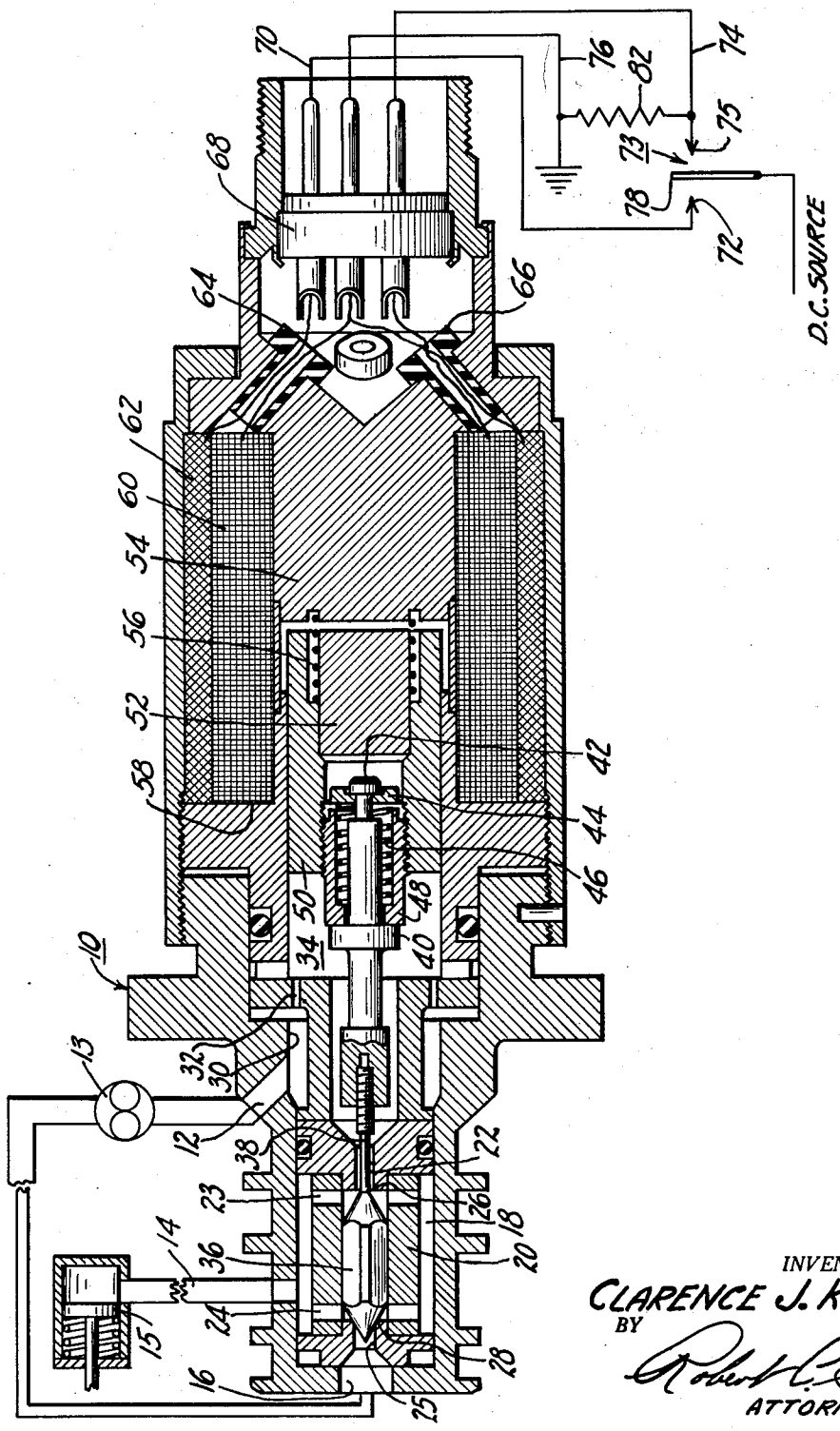
Jan. 6, 1959 C. J. KLEIN 2,867,236

SOLENOID OPERATED VALVE WITH PROVISION FOR SAFE FAILURE

Filed April 6, 1956



INVENTOR.
CLARENCE J. KLEIN
BY
Robert C. Smith
ATTORNEY

United States Patent Office

2,867,236

Patented Jan. 6, 1959

2,867,236

SOLENOID OPERATED VALVE WITH PROVISION FOR SAFE FAILURE

Clarence J. Klein, South Bend, Ind., assignor to Bendix Aviation Corporation, South Bend, Ind., a corporation of Delaware

Application April 6, 1956, Serial No. 576,711

8 Claims. (Cl. 137—623)

The present invention relates to fluid pressure control devices and, more particularly, to an electrically actuated valve structure for controlling servo pressures which has a provision for insuring safe failure.

In designing servo systems, especially for use on aircraft, it is often necessary that some means be provided for controlling the application of a relatively high fluid pressure against a control piston or other member. In many cases, it is essential that, if a member has been subjected to a high servo pressure and has, as a result, been moved to a certain position, it must remain in that position and not seek a new or former position as a result of a loss of electrical power. It is accordingly an object of the present invention to provide an electrically actuated device for controlling servo pressures which will maintain a safe position even though electrical power is lost.

It is another object of the present invention to provide an electrically actuated fluid pressure controlling device in which the movable members may be permitted to operate immersed in fluid.

It is another object of the present invention to provide a device which will accomplish the above objects and which is so designed as to have great resistance to damage or malfunctioning from shock, vibration, or contamination of the operating fluid. It is a further object to provide a device which will accomplish the above objects and which is capable of being constructed in a very small and comparatively light package.

Other objects and advantages will become apparent from the following specification taken in connection with the accompanying drawing, in which the single figure shows a cross sectional view of my control device in combination with a schematic representation of the associated switching circuit.

Referring to the drawing, a housing is shown generally at numeral **10** having an inlet port **12** communicating with a source of high fluid pressure supplied by a pump **13**, a servo outlet port **14** communicating with a power piston **15** and an outlet port **16** which communicates with the low pressure side of the servo pressure source. Within housing **10** is a chamber **18** having permanently positioned therein a member **20** having a series of ports **22**, **23**, **24** and **25** and a pair of valve seats **26** and **28**. Fluid flowing into housing **10** through inlet port **12** enters an annular chamber **30**, passes through a series of orifices **32** entering a chamber **34**. From chamber **34** the fluid is in communication with the interior of member **20** through passage **22**. Positioned within member **20** and arranged to move axially therein against either seat **26** or seat **28** is a valve member **36**. This valve is actuated through a shaft **38** having positioned thereon a collar **40** and a stop **42**. Stop **42** is urged against a face of an annular spring retaining member **44** through the action of a spring **46**. The other end of spring **46** exerts a force against an annular spring retainer member **48** threadedly engaged with a soft iron armature **50**. It will thus be seen from the foregoing that spring **46** acting through retainer **44** and

stop member **42** exerts a force urging member **38** and hence valve **36** to the right. Armature **50**, which is a hollow cylindrical soft iron member, carries with it a permanent magnet member **52** and both armature **50** and magnet **52** are adapted to abut against a soft iron pole member **54**. A spring **56** tends to urge armature **50** and magnet **52** away from the face of pole member **54**. Housing **10** has a large cylindrical indentation **58** which carries a primary winding **60** positioned concentrically with respect to armature **50** and pole member **54** and also a secondary winding **62** wound around the outside of winding **60**. The leads from windings **60** and **62** are drawn through a pair of Teflon liners **64** and **66** positioned in channels drilled in member **54**. These leads are fastened as shown to a standard connector shown generally at member **68**.

The windings **60** and **62** are connected to an electrical switching circuit shown schematically on the drawing in which one lead from winding **62** is connected to a wire **70** and a stationary contact **72** forming part of a switch **73**. Winding **60** is connected through a lead **74** to a stationary contact **75**. The opposite terminals of each of windings **60** and **62** are connected through the center contact of connector **68** and a wire **76** to ground. A movable contact **78** of the switch is connected to a direct current source. It will be observed from the foregoing that either winding **60** or winding **62** may be energized through manipulation of movable contact **78**, but that at no time are both windings energized. A resistor **82** is connected between wires **74** and **76** in such manner that it effectively forms a shunt across the primary winding **60**. The function of this resistor will be discussed below in relation to the operation of my invention.

It is the function of the device herein described to control the flow of servo fluid at a comparatively high pressure to the controlled power piston **15** downstream of outlet port **14**. As shown in the drawings, valve **36** is held against seat **28**, servo fluid will flow into port **12** and chamber **30** through orifices **32**, into chamber **34** through passages **22**, **23**, and out of port **14**. This may be considered the normal or non-energized position of my device. Upon energization of winding **60** through the closing of movable contact **78** on stationary contact **75**, a magnetomotive force will ensue causing a flux path linking housing **10**, armature **50**, and pole member **54**. This force will cause armature **50** to move toward the right thus abutting against the face of pole member **54** against the action of spring **56**. As armature **50** is moved to the right, it carries with it member **48**, spring **46**, retainer **44**, shaft **38**, and hence, valve **36**, which will be urged against seat **26** on the right end of member **20** thereby interrupting communication between ports **12** and **14** and opening communication between ports **14** and **16**. This will result in a sharp reduction in servo pressure against power piston **15** downstream of port **14** permitting it to move to the right. The above members are so arranged that valve member **36** will contact seat **26** before armature **50** reaches pole member **54**. Movement of armature **50** after valve member **36** is seated simply results in compressing of spring **46**. This lost motion structure insures that valve member **36** will seat even though wear occurs on either valve **36** or seat **26**. Should electrical power fail and winding **60** no longer be energized, the armature **50** will remain held against pole member **54** through the action of permanent magnet **52**. Should it be desired to return the valve **36** to its position as shown in the drawing, it is necessary that movable contact **78** be switched against stationary contact **72** so that secondary winding **62** can be energized. Upon energization of the secondary winding, a magnetomotive force is produced which effectively counteracts that pro-

duced by the armature magnet **52** and allows the armature to move to the left through the action of spring **56**, thus moving valve **36** against seat **28**.

The amount of current supplied to secondary winding **62** must be just sufficient to temporarily overcome the effect of permanent magnet **52** and must not be enough to cause an actual reversal of polarity of the permanent magnet. It is possible, however, in any application where power supplies are not precisely regulated that voltage surges could be impressed on this winding several times larger than is desired. Resistor **82** has been placed across the primary winding in order to meet this problem. It will be recognized that there will be a transformer action taking place between the windings **60** and **62** and that the greater the voltage surge occurring in winding **62**, the greater will be the corresponding increase in voltage across winding **60**. The resistor **82** provides a relatively low impedance path across winding **60** which prevents the translation of these voltage surges into a magnetomotive force which would effectively reverse the polarity of magnet **52**.

While only one embodiment has been shown and described herein, modifications and changes in size and relationship of parts may be made to suit requirements.

I claim:

1. In a fluid pressure control device comprising a hollow cylindrical housing, an inlet port in said housing connected with a source of fluid under pressure, a first outlet port connected to a servo system, a second outlet port in communication with a source of low fluid pressure and a valve member operable to block communication between said outlet ports and permit communication between said inlet port and said first outlet port when in one position and to block communication between said inlet port and said first outlet port and permit communication between said outlet ports when in another position: means controlling the position of said valve including a soft iron pole member positioned within said housing in such manner as to close one end of said housing, a hollow cylindrical soft iron armature resiliently attached to said valve and movable axially in said housing to abut against said pole member, a cylindrical permanent magnet positioned within said armature, a spring positioned between said armature and said pole member, a first winding embedded in said housing and positioned concentrically with respect to said pole member and said armature, said winding being moved in such direction that, upon energization, the magnetomotive force developed thereby urges said armature toward said pole piece, a second winding positioned concentrically with respect to said first winding and wound so that upon energization a magnetomotive force is produced opposing the first named magnetomotive force.

2. A fluid pressure control device comprising a housing, an inlet port in said housing, first and second outlet ports in said housing, a valve member operable to block communication between said outlet ports and permit communication between said inlet port and one of said outlet ports when in one position and to block communication between said inlet port and said outlet ports and permit communication between said outlet ports when in another position, a pole member positioned in one end of said housing, an armature resiliently attached to said valve and movable axially in said housing, a permanent magnet positioned within said armature, resilient means positioned between said armature and said pole member, a first

winding positioned concentrically with respect to said pole member and said armature which, when energized, produces a magnetomotive force urging said armature toward said pole piece, a second winding positioned concentrically with respect to said first winding which, when energized, produces a magnetomotive force opposing the first named magnetomotive force.

3. A fluid pressure control device as set forth in claim 2 wherein a resistor is connected across said second winding, and a switch is connected to both of said windings in such manner that one or the other of said windings may be energized.

4. A fluid pressure control device comprising a housing, a plurality of ports in said housing, a valve member in said housing operable to block communication between certain of said ports when in one position, and between certain other of said ports when in another position, a pole member positioned in one end of said housing, an armature operably connected to said valve and adapted to reciprocate in said housing, a spring positioned between said armature and said pole member, a first winding which when energized produces a first magnetomotive force urging said armature toward said pole piece, a permanent magnet operably associated with said armature producing a force whereby said armature, once placed in abutment with said pole piece, is caused to remain in abutment with said pole piece against the force of said spring even though said first winding becomes de-energized and a second winding which, when energized, produces a magnetomotive force opposing that produced by said permanent magnet.

5. A fluid pressure control device as set forth in claim 4 wherein a resistor is connected across said second winding, and a switch is connected to both of said windings in such manner that one or the other of said windings may be energized.

6. In a fluid pressure control device including a conduit connected to a source of fluid under pressure, a valve member positioned in said conduit in such manner that when in one position communication is interrupted and when in another position communication is permitted through said conduit: means controlling said valve comprising an armature operably connected to said valve, a first winding in inductive relation with said armature which when energized produces a magnetomotive force tending to move said valve to one of said positions, a permanent magnet associated with said armature producing a magnetomotive force whereby said armature is caused to remain in said one position even though said winding becomes de-energized, and a second winding which when energized produces a magnetomotive force opposing that produced by said permanent magnet.

7. A fluid pressure control device as set forth in claim 6 wherein said connection between said valve and said armature includes a resilient member.

8. A fluid pressure control device as set forth in claim 6 wherein a resistor is connected across said second winding, and a switch is connected to both of said windings in such manner that one or the other of said windings may be energized.

References Cited in the file of this patent

UNITED STATES PATENTS

2,407,184	Sparrow	Sept. 3, 1946
2,579,723	Best	Dec. 25, 1951