United States Patent

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[54] **FLUID PRESSURE MAGNETICALLY OPERATED SWITCH WITH IMPROVED FLOW-RESPONSIVE ACTUATOR MEANS**
5 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **200/81.9,** 200/83
[51] **Int. Cl.** **H01h 35/40**
[50] **Field of Search** ..... 200/81.9, 81.9 (HG), 81.9 (M), 83.33, 83.6, 83.71, 84.3, 61.45 (M)

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ABSTRACT: A flow-switch assembly for use in connection with a substantially horizontally disposed fluid-carrying line. The assembly includes a bushing for mounting the assembly on the line. A vane is pivotally carried by the bushing and, under no-flow conditions in the line, it normally extends vertically into the line. A magnetic member is vertically slidable in a housing mounted on the bushing. A cam is provided on the vane and a cam follower responsive to movement of the cam is connected to the magnetic member. A magnet is carried on an arm which pivots towards the magnetic member as it moves into a position of proximity with the magnet, after the cam follower is moved to a raised position by the cam. A mercury-type switch is responsive to the movement of the magnet for opening or closing electrical contacts.

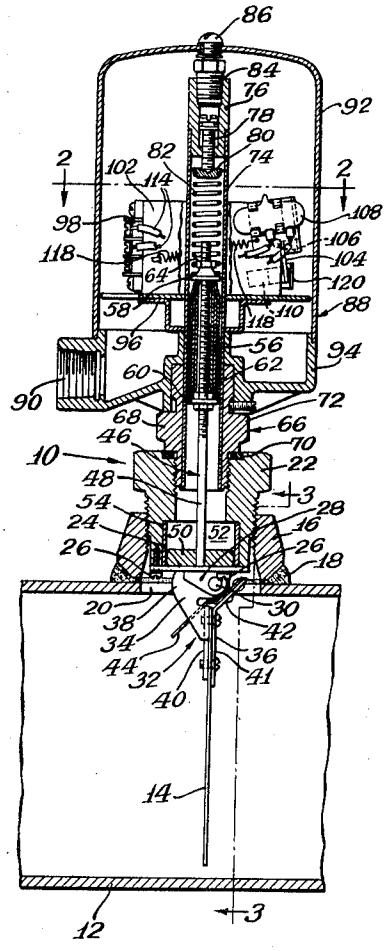


FIG. 1.

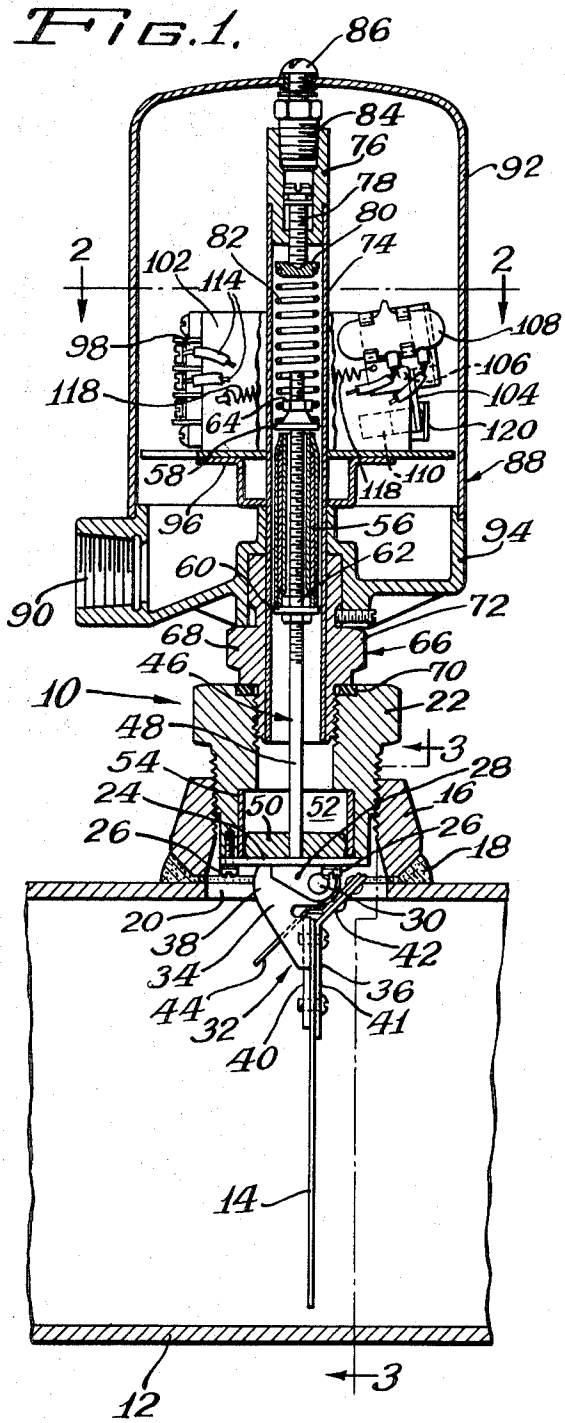


FIG. 2.

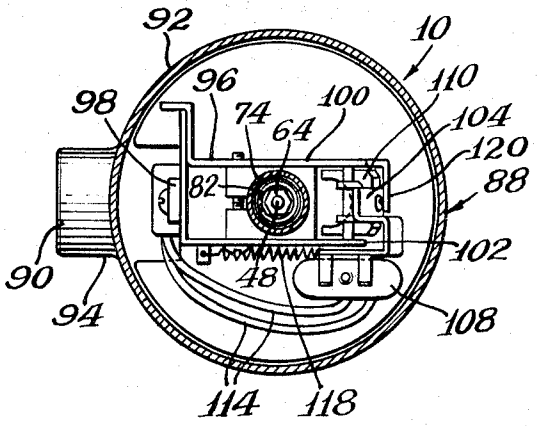
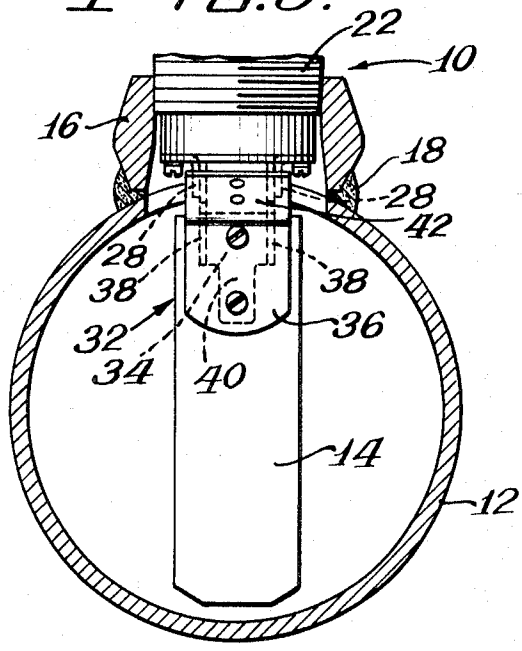


FIG. 3.



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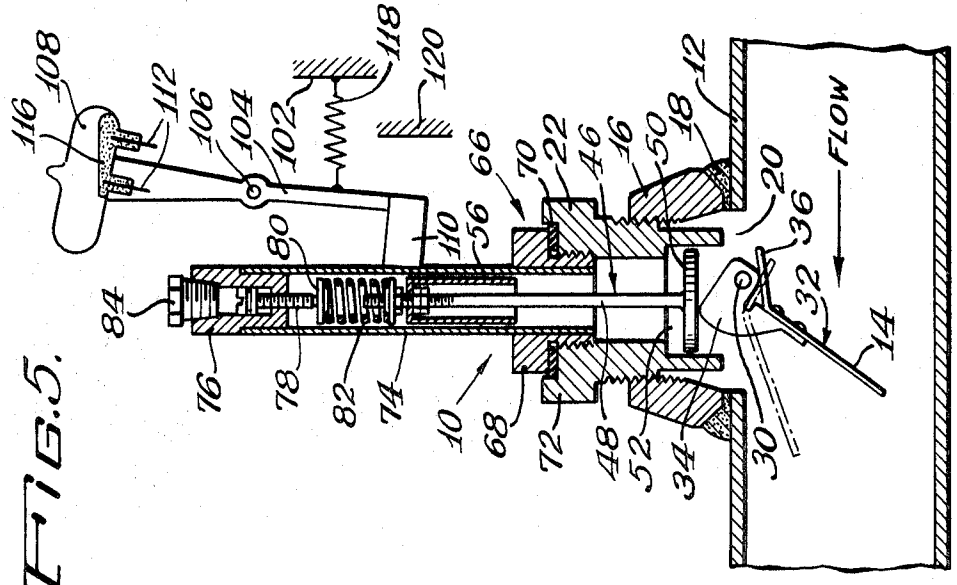


FIG. 5.

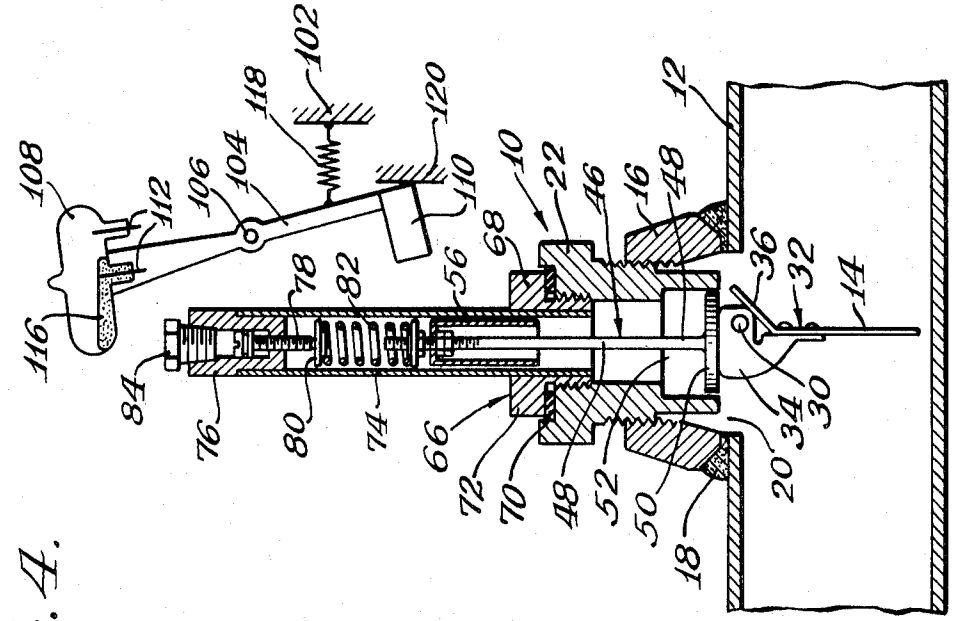


FIG. 4.

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FLUID PRESSURE MAGNETICALLY OPERATED SWITCH WITH IMPROVED FLOW-RESPONSIVE ACTUATOR MEANS

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION AND DESCRIPTION OF THE PRIOR ART

This invention relates to a flow-switch assembly for detecting flow in a horizontally disposed carrying line for various fluids or fluidlike materials, including liquids and gases.

Flow-actuated electrical switches are used for detecting the flow of fluids, such as liquids, gases, and the like through pipes, ducts, etc. Normally, these flow switches activate or deactivate equipment when there is flow or no-flow in a pipe. One use of these switches is for stopping a motor driving a pump when there is little flow or no-flow from the pump to thereby protect the pump from overheating. Such switches may also be used for protecting other types of similar equipment which are normally unattended. These flow switches can also be used for automatically starting auxiliary pumps or engines when, for example, the main pumps are out of service and there is no flow from the main pump. Flow switches can also be used for sequentially starting and stopping pumps in accordance with flow in a line. Water colled engines can be stopped for protection by these switches when cooling water flow to the engine is interrupted for one reason or another. It is seen that such electrically actuated flow switches have a wide variety of uses.

Known automatic vane-type flow switches commonly include a vane which normally hangs vertically downwardly into a substantially horizontal pipeline. When there is flow in the line, the vane tilts from the normal vertical position due to the force of the moving fluid. The tilting movement of the paddle or vane, by mechanical connection, operates a switch. In one structure, the tilting movement of the vane causes physical tilting of an actuator which, in turn, trips a switch arm or button. Other flow switches use various mechanical connections between the vane and the switch, including bellows, diaphragms, various types of mechanical linkages, and the like.

Because of the required mechanical connections, some of the known flow switches particularly encounter difficulties when there are high liquid-flow rates in the pipeline. Because these paddles or vanes are normally limited in their pivotal motion because of the required mechanical connections, a high liquid-flow rate may actually break the vane. Such breakage can ultimately lead to serious damage to the equipment which the switch is designed to protect. Furthermore, since the vanes extend down into the pipeline, there is a pressure drop in the system because the mechanical mounting does not permit the vane or paddle to tilt or move sufficiently out of the fluid flow path to avoid undesired pressure drop in the line.

An additional problem encountered with prior art devices is their sensitivity to flow pulsations or gas pockets in the pipeline. This sensitivity is a result of the limited pivoting angle of the vanes used in the prior art devices. The more limited the pivoting of the vane, the more sensitive is the switch to undesired tripping or actuation. Also, the prior art devices commonly work most satisfactorily when they are mounted in pipe sections of substantial horizontal length on both sides of the vane so there is laminar flow, which is needed to avoid flow pulsations which, in turn, leads to undesired switch actuation.

SUMMARY OF THE INVENTION

It is therefore an important object of this invention to provide an improved flow switch which avoids many of the disadvantages of prior art flow switches.

It is also an object of this invention to provide an improved flow switch which avoids the use of mechanical couplings between the vane or paddle, which is responsive to the flow of liquid in the pipe, and the electrical switching mechanism itself.

It is yet another object of this invention to substantially reduce the pressure drop around the vane used in vane-actuated flow switches when there is flow in the line.

It is yet another object of this invention to provide a vane-actuated flow switch wherein the vane is less subject to breakage than prior art vane switches.

It is still a further object of this invention to provide a vane-actuated flow switch wherein a magnetic coupling arrangement is provided between the switch and the vane.

It is still another object of this invention to provide a vane-actuated flow switch wherein the vane, upon flow in the pipeline, is movable to a position substantially longitudinal to the direction of liquid flow, to thereby reduce pressure drop around the vane.

It is yet another object of this invention to provide an improved vane flow switch which is not susceptible to undesired actuation from flow pulsations or gas pockets in the line.

It is also another object of this invention to provide a vane actuated flow switch which does not require long straight pipe sections on either side of a vane, but rather can be located in short horizontal pipe sections.

It is yet a further object of the invention to provide a flow switch that, while in service, can have its switching point adjusted to the desired flow rate.

Further purposes and objects of this invention will appear as the specification proceeds.

The foregoing objects are accomplished by providing a flow switch assembly for use with a substantially horizontally disposed fluid-carrying line, said assembly comprising, in combination, a member for mounting the assembly on the line, a flow-responsive member pivotally connected to the support member and, at no-flow conditions in said line, extending substantially vertically downwardly into the line from the pivot connection, a first magnetic element movably carried by the support means between a first position and a second position, a member responsive to the movement of the flow-responsive member from its normal vertical position to an angular position, when there is flow in the line, for moving the first magnetic element from its first position to its second position, a second magnetic element movable from a first location to a second location in response to movement of the first magnetic element to a second position and a switch which is responsive to the movement of the second magnetic element from the first location to the second location for opening or closing an electrical circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

A particular embodiment of the present invention is illustrated in the accompanying drawings wherein:

FIG. 1 is a vertical cross-sectional view through my improved vane-actuated flow switch;

FIG. 2 is a cross-sectional view taken along the line 2–2 of the embodiment of FIG. 1;

FIG. 3 is a cross-sectional view taken along the line 3–3 of the embodiment of FIG. 1;

FIG. 4 is a chematic view illustrating the position of the vane-actuated flow switch, shown in FIGS. 1—3, when there is no flow in a pipe; and

FIG. 5 is a schematic view, similar to FIG. 4, except the flow switch is shown in position when there is flow in the pipeline.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1—3, my improved flow switch is mounted on a pipeline 12. In such a vane-actuated flow switch 10, the pipeline portion 12 is in a substantially horizontal position so that vane or paddle member 14 of the switch 10 normally hangs in a vertical position, as shown in FIG. 1, when there is no flow in the pipeline 12. The flow switch 10 is used for detecting flow of any of a variety of materials in the line

12, including various liquids and gases. For purposes of simplicity, the term "fluid," as used hereafter, is intended to encompass any of a variety of liquids and gases which are commonly transported through a pipeline 12.

A threaded connection 16 is welded at 18 to the wall of the line 12 which surrounds an aperture 20 in the line 12. A flow switch mounting bushing 22 is threadably and sealably received by the connection 16 by means of a pipe thread connection therebetween.

A vane support plate 24 is secured to the annular lower face of the bushing 22 by screws 26. The plate 24 includes an open central portion and downturned support ears 28. The ears 28 carry a pivot pin 30 which pivotally carries the vane-cam assembly, generally 32. The vane-cam assembly 32 includes a cam portion 34, the vane portion 14, and a rigid stop portion 36, all of which are secured together. The cam portion 34 comprises a pair of spaced upstanding cam plates 38 which are interconnected by a central portion 40. The rigid stop portion 36 includes a lower connecting section 41 and an upwardly angled rigid stop section 42 which acts to limit overtravel of the vane 14 as it returns to the normal vertical down position. The vane portion 14 is interposed between the stop portion 36 and the interconnecting central portion 40 of the cam portion 34. Mounting screws 44 secure the three portions of the assembly 32 together, as shown in FIGS. 1 and 3. The cam plates 38 include offset apertures to pivotally carry the assembly 32 on the pin 30, thereby defining the enlarged camming portion of the plates 38. A resilient or spring stop and return member 44 is secured to the stop portion 42 and extends angularly downwardly between the cam plate portions 38. The spring stop 44 acts to limit the pivoting upward clockwise movement, as viewed in FIG. 1, of the vane 14 when there is flow in the pipeline 12. The member 44 also assists in driving the vane 14 back to the starting position when there is no flow in the line 12. The center of gravity of the assembly 32 is such that it hangs in a vertical direction, when there is no flow, from the pivot pin 30.

The upper camming edge of the cam portion 34 bears against the lower end of a cam follower assembly 46. The cam follower assembly 46 includes a stem 48 and a plate portion 50 which is rigidly secured to the lower end of the stem 48. The plate portion 50 is vertically and slidably received with a lower bore 52 of the bushing 22. Desirably, a cylindrical liner 54 is secured in the bore 52 for assuring slidable, corrosion free nonbinding contact or relationship with the edges of the cam follower plate 50. For proper operation of the flow switch 10, it is important that the cam follower assembly 46 is freely slidable in a vertical direction.

At the upper end of the cam follower assembly 46, a magnetic attract member 56 is adjustably mounted. The magnetic attract member 56 is generally tubular in structure and comprises a welded sleeve having inner and outer tubular members of corrosion resistant, nonmagnetic stainless steel and an intermediate enclosed tubular member of magnetic steel. The attract member is mounted between an upper flange 58 and a lower flange 60. The lower flange 60 is confined between a pair of adjustable lock nuts 62 which are threadably mounted on the stem 48. The nuts 62 may be adjusted lengthwise of the stem so that the flange 60 can be set on the stem at any desired level. Similarly, the upper flange 58 is adjustably received on the threaded portion of the stem 48 and is held at its adjusted position by a lock nut 64.

The cam follower assembly 46 and magnetic attract member 56 are both movably received within a tubular housing, generally 66, which is secured to the upper end of the bushing 22. The tubular housing 66 includes an outer support portion 68, which is threadably received in the upper bore of the bushing 22, and an inner elongated tubular member 74, A seal 70 is interposed between the intermediate flange 72 of the outer support portion 68 and an upper annular recess in the bushing 22. The elongated tubular member 74, which is made of nonmagnetic material, is securely received, by welded construction, in the inner bore of the outer support member 68. The tubular member 74 is enclosed at its upper end by a welded end plug 76. The plug member 76 includes a central well portion having a threaded lower opening which threadably receives a spring-adjusting screw 78. The spring-adjusting screw 78, which is sealably received within the well portion by use of an O-ring, bears against an upper spring guide 80 which in turn bears against the upper end of a tension-adjusting spring 82. The lower end of the tension-adjusting spring 82 bears against the upper flange 58, which serves the additional function of being a spring guide. The adjusting screw 78 is adjusted so as to vary the spring tension acting against the upper flange 58, as desired, so as to ultimately adjust the force bearing against the cam portion 38 of the cam-vane assembly. It is important that the adjustment can be made when the line is in service. By appropriate adjustment of the tension of the spring 78, it is possible to adjust the vane 14 to tilt or move to an actuation position only when the force of the moving fluid in the line is above a preselected level.

The upper end of the plug 76 receives an enclosing plug 84 by pipe thread connection which prevents leakage if the O-ring seal leaks. The plug, in turn, threadably receives a mounting screw 86. A housing, generally 88, at its lower end, is secured to the outer support portion 68 of the housing 66 and, at its upper end, is secured by the mounting screw 86. The housing 88 includes the upper housing portion 92 and a lower housing portion 94. The upper and lower portions 92 and 94 are in peripheral engagement, as best shown in FIG. 1. The upper portion is desirably made by forming sheet metal to a desired shape and the lower portion is a machined casting. The lower portion 94 also includes a conduit outlet 90 for the passage of electrical connecting wires (not-shown).

A switch support plate 96 is enclosed in the chamber defined by the housing 88 and is rigidly secured to the lower housing portion 94 and to the tubular housing 66. The switch support 96 has an electrical terminal block 98 mounted thereto. A pair of leads 114 are secured to the block 98 and are connected to the mercury switch 108. The terminal block 98 also receives leads (not shown) from external controls, which leads pass through the outlet 90 and are electrically connected through the block 98 to the leads 114.

The switch support 96 has a pair of upright supports. A pivoted switch-mounting assembly or arm 104 is carried by a pin 106, which is mounted on a horizontal axis between the upright supports 100 and 102. A mercury switch 108 is secured to suitable mounting clips provided on the arm 104. A permanent magnet 110 is secured to the inner portion of the arm 104 and is pivotally aligned with the tube 74. As the magnet 110 is attracted to the magnetic attract member 56, the arm 104 and thereby the mercury switch 108 are also tilted on the pivot 106. As the mercury switch 108 is tilted from the position shown, the mercury contained within the switch 108 causes electrical current to flow between the internal leads of the switch 108. The leads 114 or wires pass from the switch internal leads to the terminal block 98 where the desired external connections can be made to an external control for controlling the operation of a motor, pump, or the like. A return spring 118 is connected between the switch frame 102 and the arm 104 to assure return of the arm to the rest position. A stop 120 on frame 100 limits the movement of the support arm.

Although a mercury-type switch is useful in most applications, there are some instances when such a switch is not used. For example, mercury cannot be used if the apparatus is used on a nuclear installation. Mercury switches are also undesirable if extreme vibration is present, which can splash mercury across the contacts and thereby make a false circuit. In such cases, a snap-type, dry-contact switch can be used; the tilting movement of an assembly carrying the magnet operates the lever of a rigidly mounted switch. Also, a pneumatic-type switch can be used if no electricity is available at the place of use; in such installations, the pivoting assembly carrying the element moves a flapper which opens or closes a nozzle on the air-control valve.

In describing the operation of the flow switch 10, reference will be made to FIGS. 4 and 5 which schematically show the embodiment of the flow switch 10, shown in detail in FIGS. 1—3. FIGS. 4—5 show all the essential operating elements of the switch 10 and its operation can be clearly understood by referring thereto. The attract member 56 and the magnet 110 are shown in their preferred arrangement although it is to be understood that the magnet portion of the magnetic coupling may be carried in the tube 74 and the magnetic attract portion may be pivoted on the pin 106.

Referring to FIG. 4, when there is no flow in the pipeline 12, the vane 14 of the flow switch remains in the vertically down position. Cam follower assembly 46 rests on the upper side of the cam plates 38. The magnetic attract member 56 is, at this time, out of the magnetic attraction field of the magnet 110, which is secured to the same arm 104 as the mercury switch 108. In this position, the mercury 116 contained in the switch closes only one internal switch lead 112. The spring 118 is used for normally maintaining the mounting assembly 104 in a nonoperative position, as shown in FIG. 4.

The vane 14, which extends into the pipeline 12, resists pivoting movement in response to flow in the pipeline 12 due to the weight of the cam follower assembly 46 and due to the spring tension applied to the cam follower assembly 46 by the tension-adjusting spring 82. When it is desired to adjust this switch so that it is responsive to relatively little flow in the pipeline 12, the adjusting screw 78 is threaded upwardly so that relatively little if any spring tension is applied to the follower. On the other hand, when it is desired to have significant flow in the line before there is actuation of the switch 108, the spring 82 is threaded downwardly so that substantial spring tension is applied to the follower 46.

When there is flow in the line, as seen in FIG. 5, the force of the flowing fluid acts directly against the planar portion of the vane 14 which is transverse to fluid flow. When the flow is at a given level according to the spring setting, the vane 14 pivots in a counterclockwise direction, as seen in FIG. 5, about the pivot pin 30, through a relatively large angle, such as about 45°. Since the only resistance to the pivoting movement of the vane 14 and thereby to the cam portion 34 is from the weight of the follower 46 and from the spring tension, the vane 14 pivots towards a position substantially longitudinal to fluid flow so that there is minimal pressure drop around the vane. Also, by substantially moving into a position substantially longitudinal to fluid flow, the vane is subject to little likelihood of breakage from the force of fluid moving at a high rate.

As the vane and thereby the cam portion 36 is pivoted upwardly, the cam follower 46 is driven upwardly by contact between the cam plate 38 and the cam follower plate portion 50. This vertical movement drives the stem 48 and thereby the magnetic attract member 56 upwardly within the nonmagnetic tubular housing 74. When the magnetic member 56 is thereby moved upwardly, it moves into the magnetic field of the permanent magnet 110. The magnet 110 is thereby drawn to the magnetic attract member 56, causing pivoting of the mounting arm 104. The magnet 110 pivots until it engages the outer surface of the nonmagnetic tube 74. As the assembly pivots to this position, the mercury switch 108 is also pivoted and the mercury 116 contained therein encloses both the leads 112 so that there is electrical current flowing from one lead to the other, thereby completing an electrical circuit for controlling an external pump, motor, or the like.

The vane 14 for the switch 10, being pivoted through an angle of about 45° or greater during flow in the pipeline 12, does not cause undesired closing and opening of the switch contacts when there is flow pulsation in the line. The relatively large angle avoids complete return of the vane to the vertical position during momentary no-flow conditions. An additional advantage of this lack of sensitivity to flow pulsation is that the horizontal pipe portion 12 can be quite short since laminar flow is not essential.

The elimination of mechanical connections and the provision of magnetic coupling between the pivoting movement of the vane 14 and the mercury switch 108 provide for a high degree of reliability of the described flow switch 10. The device 10 is readily adjusted to be sensitive only to flow of a desired amount. Little, if any, breakage can occur to the vane and little pressure drop occurs around the vane. The described mounting of the vane and the described magnetic coupling arrangement between the vane and the mercury switch provide many advantages for the described switch 10, which advantages are not found in prior art devices.

While in the foregoing there has been provided a detailed description of a particular embodiment of the present invention, it is to be understood that all equivalents obvious to those having skill in the art are to be included within the scope of the invention as claimed.

I claim:

1. A flow-switch assembly having a pair of mutually attracting magnetic elements with one element being a magnet and the other being of magnetically permeable material comprising, in combination, a body with a part for mounting the assembly to a fluid-carrying line, an actuator including a first of the magnetic elements having an inactive position and movable linearly along a path to an active position and a stem connected to said first magnetic element with a cam follower disc thereon, a second of the magnetic elements movably mounted on a part of said body whereby movement of said first element to active position causes attraction and movement of said second magnetic element, switch means actuated in response to movement of said second magnetic element, a vane carried by said body for positioning in said line transverse to the path of fluid flow in said line, a pivot connection offset from said path for pivotally mounting the vane to the body, and a cam movable with said vane and engageable with the surface of said cam follower disc whereby a predetermined rate of flow in said line will pivot said vane and cam with resulting movement of the cam follower disc and first magnetic element to active position while further movement of the vane to a position substantially longitudinal of fluid flow in said line is permitted with only slight additional movement of said first magnetic element along said path.

2. A flow switch assembly as defined in claim 1 including a coil spring acting on said first magnetic element to resist movement of said first magnetic element along said path to active position, and means accessible from the exterior of the body for adjusting said spring to vary said resistance to movement and thereby vary the magnitude of said predetermined rate of flow.

3. A flow switch assembly as defined in claim 2 wherein said accessible means includes an adjusting screw carrying a sealing O-ring.

4. A flow-switch assembly having a pair of mutually attracting magnetic elements with one element being a magnet and the other being of magnetically permeable material comprising, in combination, a body with a part for mounting the assembly to a fluid-carrying line, an actuator including a first of the magnetic elements having an inactive position and movable linearly along a path to an active position and a stem connected to said first magnetic element with a cam follower disc thereon, a spring urging said actuator toward the inactive position, a second of the magnetic elements movably mounted on a part of said body whereby movement of said first element to active position causes attraction and movement of said second magnetic element, switch means actuated in response to movement of said second magnetic element, a vane pivotally carried by said body for positioning in said line transverse to the path of fluid flow in said line, a cam movable with said vane and engageable with the surface of said cam follower disc whereby a predetermined rate of flow in said line will pivot said vane to a predetermined angle relative to fluid flow and the cam will cause resulting movement of the cam follower disc and first magnetic element to active position against the action of the spring while further movement of the vane to a position substantially longitudinal of fluid flow in said line is permitted by slight additional movement of said first magnetic

element along said path, and means accessible from the exterior of the assembly for varying the urging force of the spring to vary the magnitude of said predetermined flow.

5. A flow-switch assembly as defined in claim 4 wherein a pivot connection pivotally mounts said vane to the body with the pivot connection offset to one side of an extension of said path, said cam having an operative surface at a distance from said pivot connection and at the opposite side of said path therefrom whereby said cam surface acts on the cam follower disc through a substantial moment arm through the entire range of vane movement.