one of the valves and wire stems therefor.

Fig. 4 is a section taken approximately on line 4—4 of Fig. 1, showing the manually controlled bypass valve.

Fig. 4A is a section taken along line 4*a*—4A of Fig. 1, showing the pump construction.

Fig. 5 is a sectional detail of an automatic bypass valve, permitting overcontrol.

Fig. 6 is a diagram illustrating the operation of the pump and circulating liquid.

The housing of the instrument is a casting preferably integral with the servo motor cylinder 12 and the crank housing 11. On top of the open part of the housing 11 the electric motor 13 is closely fitted, which has a flange which fits the ring-shaped extension of the housing 11 and is connected to the same by means of bolts 15. An outer cover 16 may be fitted over the electric motor in order to protect it.

The housing is filled with oil to just below the pipe 19, the purpose of which will be explained hereinafter. The oil pump 18 is mounted on a machined surface 17 of the housing 11 by means of a spacer 19. The control of the pump is effected by a differential pressure membrane 20, the housing 21 of which is attached to the casing 11 from the outside, and the transmission linkage of which projects through the wall at 22. The differential pressure acting upon membrane 20 is generated by one or more control instruments provided with pneumatic transmission systems responsive to steering impulses caused by change of course, speed of change of course and angular acceleration around the vertical axis of the aircraft in the case of an automatic steering device. Such a transmitting instrument is described in the copending application of Adam Kronenberger for Automatic Steering Device for Aircraft, Serial No. 312,691, filed January 6, 1940, and in the application of Guido Wunsch, Adam Kronenberger and Karl Bauer for Angular Rate Gyroscope for Automatic Steering, Serial No. 312,692, filed January 6, 1940.

The oil pump 18 consists of three plates 23, 24 and 25 which are connected to each other by means of screws 26. The metal plate 24 has openings for three gears 28, 29 and 30, the middle gear of which is driven by the electric motor 13 to which it is connected by means of a coupling 31, of which in this drawing only the ends connected to the motor and to the pump are shown. As it is not difficult to line up the motor with the axis of the gear 29, the coupling may be made rigid.

The two driven gears 28 and 30 have hollow shafts and contain small piston valves 31 and 32. Said valves are connected to spring wires 33 and 34 and are adjustable in their position by screws 35 and 36 to which the wires have been secured. The screws are mounted in a plate 37 which is pivoted by means of a leaf spring 38. The other end of the leaf spring is connected to a bracket 39 resting on the pump. The plate 37 carries an arm 40 to which the linkage 17 and 18 of the membrane 20 is connected.

The free ends of the valves 31 and 32 project into ring-shaped channels 41 and 42, respectively, from which the pressure oil, through openings 43 and 44, seeps into the pump housing. Passages 45 and 46 are connected with the channels 41 and 42 which, for simplicity, in Fig. 6 are shown in the plane of the axes of the pump gears.

but which actually have the position shown in Figs. 1 and 4.

The preferred construction for securing the wires 33 and 34 at both ends is shown in Fig. 3. Each piston valve 31 and 32 is provided with a threaded hole at the top which is adapted to receive slotted and drilled plugs 63'' and 64''. Into the holes of these plugs, wires 33 and 34 are inserted, bent over and soldered or welded. The top end of each wire is located in similar plugs 65 and 66 which also have been drilled and slotted and which are secured within the screws 35 and 38, which are preferably knurled on the outside and which may be closed at the top by means of screw plugs 71 and 72. Screws 35 and 36 may be secured against accidental movement by means of springs 68 and 78.

Because of the turning of gears 28, 29 and 30, oil is sucked from recesses 47' and 48' of spacer 19 through the holes 47 and 48 in the lower plate 25 and is forced into the passages 45 and 46 (Figs. 1 and 2). These passages, as shown in Figs. 1 and 6, lead into passages 49 and 50 which are connected to the cylinder 12 and the crank housing 12'', respectively, thereby carrying oil to both sides of the servo motor piston.

Normally, the two valves 31 and 32 have the position shown in Fig. 1, in which the oil forced into the passages 45 and 46 can flow out of the openings 43 and 44 practically without resistance. If, however, because of a steering impulse, the crank 48 is tilted and thereby one of the two pistons is moved downwardly, the respective cross section of the overflow opening is restricted and, therefore, pressure will increase in the corresponding line 45 or 46 which causes an increase in pressure in the chamber 12 or 12'', respectively, of the servo motor. The pressure thereby exerted against the piston 51 is transmitted to the crank 53 and results in a turning motion of the shaft 55 pivoted in an extension 54 of the housing. By attaching a coupling to this shaft, the servo motor may be connected to the rudder of the craft.

The motion of the pistons 31 and 32 within the shafts of the gears 26 and 30 is practically without any friction as the oscillating motion of the pistons is superimposed upon the turning motion of the gears, and as good lubrication is always provided due to the fact that the pump runs completely under oil. In order to prevent back pressure against the pistons 31 and 32 while the oil escapes from the openings 43 and 44, these openings have been widened toward the outside as shown in Figs. 1 and 3, which facilitates the escape of the oil.

According to the invention, the pump 10 is directly attached to the machined surface 17 of the housing 11 with elimination of pipe connections. This is done by means of a spacer 19 which allows short-circuiting the two sides of the servo motor.

Fig. 4 shows a horizontal section through the middle of the short-circuiting valve. The passages 45 and 46 are connected each to a ring-shaped space 56 and 57. These two passages are short-circuited by a piston 59 when the same is in its normal position. For this purpose the piston is provided with lateral holes 59 and 60 which are connected to each other by means of a hole 61 extending axially of the piston. The upper end of the piston, which is made of magnetic material, projects into the core of an electromagnet, the core 62 of which is surrounded by a coil 63. This coil is so connected to the electric motor 13 that it is excited as soon as the motor is started. The magnetic field now pulls the piston 58 against the action of a leaf spring 64 into the coil and thereby interrupts the short-circuiting connection between the holes 59, 60 and the ring-shaped spaces 56 and 57. Inasmuch as the passages 45 and 46 are no longer short-circuited, motion of the steering pistons 31 and 32 can result in pressure which will result in motion of the servo motor piston 51, as previously described. In order to limit this pressure, two safety valves have been attached to the passages 45 and 46 which are connected to passages 64' and 65 in the spacer 19 (Fig. 4). Fig. 5 shows one of the two valves in detail.

The valve housing has on the outside a thread 87 by means of which it is screwed into the spacer 19. A hole 88 provided on the bottom affords the connection to the passages 85 or 64', respectively. The opening 88 is kept closed by means of the valve 69' as long as the oil pressure does not overcome the force of the spring 70', which may be adjusted by means of the screw plug 71. Oil which might escape through the valve flows through the hole 72' back into the instrument housing. In order not to restrict the entrance of the oil into the suction lines 47 and 48 in Fig. 4, the spacer 19 is hollowed out at 47' and 48' (Fig. 4). Between the lower pump plate 25 and the short-circuited element 18 there is provided a channel 62 (Fig. 1) which serves the purpose of carrying away the pressure oil which might escape along the passage 83 due to slight leakage through the bearings. In this way no one-sided pressure on the lower part of the shaft of gear 29 can accumulate, which might press the gear upwardly against plate 23 and which might cause considerable friction.

The connections 73 and 74 of the diaphragm housing 21 are shown in Fig. 2 as being located in one plane. This was done in order to better show their construction. As shown in Fig. 1, the connections are actually located to the right and left of the diaphragm. It has been mentioned earlier that the diaphragm is attached to the housing 11 from the outside and that the connecting linkage projects from the wall into the inside. In order to keep the housing tight against the diaphragm casing, two small soft membranes 75 and 76 have been provided which are rigidly connected to the diaphragm 20, which is preferably made of metal. The connection is secured by nuts on a pin 77, the end of which is threaded. The other end of the pin carries a spring wire 78 which terminates in a little screw 84 which effects the connection with the crank 48.

In order to be sure that the metal diaphragm 20 can move without restriction, the small auxiliary membranes 75 and 76, as shown in Fig. 1, have been made loose enough so as not to counteract the motion of the membrane 20. In the present design the pipe lines 73 and 74 are kept below atmospheric pressure, so that the outer pressure tries to push the membranes 75 and 76 into the housing 21. If pressure greater than atmospheric pressure is to be used, the membranes should be formed in the opposite way so that they are bulging toward the outside. The connecting pin 77 is surrounded by the previously mentioned protecting pipe 79, which serves the purpose of preventing the oil in the housing from reaching the auxiliary membrane 76 in case the aircraft is banking.

The operation of the machine is started by closing a switch (not shown) to cause the motor

13 to run. The coil 63, which is connected parallel thereto, is excited at the same time and the short-circuit between the passages 45 and 46 is removed. If the airplane deviates from the desired flying attitude, a differential pressure is produced in the known way and influences the diaphragm 20, which causes tilting of the lever 40. As explained before, this causes differential pressure in the passages 45, 46, 49 and 50 which moves the servo motor piston and causes a rudder movement in a sense to correct for the original deviation.

It is possible to use the rudder machine for desired motions of the rudder which may be controlled by a hand switch. In place of the differential pressure diaphragm 20, an electric relay or a rotary magnet may be used without deviating from the fundamental principle of the invention.

As many changes could be made in the above construction and many apparently widely differene embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

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