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MAGNETICALLY OPERATED ELECTRIC SWITCH
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The present invention relates to a magnetically operated electric switch. More particularly, the invention relates to a magnetically operated electric switch wherein the contacts may complete or open an electric circuit in response to changes in the pressure of a hydraulic or pneumatic fluid.

An important object of the invention is to provide an electric switch which can respond rapidly to changes in fluid pressure, which can be put to long-lasting use with a minimum of wear upon its parts, and which can be put to a number of different uses in many types of hydraulic or pneumatic control systems or the like.

Another object of the invention is to provide a magnetically operated electric switch which may be readily adjusted so that its contacts will open or close in response to a desired fluid pressure change, which can be adjusted and regulated with a minimum of effort, and which can be adjusted in more than one way.

A further object of the invention is to provide an electric switch of the above outlined characteristics whose component parts may be assembled into a self-contained unit, wherein the contacts are fully protected from dust and/or moisture, and which can be readily utilized as an advantageous substitute for presently utilized electric switches of conventional construction.

An additional object of the invention is to provide an improved magnetic operating unit for an electric switch of the above outlined characteristics.

A further object of the invention is to provide an electric switch which is operated by one or more magnets and wherein the opening and closing of contacts may be effected either by a liquid medium or by compressed gas without necessitating any changes in its construction.

Briefly stated, one feature of my invention resides in the provision of an electric switch which comprises a pair of contacts preferably consisting of elastically deformable ferromagnetic material and movable with reference to each other between conditions of engagement and disengagement to thereby complete or open an electric circuit and normally assuming one of such conditions, a cylinder defining a chamber, actuating means at least a portion of which constitutes a permanent magnet and comprising a piston movable in the cylinder chamber between a first position in which the magnetic field of the permanent magnet is effective to change the condition of the contacts and a second position in which the magnetic field is ineffective upon the contacts so that the contacts assume their normal condition, and fluid-conveying conduit means communicating with the cylinder chamber at one side of the piston. The piston is responsive to a predetermined fluid pressure change in the conduit means to move from the one to the other position.

For example, the contacts can be normally held open and the piston itself may constitute a permanent magnet which is movable nearer to and thereby effects closing of the contacts in response to a pressure rise in the conduit means. The switch may further comprise regulating means for biasing the piston to its one position and to vary the pressure to which the piston responds by moving to the other position. Such regulating means may comprise one or more springs, a permanent magnet, or simply a valve which regulates the pressure prevailing at the other side of the piston.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved electric switch itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawings, in which:

FIG. 1 is a sectional view of a magnetically operated electric switch which is constructed in accordance with a first embodiment of my invention and wherein the actuating means consisting of a piston-like permanent magnet;

FIG. 2 is a similar sectional view showing a modified electric switch wherein the position of the contacts may be changed in the axial direction of the piston;

FIG. 3 is a sectional view of a third electric switch wherein the exact fluid pressure which is necessary to change the position of the piston is adjustable by a second permanent magnet; and

FIG. 4 is a sectional view of a fourth electric switch wherein the actuating means comprises a stationary permanent magnet.

Referring first to FIG. 1, there is shown a magnetically operated electric switch which comprises a housing 10 consisting of a diamagnetic material, for example, brass or another copper alloy. The lower portion 10b of the housing 10 constitutes a conduit having a passage in the form of a bore 11 which serves to convey a hydraulic or pneumatic fluid whose pressure changes will cause the contacts 20, 21 of the switch to open or close. The bore 11 communicates with a narrow channel 13 which allows pressure fluid to enter the lower end of an elongated cylinder chamber 12 so that the fluid flowing through the conduit 10b may act upon the underside of a reciprocable piston 15 which constitutes the actuating means of the electric switch. This piston is an axially magnetized permanent magnet which normally assumes the end position shown in FIG. 1. The chamber 12 is machined into the upper portion 10a of the housing 10 which constitutes a cylinder and is but need not be integral with the conduit 10b. The upper portion of the chamber 12 communicates with a port 14 which is open to the atmosphere so that the upper side of the piston 15 is subjected to the pressure of atmospheric air.

The switch of FIG. 1 further comprises a regulating device which includes a prestressed helical spring 16 consisting of non-magnetizable material and serving to bias the piston 15 to the lower end position in which the piston remains by abutting against an internal shoulder of the cylinder 10a. The bias of the spring 16 may be changed by an adjusting member here shown as an externally threaded plug 17 which is screwed into a tapped bore 12c constituting the upper end portion of the cylinder chamber 12. By engaging the milled head 17a of the plug 17, the operator can rotate this plug to thereby change the initial bias of the spring 16.

The cylinder 10a is provided with a second chamber 18 which is adjacent to and parallel with the chamber 12. This second chamber 18 accommodates a pair of ferromagnetic contacts 20, 21 which are movable with reference to each other between conditions of engagement and disengagement to respectively complete and open an electric circuit. In the embodiment of FIG. 1, the contacts 20, 21 normally assume the condition of disengagement from each other so that the corresponding circuit is open. The terminals of the contacts are preferably surrounded by a protective tube 19 consisting of glass or other suitable material. Portions of the contacts 20, 21 are embedded in the material of the tube 19. It will be seen that the terminals of the contacts 20, 21 overlap and are rather closely adjacent to each other. The material of

these contacts is elastic so that their terminals automatically assume the condition shown in FIG. 1 unless they are subjected to action of a force which is strong enough to change the normal condition of the contacts in order to complete the electric circuit of the switch.

When the piston 15 assumes the end position of FIG. 1, i.e., when this piston is free to follow the bias of the spring 16, its magnetic field is not effective to change the condition of the contacts 20, 21. In other words, the contacts are then located at least partly outside of the magnetic field of the piston 15. However, if the pressure of fluid in the bore 11 and channel 13 increases to a predetermined extent, the spring 16 yields and allows the piston 15 to move toward the other end position whereby its magnetic field moves nearer to the contacts 20, 21 and the terminals of the contacts are closed by magnetic force to complete the electric circuit.

For example, the conduit 10b may form part of a line 11c serving to convey oil, water, compressed air or another fluid from a source 11a to a consumer 11b, and the line 11c may contain a safety valve 11d in the form of a solenoid valve which is connected in circuit with the contacts 20, 21 to seal the consumer 11b from the source 11a as soon as the fluid pressure in the bore 11 and channel 13 reaches an undesirably high level. Obviously, the electric switch of FIG. 1 is susceptible of many other uses in various types of hydraulic or pneumatic systems.

The electric switch of FIG. 2 differentiates from the switch of FIG. 2 only in that the cylinder 10a' of the housing 10' is formed with a large second chamber 22 which accommodates the tube 19 with contacts 20, 21 and an adjusting device which can change the position of the tube 19 with reference to the piston 15. This adjusting device comprises a carrier here shown as a spindle nut 23 which meshes with the stem of a spindle 24 having a knurled head 24a adapted to be rotated by hand to thereby change the axial position of the nut 23 and tube 19. The axis of the spindle 24 is parallel with the longitudinal extension of the cylinder chamber 12. The plug 17 is replaced by a plug 17' whose head 17a' is slotted so that it may be engaged by a screwdriver or the like. Otherwise, the construction of the switch shown in FIG. 2 is identical with that of the previously described switch. Since the position of the contacts 20, 21 with reference to the piston 15 may be changed while the piston 15 is stationary, the switch of FIG. 2 is adjustable within a wide range so that the contacts 20, 21 will assume the condition of engagement and will close the electric circuit in response to any desired fluid pressure change in the bore 11 of the conduit 10b'.

FIG. 3 illustrates an electric switch having a housing 10'' including a cylinder 10a'' and a conduit 10b''. The channel 13'' is longer than the channel 13 and the regulating means for the piston 15 comprises a threaded plug 25 having a milled head 25a and constituting an axially magnetized permanent magnet. The piston 15 also constitutes a permanent magnet and its south pole is located at the upper end thereof. The south pole of the plug 25 is located at its lower end so that the two magnets repel each other whereby the piston 15 is biased to the end position of FIG. 3 and remains in such position until the pressure of fluid flowing through the bore 11'' rises sufficiently to move the piston 15 upwardly to such an extent that the magnetic field of this piston changes the condition of the contacts 20, 21. The bias of the plug 25 upon the piston 15 may be changed when the plug 25 is rotated and moves axially toward or away from the piston.

Referring finally to FIG. 4, there is shown a fourth electric switch wherein the actuating means for changing the condition of the contacts 20, 21 comprises a perma-

nent magnet 26 received in a chamber 26a of the cylinder 110a and a piston 115 which is reciprocable in the cylinder chamber 112. The piston 115 comprises a body 27 of diamagnetic material and at least one ferromagnetic element 28 which is embedded in the material of the body 27. The permanent magnet 26 is stationary and is located substantially diametrically opposite the tube 19 which is inserted into the chamber 118 of the cylinder 110a. For example, the body 27 may consist of brass and the element 28 may consist of a strip of iron. In the end position of FIG. 4, the piston 115 shields the contacts 20, 21 from the magnetic field of the permanent magnet 26 so that the magnetic field is ineffective and cannot change the condition of the contacts. However, when the piston 115 responds to a predetermined fluid pressure rise in the conduit 111 and channel 113, the magnetic field of the permanent magnet 26 is effective to change the condition of the contacts 20, 21 so that these contacts complete the electric circuit.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of my contribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. An electric switch, comprising a pair of ferromagnetic contacts movable with reference to each other between conditions of engagement and disengagement and normally assuming one of said conditions; a cylinder defining a chamber having a first end and a second end; actuating means including a piston constituting a first axially magnetized permanent magnet and movable in said chamber between a first position in which the field of said permanent magnet is effective to change the condition of said contacts and a second position in which said field is ineffective upon said contacts; a second axially magnetized permanent magnet provided in said cylinder at one end of said chamber, said permanent magnets having their axes in alignment and having like poles adjacent to each other so that said piston is normally biased to one of said positions at the other end of said chamber; and fluid-conveying conduit means communicating with said cylinder at the other end of said chamber and at the respective side of said piston, said piston being responsive to a predetermined fluid pressure change in said conduit means to move from said one to the other position thereof.

2. An electric switch as set forth in claim 1, wherein said cylinder is provided with internal threads at said one end of the chamber and wherein said second permanent magnet is provided with external threads meshing with said internal threads so that the bias of said second permanent magnet upon said piston is adjustable in response to rotation and resultant axial displacement of said second permanent magnet.

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