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ELECTRICAL SPEED-RESPONSIVE SWITCH WITH TIME-DELAY

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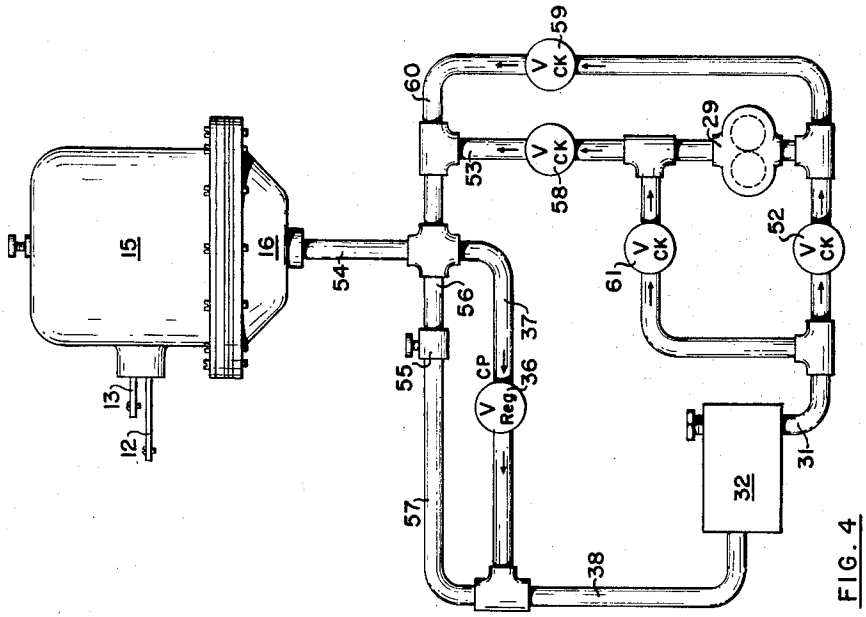



FIG. 4

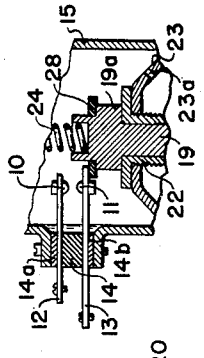



FIG. 2

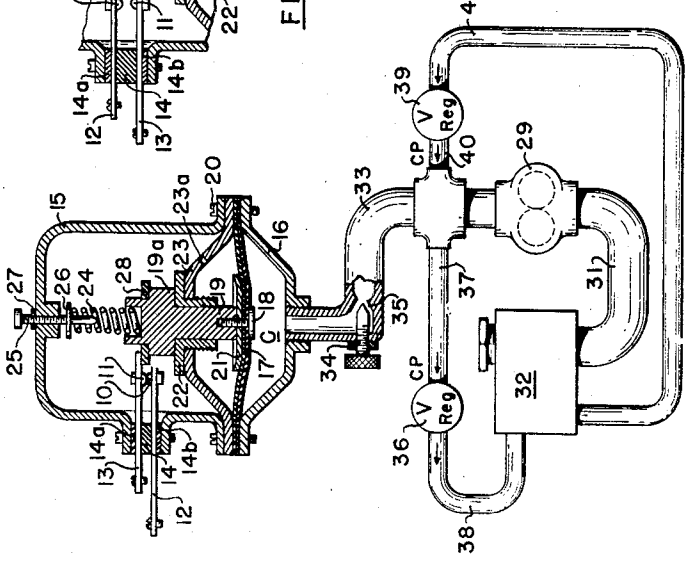



FIG. 1

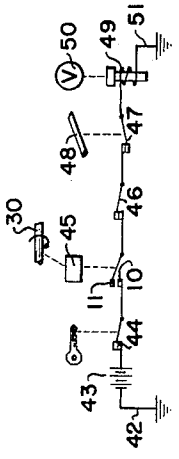



FIG. 3

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# ELECTRICAL SPEED-RESPONSIVE SWITCH WITH TIME-DELAY

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18 Claims. (Cl. 200—83)

This invention relates to electrical, speed-responsive, time-delay switches having separable electrical switch contacts that are actuated by a fluid pressure-responsive actuating unit having normal and reverse operations which occur, respectively, at a relatively higher and reduced fluid pressure, wherein at least one of said operations is subject to a time-delay following a change in the speed of a driving member which is coupled mechanically to a pump for pressurizing the said fluid.

The actuating unit may be coupled to the switch contacts as desired, e. g., either to close or to open the contacts upon the normal operation. Similarly, the time-delay may occur in either the normal or the reverse operation of the actuating unit, or in both of said operations. It is evident, therefore, that the switch is applicable to a variety of uses.

One specific application of the electrical switch is as a component of a brake-holding system for motor vehicles equipped with hydraulic brakes, especially those having automatic transmissions, wherein the brakes, after application, are held in applied position until the accelerator pedal is depressed provided that the speed of the vehicle at the time the brake pedal is released has remained for a predetermined time-delay period at less than a predetermined speed, such as zero or a low value up to, say, one to five miles per hour. In such an application the electrical switch is coupled mechanically to an element of the vehicle that rotates at a speed determined by the vehicle speed, e. g., the drive shaft or the speedometer cable, and the contacts are kept open while the vehicle is in motion and thereafter until the vehicle has, throughout the said time-delay period, not exceeded the said predetermined speed. The contacts are connected in an electrical circuit that includes at least a source of electric potential, an accelerator pedal-actuated circuit breaker, and the coil of a solenoid-controlled valve which is interposed in the hydraulic brake fluid line and traps brake fluid at the brake cylinders so long as the coil is energized, the said valve being by-passed by a non-return valve which permits flow of brake fluid from the master cylinder to the brake cylinders although the solenoid-controlled valve is closed.

The time-delay in such an application is usually between about 0.8 and four seconds, e. g., two seconds. Such a delay is advantageous under many traffic conditions because it permits the brakes to be released and vehicle travel to be continued with the engine idling by simply releasing the brake pedal promptly after the vehicle has been brought to a stop or to a speed below the said predetermined speed. Without the time-delay the brakes could be released after such a reduction in forward travel only by depressing the accelerator pedal or otherwise interrupting the said electrical circuit.

It is the main object of the invention to provide an improved electrical switch having separable switch contacts and a hydraulic actuating system for said contacts that includes a pump which can be coupled mechanically to a variable-speed drive member, wherein the actuation



of said contacts in at least one direction is delayed after a change in the speed of said drive member.

It is a further object to provide an electrical switch as indicated in the preceding paragraph which includes a fluid pressure-responsive actuating unit for the switch contacts wherein means are provided for protecting the actuating unit and other parts of the hydraulic system against damage from extreme fluid pressure conditions, that is, excessively high pressure, such as could be generated by operation of the pump at high speed, and/or excessively low pressures or suction, such as could result from operation of the pump in a reverse direction.

Still another object is to provide an electrical switch of the type indicated in the main object which will actuate the switch contacts to one condition (either open or closed) when the said drive member attains a predetermined speed, regardless of the direction of movement of said member, and actuates the contacts to the opposite condition (closed or open, respectively) when the speed is zero or below a predetermined value.

In summary, the electrical switch according to the invention includes a pair of separable switch contacts, a fluid pressure-responsive actuating unit for said contacts having normal and reverse operations which occur, respectively, upon the influx or efflux of a fluid to or from a chamber having a movable wall such as a diaphragm or plunger exposed to fluid within the chamber, a positive displacement pump such as a gear pump which can be coupled mechanically to a drive member, the pump being coupled by hydraulic flow means to force fluid into said chamber upon operation of the pump, and throttling means in said flow means for restricting the rate of fluid flow into and/or out of said chamber, whereby the influx and/or efflux of fluid and, thereby, the normal and/or the reverse operation of the actuating unit is delayed following a change in the speed of the pump. Efflux of fluid from the said chamber can be either through the pump or through an auxiliary duct.

Additional features will be described in the sequel in connection with the accompanying drawing which show certain preferred embodiments by way of example, wherein:

Figure 1 is a diagrammatic view of the switch, certain parts being shown in section;

Figure 2 is a fragmentary view of a part of the switch showing a modification;

Figure 3 is a schematic diagram of the electrical circuit of a vehicular brake-holding system to which the switch of Figure 1 may be applied; and

Figure 4 is an elevation view of a modified arrangement of the hydraulic elements of the switch whereby the switch responds to movement of the drive member in either the forward or reverse direction of the member.

Referring to Figure 1, the switch comprises a pair of separable electrical switch contacts **10**, **11**, mounted on resilient, conducting springs or strips **12**, **13**, which are secured in spaced relation by an insulating block **14** and are mounted to a housing **15** in electrically insulated relation by insulating members **14***a* and **14***b*. The outer ends of these strips have suitable means for making electrical connections to circuit elements. The housing is attached at the bottom to a lower closure **16** which defines in part a fluid displacement chamber C. This chamber is bounded at the top by a movable wall, embodied in the particular construction here illustrated as a flexible diaphragm **17** which is fastened by a screw **18** to the bottom of a vertically reciprocable plunger **19**. The margin of the diaphragm is sealed by clamping to the rim of the closure **16** by means of cap screws **20**. A downwardly convex washer **21** is interposed between the diaphragm and the plunger. The plunger is guided by a ferrule **22** which is externally threaded to an intermediate, upwardly dished

support wall 23 which is mounted between the housing 15 and the diaphragm and has a port 23*a*. Upward travel of the plunger and diaphragm is limited by engagement of the washer 21 with the bottom of the ferrule 22, and downward travel is limited by engagement of a downwardly directed shoulder 19*a* of the plunger with the top of the ferrule. The plunger is biased downwards by a coiled spring 24 which is positioned at the bottom by a recess in the top of the plunger 19 and is further guided internally by the lower part of a bias-adjusting screw 25 which is in threaded engagement with the housing 15. The top of the spring 24 bears against a washer 26 which engages a downwardly directed shoulder on the bias-adjusting screw, and the latter carries a lock nut 27. By axial adjustment of the screw 25 and washer 26 the spring 24 can be made to exert the desired force against the plunger 19. The plunger 19 carries on an upwardly directed shoulder thereof an insulating washer 28 which engages the under side of the tip of the resilient strip 13.

It is evident from the foregoing that the chamber C, diaphragm 17, plunger 19, spring 24, washer 28 and the associated parts collectively constitute an actuating unit which opens the switch contacts 10 and 11 during the normal operation of the unit, wherein the diaphragm moves upwards, and which closes the switch contacts during the reverse operation, wherein the diaphragm moves downwards.

The hydraulic system includes a positive displacement pump, such as a gear pump 29, having in this embodiment clearances permitting seepage of fluid when the pump is not running or is running at low speed. In other words, an inexpensive gear pump is suitable. This pump is adapted to be coupled mechanically to a drive member, represented in Figure 3 by a shaft 30, in response to the speed of which the switch is to be operated. For applications wherein the drive member operates in two directions, as in the case of a vehicular drive shaft or speedometer cable, the pump should be of the reversible type. The inlet port of the pump, that is, the port taking suction during the forward operation and shown at the bottom, is connected by a pipe 31 to a fluid reservoir 32 which contains a suitable hydraulic fluid, such as oil. The discharge port is connected by a duct 33 to the displacement chamber C. Interposed in this duct is a flow-restricting device, such as a throttling valve which includes an axially adjustable, threaded needle 34 having a tapered point which cooperates with a tapered orifice in a transverse wall 35 to provide a restricted flow passageway. The duct 33 is also connected through a pressure-relief valve 36 and pipes 37 and 38 to the reservoir 32. The valve 36 is adapted to return fluid to the reservoir whenever the pressure in the duct 33 rises to a predetermined level, thereby preventing a build-up of excessive pressure therein. The duct 33 is further connected to the reservoir 32 through a vacuum-relief valve 39 and pipes 40 and 41. The valve 39 is adapted to admit fluid from the reservoir to the duct 33 whenever the pressure in the duct falls to below a predetermined level, thereby preventing the genration of excessive suction in the duct during reversed operation of the pump. It will be noted that the pipes 37 and 40 are connected to the duct 33 between the throttling valve and the pump, whereby fluid flowing through the valves 36 and 39 need not pass through the throttling valve.

Operation is as follows: Prior to operation of the pump 29 the parts are in the positions shown in Figure 1, and the contacts 10 and 11 are in engagement.

When the pump 29 is operated forwardly, oil flows from the reservoir 32 via pipe 31 and is pumped upwards through the duct 33 and the throttling valve at 35 into the displacement chamber C; this forces the diaphragm 17 and plunger 19 upwards against the force of the bias spring 24, whereby the washer 28 lifts the resilient strip 13 to raise the contact 11 and open the switch. The throttling valve limits the rate of fluid flow into the chamber C and can delay the opening of the switch contacts with certain relations of the settings of the screw 25 and needle 34 and operating pressure of the pressure-relief valve 36, as will be explained hereinafter. Fluid delivered by the pump in excess of the amount entering the chamber C flows through the valve 36 and the pipes 37 and 38 to the reservoir 32, thereby protecting the hydraulic system, especially the diaphragm 17, throttling valve and pump against excessive pressure. This feature is of particular importance when the pump is coupled to a drive member that operates continuously for protracted periods, as in the case of automobile drive shafts.

When the pump 29 is stopped or operated at a very low speed fluid seeps through the pump clearances toward the pipe 31 and into the reservoir 32 until the pressures at the pump ports are equal. The bias spring 24 expands to force the diaphragm 17 downwards, thereby expelling fluid from the chamber C and maintaining within the duct 33 a pressure slightly in excess of the reservoir pressure until the diaphragm and plunger 19 are in lowermost position. During this downward movement the washer 28 descends and permits the resilient strip 13 to move down to close the switch contacts 10 and 11. The escape of fluid from the chamber C is retarded by the throttling valve to a degree determined by the setting of the needle 34, thereby imposing a time-delay in the reverse operation of the actuating unit. It may be noted that there will be only a small pressure differential across the throttling valve, determined largely by the stiffness of the bias spring 24, so that an appreciable time-delay, up to several seconds, can be attained.

A similar escape of fluid occurs when the pump 29 is operated in the reverse direction, but the suction generated by the pump in the duct 33 results in a slightly shorter delay. The influence of the pump suction in this situation is limited by the action of the vacuum-relief valve 39, which admits fluid from the reservoir into the duct 33 and thereby limits the suction or underpressure. This admission of fluid is further useful in preventing damage to the hydraulic system, particularly the diaphragm 17, which could otherwise be subjected to excessive suction, and the pump, which could otherwise run dry if operated in reverse for a protracted period.

In many applications, including that to be described, no appreciable time-delay in the normal operation is desired. This rapid upward movement of the diaphragm is readily achieved by providing a pressure-relief valve 36 having a sufficiently high operating pressure in relation to the stiffness of the spring 24 so that a moderately high pressure is built up within the duct 33 and, hence, across the throttling valve when the pump operates in the forward direction. This induces a rapid flow of fluid through the throttling valve. Excessively high pressures within the duct 33 are, however, often undesirable, since this causes a waste of power because the pump, when operated continuously, must pump fluid against the pressure determined by the relief valve. For this reason it may be desirable to use a light spring 24. Using a pressure-relief valve with a lower operating pressure and/or a stiffer spring 24 of course has the opposite effect and increases the time-delay during the normal operation.

The actuating unit may be arranged to close the contacts during normal operation. Such an arrangement is shown in Figure 2, wherein like reference numbers denote like parts, and wherein the resilient strip 13 is mounted below the shorter strip 12 and the contacts 10 and 11 are normally separated. Upward movement of the plunger 19 during normal operation causes the washer 28 to engage the strip 13 to close the contacts, while downward movement during reverse operation permits the strip 13 to move down to open the contacts.

The switch shown in Figure 1 may be applied, for example, to a vehicular brake-holding system having the electrical circuit shown in Figure 3. This circuit may be

traced from a ground connection 42 through a storage battery 43, the ignition switch 44, the contacts 10 and 11 which are actuated by the actuating unit of the invention, represented generally at 45 and coupled to a drive shaft 30, a normally closed, manually operable switch 46 which may be mounted on the dash board to disable the brake holder when desired, a normally closed interrupter switch 47 which is mechanically connected to the accelerator pedal 48 so as to be opened whenever the pedal is depressed, the coil 49 of a solenoid valve 50, and a ground connection 51. It will be understood that the valve 50 is connected between the master cylinder and the brake cylinders and is closed whenever the coil 49 is energized, the valve being constructed as or by-passed by a check valve which permits flow of brake fluid at all times from the master cylinder to the brake cylinders. In operation, the ignition switch 44 being closed, the contacts 10 and 11 are separated by the unit 45 when the vehicle moves forward to rotate the shaft 30. When the vehicle is retarded, release of the pedal 48 closes the switch 47 but the contacts 10 and 11 remain open until the expiration of a time-delay period after the shaft 30 has stopped turning or during which it has turned so slowly that the pump permits seepage of fluid. During this time-delay period the brakes can be released by simply releasing the brake pedal. However, if the brake is released after the contacts 10 and 11 close, the pedal 48 remaining released, so that the coil 49 is energized, the valve 50 traps brake fluid in the brake cylinders despite release of the brake pedal. To release the brakes it is necessary merely to depress the accelerator pedal, thereby opening the circuit by the switch 47 and opening the valve 50.

Various other arrangements of flow restrictive devices may be used. Thus, a fixed restriction, such as an orifice plate may be substituted for the adjustable throttling valve, or the gear pump itself, since it provides restricted clearances, can function to control the rate of fluid efflux from the displacement chamber, making the use of the additional restriction in the duct 33 unnecessary under certain requirements. Also, the flow restriction need not be placed in the duct 33 but may be in a separate return duct, in the manner described in connection with Figure 4.

Figure 4 shows a variant wherein the actuating unit performs its normal operation whenever the pump operates at a sufficient speed, regardless of the direction of operation. In this view reference numbers corresponding to those used in Figure 1 denote like parts, the pump 29 being reversible. The lower pump port, which is the inlet port during forward operation, is connected in fluid-receiving relation to the supply pipe 31 through a non-return valve 52. The upper, discharge port is connected to the displacement chamber in the closure 16 through ducts 53 and 54, which are further connected through the pressure-relief valve 36 and pipes 37 and 38 to the reservoir 32. These ducts are further connected through a flow restricting device 55, which may be an adjustable throttling valve, and pipes 56 and 57 to the reservoir for the return of fluid to the latter at a restricted rate which determines the time-delay in the reverse operation of the actuating unit.

A non-return valve 58 is interposed in the duct 53 to prevent fuid flow toward the pump. A similar non-return valve 59 is interposed in a duct 60 which interconnects the lower pump port with the junction of the ducts 53 and 54. The valve 59 and duct 60 conduct fluid to the displacement chamber during reverse operation of the pump, during which the upper pump port receives fluid from the supply pipe 31 via a non-return valve 61.

Operation is as follows: The pump 29 delivers fluid to the duct 54 whenever operated, the fluid flow being through valves 52 and 58 during forward operation and through valves 61 and 59 during reverse operation. This forces fluid into the displacement chamber to cause normal operation of the actuating unit; excess fluid is returned through the pressure-relief valve 36 to the reservoir 32, in addition to fluid returned continuously through the flow restricting device 55. When the pump is stopped or operated at reduced speed at which it delivers fluid at a rate less than that flowing through the restricting device 55, the diaphragm expels fluid at a restricted rate through this device, resulting in reverse operation of the actuating unit with a time-delay.

We claim as our invention:

1. An electrical, speed-responsive, time-delay switch comprising: a pair of separable electrical switch contacts; means including a fluid displacement chamber and a movable wall exposed to fluid in said chamber for actuating said contacts; a pump; means for supplying fluid to said pump; flow means including a hydraulic coupling between said pump and said displacement chamber for delivering fluid to said chamber upon operation of the pump and for discharging fluid from the chamber; and means for restricting the rate of fluid flow through said flow means in at least one direction between said chamber and the outside of said chamber, thereby effecting a delay in the operation of said actuating unit following a change in the operation of the pump.

2. An electrical switch according to claim 1 wherein said hydraulic coupling is a duct connected to deliver fluid from the pump to said displacement chamber.

3. An electrical switch according to claim 2 wherein said pump is reversible, in combination with means for admitting fluid to said duct when the pressure therein falls below a predetermined level, thereby to prevent excessive suction when the pump is operated in a direction to withdraw fluid from the said duct.

4. In combination with the elements recited in claim 2, means for relieving fluid from said duct to prevent a build-up of excessive pressure when the pump is operated at high speed.

5. An electrical switch according to claim 2 wherein said means for restricting the rate of fluid flow is a flow restriction in the said duct between the pump and the displacement chamber.

6. An electrical switch according to claim 5 wherein said duct is open for two-directional fluid flow and said pump has clearances which permit seepage, whereby the discharge of fluid from the chamber is through said duct and pump.

7. An electrical switch according to claim 2 wherein said duct is open for two-directional fluid flow and said pump has clearances which permit seepage of fluid at a restricted rate, said pump clearances constituting at least in part the said means for restricting the rate of fluid flow, whereby the discharge of fluid from the chamber is through said duct and pump.

8. An electrical switch according to claim 2 wherein said means for restricting the rate of fluid flow is a flow restriction in an auxiliary duct which is separate from said duct interconnecting the pump and chamber and is connected to said displacement chamber for the discharge of fluid therefrom, said interconnecting duct having therein a non-return valve connected to prevent the flow of fluid toward the pump.

9. An electrical switch according to claim 1 wherein said means for restricting the rate of fluid flow is a flow restriction in a discharge duct which is separate from said hydraulic coupling and is connected to said displacement chamber for the discharge of fluid therefrom.

10. An electrical, speed-responsive, time-delay switch comprising: a fluid reservoir; a pair of separable electrical switch contacts; a fluid pressure-responsive actuating unit for said contacts including a fluid displacement chamber and a movable wall exposed to fluid in said chamber; a positive displacement pump adapted to be driven at a variable speed and having inlet and discharge ports of which the former is connected to said reservoir;

means for admitting fluid from the latter pump port to said displacement chamber and for returning fluid from said chamber to the reservoir, thereby effecting normal and reverse operations of said unit; a pressure-relief valve having the discharge thereof connected to said reservoir and the pressure-regulated intake thereof connected to said discharge port; and means including a flow-throttling passageway for restricting the rate of return of fluid from said chamber to the reservoir, thereby effecting a time-delay in the said reverse operation of said unit after a change in the pump speed which reduces the delivery of fluid to the chamber.

11. An electrical switch according to claim 10 wherein said flow-throttling passageway is adjustable to vary the flow resistance thereof, whereby the rate of fluid return and, thereby, the time-delay can be varied.

12. An electrical switch according to claim 10 wherein said pump is reversible, whereby upon reversal of the pump the first-mentioned port functions as a discharge port and the latter-mentioned port functions as an intake port, in combination with a vacuum-relief valve having the intake thereof connected to said reservoir and the discharge thereof communicating with said latter-mentioned port of the pump.

13. An electrical switch according to claim 12 wherein said first-mentioned pump port is in free, two-way communication with said reservoir.

14. An electrical switch according to claim 13 wherein said latter-mentioned pump port is in two-way communication with said displacement chamber and said pump has clearances sufficient for the return of fluid from said chamber by seepage when the pump is stopped.



15. An electrical switch according to claim 12 wherein both said pump ports are connected in fluid-receiving relation to said reservoir through non-return valves.

16. An electrical switch according to claim 15 wherein both said pump ports are further connected to said displacement chamber through non-return valves connected to prevent flow of fluid toward the pump.

17. An electrical switch according to claim 10 wherein said flow-throttling passageway is a flow restriction in a separate duct connected between said displacement chamber and the reservoir for the return of fluid to the reservoir.

18. In combination with the elements recited in claim 10, biasing means on said movable wall tending to expel fluid from the chamber, and means for varying the bias on said wall.

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