ELECTROMAGNETICALLY OPERATED VALVE

Inventor: Lamberto Vanti, Milan, Italy
Assignee: Sirai S. r. l. Societa' Italiana Regolatari Automatici Industriali, Milan, Italy

Filed: Feb. 12, 1973
Appl. No.: 331,876

Foreign Application Priority Data
Feb. 10, 1972 Italy 020448/72

U.S. Cl. .................................. 137/596.17
Int. Cl. .................................. F16k 11/10
Field of Search ...................... 137/596.17, 596.16; 251/138, 129, 282

References Cited
UNITED STATES PATENTS
2,404,514 7/1946 McClure ...................... 137/596.17
2,612,907 10/1952 Harris .......................... 251/129
3,113,422 12/1963 Watson ..................... 137/596.16 X

Primary Examiner—Henry T. Klinkgiek
Assistant Examiner—Robert J. Miller
Attorney, Agent, or Firm—Wenderoth, Lind & Ponack

ABSTRACT
An electromagnetically operated valve, comprising a movable assembly having at least a shiftable component carrying valve means to control passages between valve chambers. The movable assembly and the shiftable component are subjected to balanced axial thrusts due to pressure fluid in each operating position thereof.

4 Claims, 4 Drawing Figures
ELECTROMAGNETICALLY OPERATED VALVE

BACKGROUND OF THE INVENTION

This invention concerns an electromagnetically operated valve, in particular for high and very high pressure fluids, wherein at least one valve component, axially movable under the action of control devices, comprises one or more valve means to selectively control as many valve seats or passages, between valve sections or chambers that are in turn connected with suitable equipment or work means, as e.g. a pressure fluid source, a fluid consumer and an exhaust.

More specifically, the present invention concerns an electromagnetic valve of the type referred to and designed for applications wherein besides an unusually quick operation, a low or very low valve driving force is required, as when controlling hydraulic servo-systems wherein means for alternately and selectively connecting a consumer circuit with a pressure liquid source and with an exhaust, are provided. Such valve connection means, wherein pressures up to 120 – 150 kg/sq.cm. are involved, should operate in a nearly instantaneous manner, both to connect the consumer with the pressure source, and to connect the consumer with the exhaust.

For the above applications, electromagnetically controlled flow distributors are already known such distributors substantially including a movable element sealingly fitted in a seat, and comprising two tightly separated chambers that can be positioned in order to establish a direct communication between the consumer and a pressure source, or between the consumer and an exhaust, respectively. However, such devices entail great difficulties in securing a positive seal at the unusually high pressures involved, and further they show relatively long element or shuttle strokes and then proportionally high power requirements to a related electromagnetic control.

SUMMARY OF THE INVENTION

An object of the invention is to provide a valve adapted to control, in particular when operated by electromagnetic means, high and very high pressure fluids with short strokes of its movable element or shuttle and a reduced driving power. The word "valve" is to be understood in its limitingative meaning excluding distributors and comprising only a structure wherein each valve means controls a related fixed valve seat connecting valve chambers or passages.

Another object of this invention is to provide a valve of the above type, and in particular a three-way valve, adapted for hydraulic servo-systems and similar applications.

Accordingly, this invention concerns a valve of the type stated above, which is essentially characterized in that it comprises a moving assembly having one or more axially slidable components each of which carries one or more valve means, to selectively control as many connecting passages between two or more valve chambers, and wherein the axial thrusts exerted on the moving assembly by the fluid pressure are wholly balanced both on the whole and individually in each valve chamber and in all axial positions of the assembly and components. Thus, and in particular for such applications, all advantages shown by conventional valves, i.e., a very short operating stroke and a superior sealing action, can be attained, while on the other hand the valve according to this invention may be operated with a reduced power, owing to a very short stroke of its movable components and to the fact that no pressure fluid forces need be overcome. Such valve may be advantageously operated by an electromagnetic control comprising a core appertaining to the moving assembly and adapted to bring the component in one of its operating positions, while the other operating position can be attained by such component, after an electromagnetic deenergisation, e.g. by the action of spring means.

According to a preferred embodiment of this invention, the slidable component or components are reciprocated within a related guide body, wherein at least one of the chambers is formed, such chamber being axially defined on one side by a passage that is controlled by a valve means of the component, while on the opposite side the chamber is closed by a sealing portion of the same component. The component valve means and sealing portion surfaces, that are acted upon by the pressure fluid in opposite directions, have projections extending at a right angle to the component axis and which have equal areas. Further, the passage or valve seat establishes a communication between the body chamber and a further chamber, that lies outside of the guide body and fluidly communicates with both axial ends of the moving assembly, including the component(s) and core. The assembly axial ends are shaped in such a manner that the axial thrusts exerted thereon by the fluid pressure are completely balanced with each other.

The guide body may have two axially opposed chambers respectively connected with feed and exhaust means and alternatively controlled by two valve means of a single slidable component, in order to alternatively open the body chambers into an outer chamber connected with consumer means and in communication with both ends of the slidable component and core.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an axial section across a valve, according to this invention, as shown in one of its operating positions.

FIG. 2 is a partial axial section, similar to that of FIG. 1, of the same valve in the other operating position thereof.

FIG. 3 is an enlarged partial sectional view of an alternative embodiment of the valve.

FIG. 4 is a diagrammatic axial section of a further embodiment.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIGS. 1 and 2, a valve 10 essentially comprises two main parts, connected and cooperating with each other, i.e., a part 12, forming the valve proper, and a part 14 forming an electromagnetic valve controlling means.

Valve part 12 comprises an outer body 16 having three ports, i.e., a port 18 for communication with a source of pressure fluid, a port 20 for communication with a consumer means and a port 22 for communication with an exhaust means. Body 16 further comprises a central cylindrical bore 24, wherein a cylindrical guide body 30 is fastened and sealed by packings 26.

Guide body 30 has a central cylindrical bore 32, wherein a slidable valve component is tightly guided, as will be explained in more detail below. Body 30 is
designed to cooperate with bore 24 of body 16, as well as with fixed closure walls 34 and 36 in bore 24, in order to define two similar and symmetrically opposite chambers 38 and 40, that are connected with feed port 18 and closure exhaust port 22, respectively. Closure walls 34 and 36—at least one of which carries a seal 28—are formed with valve seat defining axial passages 42 and 44, by means of which chambers 38 and 40 can communicate with a common outer chamber 46, that is in turn connected with consumer port 20.

As previously stated, within cylindrical bore 32 of body 30 is slidingly fitted a valve component or shuttle 48, having a truncated-cone head 50, that forms a closing means for valve passage or seat 42. Shuttle 48 has from head 50 a reduced diameter stem 52 extending across chamber 38 ending in a truncated-cone bottom head 54, that merges into a main cylindrical shuttle portion which is slidingly fitted in bore 32, the head surfaces 50 and 54 being able to balance the axial thrusts that are exerted on shuttle 48 by the pressure fluid in chamber 38.

The lower section of the main cylindrical portion of shuttle 48 ends in a truncated cone portion 56, within the other chamber 40, and then a reduced diameter stem 58 extending across chamber 40 and bearing at its free end against a ball 60 adapted to close passage or seat 44. Ball 60 is urged in the direction of stem 58 by a spring means 62, that is held by a threaded element 64, having an axial bore 66, for connection with outer chamber 46. In order to allow valve assembling operations, chamber 46 is closed by a threaded plug 68, screwed onto the end of body 16.

The top of shuttle 48 extends beyond passage 42 and is formed with an annular projection 70, that acts to keep passage 42 open through the dynamic action thereon of fluid flowing out of seat 42. The shuttle top further carries an axial projection 72, that is acted upon by electromagnetic control means.

The electromagnetic control means comprise a moveable core 74 axially guided with a given clearance within a cylindrical seat 86 that is welded to a valve outer chamber top closing element 76, threadedly secured to body 16. In the lower end of core 74 (as shown in the drawing) a dead bore 78 in formed, wherein a cup 80 is housed. Cup 80 acts on the axial projection 72 of shuttle 48 and is biased by a compression spring 82, also housed in bore 78 and having a stiffness greater than that of spring 62, in order to compensate for possible stroke differentials of the core and shuttle. A stationary upper holding element 86 carries guide 86' and is screwed onto a plug 88 adapted to close structure 90, wherein an electromagnet winding 92 is housed. Plug 88 is acted upon by a stabilizing spring 84, housed between element 86 and the top of core 74.

The operation of valve is as follows. Assuming that an electromagnet energisation results in a core motion away from shuttle 48, when the electromagnet is deenergised, the valve lies in the position as shown in FIG. 1, due to the action of spring 84. The seat 42 is then closed by valve means 50, that rests on the edge thereof, while spring 82 is compressed. Conversely, passage 44 is open and spring 62 is compressed, the stiffness of spring 62 being lower than that of springs 82 and 84. Then, the pressure fluid coming from source port 18 fills chamber 38 and the axial thrusts, as exerted on shuttle 48 by the fluid pressure, are wholly balanced in chamber 38, as above explained. Chambers 46 and 40 are connected with the exhaust port 22.

Starting from the above conditions, an electromagnet energisation results in a practically instantaneous shifting of shuttle 48, due to the action of spring 62 and with a compression of spring 84. Such shifting causes the passage 42 to open, and such opening is assisted by the dynamic action exerted by the fluid acting on the annular projection 70. Simultaneously the passage 44 is closed and the pressure fluid fills chamber 46 and then is fed to consumer port 20. Even under such conditions and during the transition step, the axial thrusts exerted by the pressure fluid on shuttle 48 are wholly balanced. Indeed, as it can be readily seen in FIG. 2, the pressure fluid in chamber 38, in the upper section of chamber 46 and in a seat 46', between core 74 and holding element 86, exerts on the valve moving assembly (shuttle and core) a downwardly directed stress (as in the drawing) that corresponds to the product of the fluid pressure value and the surface area of shuttle 48 in a cross-section taken perpendicularly to the axis thereof in the shuttle portion guided within bore 32. In fact, a downwardly directed thrust, as exerted by the pressure fluid within chamber 46', is partially balanced by an upwardly directed thrust as exerted against the exposed surfaces of core and shuttle in chambers 46 and 38, whereby the downwardly directed resultant trust is equal to the product of the fluid pressure value and the cross-section of stem 52, plus the action on the surface 54. However, this downwardly directed thrust is balanced by an equal, oppositely directed thrust, as exerted by the fluid pressure in the lower section of chamber 46 against valve means 60. Accordingly a successive valve motion can be performed quickly and with a low force.

From the above, it can be easily understood that the valve according to this invention can be operated also when core 74 is shifted toward shuttle 48 upon an electromagnet energisation. In this occurrence, the valve will be opened upon an electromagnet deenergisation, by the action of spring 62 that will show a stiffness greater than that of spring 84. Then, spring 84 acts only as core holding and centering means, while the valve closure is caused by an electromagnet energisation.

Finally, as shown in FIG. 3, a cone-shaped valve means 60", e.g. screwed as by 94 to stem 58, may be substituted for ball 60. In any occurrence the pressure fluid is always axially fed to passage 44 in order to wholly envelope valve means 60 or 60' and attain the best hydrodynamic conditions.

It is to be understood that this invention may take the form of many other embodiments, with different modifications, according to particular use requirements. Thus, e.g., as shown in FIG. 4, the slideable component 48 may be subdivided into two components 48' and 48", which are simultaneously operated by core 74 and spring means 62' and 62". Each component defines a chamber 38 and 40 in body 30 which fluidly communicate with a common chamber 46 by means of a passage 46'.

While specific embodiments of this invention have been herein shown and disclosed, it is to be understood that many changes may be made therein, without departing from the spirit and scope of the invention. I claim:

1. An electromagnetically operated valve for the control of high pressure fluids, said valve comprising:
a valve body having cylindrical bore means extending completely therethrough;
elongated valve component means positioned to slide within said cylindrical bore means;
first chamber means formed between said valve body and a first end portion of said elongated valve component means;
a first valve seat adjacent said first end portion of said elongated valve component means;
second chamber means formed between said valve body and a second end portion of said elongated valve component means;
a second valve seat adjacent said second end portion of said elongated valve component means;
a first port connected to said first chamber means and to a source of pressure fluid; 1
a second port connected to said second chamber means and to an exhaust;
a passage exterior of said cylindrical bore means connecting said first and second valve seats;
a third port connected to said passage and to a consumer device;
elastic means operable on one end portion of said elongated valve component means urging said elongated valve component means to a first position into contact with one of said first or second valve seats, thereby connecting said third port with one of said first or second ports; and
electromagnetic valve controlling means operable on an opposite end portion of said elongated valve component means for selectively moving said elongated valve component means to a second position into contact with the other of said first or second valve seats, thereby connecting said third port with the other of said first or second ports.

2. A valve as claimed in claim 1, wherein said cylindrical bore means comprises a single bore; and said elongated valve component means comprises a single component having a cylindrical mid-portion in sliding contact with said single bore, first and second reduced diameter sections extending from both ends of said mid-portion and in communication respectively with said first and second chamber means, and first and second valve contacting surfaces respectively at the remote ends of said first and second reduced diameter sections for contact respectively with said first and second valve seats.

3. A valve as claimed in claim 1, wherein said cylindrical bore means comprises first and second bores; said elongated valve component means comprises first and second components; said first component having a cylindrical lower end portion in sliding contact with said first bore, a reduced diameter mid-portion in communication with said first chamber means, and a valve contacting upper end portion for contact with said first valve seat; and said second component having a cylindrical upper end portion in sliding contact with said second bore, a reduced diameter mid-portion in communication with said second chamber means, and a valve contacting lower end portion for contact with said second valve seat.

4. A valve as claimed in claim 1, wherein said electromagnetic valve controlling means comprises a movable core, a coil surrounding said core, and spring means having a stiffness greater than said elastic means positioned between said core and said elongated valve component means for urging said elongated valve component means into said second position.