July 4, 1950 R. C. GRIFFITH 2,513,476

TEMPERATURE COMPENSATING MEANS

Filed June 12, 1944 2 Sheets-Sheet 1

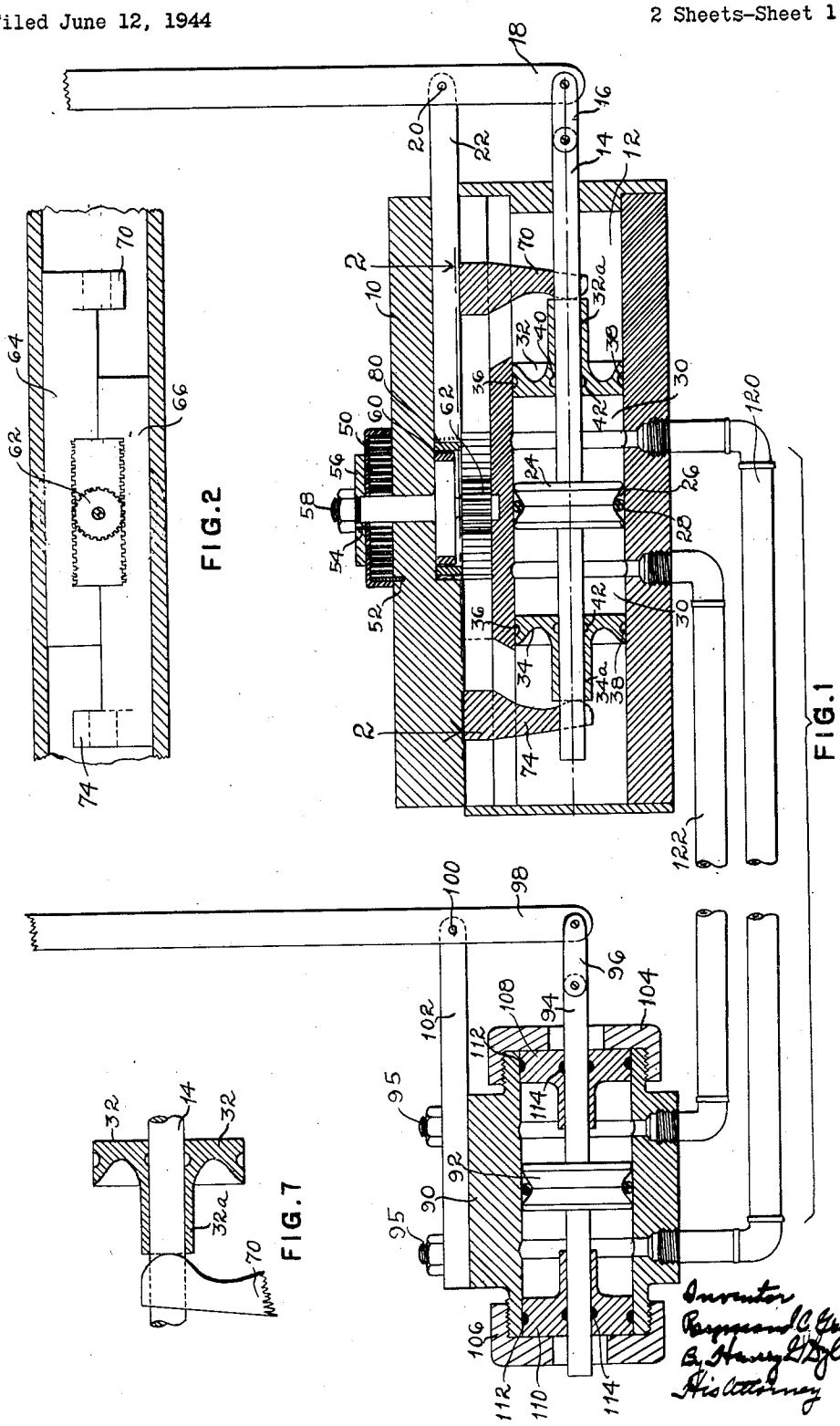


FIG. 1

FIG. 2

FIG. 7

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TEMPERATURE COMPENSATING MEANS

Filed June 12, 1944 2 Sheets-Sheet 2

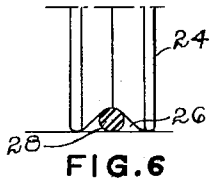


FIG.6

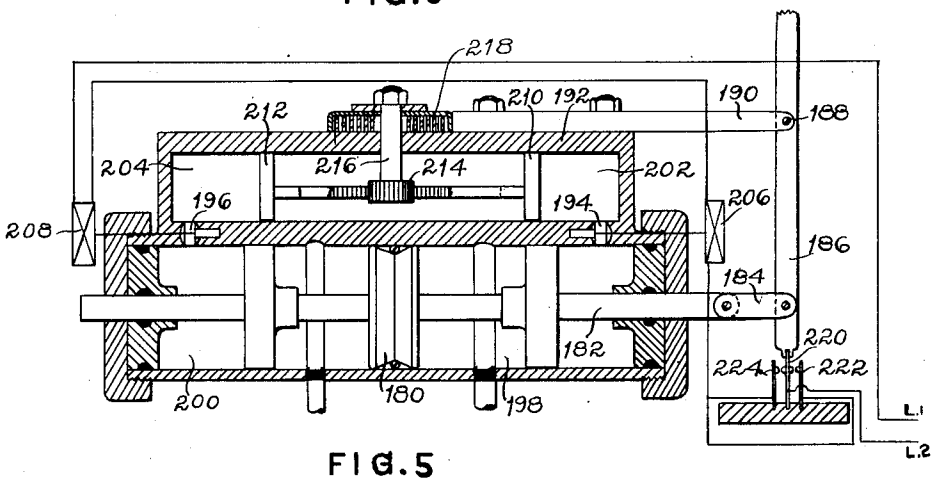


FIG.5

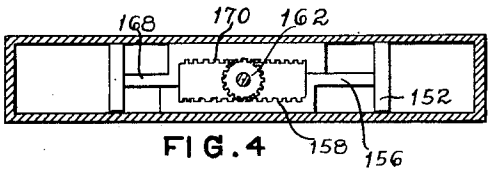


FIG.4

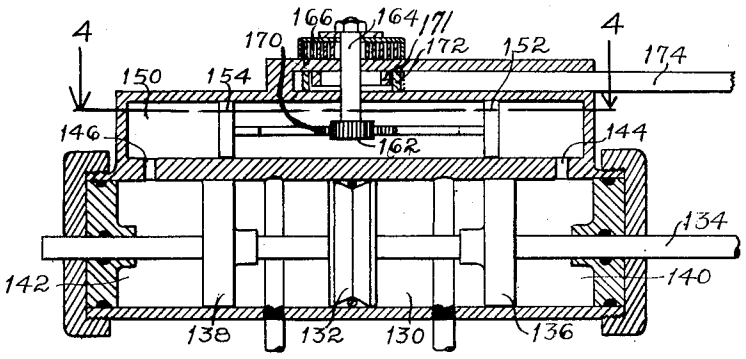


FIG.3

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TEMPERATURE COMPENSATING MEANS

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Application June 12, 1944, Serial No. 539,886

10 Claims. (Cl. 60—54.5)

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This invention relates to hydraulic actuating mechanism and more particularly to a hydraulic actuating mechanism permitting the fluid to expand and contract in response to changed temperature conditions.

An object of this invention is to provide a double channel control mechanism having a master unit and a motor unit, wherein the hydraulic fluid is permitted to expand and contract in response to temperature changes without influencing the accuracy and the sensitivity of the device.

Another object of this invention is to provide for adjustments in the volumetric cavity for two fluid channels of equal capacity, which volumetric cavity adjustments operate simultaneously and equally.

Another object of this invention is to provide for adjustments in the volumetric cavity for two fluid channels of equal capacity, which volumetric cavity adjustments operate simultaneously and equally, said volumetric adjustments being made inoperative whenever the hydraulic control mechanism is actuated from one position to another.

Another object of this invention is to provide a hydraulically controlled remotely mounted device, which device has accuracy, ample power and great sensitivity.

Other objects and advantages reside in the construction of parts, the combination thereof and the mode of operation, as will become more apparent from the following description.

Referring to the drawings:

Figure 1 discloses a hydraulic driving unit, which may be referred to as the master, and a driven unit, which may be referred to as the motor unit.

Figure 2 is a fragmentary sectional view taken substantially on the line 2—2 of Figure 1.

Figure 3 is a cross sectional view of a modification of a driving unit wherein compensation for contraction and expansion of the hydraulic fluids is hydraulically controlled.

Figure 4 is a fragmentary cross sectional view taken substantially on the line 4—4 of Figure 3.

Figure 5 is a cross sectional view of another modification wherein the mechanism for causing the adjustment compensating for contraction and expansion of the fluids is made inoperative by electric control means.

Figure 6 is an enlarged fragmentary view of a portion of the piston with the sealing unit shown in cross section.

Figure 7 is an enlarged cross sectional view of one of the floating pistons and a portion of

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the mechanical control mechanism used in the preferred embodiment.

Hydraulic means have been used to control mechanism remotely located. Generally, a piston is used to actuate the fluid supplied by conduits to a remote point where the fluid actuates the piston in one direction, the piston being returned by some type of a mechanical or driving device, the most common practice consisting of a spring actuating the piston into home position. This type of control mechanism, however, is not absolutely reliable, in that the remote piston is not positively returned to home position. If the resistance for returning this piston to home position is greater than the force exerted by the spring, the piston will not be returned. Such a return of the piston may be prevented by the congealing or the resistance of the fluid, by the piston sticking, by the load or by a combination of the above. Furthermore, the position of the piston depends upon the volume of the hydraulic fluid, which volume varies in response to temperature changes, as is well known to those skilled in the art.

That being the case, it is desirable to provide a remote control wherein the controlled unit or the driven unit, sometimes referred to as the motor unit, is positively driven in both directions. This is accomplished by utilizing two hydraulic fluid motors operating in parallel, the fluid of one motor being confined to one side of the pistons, the fluid of the other motor being confined to the other sides of the pistons. Theoretically, such a system seems to be the ideal solution; but in practice, such a system is not satisfactory unless means is provided for taking care of the contraction and expansion of the fluids and expansion and contraction of the parts used in confining the fluids.

Such means has been provided in the device disclosed herein in such a manner that volumetric displacements, due to contraction or expansion, operate simultaneously and equally, so that the volumetric displacement in both fluid channels is the same from time to time. The device for compensating for changes in volumetric displacement is preferably made inoperative, or substantially so, when the control mechanism is used in actuating a remotely located mechanism, as will appear more fully from the detailed description that follows.

Master unit

In the drawings, the reference character 10 indicates the main body portion of the master drive unit. This body portion 10 is provided with

a cylindrical cavity 12. This cylinder has enclosed therein a piston rod 14 connected to a link 16 actuated by a lever 18, pivotally mounted at 20 to a brake rod 22, which will be described more fully later. The piston rod 14 has fixedly attached thereto a slidable piston 24 provided with a peripherally disposed groove or channel 26, having seated therein a rubber ring or gasket member 28 providing a seal. The sides of the channel 26 and the cylinder wall form a 45° angle, so as to provide a suitable arrangement for sealing the juncture between the piston and the cylinder wall.

Cavities 30 are located on each side of the piston 24. In addition to the piston 24 fixedly attached to the piston rod 14, a pair of floating cylinder heads 32 and 34 are mounted for sliding engagement on the piston rod 14 and form end walls for the cavities 30, the floating cylinder head 32 being located to the right of the piston 24, as viewed in Figure 1, and the cylinder head 34 to the left of piston 24. The cylinder heads 32 and 34 are each provided with peripherally disposed channels 36, provided with sealing rings 38. In addition thereto, the cylinder heads 32 and 34 are provided with internally disposed channels 40, having mounted therein sealing rings or gaskets 42.

The floating cylinder heads 32 and 34 do not move in response to movement of the piston rod 14; but are used for the purpose of compensating for variations of volumetric displacement of the fluid caused by temperature changes resulting in expansion or contraction of the fluid and in expansion and contraction of the parts confining the fluid. In order that the slave unit, which will be described later, shall respond accurately to the movements of the master piston 24, it is absolutely essential that the movement of the two cylinder heads 32 and 34 be in opposite directions and equal. This is so as to insure the same volume for the fluid to the right of the master piston as the volume for the fluid to the left. If the two cylinder heads 32 and 34 do not move in opposite directions in unison through equal distances, it would be impossible to maintain accurate control of the motor unit. That being the case, it is necessary to provide a mechanism for controlling the movements of the two cylinder heads 32 and 34, so that these movements shall at all times be equal and in opposite directions. This may be done by a mechanical control mechanism, by a hydraulic control mechanism or by an electric control mechanism, as will appear more fully from the detailed description that follows.

In the preferred embodiment shown in Figure 1, the mechanism for controlling the movement of the cylinder heads 32 and 34 includes a spring motor having a spring 50 with one end attached at 52 to the main frame of the body portion 10 and the other end 54 attached to a washer-like member 56 fixedly attached to a bolt or stub-shaft 58 supporting a brake drum 60 and a pinion 62. Both the brake drum 60 and the pinion 62 are fixedly attached to member 58.

As may best be seen by referring to Figure 2, the pinion 62 engages teeth in member 64 and teeth in member 66. Member 64 is actuated to one side of the pinion 62 and member 66 to the opposite side, so that as the pinion 62 rotates in a clockwise direction in Figure 2, members 64 and 66 move outwardly in opposite directions. When the pinion 62 is rotated in a counterclockwise direction, members 64 and 66 move inwardly and toward each other, that is, in opposite directions. Member 64 is provided with a bifurcated arm member 70 straddling the cylinder head rod 14 and engaging the sleeve 32*a* of the piston 32. The bifurcations are arcuate, as best seen in Figure 7, so that each furcation engages the sleeve 32*a* integral with the cylinder head 32, at a single point. Member 66 is provided with a bifurcated arm or extension 74 engaging the sleeve 34*a* of the cylinder head 34. The spring motor is so positioned that the spring at all times urges or biases the arms or extensions 74 towards the cylinder heads 32 and 34 respectively, so as to maintain the fluid in the cavity under compression at all times. Due to the pinion and ratchet mechanism, the cylinder heads 32 and 34 are actuated through equal increments simultaneously in opposite directions. Whenever the volumetric displacement of the fluid decreases, the spring motor actuates the cylinder heads 32 and 34 towards each other, so as to compensate for the decrease in the volumetric displacement. Whenever the fluid expands or requires a greater space in the cylinder 12 in order to accommodate the fluid in the system, the force of the fluid actuates the cylinder heads 32 and 34 outwardly against the force exerted by the spring motor, so as to create a larger cavity in the cylinder 12 for the fluid and at the same time, wind up or tighten the spring motor.

Whenever the lever 18 is actuated so as to move the master piston 24 to the right or to the left, as viewed in Figure 1, it is very important that the movement of the piston does not actuate the floating cylinder heads 32 or 34, instead of the motor unit which will be described later. In order to prevent the piston 24 from actuating the cylinder heads 32 or 34, as the case may be, the control mechanism for changing the volumetric displacement is made inoperative whenever the lever 18 is actuated. In order to accomplish this result, the end of the brake rod or link 22 opposite the pivot 20 is fixedly attached to a brake band 80 surrounding the brake drum 60, so as to apply a brake to the brake drum 60, preventing the drum from rotating, thereby preventing the spring motor and the parts associated therewith from moving, to thereby lock the floating cylinder heads 32 and 34 in position. Upon initial operation of the lever 18 it first pivots at its connection to 16 and actuates the brake band 80 against the drum 60. In the event the lever 18 is rotated in a clockwise direction, as viewed in Figure 1, this operation causes the brake band diametrically opposite the rod 22 to engage the brake drum, in that the rod 22 is pulled outwardly away from the brake drum. In the event the lever 18 is rotated in a counterclockwise direction, the rod 22 then pushes against the brake band 80, causing the adjacent portion of the brake band 80 to contact the brake drum. Thereafter, lever 18 pivots at 20, causing the piston 24 to move in the desired direction. The brake band 80 is preferably made from rigid material provided with a suitable lining, so that irrespective of the direction of movement of the brake rod 22, the brake band will engage the brake drum so as to apply the brakes.

Motor unit

To the left of Figure 1 is shown the motor unit, which includes a cylinder 90 having mounted therein a piston 92 fixedly attached to a piston rod 94 pivotally attached to a link 96 actuating

a controlled lever 98 pivotally attached at 100 to a fixed support 102, that in the modification shown herein is attached to the cylinder 90 by a pair of bolts 95. Cylinder heads 104 and 106 threadedly engage the opposite ends of the cylinder 90 and provide abutments for piston-like members 108 and 110 mounted in the ends of the cylinder and are used to confine the hydraulic fluid. Suitable gaskets 112 and 114 are used in providing seals preventing the escape of the fluid. The cavities 30 are connected with suitable conduits 120 and 122 to the cavities on the opposite side of the piston 92.

As may best be seen by referring to Figure 1, the cavity to the right of Figure 1 of the piston 24 is connected to the cavity to the left of piston 92 and the cavity to the left of the piston 24 is connected to the cavity to the right of piston 92. By this arrangement, whenever the lever 18 is actuated so as to move the piston 24 to the right, as viewed in Figure 1, the piston 92 in the motor unit is driven to the right a like distance, causing the lever 98 to move in the same direction as the lever 18 through substantially the same distance. This permits a remote control of member 98 by actuating member 18, if, for example, the upper end of member 18, as viewed in Figure 1, is moved one inch to the right, the upper end of member 98 will also move through substantially one inch in the same direction. This device may be used in remotely controlling the parts of machines in airplanes, on engines, et cetera.

In the embodiment shown in Figures 3 and 4, a control mechanism for controlling the changes in the displacement cavities includes hydraulic means. In this embodiment the cylindrical cavity 130 has mounted therein a master piston 132 fixedly attached to the piston rod 134. A pair of floating pistons or cylinder heads 136 and 138 are mounted for sliding movement on the piston rod in the cylindrical cavity 130 on opposite sides of the master piston 132. The cavities found between the master piston 132 and the floating piston 136 and between the master piston 132 and the floating piston 138 contain the hydraulic fluid used in driving this motor unit. The cavities 140 and 142 beyond the pistons 136 and 138 respectively, contain a second hydraulic fluid, adapted to pass through ducts or passages 144 and 146 into the cylindrical cavities 148 and 150, having mounted therein pistons 152 and 154.

The piston 152, as may be best seen by referring to Figure 4, is provided with a piston rod 156 integral with a rack 158 engaging a pinion 162 fixedly attached upon a stubshaft or bolt 164 actuated by a spring motor 166. The piston 154 is connected to a piston rod 168 integral with a rack 170 also meshing with the pinion 162. The spring motor and the pinion 162 operate in a manner similar to the spring motor and pinion disclosed in the preferred embodiment. A brake drum 171 is fixedly attached to the stubshaft 164 and is subject to the influence of a braking mechanism 172 actuated by a brake rod in a manner similar to that disclosed in connection with the preferred embodiment. If the hydraulic fluid expands in the cavities 130, the floating pistons 136 and 138 will separate or move outwardly, actuating the hyraulic fluid in the cavity 140 and 142, so as to actuate the pistons 152 and 154 against the force of the spring motor. By this arrangement, the volumetric displacement is controlled by a hydraulic mechanism, so that

the displacement in the two cavities forming the parallel circuits is substantially identical.

An electric control mechanism for controlling a portion of the volumetric expansion mechanism has been shown in Figure 5. In the modification disclosed in Figure 5, a master piston 180 is fixedly mounted upon a piston rod 182 pivotally attached to a link 184, pivotally joined to a lever 186, mounted upon a fulcrum 188 upon a bracket 190, fixedly secured to the frame 192 of the master unit. Passages 194 and 196 extend from the cavities 198 and 200 to the cavities 202 and 204 respectively in the auxiliary cylinder. An electromagnetc valve 206, shown schematically, is used in opening and closing the passage 194. An electromagnetic valve 208, shown schematically is used in opening and closing the passage 196.

A piston 210 forms one wall of the cavity 202 and a piston 212 forms one wall for the other cavity 204. These pistons are connected by a suitable rack mechanism similar to that disclosed in Figure 4 to a pinion 214 fixedly attached to the stub shaft 216 actuated or controlled by a spring motor 218. In this modification a brake has not been used; but instead, the same results are obtained by closing the electromagnetic valves 206 and 208, so as to close the passages 194 and 196, thereby confining the hydraulic fluid in the cavities 198 and 200 to these cavities. When the electromagnetic valves 206 and 208 are closed, the volumetric displacement compensating mechanism is inoperative.

The electromagnetic valves 206 and 208 are controlled by any suitable electrical circuit, one of which has been shown schematically in Figure 5. This electrical circuit includes a double throw switch including a contact carrying member 220 having one end seated between the furcations of the bifurcated end of the lever 186. Member 220 carries a pair of contacts, one on either side. One of these contacts is adapted to engage a fixed contact 222 and the other is adapted to engage a fixed contact 224. The contacts 222 and 224 are connected in series with the electromagnets of the electromagnetic valves 206 and 208. The movable contact element 220 is connected to line L_2. One terminal of the electromagnet 208 is connected to line L_1. By this arrangement it may be readily seen that if the lever 186 is actuated to the right or to the left, as viewed in Figure 5, the circuit to the magnets of the electromagnetic valves 206 and 208 is energized so as to cause the valves to close the passages 194 and 196, thereby confining the fluid to the slave unit and the main cylinder of the master unit. As soon as the lever 186 is adjusted into the home position shown in Figure 5, the circuit to the electromagnets is opened, thereby deenergizing the electromagnetic valves, so as to cause these valves to open the passages 196 and 198.

Various other modes of controlling the operation of the mechanism for compensating for contraction and expansion of the hydraulic fluid may be used within the purview of this invention, providing the compensating devices in the two chambers or cavities, one on either side of the master piston, are adjusted in unison simultaneously to equal increments.

In each of the above devices the two hydraulic circuits extending from the master unit to the motor unit are arranged in parallel and are substantially identical as to volumetric fluid capacities. Thus, the fluids in the two circuits extending side by side are subjected to the same

temperature changes, resulting in equal expansion or contraction of the fluid.

In the preferred embodiment the piston areas in the master unit and in the motor unit are substantially equal. Likewise, the effective lengths of the lever 18 and the lever 98 are substantially the same, resulting in substantially equal movements of the two levers. The relative movements of the two levers may be altered by changing the relative ratios and dimensions of the master unit with respect to those of the motor unit.

In the preferred embodiment the mechanism for adjusting the available space for the hydraulic fluids to accommodate expansion and contraction thereof has been incorporated into the master unit. For some installations this mechanism may be incorporated into the motor unit, or, for some purposes, this mechanism may be incorporated as a separate and distinct unit, depending entirely upon the uses to which the unit is to be put.

Although the preferred embodiment of the device has been described, it will be understood that within the purview of this invention various changes may be made in the form, details, proportion and arrangement of parts, the combination thereof and mode of operation, which generally stated consist in a device capable of carrying out the objects set forth, as disclosed and defined in the appended claims.

Having thus described my invention, I claim:

1. A hydraulically driven remote control system including a master unit and a motor unit, each of said units including a cylinder and a piston mounted in the cylinder, a pair of hydraulic fluid circuits, each of said circuits including a conduit which connects one side of the cylinder in the master unit to one side of the cylinder in the motor unit, the other conduit connecting the other side of the cylinder in the master unit to the other side of the motor unit, hydraulic fluids in said conduits, said hydraulic fluids filling said conduits and the available space in the cylinders, means for compensating for changes in the volume of the fluids caused by expansion and contraction of the hydraulic fluids, said compensating means including movable cylinder heads in the cylinder of the master unit, said compensating means compensating equally for the fluids in the two circuits so that the available space for the fluid on one side of the pistons is equal to the available space on the other side of the pistons and means for arresting the compensating means when the master unit is driving the motor unit.

2. A hydraulically driven remote control system including a master unit and a motor unit, each of said units including a cylinder and a piston movably mounted in the cylinder, said system including a pair of hydraulic fluid circuits of substantially equal fluid capacity, one fluid circuit including the cylindrical cavity to one side of the piston in the master unit and the cylindrical cavity to one side of the piston in the motor unit, and a conduit for interconnecting said cavities, the other fluid circuit including the cylindrical cavity on the other side of the piston in the master unit and the cylindrical cavity on the other side of the piston in the motor unit and a conduit for interconnecting said last mentioned cavities, means for compensating for expansion and contraction of the hydraulic fluid in each of said circuits, said compensating means including movable cylinder heads in the master unit, said means including an equalizing mechanism for moving the cylinder heads to change the available space for the fluids in the circuits simultaneously and equally and means for arresting the compensating means when the master unit is driving the motor unit.

3. A hydraulically driven remote control system including a master unit and a motor unit, each of said units including a cylinder and a piston movably mounted in the cylinder, said system including a pair of hydraulic fluid circuits of substantially equal fluid capacity, one fluid circuit including the cylindrical cavity to one side of the piston in the master unit and the cylindrical cavity to one side of the piston in the motor unit, and a conduit for interconnecting said cavities, the other fluid circuit including the cylindrical cavity on the other side of the piston in the master unit and the cylindrical cavity on the other side of the piston in the slave unit and a conduit for interconnecting said last mentioned cavities, mechanical means for compensating for expansion and contraction of the hydraulic fluid in each of said circuits, said means including movably mounted cylinder heads in the master unit moving in opposite directions through equal increments in response to equalizing mechanism for changing the available space for the fluids in the circuits simultaneously and equally and means for arresting the movement of the movably mounted cylinder heads when the master unit drives the motor unit.

4. A hydraulically driven remote control system including a master unit and a motor unit, each of said units including a cylinder and a piston movably mounted in the cylinder, said system including a pair of hydraulic fluid circuits of substantially equal fluid capacity, one fluid circuit including the cylindrical cavity to one side of the piston in the master unit and the cylindrical cavity to one side of the piston in the motor unit, and a conduit for interconnecting said cavities, the other fluid circuit including the cylindrical cavity on the other side of the piston in the master unit and the cylindrical cavity on the other side of the piston in the motor unit and a conduit for interconnecting said last mentioned cavities, hydraulic means for compensating for expansion and contraction of the hydraulic fluid in each of said circuits, said means including movably mounted cylinder heads in the master unit moving in opposite directions through equal increments in response to equalizing means for changing the available space for the fluids in the circuits simultaneously and equally and means for arresting the movement of the movably mounted cylinder heads when the master unit drives the motor unit.

5. A hydraulically driven remote control system including a master unit and a motor unit, each of said units including a cylinder and a piston movably mounted in the cylinder, said system including a pair of hydraulic fluid circuits of substantially equal fluid capacity, one fluid circuit including the cylindrical cavity to one side of the piston in the master unit and the cylindrical cavity to one side of the piston in the motor unit, and a conduit for interconnecting said cavities, the other fluid circuit including the cylindrical cavity on the other side of the piston in the master unit and the cylindrical cavity on the other side of the piston in the motor unit and a conduit for interconnecting said last mentioned cavities, means for compensating for expansion and contraction of the hydraulic fluid in said circuits, said last mentioned means including movable cylinder heads, electromagnetic control means including magnetic valves arresting the

movement of the movable cylinder heads when the piston in the master unit is actuated, said movable cylinder heads being mounted in the cylinder of the master unit and equalizing means for causing the compensating means in the two circuits to be adjusted equally and simultaneously and means for arresting the movement of the movably mounted cylinder heads when the master unit drives the motor unit.

6. A hydraulically driven remote control system including a motor unit, each of said units including a cylinder and a piston mounted in the cylinder, a pair of hydraulic fluid circuits, each of said circuits including a conduit which connects one side of the cylinder in the master unit to one side of the motor unit, hydraulic fluids in said conduits, said hydraulic fluids filling said conduits and the available space in the cylinders, means in the master unit for compensating for changes in the volume of the fluids caused by expansion and contraction of the hydraulic fluids, said compensating means compensating equally for the fluids in the two circuits so that the available space for the fluid on one side of the pistons is equal to the available space on the other side of the pistons, and brake means including brakes arresting the movement of the compensating means, which brakes are applied in response to loading the master unit so as to make the compensating means inoperative when the master unit operates the motor unit.

7. A hydraulically driven remote control system including a master unit and a motor unit, each of said units including a cylinder and a piston movably mounted in the cylinder, said system including a pair of hydraulic fluid circuits of substantially equal fluid capacity, one fluid circuit including the cylindrical cavity to one side of the piston in the master unit and the cylindrical cavity to one side of the piston in the motor unit, and a conduit for interconnecting said cavities, the other fluid circuit including the cylindrical cavity on the other side of the piston in the master unit and the cylindrical cavity on the other side of the piston in the motor unit and a conduit for interconnecting said last mentioned cavities, means for compensating for expansion and contraction of the hydraulic fluid in each of said circuits, said means including movable cylinder heads for one of the cylinders moving in unison in response to equalizing mechanism for changing the available space for the fluids in the circuits simultaneously and equally, and means for making the compensating means inoperative when the master unit operates the motor unit.

8. A hydraulically driven remote control system including a master unit and a motor unit, each of said units including a cylinder and a piston movably mounted in the cylinder, said system including a pair of hydraulic fluid circuits of substantially equal fluid capacity, one fluid circuit including the cylindrical cavity to one side of the piston in the master unit and the cylindrical cavity to one side of the piston in the motor unit, and a conduit for interconnecting said cavities, the other fluid circuit including the cylindrical cavity on the other side of the piston in the master unit and the cylindrical cavity on the other side of the piston in the motor unit and a conduit for interconnecting said last mentioned cavities, mechanical means for compensating for expansion and contraction of the hydraulic fluid in each of said circuits, said means including movable cylinder heads for one of the

cylinders moving through equal increments in response to equalizing mechanism for changing the available space for the fluids in the circuits simultaneously and equally, and means for making the compensating means inoperative when the master unit operates the motor unit.

9. A hydraulically driven remote control system including a master unit and a motor unit, each of said units including a cylinder and a piston movably mounted in the cylinder, said system including a pair of hydraulic fluid circuits of substantially equal fluid capacity, one fluid circuit including the cylindrical cavity to one side of the piston in the master unit and the cylindrical cavity to one side of the piston in the motor unit, and a conduit for interconnecting said cavities, the other fluid circuit including the cylindrical cavity on the other side of the piston in the master unit and the cylindrical cavity on the other side of the piston in the motor unit and a conduit for interconnecting said last mentioned cavities, hydraulic means for compensating for expansion and contraction of the hydraulic fluid in each of said circuits, said means including movable cylinder heads for one of the cylinders moving through equal increments in response to equalizing means for changing the available space for the fluids in the circuits simultaneously and equally, and means for making the compensating means inoperative when the master unit operates the motor unit.

10. A hydraulically driven remote control system including a master unit and a motor unit, each of said units including a cylinder and a piston movably mounted in the cylinder, said system including a pair of hydraulic fluid circuits of substantially equal fluid capacity, one fluid circuit including the cylindrical cavity to one side of the piston in the master unit and the cylindrical cavity to one side of the piston in the motor unit, and a conduit for interconnecting said cavities, the other fluid circuit including the cylindrical cavity on the other side of the piston in the master unit and the cylindrical cavity on the other side of the piston in the motor unit and a conduit for interconnecting said last mentioned cavities, means for compensating for expansion and contraction of the hydraulic fluid in said circuits, said last mentioned means including movable cylinder heads for one of the cylinders moving through equal increments in response to equalizing means for causing the compensating means in the two circuits to be adjusted equally and simultaneously, and electric means for making the compensating means inoperative when the master unit operates the motor unit.

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