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HYDRAULIC CONTROL

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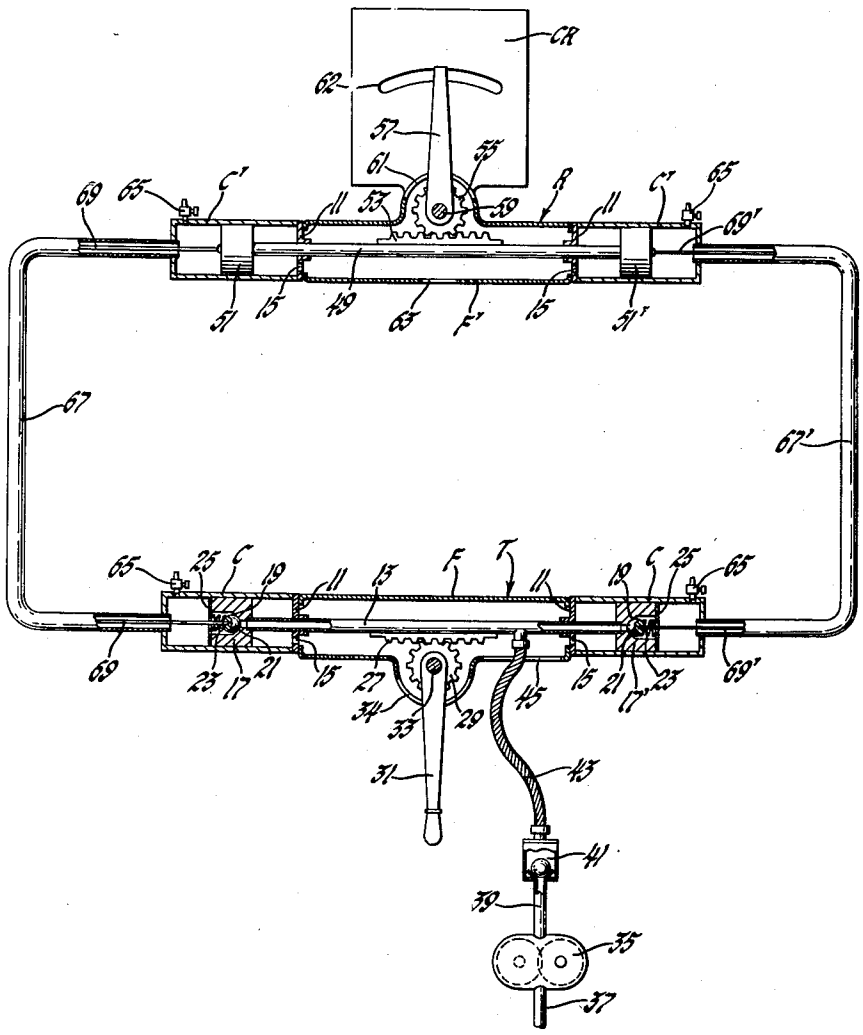


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## HYDRAULIC CONTROL

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This invention generally relates to telemotor apparatus and more particularly to improvements in hydraulic telemotor apparatus.

The principal object of this invention is to provide simple hydraulic transmitter and receiver mechanisms in which the moving parts are enclosed and hydraulic connections therebetween enclose hydraulic fluid leakage make-up apparatus for maintaining the receiver mechanism in phase with the transmitter.

The combined hydraulic telemotor apparatus by which this object is accomplished and other novel features thereof will become apparent by reference to the following detailed description and single drawing illustrating this apparatus and connections therebetween for accurately positioning a control mechanism from a control element located remotely with respect thereto.

In the drawing a hydraulic transmitter mechanism is generally indicated by the character reference T and a hydraulic receiver mechanism is generally indicated by the character reference R.

The transmitter T includes a hollow central frame F having a pair of aligned cylinders C each provided with a removable cylinder head 11 at one end. The respective cylinder heads are removably secured in axial alignment to opposite sides of the frame F. A hollow piston rod 13 is supported for reciprocal movement in aligned openings in the heads 11, each of which are provided with a fluid leakage vent opening 15 communicating with the interior frame. Pistons 17 and 17' are secured on each end of the piston rod 13 for fluid tight sliding relation in a respective cylinder C. Each of the pistons 17 and 17' is provided with an axial passage communicating with the interior of the hollow piston rod 13 and an outwardly facing conical seat surface 19 is formed in each of these passages on which a ball valve 21 is retained seated by a spring 23, the outer end of which engages an annular spring seat 25 secured to the outer face of each of the pistons 17 and 17'. Reciprocal movement of the pistons 17 and 17' is accomplished by a central piston rod rack portion 27 shown meshing with a pinion 29 secured to a manually operable control lever 31 shown pivoted at 33 to the frame F and projecting outwardly through a slot 34 in the frame.

A hydraulic pressure source such as a supply pump 35 having a suitable pressure relief passage, not shown, and an intake pipe 37 connected to a suitable source of hydraulic fluid, not shown, and a pressure supply pipe 39 including

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a non-return pressure operated supply valve 41 is provided to maintain the transmitter and receiver T and R and fluid connections therebetween completely filled with hydraulic fluid under pressure and to supply make-up fluid leaking therefrom. The non-return supply valve is connected by a flexible conduit 43 extending through another slot 45 in the frame F and connected to the hollow piston rod 13. Any leakage of fluid past the pistons 17 and 17' drains outwardly of the inner ends of the cylinders C through the vent openings 15 in the cylinder heads 11 to the interior of the frame F and drains outwardly through the slots 34 and 45 therein.

The hydraulic receiver mechanism R comprises a similar hollow frame F' having cylinders C' and removable cylinder heads 11 on one end identical to that on the transmitter mechanism T. The respective cylinder heads 11 being likewise secured in axial alignment on each side of the receiver frame F' in similar manner and a piston rod 49 is reciprocal in openings therein. The receiver pitsons 51 and 51' are secured to the ends of the piston rod 49 for fluid tight sliding movement in the respective cylinders C' of the receiver mechanism R. The piston rod 49 is likewise provided with a central rack portion 53 shown meshing with a pinion 55 secured to a controlled lever 57 and pivoted at 59 to the frame F'. The controlled lever 57 serves as the movable element of a controller generally indicated by the character reference CR and is shown extending through a slot 61 in the frame F' of the receiver mechanism R and through a slot 62 of the controller CR. The frame slot 61 and another opening 63 therein serves to drain off any fluid leakage past the receiver pistons entering the frame F' through the vent openings 15 in the cylinder heads 11.

Each of the outer closed ends of the transmitter and receiver cylinders C and C' are provided with bleed valves 65 which may be opened to bleed air and vapor therefrom in order to completely fill this portion of the cylinders with hydraulic fluid.

A fluid conduit 67 connects the outer ends of the left transmitter and receiver cylinders C and C' and another fluid conduit 67' is provided to connect the outer ends of the right transmitter and receiver cylinders C and C'. A small diameter Bowden wire 69 is connected between the ball valve 21 seated in the left transmitter piston 17 to the left receiver piston 51 and another Bowden wire 69' is connected between the ball valve 21 in the right transmitter piston 17' and the right receiver piston 51'. With control and

controlled levers 31 and 57 and the transmitter and receiver pistons shown in phase in the mid-stroke position or in any other inphase position in the transmitter and receiver cylinders the ball valves 21 are retained seated by the springs 23 in the seats 19 in the transmitter pistons 17 and 17' and there is no stress on the Bowden wires 69—69' and air bleeding and complete filling of the outer ends of the cylinders and connecting conduits with hydraulic fluid is accomplished by opening the cylinder bleed valves 65 and starting operation of the pump 35. This causes hydraulic fluid under pressure from the pump 35 to pass through the pressure opened pump non-return supply valve 41 to the hollow transmitter piston rod 13. The pressure in the hollow piston rod 13 forces the ball valves 21 in the transmitter pistons 17 and 17' outwardly of the seats against the action of the springs 23 and applies compression force necessary to cause the Bowden wires 69 and 69' to buckle to force hydraulic fluid into and bleed air from the outer ends of the transmitter and receiver cylinders C and C' and conduits 67 and 67' through the open bleed valves 65 in the cylinders and completely fill the cylinders and conduits with hydraulic fluid, after which the bleed valves 65 are closed. Upon fluid pressure equalization on opposite sides of the ball valves 21 in the transmitter pistons these valves will be seated by the springs 23 and the straightening of the buckled wires 69 and 69'. The pump discharge valve 41 will also be seated.

The operation of the above described system is as follows: Movement of the transmitter pistons 17 and 17' to the left, upon counterclockwise movement of the manual control lever 31 and pinion 29 meshing with the rack on the hollow piston rod 13, causes hydraulic fluid to be displaced through the left conduit 67 from the left transmitter cylinder to the left receiver cylinder and also causes fluid to be displaced through the right conduit 67' from the right receiver cylinder to the right transmitter cylinder. If there is no fluid leakage past the transmitter and receiver pistons the receiver piston rod 49 will accordingly be moved to the right at the same rate and the same amount as the transmitter piston rod 13 is moved to the left. The teeth of the pinion 55 secured to the controlled lever 57 and the rack 53 on the receiver piston rod are of identical construction to the pinion 29 and rack 27 on the transmitter, the controlled lever 57 will accordingly be moved counterclockwise angularly at the same rate and amount as the control handle 31. If no leakage of fluid past the pistons occurs the Bowden wires 69 and 69' will move with the pistons without being stressed and the ball valves 21 in the transmitter pistons 17 and 17' will be held seated by the springs 23. If, however, fluid leakage occurs past any transmitter or receiver piston the receiver pistons 51 and 51' will be moved to the right at a lesser rate and amount than the transmitter pistons and lag these pistons. This causes the right Bowden wire 69' to be tensioned to pull the ball valve in off the seat in right transmitter piston 17' and make-up fluid pressure past this ball valve and past pump discharge valve 41 occurs to cause make-up fluid to enter to the right-hand conduit 67' to replace the fluid leakage past transmitter or receiver pistons. It will be evident that the left Bowden wire 69 at this time will be compressed and will buckle slightly by this lagging of the receiver pistons, due to fluid leakage, and the ball valve 21 in the left transmitter piston 17 will accordingly be seated therein by this buckling of the Bowden wire 69 and also by the force of the spring 23 to prevent entrance of any make-up fluid due to leakage past the left transmitter and receiver pistons 17 and 51, to the left conduit 67 at this time. Make-up of fluid to the left conduit 67 occurs only upon subsequent reverse movement of the transmitter pistons to the right as long as the right Bowden wire 69' is tensioned and holds the ball valve in the right transmitter piston 17' unseated and fluid pressure in the right-hand conduit due to this reverse movement of the transmitter pistons to the right will then cause unseating of the ball valve in the left-hand transmitter piston 17 and transfer of fluid to make up for the leakage past the left-hand transmitter and receiver pistons. When the right-hand transmitter piston 17' moves to the right far enough to cause seating of the ball valve therein the transmitter pistons are again in phase with the receiver pistons and the receiver pistons will then be moved to the left at the same rate and amount as the transmitter pistons are moved to the right if no fluid leakage occurs past any of the pistons. If such fluid leakage occurs the receiver pistons 51 and 51' will again lag behind the transmitter pistons 17 and 17' causing tensioning of the left Bowden wire 69 and unseating of the ball valve 21 in the left transmitter piston 17 and make-up fluid pressure will be applied to the left conduit 67 past this ball valve and pump discharge valve 41, the right Bowden wire 69' at this time being buckled by compression, causing the ball valve in the right transmitter piston 17 to be retained on the seat therein, prevents fluid pressure make-up to the right conduit 67'. Fluid pressure make-up to the right-hand conduit 67' and rephasing of the transmitter and receiver pistons taking place on subsequent reverse movement of the transmitter pistons to the left in a similar manner to that previously described.

The above described telemotor apparatus and fluid make-up valves and valve operating mechanism is completely enclosed in the transmitter and receiver cylinders C and C' and interconnecting conduits 67 and 67' and adequately lubricated by the hydraulic fluid therein and grit cannot enter to cause wear and lost motion to occur, phased movement of a control and controlled lever located at distant locations and thereby providing full make-up of any fluid leakage past any piston therein to one side of the mechanism for one direction of movement of the transmitter pistons and subsequent rephasing of the transmitter and receiving pistons at the start of the reverse stroke of the transmitter pistons by transfer of some of the make-up fluid to the opposite side of the transmitter and receiver mechanism.

I claim:

1. In apparatus of the type described, the combination of transmitter and receiver cylinder means, each having piston means movable therein, one piston means having a fluid passage extending between the ends and forming outwardly facing valve seats adjacent the ends, valves cooperating with the seats, a source of hydraulic fluid make-up pressure, a fluid supply connection interconnecting the pressure source with the piston means fluid passage intermediate the valve seats, a fluid conduit interconnecting one end of each of the cylinder means, another conduit interconnecting the other end of each of the cylinder means and a flexible wire in each

conduit interconnecting each valve with the other piston means to normally position the valves on the valve seats when both piston means are in phase, said wires acting in tension and buckling under compression upon out-of-phase movement of the two piston means to admit fluid make-up pressure to the cylinder means and conduits to compensate for leakage of fluid therefrom and bring the two piston means back in phase.

2. In apparatus of the type described, the combination of transmitter and receiver cylinder means, each having piston means movable therein, one piston means having a fluid passage extending between the ends and forming valve seats adjacent the ends, valves cooperating with the seats, springs for retaining the valves on the seats, a source of hydraulic fluid make-up pressure, a fluid supply connection including a non-return supply valve connecting the pressure source to the piston means fluid passage intermediate the valve seats, a fluid connection interconnecting one end of each of the cylinder means, another fluid connection interconnecting the other end of each of the cylinder means and a flexible wire in each conduit interconnecting each valve in the one piston means with the other piston means and normally positioning the valves on the valve seats when one piston means moves at the same rate and distance as the other piston means, said wires acting alternately under tension and buckling under compression, upon out of phase movement in opposite directions of said piston means, to open one valve at a time and admit make-up fluid and bring the two piston means back into phase.

3. In apparatus of the type described, the combination of transmitter and receiver cylinder means, piston means movable in each cylinder means, the piston means in the transmitter cylinder means serving as motion transmitting piston means and having a passage extending between the end faces and forming outwardly facing valve seats, valves movable with respect to the seats, springs retaining the valves on the seats, a source of hydraulic fluid make-up pressure, a fluid supply connection including a pressure-opened non-return valve connecting the pressure source to the passage in transmitting piston means, separate fluid connections interconnecting the respective ends of the cylinder means, a flexible wire in each conduit connecting a valve in the transmitting piston means with the piston means in the receiver cylinder serving as motion receiving piston means, said wires moving with both the piston means and normally positioning the valves on the seats when the receiving piston means follows movement of the transmitting piston means, said wires acting alternately in tension and buckling under compression on alternate strokes of the two piston means when out of phase to control unseating of the valves and admit fluid make-up pressure to bring the two piston means back in phase.

4. In apparatus of the type described, the combination of transmitter and receiver cylinder means spaced apart, each having bleed valves in the ends, a motion transmitting piston means movable in the transmitter cylinder means and having a fluid passage extending between the ends forming outwardly facing valve seats adjacent the ends, valves adjacent the valve seats, springs retaining the valves on the seats, a



source of fluid pressure, a fluid pressure supply connection including a one-way check valve interconnecting said source of fluid pressure and the piston means fluid, motion receiving piston means movable in the receiver cylinder means, separate pipes interconnecting the respective outer ends of the transmitter and receiver cylinder means, and a wire in each pipe secured between the receiving piston means and each valve of the transmitting piston means, said wires normally positioning the valves on the seats upon inphase movement of the transmitting and receiving piston means, said wires buckling on compression by unseating of the valves against the action of the springs by greater pressure behind the valves to cause complete hydraulic fluid filling of the transmitter and receiver cylinder means when the bleed valves are open, said wires acting in tension and buckling on compression when fluid leakage past the pistons causes out-of-phase movement of the two piston means to control the valves and admit make-up pressure to the cylinders and pipes from said pressure source to compensate for fluid leakage and bring the two piston means back in phase.

5. In apparatus of the type described, the combination of aligned transmitter cylinders, aligned transmitter cylinders spaced from the transmitter cylinders, manually operable bleed valves in the outer ends of each of the cylinders, separate fluid pipes each interconnecting the outer ends of a transmitter and receiver cylinders, a motion transmitter piston assembly movable in the aligned transmitter cylinders and having a fluid passage extending between the end faces and forming valve cavities and outwardly facing valve seats adjacent the ends, valves in the cavities, springs retaining the valves on the valve seats, a source of hydraulic fluid under pressure, a fluid supply connection including a non-return supply valve connecting the fluid pressure source to the piston assembly fluid passage intermediate the valve seats, a motion receiver piston assembly in the receiver cylinders, and a flexible wire in one connecting pipe secured between the transmitter piston assembly and each valve in each transmitter piston said wires being of such length to cause the valves to be normally retained seated by the springs and buckling when hydraulic pressure is applied to the valves from the source to open said valves when the bleed valves are open to completely fill the cylinders and pipes, said wires, upon closure of the bleed valves then acting alternately in tension and buckling under compression on out of phase movement of said piston assemblies in opposite directions to open one valve at a time and admit make-up pressure to opposite ends of the cylinders and pipes and thereby compensate for fluid leakage past the piston assemblies and bring the assemblies back in phase.

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