Feb. 17, 1953 W. D. TEAGUE, JR 2,628,594

ELECTROHYDRAULIC SERVO UNIT

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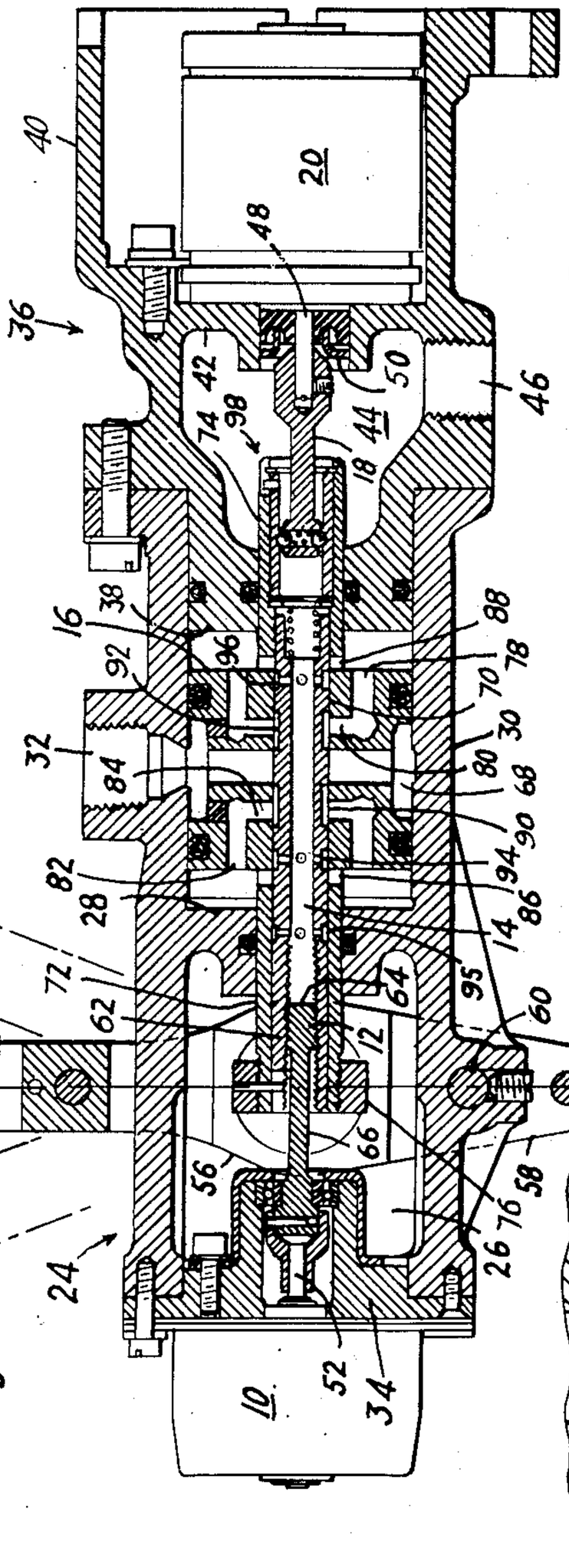

Fig. 1

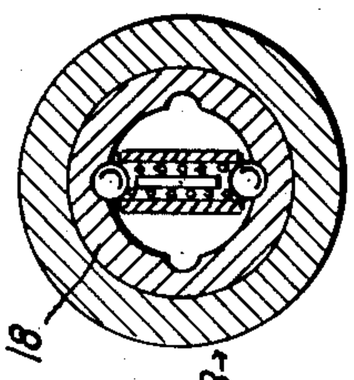

Fig. 3.

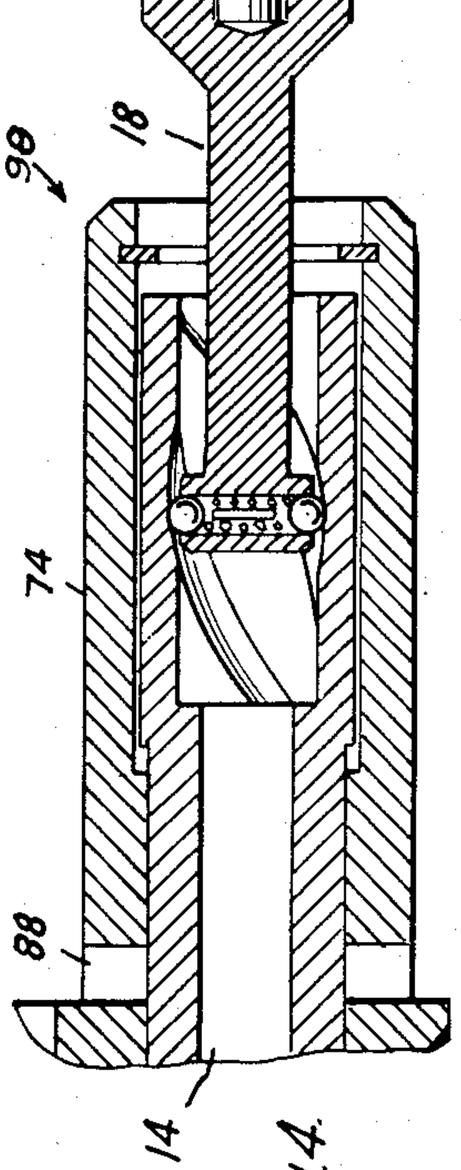

Fig. 4.

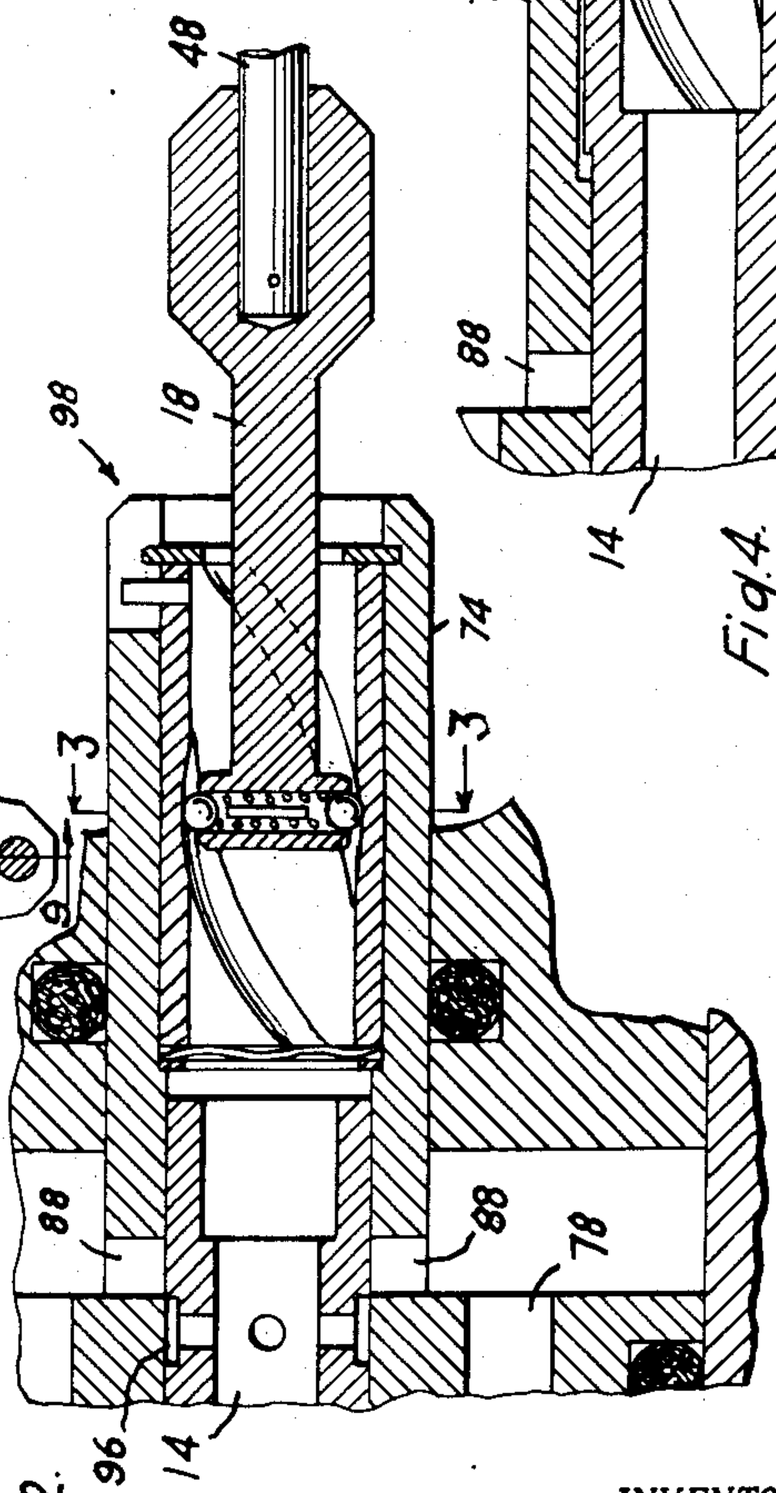

Fig. 2.

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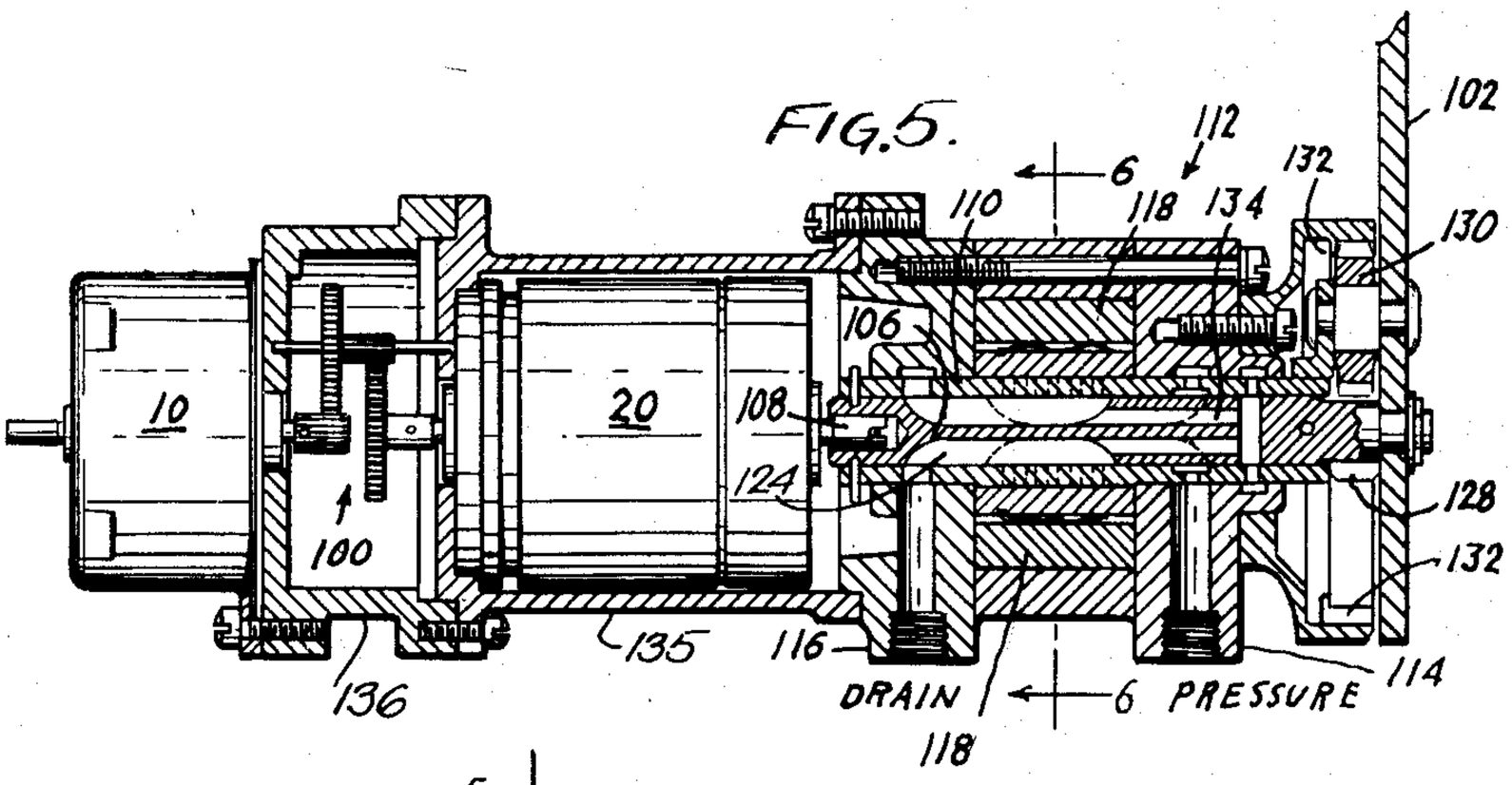
FIG. 5.



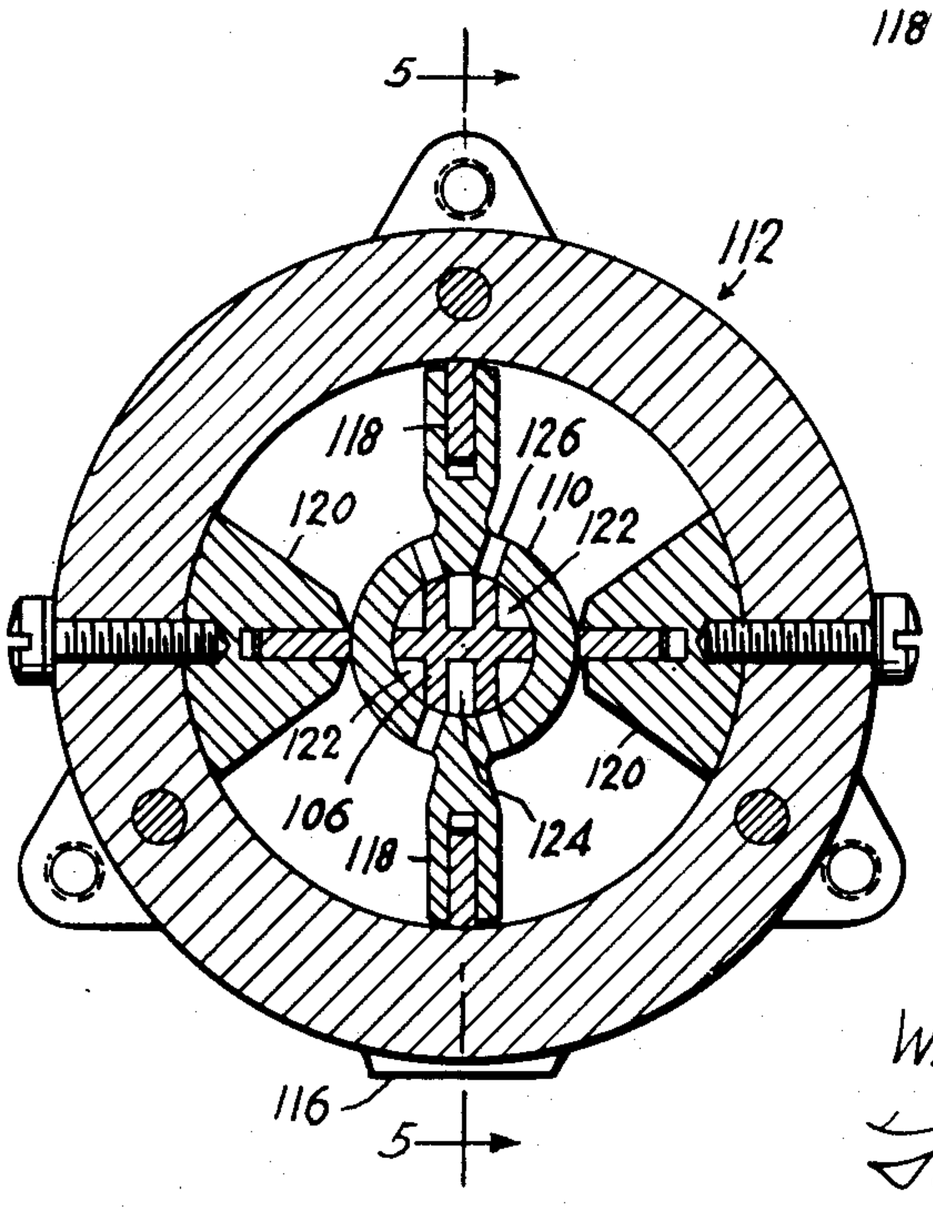


Fig. 6.

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FIG. 7

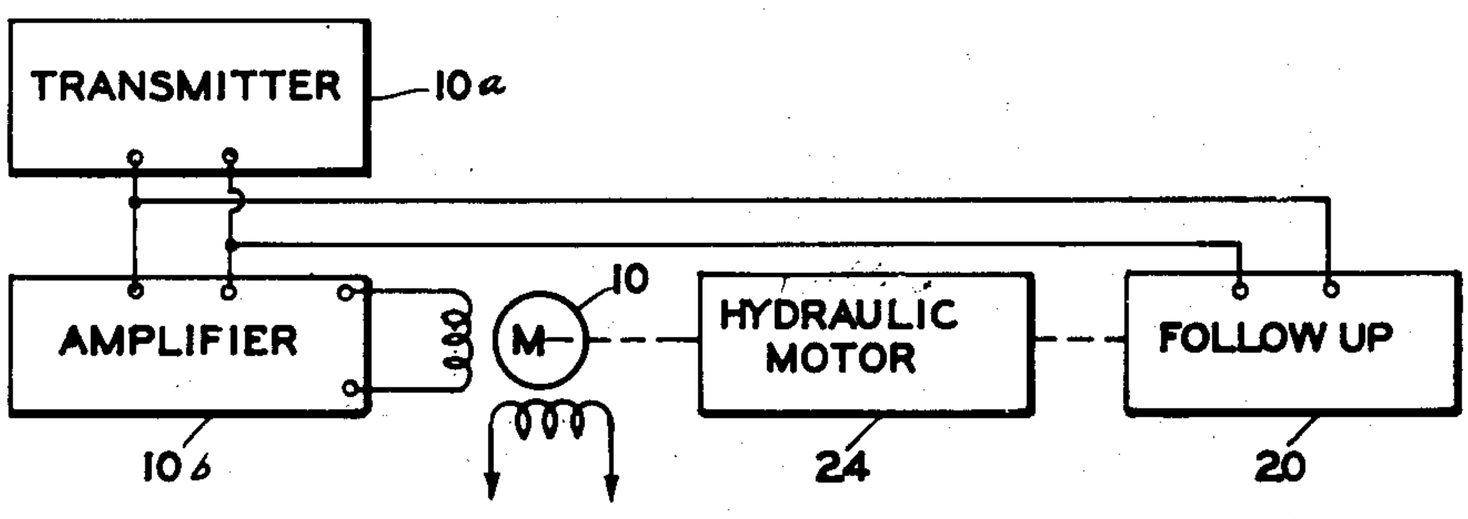


FIG. 8

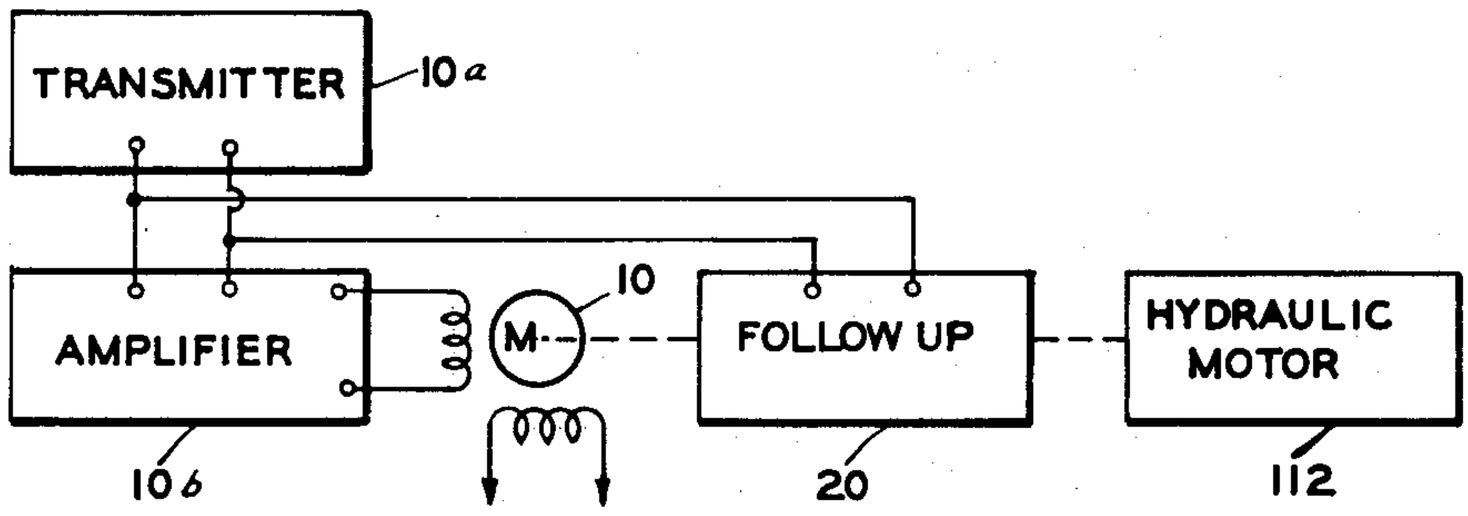
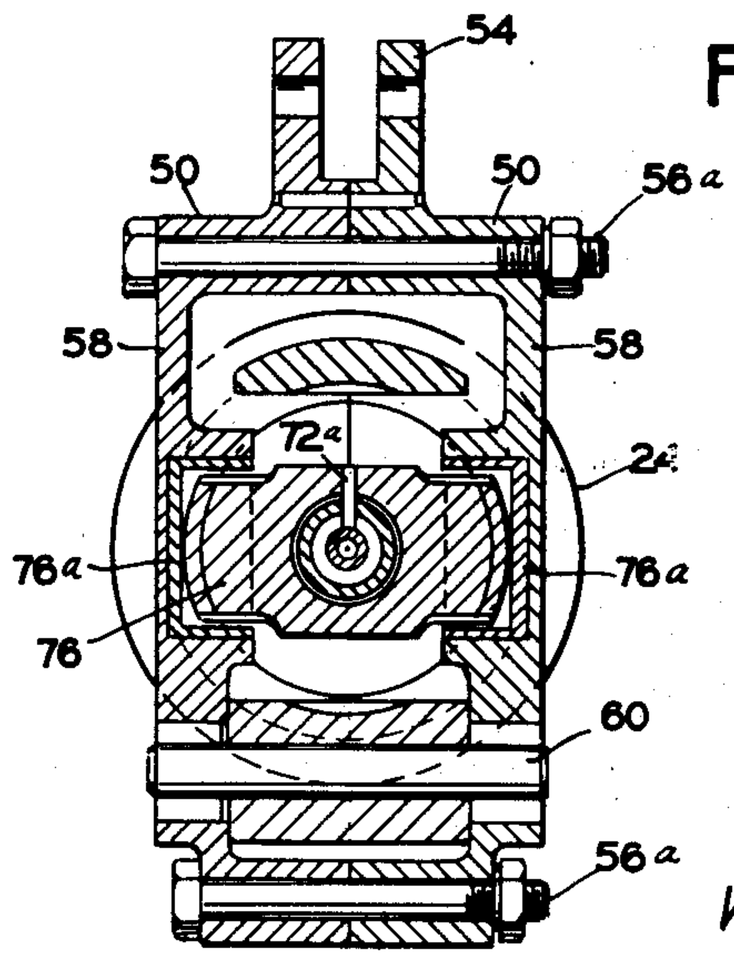


FIG. 9



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ELECTROHYDRAULIC SERVO UNIT

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3 Claims. (Cl. 121—41)

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The invention hereof relates to electrohydraulic servo units, and particularly to a unit of this character by which a lever or other operating member may be actuated in response to a signal from a remotely located control device, such as an airplane control part.

Among the objects of the invention are to overcome disadvantages of prior servo units and to do so by novel effective means.

Another object is to provide a servo unit by which the lever or operating member may be positioned accurately and rapidly against a resisting torque in response to the signal.

Other objects are to eliminate usual connecting lines, provide novel means for translating between rotary and linear motion, and to combine a drive motor, a pilot valve, a main piston and a follow up device in a compact unit.

Another object is to provide a system which is more stable than a conventional system, as by making the main piston position proportional to the pilot valve position.

Another object is to provide a unit which is more flexible in the selection and location of its parts.

Another object is to provide a device of the above indicated character which is simple and durable in construction, economical to manufacture, and effective in its operation.

These and other objects and features of the invention are pointed out in the following description in terms of the embodiment thereof which is shown in the accompanying drawings. It is to be understood, however, that the drawings are for the purpose of illustration only, and are not designed as a definition of the limits of the invention, reference being had to the appended claims for this purpose.

In the drawings:

Figure 1 is a side view partially in elevation and partially in section of an electro hydraulic servo unit constructed in accordance with the invention in one form;

Figure 2 is an enlarged fragmentary view of a portion of the structure as seen in Figure 1;

Figure 3 is a section taken substantially along the line 3—3 of Figure 2;

Figure 4 is a view similar to Figure 2 of a modification of the structure thereof;

Figure 5 is a view similar to Figure 1, taken

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substantially along the line 5—5 of Figure 6, of the invention in further modified form;

Figure 6 is an enlarged section taken substantially along the line 6—6 of Figure 5;

Fig. 7 is a diagrammatic illustration of the embodiment of the invention shown in Fig. 1;

Fig. 8 is a diagrammatic illustration of the embodiment of the invention shown in Fig. 5; and

Fig. 9 is a section taken along line 9—9 of Fig. 1.

Referring to Figure 1, the device of the form shown comprises in general, a variable phase driving motor 10 operative in response to a signal from a transmitter 10*a*, a pilot valve drive screw 12, a tubular pilot valve element 14, a main piston 16, a follow-up device drive 18, a follow-up device 20, and a torque output lever 22.

The remote control transmitter 10*a* forms no part of the present invention and any transmitter capable of inducing an electrical signal upon a displacement thereof from a null position may be used. Similarly, the variable phase driving motor 10 and follow-up device 20 per se are not shown or described since these elements are well known in the art. The only requirement of these elements necessary to the carrying out of the instant invention is that the motor 10 is capable of operation in response to a signal from the transmitter 10*a*, and the follow-up device 20 is capable of cancelling out the signal of the transmitter upon reaching a position in agreement with a displaced position of the transmitter 10*a*.

Specifically, the form of Figure 1 comprises a housing body 24 having, successively therealong from one end, from left to right as shown, in the order named, opposite side apertures 26, a partition 28, and a cylinder 30 having a fluid pressure side inlet port 32, and a closure 34 for the left hand end of the drive as shown.

A housing member 36 comprises a closed end 38 telescoping the other, or right-hand, end of the body 24, a mounting portion 40 at the other end of the housing member 36, and an intermediate wall 42 cooperating with the closed end 38 to form a chamber 44 having a side drain port 46.

The follow-up device 20 in the portion 40, includes a rotor shaft 48 operable through a seal

50 in the wall 42. The motor 10 is mounted on, and has a shaft 52 operable through the closure 34. The lever 22 includes arms 54 extending laterally of one side, the top as shown, of the housing body 24, and a split-yoke 56 embracing the body having legs 58 opposite the apertures 26 pivoted to the body, as by a shaft or pin 60, at a side of the body, the underside, as shown, opposite the arm 54 intermediate the apertures 26. The split-yoke 56 being joined together adjacent its ends by bolts 56*a*, shown in Figure 9.

The tubular pilot valve element 14 has an internal screw thread portion 62 next to the motor 10 cooperating with a nut 64 having a shank 66 by which it is connected to the motor shaft 52.

The piston 16, in the cylinder 30, is provided with a compartment 68, between the ends of the piston, open to the pressure port 32, and has a central bore 70 by which the piston axially slidably surrounds the valve element 14. The piston 16 includes a hollow extension 72 and a tubular stem element 74 continuing the bore 70 oppositely from the piston through the partition 28 and the closed end 38, respectively. A member 76, fixed to the extension 72 by a pin 72*a*, shown in Figure 9, extends, laterally oppositely of the extension 72, through the apertures 26 and is pivotally mounted in bearings 76*a* carried by the legs 58 of the lever 22.

A plurality of pairs of passages 78 and 80 each form one passage between the valve element 14 and the cylinder 30 at one side of the piston 16, and a plurality of pairs of similar passages 82 and 84 each form a passage between the valve element 14 and the cylinder 30 at the opposite side of the piston.

The extension 72 and the stem 74 have cylinder outlets 86 and 88, respectively. The valve element 14 has side cut outs 90 and 92 which, with adjacent lands on the valve are adapted to alternately open and close the piston passages 80 and 84, and ducts 94 and 96 are similarly adapted to alternately close and open the cylinder outlets 86 and 83, respectively, to drain through and along the valve element 14 to the chamber 44 and the drain port 46. Ducts 95 are provided to prevent leakage to the left, as shown, between the extension 72 and the valve element 14, and to direct fluid from the ducts 95 through the valve element to the chamber 44.

A ball bearing long-lead screw-and-nut connection 98, as better seen in Figures 2 and 3, in this instance, is connected between the stem element 74 and the shaft 48 of the follow-up device 20.

In operation, if the remote control transmitter 10*a* is turned to a new position, the signal thus induced is fed to an amplifier 10*b*, shown diagrammatically in Figure 7 and the motor 10 is caused to rotate in the correct direction to correspondingly drive the pilot valve 14 through the screw and nut 62 and 64, respectively,

Shifting of the pilot valve 14, from the null position shown, causes oil to flow to the desired end of the piston 16 to effect pressure at such end, and connects the opposite end of the piston to drain.

The piston 16 moves the lever 22, and acts through the long-lead screw connection 98 to turn the shaft 48 until the follow-up device 20 is again in agreement with the transmitter 10*a*, which action cuts out the signal to the amplifier 10*b*. The motor 10 stops, the valve 14 stops, and the piston 16 stops in a new position so that its ports are covered by the lands on the pilot valve 14.

As indicated in Figure 4, the shaft 48, instead of being driven by the piston stem 74, as above set forth, is driven directly by the valve element 14.

In Figures 5 and 6, the servo unit is shown in a modified form, and the hydraulic motor is of a rotary type instead of the linear type above set forth. Moreover, in this embodiment the relative positions of the electric motor 10, follow-up device 20 and hydraulic motor have been changed. As shown in Fig. 5, the follow-up device 20 is carried within a housing 135 that is secured to a side of the hydraulic motor casing 112. A gear box 136 is secured to the opposite side of the housing 135 and the motor 10 is secured to this gear box 136. Thus, in this embodiment, the relative positions of the elements of the servo unit are as follows: on the left extremity, motor 10, in the center, follow-up device 20; and at the right extremity, the hydraulic motor. The motor 10 is connected through suitable gearing 100 located in the gear box 136, to the shaft of the follow-up device 20. As shown diagrammatically in Figure 8, the motor 10 is electrically connected to a transmitter 10*a* and controlled by an electrical signal from said transmitter 10*a*. The follow-up device 20 is also electrically connected to said transmitter 10*a* and adapted to cancel or wipe out the signal of the transmitter 10*a*.

A rotary valve stem 106, connected to a shaft 108 of the follow-up device, is rotatable within a valve sleeve 110. The hydraulic motor casing 112 is provided with a pressure conduit 114 and a drain conduit 116 connected to a source of liquid under pressure and a sump, respectively. Radial valve pistons 118 are connected to the sleeve 110 to move therewith between radial dams 120, acting as cylinder heads to develop torque.

The valve 106 contains two pairs of pressure slots 122 and one pair of drain or exhaust slots 124. The sleeve 110 is provided with four longitudinally spaced radial holes 126, the inner ends of which cooperate with the valve slots 122 and 124 to connect the opposite sides of radial pistons 118 to pressure and drain as required to have the sleeve 110 follow the movements of the rotary stem 106.

The sleeve 110 is connected to a sun gear 128 which engages planetary gears 130 rotatably mounted on a final control lever 102, gears 130 also engaging a ring gear 132 to provide a stage of planetary gear reduction, with the result that the lever 102 moves with increased torque through a smaller angle than the vanes 118.

The end of the sleeve 110 is connected to drain through holes 134 lengthwise in the valve stem 106, and connected to the drain slots 124.

The device of Figures 5 and 6 differs from the devices of the previous figures as shown, in that the follow-up device 20 is directly driven by the motor 10, instead of by the piston 16, with a consequent increase of stability in the subcombination comprising the motor 10, the follow-up device 20 and the rotary valve 106, which otherwise tends to go into high-frequency oscillation, as on the order of twenty cycles per second, upon receiving a jolt or sharp impulse.

Such stability is also obtained with the form of Figure 4.

However, within the invention, any of the fol-

low-up connections may be employed with either the linear or rotary units.

Although several embodiments of the invention have been illustrated and described, various changes in the form and relative arrangements of the parts, which will now appear to those skilled in the art, may be made without departing from the scope of the invention. Reference is, therefore, to be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. For use with an electrical signal transmitter adapted to emit an electrical signal upon the displacement of said transmitter from a null position, a servo unit comprising a housing body having, successively therealong from one end in the order named, opposite side apertures, a partition and a cylinder having a fluid pressure side inlet port, a closure for said end, a housing member comprising a closed end telescoping the other end of said body and including a mounting portion at the other end of the member and an intermediate wall cooperating with said closed end to form a chamber having a side drain port, a follow up device in said mounting portion including a rotor shaft operable through said wall, a motor mounted on, and having a shaft operable through said closure, a lever including an arm extending laterally of one side of said body and a yoke embracing the body having legs opposite said apertures pivoted to the body at a side opposite said arm intermediate said apertures, a tubular valve element having an internal screw portion next to said motor, a nut in said screw portion connected to said motor shaft, a piston in said cylinder having a compartment between the ends of the piston open to said pressure port and the piston having a bore by which it axially slidably surrounds said valve element and including a hollow extension and a tubular stem element continuing said bore oppositely from the piston through said partition and said closed end, respectively, a member fixed to said extension extending laterally oppositely thereof through said apertures and pivotally connected to said legs, passages in said piston between said valve element and the cylinder at opposite ends of the piston, respectively, said extension and said stem having cylinder outlets, said valve element having means adapted to alternately open and close said passages and having ducts adapted to alternately close and open said cylinder outlets to drain through the valve element to said drain port, and a long-lead screw and nut connection between one of said elements and the shaft of said follow-up device, said motor and follow-up device being in electrical association with said transmitter so that a signal from said transmitter caused by a displacement thereof from a null position operates said motor thereby operating the follow-up device to cancel out the signal of said transmitter and simultaneously moving said tubular valve element to operate the piston and thus move the lever to a position in agreement with the displacement of said transmitter.

2. For use with an electrical signal transmitter adapted to emit an electrical signal upon the displacement of said transmitter from a null position, a servo unit comprising a housing having successively therealong in the order named, an end closure, opposite side apertures, a cylinder end partition, a cylinder having a fluid pressure side inlet port, an opposite cylinder end partition, a chamber having a side drain port and a unit

mounting end, a follow-up device on, and having a shaft operable through said mounting end, a motor on, and having a shaft element operable through said closure, a lever pivoted to the housing and having legs opposite said apertures, a tubular valve element having a screw portion, a unit cooperating with said screw portion and connected to said motor shaft element, a piston in said cylinder forming a compartment between the ends thereof open to said pressure port and the piston having a bore by which it axially slidably surrounds said valve element and including a hollow extension and a tubular stem element continuing said bore oppositely from the piston through said partitions, respectively, a member fixed to said extension extending through said apertures and pivotally connected to said legs, passages in said piston between said valve element and the cylinder at opposite ends of the piston, respectively, said extension and said stem having cylinder outlets, said valve element having means adapted to alternately open and close said passages and having ducts adapted to alternately close and open said cylinder outlets to said drain port, and a long-lead screw and nut connection between one of said elements and the shaft of said follow-up device, said motor and follow-up device being in electrical association with said transmitter so that a signal from said transmitter caused by a displacement thereof from a null position operates said motor thereby operating the follow-up device to cancel out the signal of said transmitter and simultaneously moving said tubular valve element to operate the piston and thus move the lever to a position in agreement with the displacement of said transmitter.

3. For use with an electrical signal transmitter adapted to emit an electrical signal upon the displacement of said transmitter from a null position, a servo unit comprising a housing having a cylinder having a fluid pressure inlet port, and a chamber having a drain port, a follow-up device on said housing and having a shaft, a motor on said housing and having a shaft, a lever pivoted to the housing, a tubular valve element having a screw portion, a nut cooperating with said screw portion and connected to said motor shaft, a piston in said cylinder forming a compartment between its ends communicating with said pressure port and the piston having a bore by which it slidably surrounds said valve element and including a hollow extension and a tubular stem element continuing said bore through one end of said cylinder and one end of said chamber, respectively, a member fixed to said extension extending through aperture means of said housing and pivotally connected to said lever, passages in said piston between said valve element and the cylinder at opposite ends of the piston, respectively, said extension and said stem having cylinder outlets, said valve element having means adapted to alternately open and close said passages and having ducts adapted to alternately close and open said cylinder outlets to said drain port, and a long-lead screw and nut connection between one of said elements and the shaft of said follow-up device, said motor and follow-up device being in electrical association with said transmitter so that a signal from said transmitter caused by a displacement thereof from a null position operates said motor thereby operating the follow-up device to cancel out the signal of said transmitter and simultaneously moving said tu-

bular valve element to operate the piston and thus move the lever to a position in agreement with the displacement of said transmitter.

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