

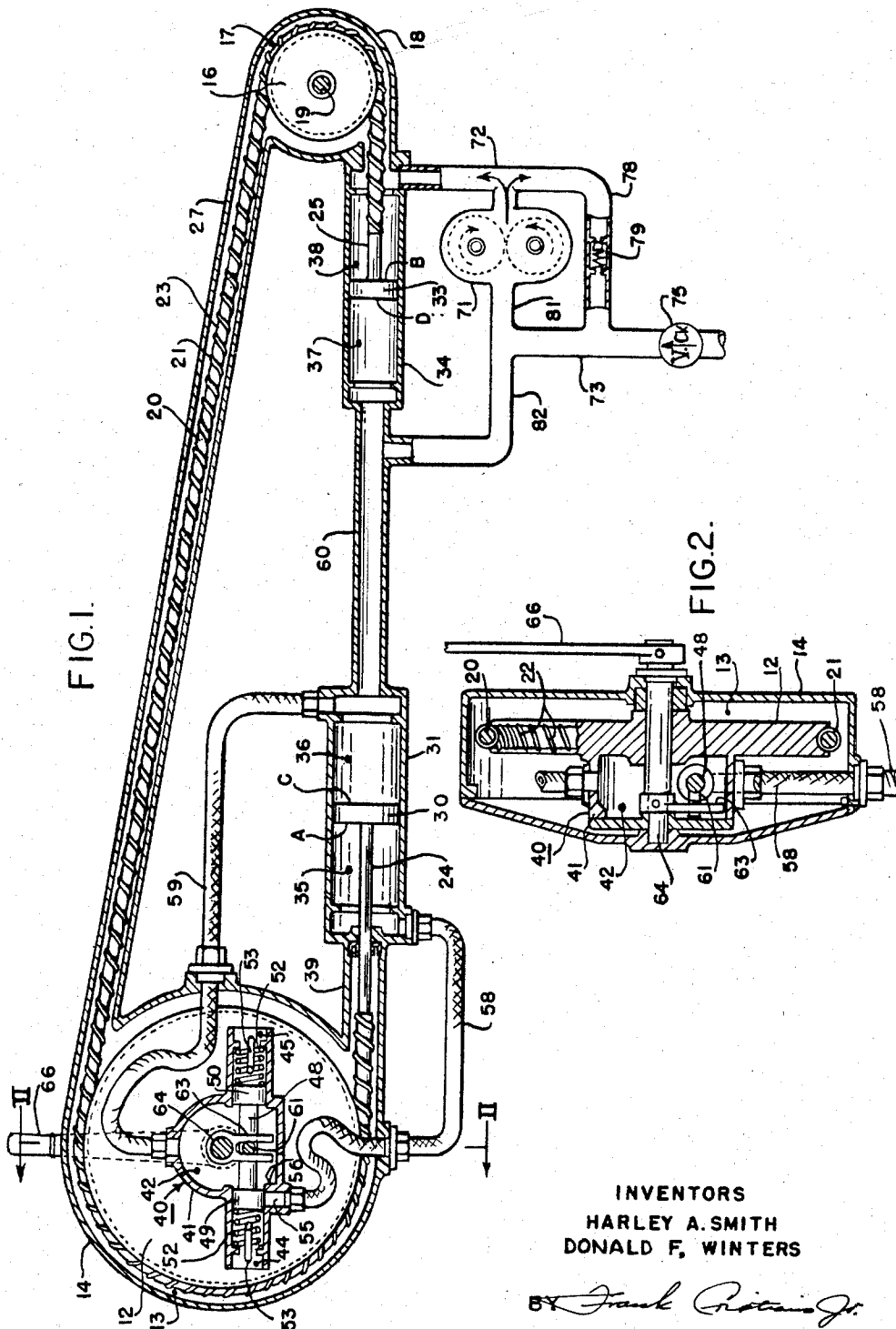
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CONTROL APPARATUS

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CONTROL APPARATUS

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This invention relates to hydraulic control systems, more particularly to a hydraulic servo-system and a control valve associated therewith for positioning a remotely disposed member, and has for an object to provide an improved valve control system of the above type.

Some of the control systems utilized to regulate the flow of fuel to an internal combustion engine, such as an aviation gas turbine, have, in the past, been provided with a lever located in the cockpit which is manually actuated by an operator and which has, in some instances, been connected by a system comprising links and bell cranks to a remotely located fuel valve which controls the fuel flow to the engine. The distance between the lever and the remotely located fuel valve, in such a system, has resulted in undesirable lost motion. When movement of the cockpit relative to the engine takes place, which may be due to relative expansion of the components of the system, an error may be introduced into the control system. The present invention provides an improved hydraulic control system in which lost motion is eliminated, error due to relative displacement of the control and cockpit is eliminated and which has a uniform response characteristic.

One embodiment of the present invention comprises a lever for controlling a remotely located rotatable shaft, the latter being associated with a fuel valve for regulating the flow of fuel to an engine. A casing structure encloses a driving sheave, a driven sheave and a cable which engages said sheaves. The casing structure is supplied with pressurized hydraulic fluid and the cable is maintained in continuous tension about said sheaves by a first piston connected to one end portion of said cable and a second piston connected to the other end portion of said cable.

The first piston is of larger cross-sectional area than the second piston. One face of each piston is subjected to a common pressure and the smaller of the two pistons has a second face which is subjected to a higher pressure, relative to the pressure common to both pistons. Likewise, the larger of the two pistons has a second face which is subjected to a pressure which is intermediate the common pressure and the higher pressure.

The lever is associated with a control valve which is rotatable with the driving sheave. The control valve includes a valve member which modulates a port and is utilized to vary the intermediate pressure between the level of the common pressure and of the higher pressure by selectively providing a communication between the fluid at the intermediate pressure and the fluid at the higher pressure or the fluid at the common pressure. In this manner, the pressure difference across the larger piston is changed and the forces across the pistons are unbalanced. The two pistons, the sheaves, and the control valve jointly move until the valve port is blocked, at which time the forces across the pistons balance. Since the driven sheave rotates the control shaft associated with the fuel valve, the fuel flow rate to the engine is thus modified accurately and in increments of any desired de-

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gree, in accordance with the degree of movement of the lever.

The foregoing and other objects are effected by the invention as will be apparent from the following description and claims taken in connection with the accompanying drawings, forming a part of this application, in which:

Fig. 1 is a diagrammatic view of a hydraulic servo-system incorporating the present invention; and

Fig. 2 is a sectional view taken along the line II-II of Fig. 1 looking in the direction indicated by the arrows.

Referring to the drawing in detail, and in particular to Fig. 1, there is illustrated a control system for regulating the fuel supplied to an internal combustion engine, for example an aviation gas turbine (not illustrated). The control system comprises a driving sheave 12 disposed in a chamber 13 provided in a casing 14 and a driven sheave 16 disposed in a chamber 17 provided in a casing 18. The driven sheave 16 is secured to a rotatable shaft 19 associated with a fuel system (not shown). The sheaves 12 and 16 are connected for joint rotation by a flexible cable 20 having spiral projections 21 engaging suitable grooves 22, illustrated in Fig. 2, in the concave peripheral surfaces of the sheaves 12 and 16.

The cable 20 is provided with a major portion 23 and with end portions 24 and 25 which project through the casings 14 and 18, respectively. The major portion 23 engages the sheaves 12 and 16 and extends through a conduit 27 which is connected to the casings 14 and 18 and provides a fluid communication between the chambers 13 and 17.

The cable end portion 24 is secured to an actuating piston or abutment 30 slidably received in a cylinder 31. The end portion 25 is secured to a balancing piston or abutment 33 slidably received in a cylinder 34. The piston 33 is smaller than the piston 30 for the hereinafter described purpose. The actuating piston 30 divides the associated cylinder into two compartments 35 and 36, and, in a similar manner, the cylinder 34 is divided by the piston 33 into two compartments 37 and 38. Suitable stops may be provided for limiting movement of the pistons 30 and 33.

The cable end portion 24 is enclosed in a conduit 39, formed integral with the casing 14 and connected to the left-hand side wall of the cylinder 31, as viewed in Fig. 1. A suitable seal is placed adjacent the left-hand end wall of the cylinder 31 to restrict fluid communication between the conduit 39 and the compartment 35. The right-hand end wall of the cylinder 34 is defined by a portion of the casing 18 which has an aperture through which the end portion 25 of the cable extends and which places the chamber 17 in communication with the compartment 38.

The driving sheave 12 is provided with a valve 40 rigidly mounted thereon and disposed within the chamber 13. The valve 40 comprises a casing 41 enclosing a central valve chamber 42 and provided with opposed end portions defining axially aligned passages 44 and 45 which are in communication with the chamber 13. Within the passages 44 and 45 is a spool valve member 48 having spaced enlarged portions or lands 49 and 50 which are slidable within the passages 44 and 45. Associated with the left-hand land 49 is an aperture or port 55 formed in wall structure 56 of the valve casing 41. The land 49 is operable to modulate the port 55 and to selectively control fluid communication between the port 55 and passage 44 or chamber 42.

Movement of the valve member 48 is resisted by springs 52 disposed at opposite ends of the valve member 48 and secured to the valve casing within the passages 44 and 45. The maximum travel of the valve member 48 is limited by suitable stops 53. The valve member 48

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is maintained in the central position, shown in Fig. 1, by the springs 52 so that the land 49 blocks the port 55. The valve member 48 is provided with a pin 61 which is engaged by a fork member 63. The fork member 63 is secured to a shaft 64 which (as best shown in Fig. 2) rotatably supports the driving sheave 12 and is, in turn, rotatably received in bearings formed in the end walls of the casing 14. A lever 66, disposed externally of the casing 14, is secured to one end of the shaft 64. Hence, arcuate movement of the lever causes linear movement of the valve member 48.

A conduit 58 provides a fluid communication between the port 55 and the compartment 35. In a similar manner, a conduit 59 places the valve chamber 42 in fluid communication with the compartment 36. The compartment 36 is, in turn, disposed in fluid communication with the compartment 37 by a conduit 60.

When the valve land 49 is moved to the left by rotation of the lever 66, the port 55 is opened and the valve chamber 42 is placed in communication with the conduit 58. When the land 49 is moved to the right, the port 55 is again opened and the passage 44 and chamber 13 are placed in communication with the conduit 58.

The foregoing system is supplied with fluid from a suitable source by a pump 71. The outlet of the pump 71 is connected by a conduit 72 to the compartment 38 and chamber 17. Fluid is supplied to the pump 71 from a suitable source (not illustrated) by a conduit 73, which, if desired, may have a suitable check valve 75 disposed therein. The conduit 72 includes a bypass portion 78 which provides fluid communication between the outlet of the pump and the conduit 73. Within the bypass conduit 78 is placed a relief valve 79 for limiting the pressure of the fluid supplied to the compartment 38. The conduit 73 communicates with two branches, branch 81 communicating with the pump inlet and branch 82 communicating with the conduit 60.

The compartment 38, chambers 17 and 13 and conduits 27 and 39 define a first volume zone which is maintained filled by the pump 71 with fluid at a constant first pressure, the pump outlet pressure as modified by the relief valve 79.

The fluid which passes through the relief valve 79 joins the fluid in the conduit 73 and fills the compartments 36 and 37, conduits 59 and 60, and valve chamber 42, which define a second volume zone, with fluid at a second pressure which is lower than the first pressure. The conduit 58 and the compartment 35 define an intermediate volume zone which is filled with fluid at a pressure intermediate the first and second pressures. The pressure within the intermediate volume zone is controlled by the valve 40 between the level of the first pressure and the second pressure. The pistons 30 and 33 are provided with outer faces A and B, respectively, and inner faces C and D. Hence the pistons are urged toward each other and the cable 20 is maintained in continuous tension about the sheaves. In addition, when the port 55 is opened and the value of the fluid pressure within the compartment 35 changes, the pistons 30 and 33 will move jointly until the force exerted by the pressure of the fluid upon the face A is balanced by the force exerted by the pressure of the fluid upon the face B.

Operation

When it is desired to change the rate of fuel being supplied to the engine, the lever 66 is rotated manually. If the lever is rotated counterclockwise, as viewed in Fig. 1, the shaft 64 and fork 63 will be likewise rotated. The fork 63 moves the pin 61 to the right, thereby shifting the valve member 48 to the right.

As the valve member 48 is moved to the right, the land 49 unblocks the port 55 and places passageway 44 in communication with the conduit 58. Accordingly, fluid at the first pressure, which is at a value higher than the fluid within the conduit 58 and the compartment 35,

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flows from chamber 13 into the conduit 58 and the compartment 35. The pressure within the compartment 35 is thereby increased, resulting in an increase in the pressure difference across the piston 30 which urges the piston 30 to the right. As the piston 30 moves to the right, the sheaves 12 and 16 are rotated jointly in counterclockwise direction and the piston 33 moves to the right. The rotation of the sheave 16 causes the shaft 19 to rotate in a like manner, thereby changing the fuel flow rate.

It will be noted that rotation of the sheave 12 also rotates the valve 40 since the valve 40 is rigidly connected to the sheave 12. The direction of rotation of the valve 40 is always in a direction which closes the valve port 55. In effect, after the valve member 48 and its land 49 has been moved to the right by the lever 66 to unblock the port 55, subsequent rotation of the sheave 12 by the cable 20 rotates the wall structure 56 and the port 55 in a direction toward the land 49. The rotation of the valve 40, in conjunction with the influence of the springs 52 tending to centralize the valve member 48, closes the port 55 and thus terminates movement of the pistons 30 and 33. During this movement, the pressure differences across the pistons 30 and 33 are sufficient to urge the pistons toward each other, thereby maintaining the cable in continuous tension.

When the lever 66 is moved in clockwise direction, the valve member 48 is shifted to the left and the valve chamber 42 is placed in communication with the port 55. Since the intermediate pressure fluid within the conduit 58 and compartment 35 is at a higher pressure than the fluid within the valve chamber 42, the intermediate pressure fluid will flow into the valve chamber 42, the conduits 59 and 60 and the compartments 36 and 37. The pressure difference across piston 30 is thus decreased. The pressure of the fluid in the compartment 35 acting on piston face A is decreased and the pressure of the fluid in the compartment 38 acting on piston face B remains unchanged, thereby resulting in a net force to the left causing movement of the pistons 30 and 33 to the left and rotation of the sheaves 12 and 16 in clockwise direction. The rotation of the sheave 16 causes the shaft 19 to rotate in a like manner, thereby changing the fuel flow rate.

A position of stability is achieved when movement of the lever in either direction terminates, since movement of the members of the control system is substantially instantaneous. That is, the members of the control system are in motion while the lever is in motion, but as soon as movement of the control lever stops, the motion of the members of the control system also stops.

In the embodiment illustrated, rotation of the lever 66 through an arc results in a rotation of the driven sheave 16 through a larger arc because the sheave 12 has a larger diameter than the sheave 16.

While the invention has been shown in but one form, it will be obvious to those skilled in the art that it is not so limited, but is susceptible of various changes and modifications without departing from the spirit thereof.

What is claimed is:

1. A control system including a manually movable lever for controlling a remotely disposed movable shaft; a driving sheave, a driven sheave, a cable engaging said sheaves and casing structure enclosing said sheaves and cable; said driven sheave being operatively connected to said shaft; means for supplying said casing structure with pressurized fluid; fluid actuated means for maintaining said cable in continuous tension about said sheaves including a first movable abutment connected to one end portion of said cable and a second movable abutment connected to the other end portion of said cable, said first movable abutment being of larger cross-sectional area than said second movable abutment; and valve mechanism for regulating the fluid pressure acting on said first movable abutment, said valve mechanism having a port

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and including a movable valve member operatively associated with said port, said valve mechanism being jointly rotatable with said driving sheave and said movable valve member being jointly movable with said lever.

2. A control system including a lever; a rotatable shaft disposed remotely from said lever; a driving sheave, a driven sheave, a cable engaging said sheaves and casing structure enclosing said sheaves and cable; said driven sheave being operatively connected to said shaft; means for supplying said casing structure with pressurized fluid; fluid actuated means for maintaining said cable in continuous tension about said sheaves including a first movable abutment connected to one end portion of said cable and a second movable abutment connected to the other end portion of said cable, said first movable abutment being of larger cross-sectional area than said second movable abutment; and valve means for regulating the fluid pressure acting on said first movable abutment, said valve means having a port and including a movable valve member operatively associated with said port, said valve means being jointly rotatable with said driving sheave and said movable valve member being jointly movable with said lever, said abutments each having one face exposed to a fluid at a common pressure, said second abutment having another face exposed to a fluid pressure higher than said common pressure, said first abutment having another face exposed to fluid at a pressure intermediate said common and said higher pressures, and said valve regulating the intermediate pressure between the level of said common and said higher pressures.

3. A control system including a lever; a rotatable shaft disposed remotely of said lever; a driving sheave, a driven sheave, a cable engaging said sheaves and casing structure enclosing said sheaves and cable; said driven sheave being operatively connected to said shaft; means for supplying said casing structure with pressurized fluid; fluid actuated means for maintaining said cable in continuous tension about said sheaves including a first movable piston connected to one end portion of said cable and a second movable piston connected to the other end portion of said cable, casing structure enclosing said pistons, said first piston being of larger cross-sectional area than said second piston; and valve means for regulating the fluid pressure acting on said first piston, said valve means having a port and including a movable valve member operatively associated with said port; said valve means being jointly rotatable with said driving sheave and said movable valve member being jointly movable with said lever, said pistons each having one face exposed to a fluid at a common pressure, said second piston having another face exposed to a fluid pressure higher than said common pressure, said first piston having another face exposed to fluid at a pressure intermediate said common and said higher pressures; said valve member being selectively movable by said lever in one direction to provide fluid communication between said intermediate pressure fluid and said higher pressure fluid, and in another direction to provide fluid communication between said intermediate pressure fluid and said common pressure fluid.

4. A control system including a lever; rotatable shaft disposed remotely of said lever; a driving sheave, a driven sheave, a cable engaging said sheaves and first casing structure enclosing said sheaves and cable; said driven

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sheaves being operatively connected to said shaft; means for supplying said casing structure with pressurized fluid; fluid actuated means for maintaining said cable in continuous tension about said sheaves including a first movable piston connected to one end portion of said cable and a second movable piston connected to the other end portion of said cable, second and third casing structures enclosing said first and second pistons, respectively, said first piston being of larger cross-sectional area than said second piston; said first piston dividing said second casing into first and second compartments, said second piston dividing said third casing into third and fourth compartments; and valve means for regulating the fluid pressure acting on said first piston, said valve means including a chamber, a port, and a movable valve member operatively associated with said port; said valve means being jointly rotatable with said driving sheave and said movable valve member being jointly movable with said lever; said first compartment containing fluid at a first pressure; said valve chamber, said second compartment and said third compartment containing fluid at a second pressure; said fourth compartment and said first-mentioned casing containing fluid at a third pressure, said third pressure being greater than said second pressure, said first pressure being intermediate said second and third pressures, said pistons each having one face exposed to the fluid at the second pressure, said second piston having another face exposed to the fluid at the third pressure, said first piston having another face exposed to the fluid at the first pressure, and said valve being operable to regulate the intermediate pressure between the level of said second and said first pressures.

5. A control system including a manually movable lever for controlling a remotely disposed movable shaft; a driving sheave, a driven sheave, a cable engaging said sheaves and casing structure enclosing said sheaves and cable; said driven sheave being operatively connected to said shaft; means for supplying said casing structure with pressurized fluid; fluid actuated means for maintaining said cable in continuous tension about said sheaves including a first movable abutment connected to one end portion of said cable and a second movable abutment connected to the other end portion of said cable, said first movable abutment being of larger cross-sectional area than said second movable abutment; and valve mechanism for regulating the fluid pressure acting on said first movable abutment, said valve mechanism having a body portion centrally mounted on said driving sheave and having a port, a valve member slidably disposed in said body portion for blocking and unblocking said port, a pair of spring members disposed at opposite ends of said valve member for urging said valve member to the port blocking position, and means including a fork member associated with said valve member and connected to said lever for moving said valve member in linear direction in response to arcuate motion of said lever.

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