April 11, 1944. E. DODSON 2,346,418

FLUID OPERATED MEANS FOR CONTROLLING APPARATUS AT A DISTANCE

Filed Feb. 18, 1942 3 Sheets-Sheet 1

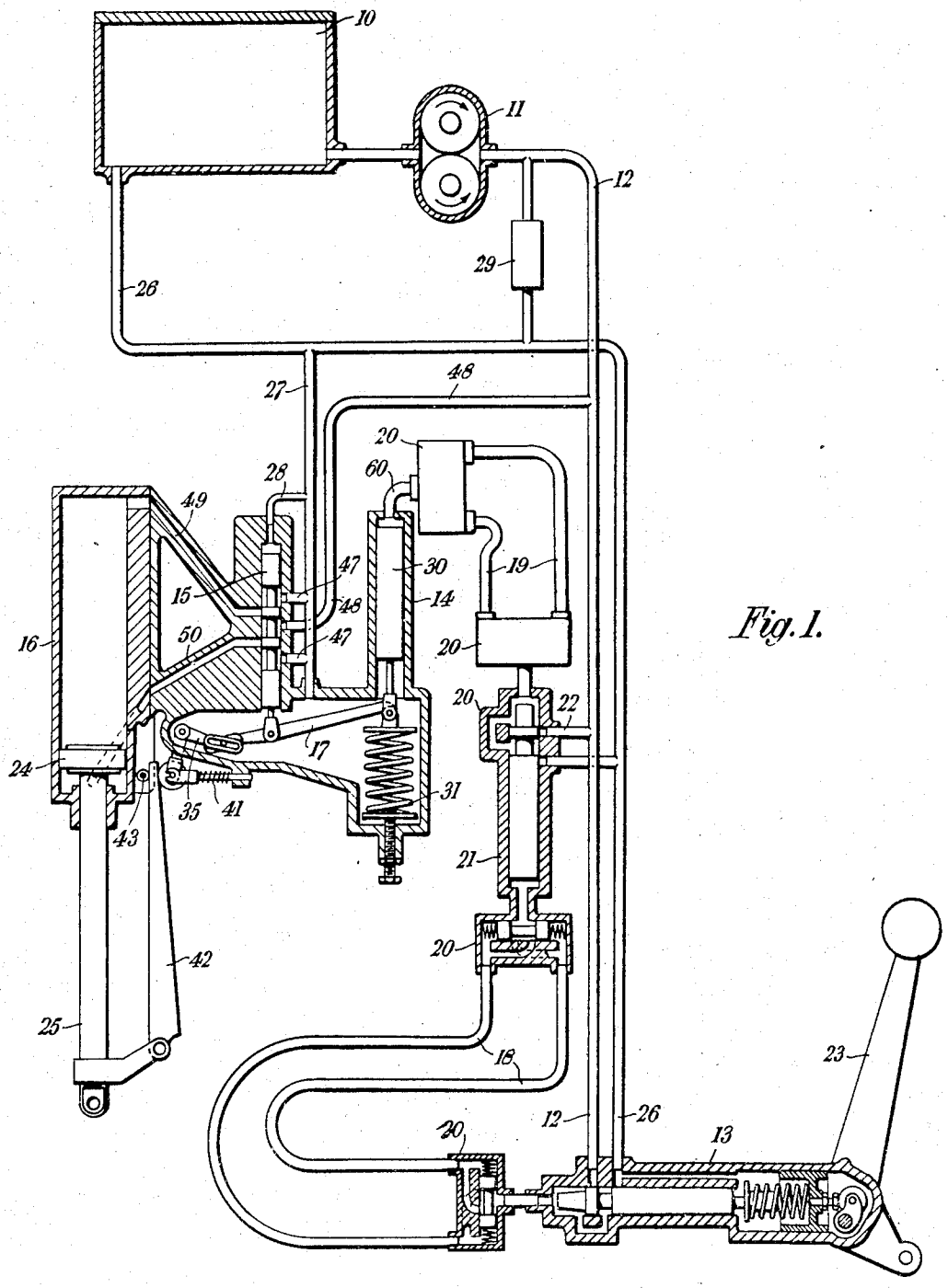


Fig. 1.

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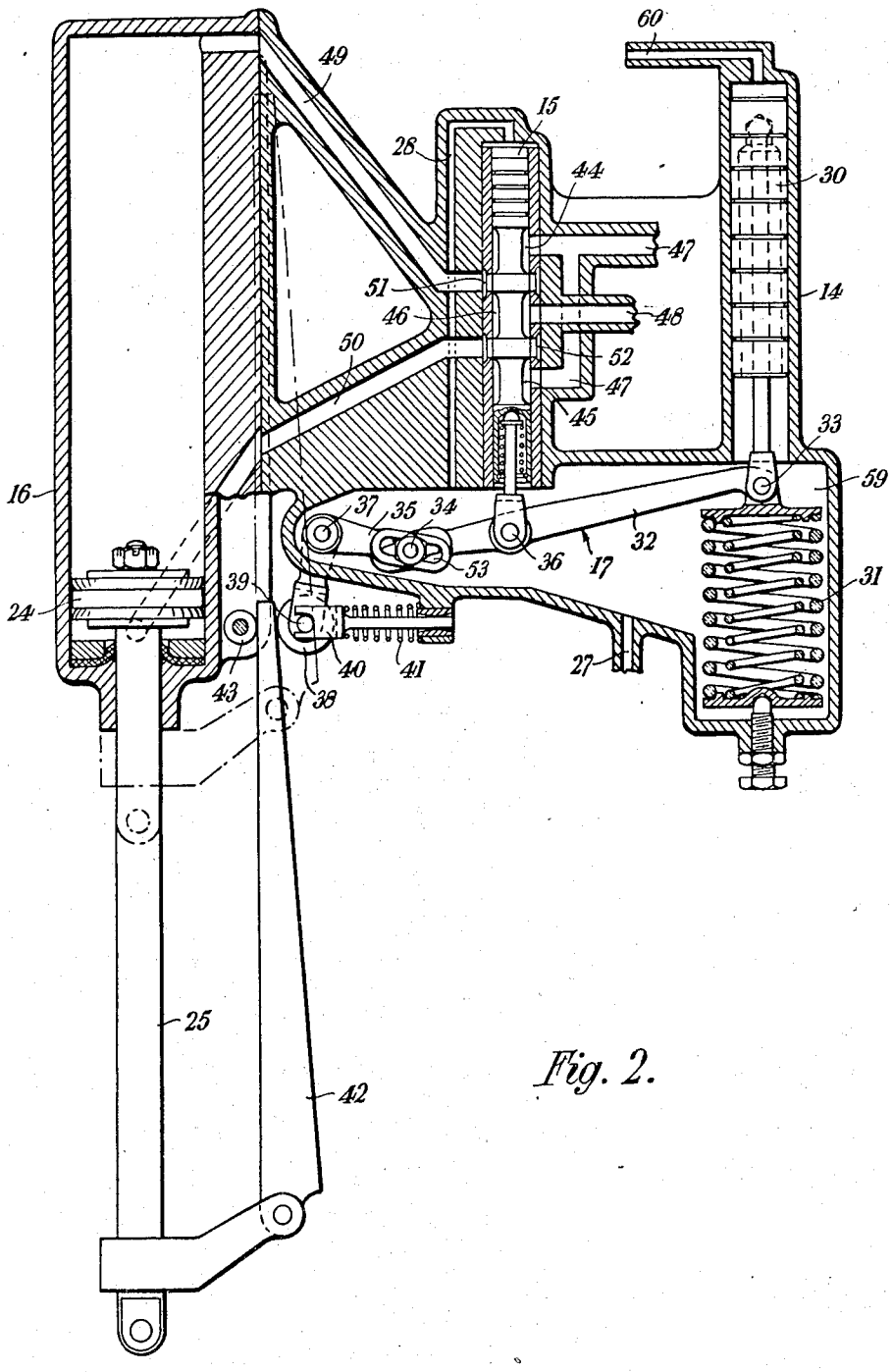


Fig. 2.

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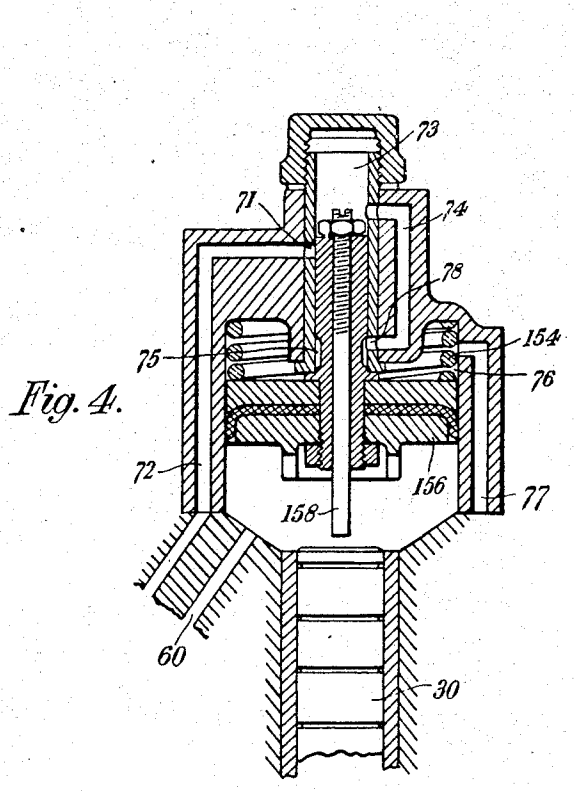


Fig. 4.

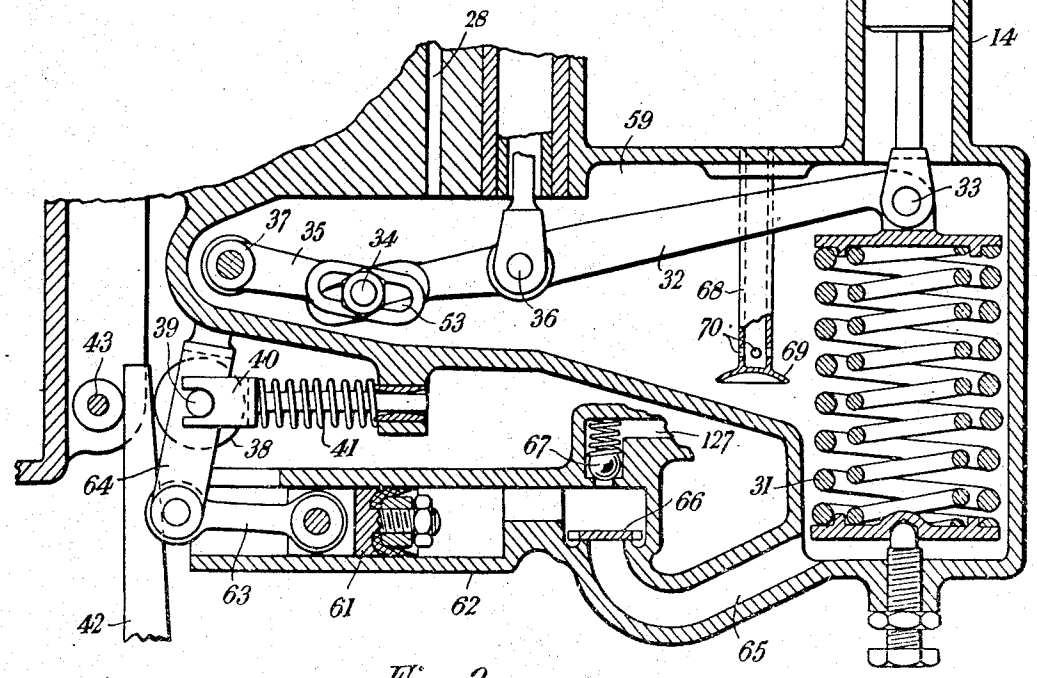
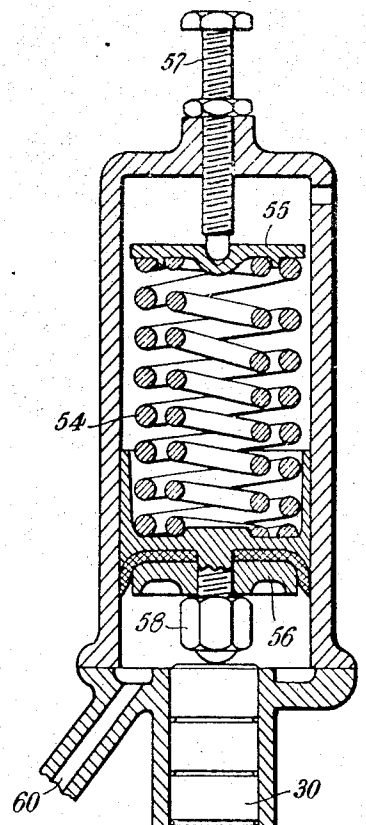


Fig. 3.



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UNITED STATES PATENT OFFICE

2,346,418

FLUID OPERATED MEANS FOR CONTROLLING APPARATUS AT A DISTANCE

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Application February 18, 1942, Serial No. 431,345
In Great Britain October 1, 1941

5 Claims. (Cl. 121—41)

This invention relates to fluid-pressure-operated remote control systems of the kind, described for example in British specification No. 483,049, comprising a sender unit at one station, a receiver unit at a distant station, a pipe line connecting the two units, a control device at the first station coupled to the sender unit, and an apparatus at the distant station coupled to the receiver unit and arranged to be operated, in accordance with the setting of the control device, by fluid pressure transmitted through the pipe line to the receiver unit under the control of the sender unit.

In British specification No. 483,049 and United States application Serial No. 358,415, I have described receiver units for remote control systems of the above kind, comprising a bellows or diaphragm sensitive to the pressure in the pipe line, a hydraulic servo-motor, a piston valve fixed to the sensitive bellows or diaphragm for controlling connections from pressure and exhaust to the cylinder of the servo-motor so as to produce a movement of the power piston of the servo-motor in the opposite direction to that of its own movement, and a follow-up gear constituted by a link, pivoted at one end to a fixed point, pivoted at its other end to the power piston, and pivoted centrally to a member linked to the piston valve.

With such an arrangement, the sensitive element will always occupy the same position when the piston valve is in its neutral position, irrespective of the pressure in the pipe line, the pressure on the sensitive member exerted by the fluid in the pipe line being balanced by the pressure of a spring (which may be constituted by the bellows itself where a bellows is employed as the sensitive element) the compression of which is varied by the movement of the power piston.

It is an object of the invention to provide a modified form of receiver unit which will enable a movement of the power piston to be obtained, which conforms more exactly with variations in the pressure in the pipe line.

In the receiver unit according to the invention the power piston, the piston or equivalent valve for controlling the same and the sensitive element are disposed in separate chambers, the sensitive element is balanced by a spring the load on which is determined only by the pressure in the pipe line and not by the movement of the power piston, and the follow-up gear is constituted by a swinging link, operatively connected at its ends to the power piston and to the sensitive element respectively and operatively connected to the valve at an intermediate point. With this arrangement the sensitive element will take up different positions as the pressure in the pipe line is altered, and the point of connection of the end of the swinging link to the sensitive element becomes, in effect, a fixed fulcrum until the pipe line pressure is changed. In order that this point may be as nearly as possible a fixed fulcrum, the point of connection of the piston or equivalent valve to the link should be located nearer to the point of connection of the power piston than to that of the sensitive element, so as to obtain a mechanical advantage enabling the sensitive element to remain stationary while the valve is being returned to the neutral position on movement of the power piston.

Where the receiver unit is to be used for pneumatic transmission, the sensitive element may be constituted by a diaphragm, but for high pressure hydraulic transmission it is necessary to use a piston or bellows.

A further object of the invention is to enable a long power stroke to be obtained, which is often desirable to avoid mechanical complication to achieve multiplication of the movement. It is not feasible to obtain this with a direct connection between the power piston and the swinging link of the follow-up gear, as the link would have to be made impossibly long and the valve would have to be placed at too large a distance from the power piston.

According to the invention, this object is achieved by means of an indirect connection between the power piston and the swinging link, such that a large movement of the power piston only communicates a small oscillating movement to the link. Thus an inclined plane, running on a roller external to the cylinder, may be attached to the power piston, this plane cooperating with a roller mounted on one end of a bell-crank lever pivoted at its other end to the swinging lever, and a spring being provided for maintaining the roller in contact with the inclined plane.

Some alternative forms of receiver unit constructed in accordance with the invention will now be described in detail, by way of example, with reference to the accompanying drawings in which—

Fig. 1 is a diagram showing a hydraulic remote control system embodying a receiver unit according to the invention,

Fig. 2 is a vertical section, on an enlarged scale, through the receiver unit shown in Fig. 1,

Fig. 3 is a similar section through a portion of an alternative form of receiver unit, and

Fig. 4 is a vertical section showing an alterna-

tive form of biasing device to that shown in Fig. 3.

The system shown in Fig. 1 comprises a reservoir 10 to contain oil, a pump 11, serving to pump the oil via a pipe 12 to a sender unit 13, the details of which are fully described in my United States application Serial No. 431,344 and a receiver unit 14, relay valve 15, servo-motor 16 and follow-up gear 17 the details of which are fully described below.

The sender unit 13 is connected to the receiver unit 14 by a pipe line consisting of two duplicated sections 18, 19. At each end of each duplicated section of the pipe line is located a cut-out valve 20 constructed as described in my United States application Serial No. 419,719, these cut-out valves serving to cut off the supply of pressure fluid from a broken or damaged pipe in either section of the duplicated line. Between the two duplicated sections of the line is disposed a relay valve 21, the construction of which is fully described in my United States application Serial No. 431,343. This relay valve 21 serves, when required, to boost up the pressure in the portion 19 of the pipe line connected to the receiver unit 14 by pressure tapped direct from the pressure line 12 through a branch pipe 22, and at the same time preserves an equal pressure in the two portions 18, 19 of the pipe line.

The sensitive piston 30 of the receiver unit 14 takes up a position determined by the position of the actuating member 23 of the sender unit, and causes the piston 24 of the servo motor 16 to take up a corresponding position. The apparatus to be remotely controlled is connected to the piston rod 25, and its setting is therefore determined by the setting of the actuating member 23 of the sender unit.

The pressures on the non-operating ends of the transmitter and receiving elements in the sender and receiver units are balanced by connecting them to exhaust by pipes 26, 27 respectively. The two ends of the relay valve 15 controlling the servo motor are likewise exposed to the same balancing pressure by means of the conduits 27, 28. A relief valve 29 connects the pipes 12 and 26.

As shown in Fig. 2, the sensitive piston 30 of the receiver unit is exposed at its upper end to the pressure in the signal line from the sender unit acting through the pipe 60 and is balanced by a spring 31, and the follow-up gear 17 is constituted by a swinging link 32, pivoted at one end 33 to the sensitive piston and at the other end 34 to one arm of a bell-crank lever 35 operatively connected to the power piston 24 of the servo-motor 16. Intermediately of its length at 36, the link 32 is connected to the piston valve 15. The bell-crank lever 35, which is mounted on a fixed pivot 37, carries on its other arm a roller 38. The spindle 39 on which this roller is mounted, rests in the forked end of a member 40 which is urged by a spring 41 to press the roller 38 against an inclined plane 42 fixed to the piston rod 25 of the servo-motor and running on a roller 43 external to the cylinder of the servo-motor.

The piston valve 15 is formed with two end annular grooves 44, 45 and with a central annular groove 46. The end grooves 44, 45 are permanently in communication with the limbs of a bifurcated pipe 47 connected to exhaust, and the central groove 46 is in permanent communication with a pipe 48 leading from the pressure line 12. The piston valve controls two passages 49, 50 leading respectively to the top and bottom of the cylinder of the servo-motor.

Normally the piston valve 15 occupies the central position shown in Fig. 2, in which it masks ports 51, 52 communicating respectively with the passages 49, 50. If, however, the pressure in the signal line should increase, the sensitive piston 30 will move down, compressing the spring 31. This will cause the link 32 to swing clockwise about the fulcrum 34, thereby moving the piston valve 15 down. This admits pressure from the pipe 48, through the groove 46, port 52 and passage 50 to the bottom of the servo-motor cylinder, and connects the top of the cylinder to exhaust through the passage 49, port 51 and groove 44. The power piston 24 will accordingly rise, thereby, through the agency of the inclined plane, rocking the bell-crank lever 35 counterclockwise, and causing the link 32 to swing clockwise about the fulcrum 33, until it has lifted the piston valve 15 back into its central position. The upward movement of the power piston 24 will then cease, the power piston having moved a distance determined by the increase in pressure in the signal line and having set the apparatus coupled to the piston rod 25 accordingly.

Similarly, if the pressure in the signal line should fall, the spring 31 will cause the sensitive piston 30 to rise, thereby lifting the piston valve from the central position. This will admit pressure from the pipe 48 and through the groove 46, port 51 and passage 49 to the top of the servo-motor cylinder, and connect the bottom of the cylinder to exhaust through the passage 50, port 52 and groove 45. The power piston 24 will accordingly descend, thereby, owing to the withdrawal of the inclined plane 42, enabling the spring 41 to rock the bell-crank lever 35 clockwise and pull the piston valve 15 down into its central position again.

With this arrangmenet, each time the pressure in the signal line changes, the sensitive piston 30 will take up a corresponding position such that the pressure in the signal line is balanced by the spring 31, and, during the consequent movement of the servo-motor piston, the point 33 will remain a fixed fulcrum. It will be observed that the point of connection 36 of the piston valve to the swinging link 32 is located nearer to the point of connection 34 of the power piston than to that 33 of the sensitive element, thus obtaining a mechanical advantage which will enable the sensitive element to remain stationary while the valve is being returned to the central position on movement of the power piston.

The purpose of the indirect connection between the power piston 25 and the swinging link 32, constituted by the inclined plane 42 and the bell-crank lever 35, is to enable a very long power stroke to be obtained. If a direct connection were used, the link 32 would have to be made impossibly long and the valve 15 would have to be placed at too large a distance from the power piston. The slope of the inclined plane 42 will determine the amount of movement given to the power piston for a given alteration in the signal line pressure. Also the connection between the bell-crank lever 35 and the swinging link is, due to the fact that the bell-crank lever is formed with a slot 53 embracing the pivot pin 34, an adjustable one. This enables a number of apparatus according to the invention to be synchronized with one another despite minor differences in spring strength and slight machining inaccuracies.

It is in some cases desirable if the signal lines

are shot away, or otherwise caused to be inoperative, and the pressure line for supplying the power piston remains intact, for the power piston to take some predetermined position in the cylinder as, for instance, to centralise an aircraft control. To this end an arrangement similar to that which is the subject of my copending United States application Serial No. 419,720 may be used.

An arrangement of this character is shown in Fig. 3. The receiver unit shown in this figure is identical with that shown in Fig. 2, apart from the inclusion of this added feature, and also means, which will be later described for evacuating leakage fluid from the chamber containing the spring 31.

In the arrangement shown in Fig. 3, there is disposed above the sensitive piston, a spring 54 held in compression between a plate 55 and a piston 56. The plate 55 bears against an adjusting screw 57 and the piston 56 carries on its undersurface a tappet 58. Normally the pressure in the signal line, admitted through the pipe 60, is sufficient to hold the spring 54 compressed, with the result that the tappet 58 is held away from and does not impede the movements of the sensitive piston 30. Should however the pressure in the signal line fail or fall below a predetermined minimum, the spring 54 will cause the tappet 58 to descend and overpower the balancing spring 31, thus moving the sensitive piston 30 and hence setting the power piston 24 to a predetermined position. The adjusting screw 57 serves to vary the compression of the spring 54 and hence the position to which the sensitive piston 30 will be moved under these conditions.

Glanding of the sensitive piston 30 is inadvisable, so that pressure liquid may leak from the signal line past the piston into the spring chamber 59. In the case of the apparatus shown in Fig. 2 this leakage is evacuated to exhaust through the pipe 27. In the case of the arrangement shown in Fig. 3, a pump is provided for evacuating the leakage. This is constituted by a piston 61 working in a cylinder 62 and connected by a link 63 to an extension 64 of the bell-crank lever 35. The cylinder 62 communicates with the spring chamber 59 by a passage 65, controlled by a plate valve 66, and with exhaust by a pipe 127 controlled by a ball valve 67. As will be readily understood this pump is operated by the movements of the power piston 24. The spring chamber 59 is provided with a vent to atmosphere, constituted by a tube 68 closed at its lower end by a deflector plate 69 and provided with vent holes 70. If the apparatus should be turned upside down, which is of course likely when it is installed in an aircraft, the leakage fluid will be flung against the top of the spring chamber 59 and the deflector 69 will prevent it from escaping through the air vent.

Fig. 4 shows an alternative form of biassing device for moving the sensitive piston 30 to a predetermined position in the event of failure of the signal line pressure. This is constituted by a piston 156, carrying a tappet 158, which is normally held up against the action of a spring 154 by the signal line pressure admitted through the pipe 60, so that the tappet does not interfere with the movements of the sensitive piston. When the signal line pressure fails however, the piston 156 will be moved down by the spring 154, exposing a port 71 through which the full pump pressure will be admitted from a pipe 72 to the space 73 above the piston 156, thus causing the tappet 158 to move down and set the sensitive piston 30 to the predetermined position. The space 73 is normally open to exhaust, via a passage 74, port 78, groove 75 in the piston 156, space 76 and pipe 77. Immediately, however, the piston 156 begins to move down it masks the port 78 and so cuts off the space 73 from exhaust. The high pressure from the pump (e. g., 1000 lbs./sq. in.) acting on the small area at the top of the piston 156 is sufficient completely to overpower the balancing spring 31 of the sensitive piston. When however the pressure in the signal line is restored, this pressure, although only of the order of from 65 to 260 lbs./sq. in. acting on the large area at the bottom of the piston 156 is sufficient to overcome the pump pressure in the space 73, and so will move the piston 156 up again, closing the port 71 and reopening the port 78. This arrangement, although more complicated than the spring-biassing mechanism shown in Fig. 3, has the advantage of giving a long stroke on the piston without the necessity of having to provide the large housing required to accommodate a very long spring.

The arrangement according to the invention gives a more accurate control of the apparatus coupled to the power piston of the receiver unit than that described in my United States application Serial No. 358,415, for the following reasons:

Firstly, the sensitive piston does not act directly on top of the piston valve but can be placed in such a position as to give it a real mechanical advantage over the valve, and when the power piston moves the piston valve, the sensitive piston is likely to remain as a fixed fulcrum, and as its total travel is very large in relation to the necessary travel of the piston valve, small errors caused by friction will therefore have only a minor effect on the piston valve.

Secondly, the sensitive piston will always take up a definite position in relation to the signal pressure fluid and the opposing spring strength; whereas where the diaphragm is placed directly on top of the piston valve, as in United States application Serial No. 358,415, on increase of the signal line pressure the diaphragm will move in a downward direction and cause the piston valve to open a pressure port leading to one side of the power piston, and an exhaust port leading to the other side of it. Then the movement of the power piston which follows increases the compression on a spring under the piston valve until this is sufficient to move the diaphragm back to its original central position and thus return the piston valve to the central position, and this action entails an increase in the signal line pressure sufficient to cause the sender diaphragm to move against its spring and open the sender unit exhaust valve until the pressure in the signal line again balances the sender spring. The exhaust valve in the sender unit is of course loaded and some effort is required by the diaphragm to open it.

This reverse flow in the signal line is liable to cause an increase in the hysteresis factor, and a slight hunting movement of the power piston, until conditions in the signal line are again stabilised. When pressure in the signal line decreases, the return movement of the receiver diaphragm to its central position will cause a reduction in the signal line pressure which will cause the sender diaphragm to open the pressure

valve in the sender unit and re-establish the signal line pressure.

What I claim as my invention and desire to secure by Letters Patent is:

1. A receiver unit for attachment to the pipe line of a fluid-pressure-operated remote control system of the kind specified, comprising a cylinder to communicate with the pipe line, a sensitive piston in the cylinder exposed at one end to the fluid pressure in the pipe line, a balancing spring operating on the other end of the sensitive piston, a chamber containing said spring, an air vent pipe extending into the interior of said chamber from the top thereof, a deflector arranged to prevent escape of leakage fluid from the chamber through the air vent pipe in the event of the apparatus being turned upside down, a hydraulic servo-motor, a relay valve for controlling the same, and a swinging link operatively connected at its ends to the sensitive piston and to the power piston and at an intermediate point to the relay valve.

2. A receiver unit for attachment to the pipe line of a fluid-pressure-operated remote control system of the kind specified, comprising a cylinder to communicate with the pipe line, a sensitive piston in the cylinder exposed at one end to the fluid pressure in the pipe line, a balancing spring operating on the other end of the sensitive piston, a chamber containing said spring, a hydraulic servo-motor including a power piston, a relay valve for controlling the servo-motor, a swinging link operatively connected at its ends to the sensitive piston and to the power piston and at an intermediate point to the relay valve, a pump comprising a cylinder communicating by valve-controlled passages with the chamber and to exhaust, and a piston mounted for reciprocation in said chamber, and actuating means for operating the pump to expel leakage fluid from said chamber, said actuating means comprising a pivoted bell-crank, a cam member connected to the power piston, a follower on the bell-crank cooperating with the cam member, a spring for holding the follower in engagement with the cam member, and a link connecting the bell-crank and the pump piston for displacing the latter in its cylinder on movement of the power piston.

3. A receiver unit for attachment to the pipe line of a fluid-pressure-operated remote control system of the kind specified, comprising a cylinder to communicate with the pipe line, a sensitive piston in the cylinder exposed at one end to the fluid pressure in the pipe line, a balancing spring operating on the other end of the sensitive piston, a hydraulic servo-motor including a power piston, a relay valve for controlling the servo-motor, a swinging link operatively connected at its ends to the sensitive piston and to the power piston and at an intermediate point to the relay valve, a biassing piston mounted in alignment with the sensitive piston, a spring, normally overridden by the fluid pressure in the pipe line, but tending to move the biassing piston towards the sensitive piston, and a pressure inlet to the side of the biassing piston remote from the sensitive piston, said inlet being normally closed by the biassing piston but operating to admit pressure to the remote side of the biassing piston on failure of the pipe line pressure and consequent displacement of the biassing piston by the spring.

4. A receiver unit for a fluid-pressure-operated remote control system of the kind specified, comprising an element sensitive to the pressure in the pipe line, a spring for balancing the same, the load on which is determined only by the pressure in the pipe line, a hydraulic servo-motor and a valve for controlling the same, and a swinging link operatively connected at its ends to the sensitive element and to the power piston of the servo-motor, and operatively connected to the valve at a point nearer to the point of connection of the power piston than to that of the sensitive element, the receiver unit having an air vent pipe extending into the interior of the chamber containing the balancing spring of the sensitive element, and a deflector arranged to prevent escape of leakage fluid through the air vent pipe in the event of the apparatus being turned upside down.

5. A receiver unit for a fluid-pressure-operated remote control system of the kind specified, comprising an element sensitive to the pressure in the pipe line, a spring for balancing the same, the load on which is determined only by the pressure in the pipe line, a hydraulic servo-motor and a valve for controlling the same, and a swinging link operatively connected at its ends to the sensitive element and to the power piston of the servo-motor, and operatively connected to the valve at a point nearer to the point of connection of the power piston than to that of the sensitive element, the receiver unit having a biassing piston, which is normally maintained clear of the sensitive element by the pipe line pressure, said biassing piston being arranged to move when the pipe line pressure falls below a given minimum, and thereby unmask a port for admitting pump pressure to the side of the biassing piston remote from the sensitive element.

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