Sept. 16, 1958 E. E. REED 2,852,635

FLOW OPERATED SWITCH

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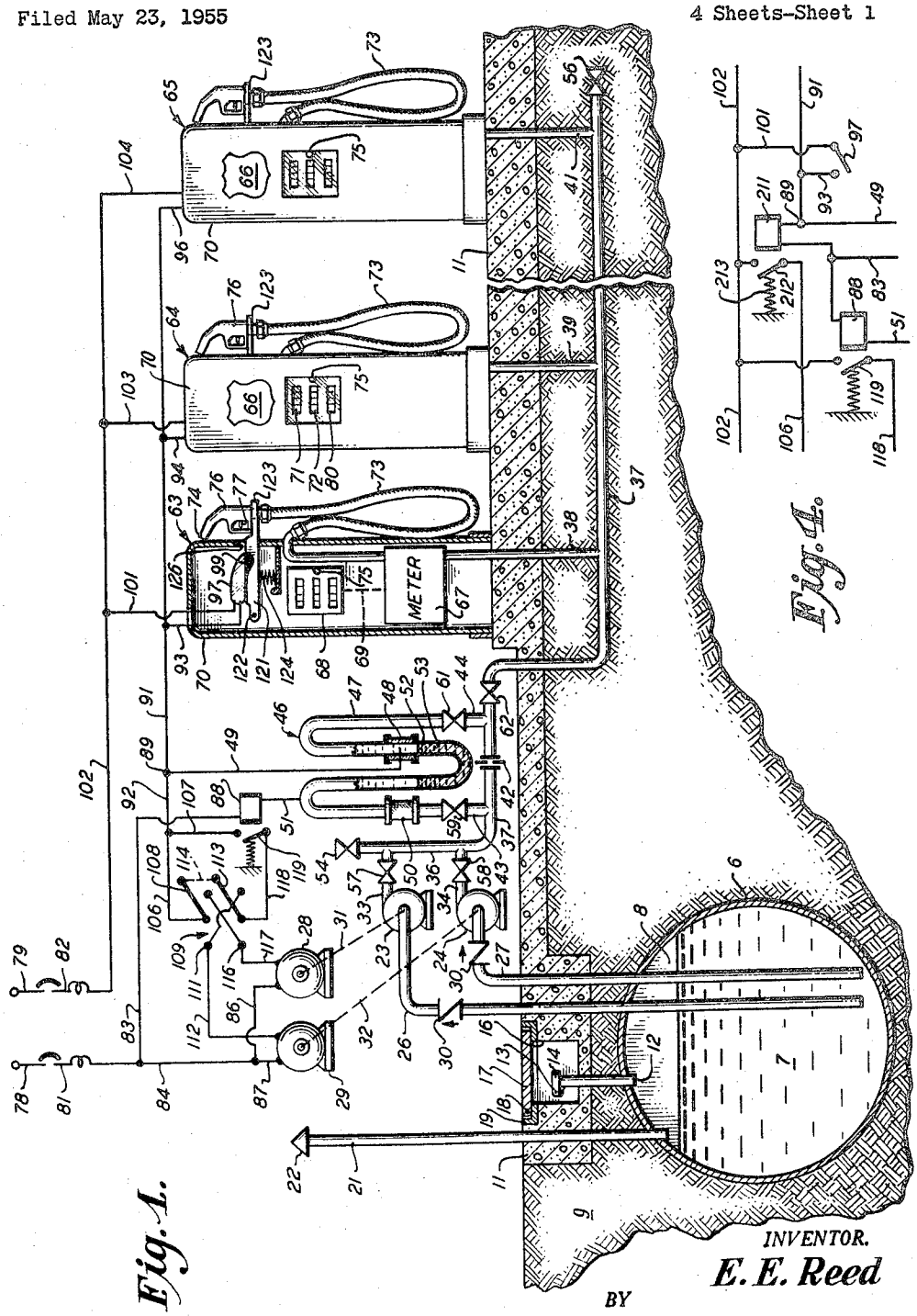

Fig. 1.

Fig. 4.

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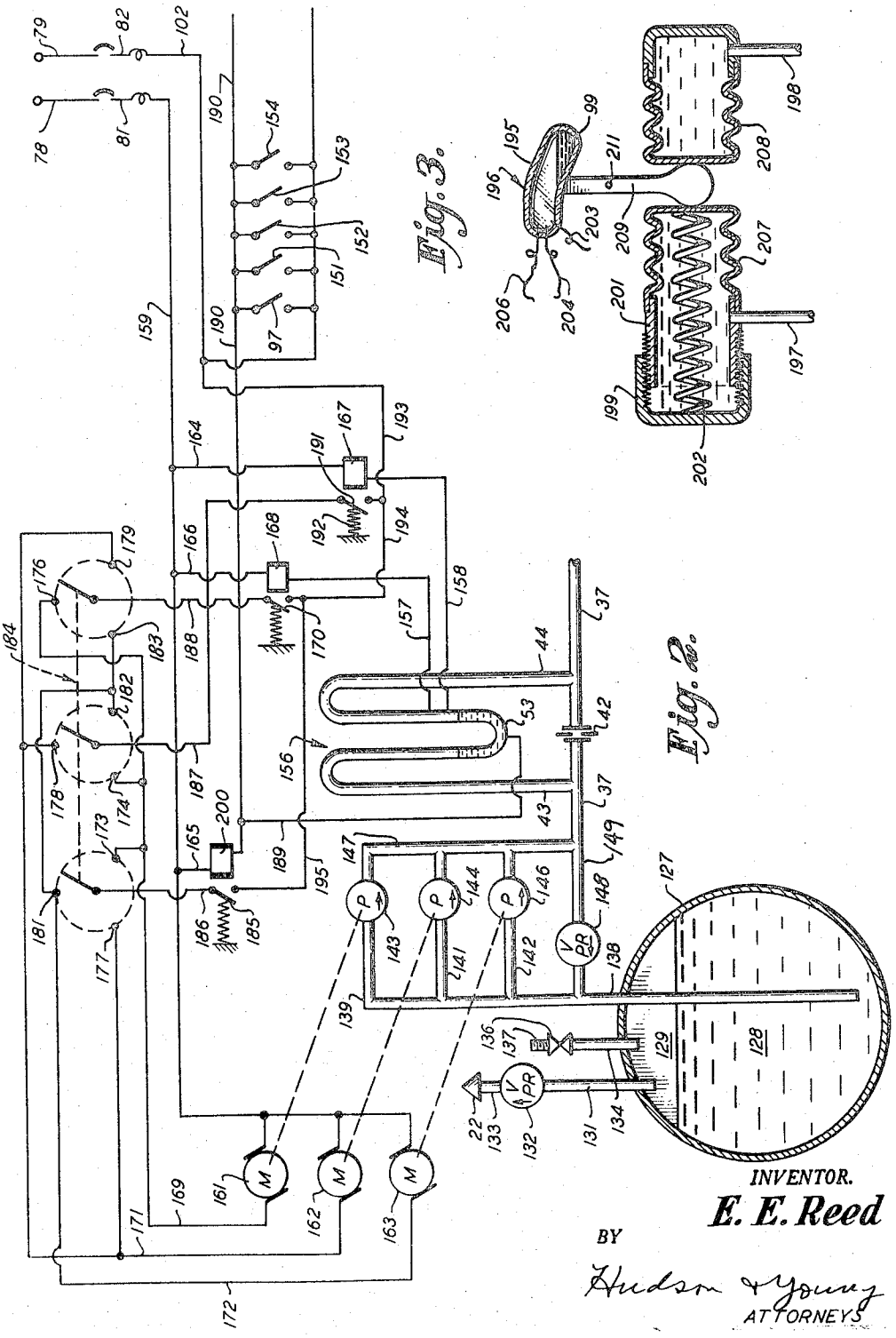

Fig. 3.

Fig. 2.

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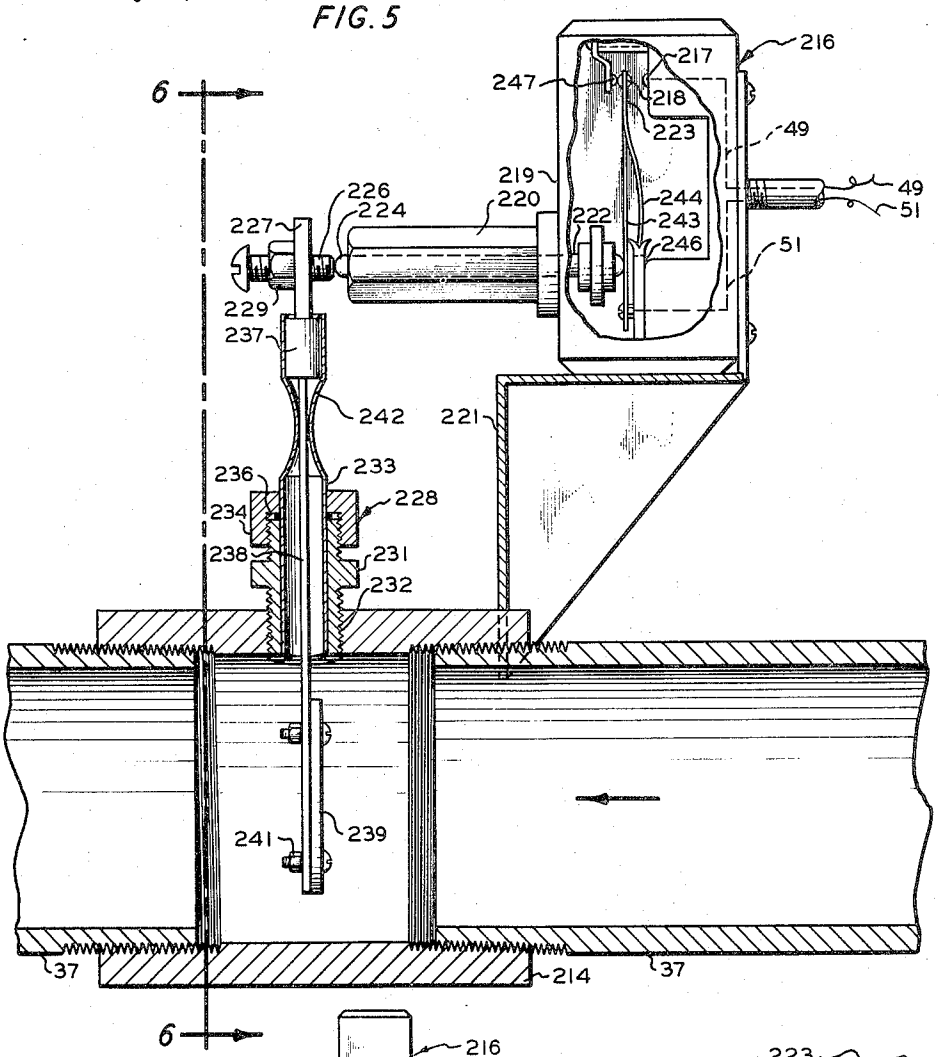
FIG. 5



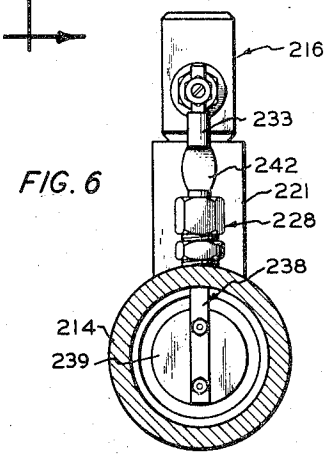


FIG. 6

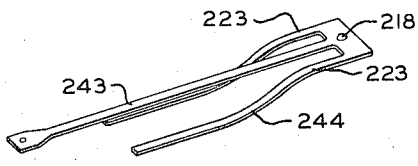


FIG. 7

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FIG. 12

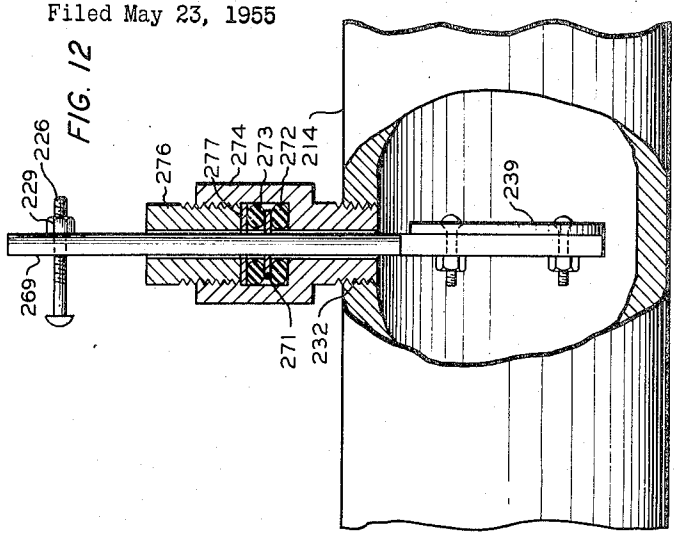


FIG. 9

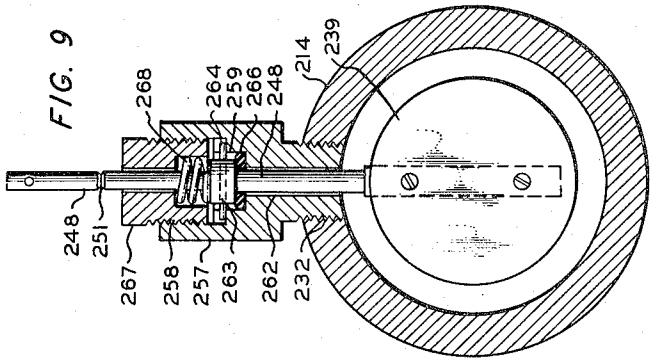


FIG. 11

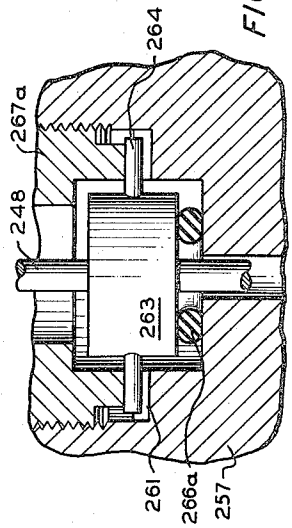


FIG. 8

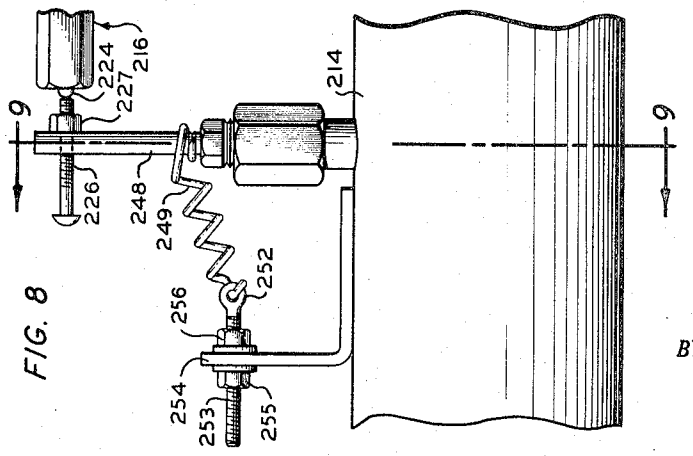
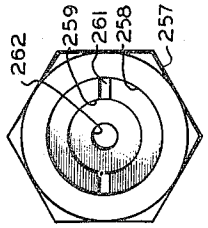


FIG. 10



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United States Patent Office 2,852,635 Patented Sept. 16, 1958

2,852,635
FLOW OPERATED SWITCH

Edwin E. Reed, Bartlesville, Okla., assignor to Phillips Petroleum Company, a corporation of Delaware

Application May 23, 1955, Serial No. 510,193
3 Claims. (Cl. 200—81.9)

This invention relates to pump control system in which the number of pumps being employed is varied with the load. In one aspect it relates to a pump control system having a plurality of pumps in which there is means to select the order in which the pumps will be called upon for service as the load on the system increases. In another aspect it relates to a fluid dispensing service station system for dispensing fluids from a storage tank to a number of dispensing stations.

This application is a continuation-in-part of my copending application Serial No. 377,170 filed August 28, 1953 for "Pump Control System and Process," the subject matter illustrated in Figures 1 to 4 being identical in both applications.

One object of this invention is to provide a pumping system with a plurality of fluid pumps with means responsive to the flow of the combined discharge of the pumps to regulate the number of pumps being employed.

Another object is to provide a process of pumping a plurality of pumps comprising selecting the order in which the pumps are to be employed and employing more pumps when increase in flow indicates this is desirable.

Another object is to provide a simple but effective control for a stand-by pump in service station operations.

A further object is to provide a completely integrated fluid dispensing service station system suitable for use in large service stations having a plurality of fluid dispensing lines connected to each storage tank, especially such large gasoline service stations as are becoming common on turnpikes, such as the turnpikes in Pennsylvania, New Jersey, New York, Oklahoma and other States.

Numerous other objects and advantages will be apparent to those skilled in the art upon reading the accompanying specifications, claims and drawings.

In the drawings:

Figure 1 is an elevational view, with parts in section and the electrical wiring system shown in conventional symbols, of a fluid dispensing system embodying the present invention suitable for use in dispensing liquid gasoline or other fluid fuels to motor vehicles.

Figure 2 is a similar view of a modified system of the same general type as Figure 1.

Figure 3 is an elevational cross-sectional view of a third modification of a differential pressure responsive means which may be substituted for either of the corresponding means in Figures 1 or 2.

Figure 4 is a modified wiring diagram for use in Figure 1.

Figure 5 is an elevational view with parts in section, or broken away, of a fourth modification of differential pressure responsive means which may be substituted for the corresponding means 42, 46, 49, 51 of Figure 1.

Figure 6 is a cross sectional view on a reduced scale of the device shown in Figure 5 taken along the line 6—6 looking in the direction indicated.

Figure 7 is a plan view of the three bladed snap-action spring 223 of the electrical switch shown in Figure 5.

Figure 8 is an elevational view with parts broken away of a fifth modification of a differential pressure responsive means which may be substituted for the corresponding means of Figure 5.

Figure 9 is a cross sectional view of the apparatus shown in Figure 8 taken along the line 9—9 looking in the direction indicated, with the helical tension spring 249 and adjustable operating screw 226 and lock nut 227 removed.

Figure 10 is a plan view of the body 257 of the device shown in Figures 8 and 9.

Figure 11 is a fragmentary sectional view of a modified form of the packing and bearing structure shown in Figure 9.

Figure 12 is a fragmentary cross sectional view of a sixth modification of a differential pressure responsive means which may be substituted for that shown in Figure 5.

In Figure 1 is shown a fluid dispensing service station system, although obviously the system is useful in other applications. However, for the purpose of illustrating this invention, a liquid fuel dispensing system suitable for dispensing such fuel to automobiles is shown in Figure 1.

In Figure 1, a storage tank 6 is shown containing liquid fuel 7 which has vapor (or air) 8 in the upper part of the tank. The storage tank 6 is buried in the earth 9 and a portion of the earth is preferably covered with a concrete slab (or slabs) 11 so that automobiles being serviced will not mire down in the mud when it rains. Tank 6 is provided with a filling line 12 having a suitable pivot 13 for connection of a pivot cover cap 14. The cap 14 is pivoted counter-clockwise about pivot 13 when the gasoline tank truck filling hose (not shown) is inserted in pipe 12 to fill tank 6 with gasoline, or other liquid. For convenience, the upper portion of the filling line 12 is located in a recess 16 in slab 11 which may be closed by a flush trap door 17 pivoted at 18 to door frame 19. While not absolutely essential, it is preferable to also have a vent line 21 to vent the vapor phase 8 to the atmosphere and this vent line 21 may be as long as desired to carry the vapors to a safe place, and the open end of vent line 21 may be covered by a suitable rain cap 22.

A plurality of pumps 23 and 24 are provided, and these may be centrifugal pumps as shown in Figure 1, or other types of pumps such as positive piston pumps or gear pumps as indicated in Figure 2. Each pump has an inlet line 26 and 27 respectively, and these inlet lines extend down near the bottom of tank 6, although it is customary to have them stop short of the bottom of tank 6 in order to provide a suitable space for the collection of water, foreign material and sediment, without the same being drawn into the inlet lines 26 and 27. Each pump has a motor 28 or 29 respectively driving the same through any suitable drive connection indicated by dotted lines 31 and 32 respectively, and while obviously other motors, gas, steam or compressed air turbines, engines, or other prime movers (not shown) could be employed, it is preferred to provide electrical motors 28 and 29 as shown. When pumps 23 and 24 are centrifugal pumps, as shown, it is necessary to have check valves 30 in lines 26 and 27 to prevent return flow to the tank through an idle pump when the other pump is pumping. With some positive pumps 143, 144 and 146, no check valve is necessary, or the check valve (not shown) is part of the pump. Pumps 23 and 24 discharge through outlet conduits 33 and 34 respectively into a common manifold 36 which in turn discharges into a discharge line 37 to which are connected dispensing lines 38, 39 and 41. Said discharge line 37 is provided with a flow restrictor 42 of any type, such as the diaphragm orifice plate shown, and this restrictor need not cause any substantial restriction of flow as long as there is enough restriction to produce a sufficiently different pressure at point 43 above that at point 44 to operate a differential pressure responsive electrical connecting means generally designated as 46.

A simple differential pressure responsive electrical connecting means is shown at 46 in Figure 1, and this means

is operative and useful in the operation of this invention. However, it is not the only type of differential pressure measuring means which can be used, as any such suitable means may be employed as shown by corresponding parts 156 in Figure 2 and 196 in Figure 3, which also are suitable for use in Figure 1. Furthermore, it is sometimes desirable to use more complicated devices which may operate between closer limits, and one such device suitable for use as said means is the magnetic flow switch with indicator (not shown) as shown in the United States patent to Jones 2,632,474 of March 24, 1953 which device is hereby made a portion of the present application by reference thereto, to avoid copying such complicated subject matter, it being obvious to those skilled in the art how to substitute the device of Jones for means 46, 156 or 196 of the present invention.

However, in many commercial installations it has been found preferable to employ a vane type differential pressure responsive means shown in Figures 5–12, and described further below.

The differential pressure responsive means 46 of Figure 1 is connected and disposed to be responsive to the difference in pressure at points 43 and 44 in discharge line 37 on opposite side of said flow restrictor 42. Means 46 consists of an M-shaped piece of pipe 47 at least a portion 48 of which is made of electrically non-conducting material for the purpose of insulating electrode 49 from the remainder of the pipe, a portion of which is electrically connected to electric wire 51. While the system will work electrically with wire 51 connected to pipe 46 in such a manner that it is also grounded through pipe 37, it is preferable not to ground any electrical equipment through fuel pipes, and therefore a section of insulating pipe 50, of corresponding structure to pipe 48, is preferably provided in order to electrically isolate 51 from ground. In the central U-shaped portion 52 of pipe 47 there is located an electrically conductive liquid 53, which may be mercury, for the purpose of completing the circuit between wires 49 and 51 through the walls of pipe 52, and mercury 53 when the mercury extends into non-conductive portion 48 far enough to contact wire 49.

A number of valves are shown merely because they are useful in emergencies, although they are not opened or closed during the normal operation of this system. During normal operation valve 54 remains closed as does valve 56 and valves 57, 58, 59, 61 and 62 remain open. The chief reason for valves 54 and 56 is that they can be used to establish communication with additional pipes (not shown) in order to connect with additional pumps (not shown) similar to pumps 23 and 24 and to additional dispensing lines (not shown) respectively similar to lines 38, 39 and 41, in case it is desired to enlarge the system, and of course valves 54 and 56 are useful if it is desired to clean out manifold 36 and pipe 37. Ordinary pipe caps (not shown) could be used in place of valves 54 and 56. Valves 57 and 58 have similar utility as in case of the complete breakdown of its respective pump one of these valves may be closed until the pump is repaired without causing a complete shut-down of the system. The chief utility of valves 59 and 61 is to permit the removal or repair of means 46 without completely shutting down the system. Valve 62 has no utility during the operation of the system, as obviously closing valve 62 would result in a complete shut-down of the system, so it remains open at all times, and is only useful to separate the system into parts when shut-down, for example so line 37 can be cleaned out without involving parts to the left of valve 62.

Each dispensing line 38, 39 and 41 leads to a separate dispensing station generally designated as 63, 64 and 65 separated from the other dispensing stations preferably by a distance greater than the length of the average automobile if one lane of automobiles is being serviced, or greater than one-half the length of one automobile if vehicles are being serviced in lanes on each side of the dispensing station, and obviously the dispensing stations can be arranged in several rows, or other groups to provide the most efficient arrangement. While only three statios, 63, 64 and 65 are shown, it is obvious that many more could be attached to discharge line 37, and the discharge line could branch after leaving point 44 in order to accommodate several rows of such dispensing stations. With more stations each station (not shown) would have a switch across wires 102 and 91 in parallel with switches 97 in stations 63, 64 and 65.

It will be noted that the dispensing stations selected for illustration in Figure 1 are objects which the public generally calls "gas pumps" but they are called dispensing stations herein because the actual pumps 23 and 24 are not located at the dispensing station. Each dispensing station, such as 63, may comprise a decorative housing 70 on the exterior of which may be placed advertising material 66 (such as the trademark of the fluid being dispensed).

The dispensing line 38 has a meter 67 disposed therein which is conventionally housed in housing 70 of the respective dispensing station 63 adapted to measure the amount of fluid passing through the same. The amount can be measured by volume, or by weight, by any suitable meter from the prior art which will meet the requirements of the law in the particular jurisdiction involved. Meter 67 drives indicator 68 as indicated by dotted line 69 and indicator 68 indicates the amount of fluid passing through the respective dispensing line 38. This indication is preferable both in terms of amount on odometer-type numbered disks 71 and as to price on similar disks 72, and while not necessary to the operation of the invention, it is commercially preferable to have means 75 to set disks 71 and 72 back to zero for each new customer along with another set of odometer disks 80 which cannot be reset and read the total amount from the time the system was installed. Odometer disks 80 may be concealed, or revealed to the customer as shown.

A portion 73 of the downstream end of each dispensing line is preferably made flexible, such as a flexible hose made of any suitable material. At a point adjacent the open downstream end 74 of each dispensing line is a dispensing shutoff valve 76 which may be opened and closed by a suitable trigger mechanism 77. A source of power for each motor is provided by means of power wires 78 and 79 which may supply direct current of opposite polarity, or alternating current of different phase, depending on which is readily available. It is customary and preferable to install circuit breakers 81 and 82, or other suitable limiting means, such as fuses, (not shown), in the present system, although this is not necessary to the invention if it is desired to take the risk of burning things up if something abnormal occurs.

Tracing the wiring circuit starting with line 78 and circuit breaker 81, the line splits into two lines 83 and 84, line 84 then splitting into two lines 86 and 87 attached to one pole of motors 28 and 29 respectively. The other line 83 runs through the solenoid of a relay 88 to wire 51, pipe 52, mercury 53, and if mercury 53 and wire 49 are in contact, through wire 49 to junction 89 where it splits into wires 91 and 92.

Wire 91 has a series of connections 93, 94 and 96 which each lead to one electrode of a tilting mercury switch 97 comprising an electrically nonconducting curved chamber containing some mercury 99. When this chamber is glass, or clear plastic, there is the added advantage that one may check the position of the mercury by looking through it. When mercury 99 contacts both wires 93 and 101 in one of switches 97, the circuit is completed to let electrical power which reached wire 92 in the preceding paragraph pass from 92 through 93, 94 or 96 and its respective switch 97 to the respective return wires 101, 103, or 104 and then to wire 102 through circuit breaker 82 back to the opposite side 79 of the power source 78 and 79.

Thus switch 97 in unit 63 and the corresponding switches in dispensing units 64 and 65 provide a plurality of first connecting means each located adjacent one of said dispensing switches, any one of which said first connecting means connects the power source to a first one of said motors 28 or 29 as will be described later.

Wire 92 splits into two branches 106 and 107. Branch 106 goes to the pivot of one blade 108 of a double blade double throw reversing switch generally designated as 109. When blade 108 is thrown to the left into contact with contact 111, it then connects to one pole of motor 29 by wire 112, and blade 113, which is forced to move with the blade 108 by rigid insulated connection 114) contacts at 116 to connect one pole of motor 28 through wires 117 and 118 with wire 107, provided relay 88 closes switch 119 to connect to wire 107. Obviously, when the reversing switch 108 is moved to the right to engage the other set of contacts pole 112 of motor 29 is then connected to wire 118, and pole 117 of motor 28 is then connected to wire 106.

Each of said first connecting means comprises said tiltable mercury switch 97 mounted on a movable member 121 pivoted to housing 70 at 122 having an open bifurcated end 123 to receive the shut-off valve housing 76 on the end of hose 73. Movable member 121 is biased upwardly against gravity by compression spring 124 when valve housing 76 is removed until the top of member 121 contacts the top of slot 126, tilting switch 97 so that mercury 99 contacts both 93 and 101, but when the weight of the hose 73 is added to end 123 of member 121 by placing valve 76 thereon, member 121 moves down into the position shown in Figure 1 contacting the bottom of slot 126 and tilting switch 97 so that mercury 99 fails to contact both 93 and 101, which breaks the circuit between them.

Figure 2 shows a modified system, similar in many ways to Figure 1, which system illustrates chiefly how the system of Figure 1 can be expanded to add more pumps, and how the fluid being dispensed can be a fluid having a high vapor pressure, or a liquefied gas, or just a vapor or gas without any liquid phase. Figure 2 also shows how positive displacement pumps can be employed in such a system.

In Figure 2 the storage tank 127 contains a liquid 128 having a high vapor pressure producing high pressure in space 129. For example, liquid 128 can be butane, or propane, or mixtures of the same and/or any light hydrocarbon, which materials have proved to be very valuable fuels for use in automobiles (not shown) when they are equipped to burn the same, or liquid 128 and gas 129 may be replaced by a continuous gaseous phase, because the present invention applies just as well to the handling of gases as liquids. Because of the high vapor pressure of gas 129, it is necessary to provide pressure vent line 131 with a pressure relief valve 132 set so it only relieves pressure through outlet 133 when the pressure in space 129 is approaching a dangerous value. Filling line 134 is the same as corresponding part 12 of Figure 1 in function, but valve 136 and threaded connection 137 prevent loss of vapor during and after filling.

A single dip tube 138 is provided for withdrawing liquid (or gas if there is no liquid phase, or tube 138 is constructed to terminate in the vapor space 129) from tank 127 and splitting the same to inlets 139, 141 and 142 of pumps 143, 144 and 146 respectively. The output of these pumps is combined in manifold 147 and if the pressure therein is above a predetermined maximum pressure set by relief valve 148, the pressure is reduced by passing some of the fluid through bypass line 149 and relief valve 148 back to line 138. The fluid from manifold 147 normally passes through discharge line 37, and flow restrictor 42, which are given these numbers because they are the same as in Figure 1, and said discharge line runs to a series of dispensing lines (not shown) similar to lines 38, 39 and 41 leading to dispensing stations similar to 63, 64 and 65 of Figure 1, each one of which is provided with means for operating switches 97, 151, 152, 153 and 154 respectively which are like switches 97 in Figure 1. Differential pressure responsive electrical switching means 156 is similar to means 46 of Figure 1 except that there are two electrode wires 157 and 158 in place of the one wire 49, the second wire 157 obviously completing its circuit responsive to a higher predetermined minimum pressure than wire 158, wire 157 connecting a third motor to a power source. For each additional motor positive pumps 143, 144 and 146, such as gear pumps, may need no check valves, however, if they do, check valves like 30 of Figure 1 can be inserted in their individual inlet or outlet lines.

In Figure 2 starting with power source 78, the same as in Figure 1, the current passes through circuit breaker 81 into wire 159 which runs to one pole of each of motors 161, 162 and 163. Wire 159 has three branching wires 164, 165 and 166 connected thereon running through relay solenoids 167, 200 and 168 respectively to wires 158, 190, and 157 respectively.

The opposite poles of motors 161, 162 and 163 are connected to wires 169, 171 and 172 respectively. There are provided three three-contact single blade switches ganged together by an operating member and generally designated as 184. The wire 169 runs to the four o'clock contact 173 of one switch, the eight o'clock contact 174 of the second and the twelve o'clock contact 176 of the third, while wire 171 runs to the eight o'clock contact 177, the twelve o'clock contact 178, and the four o'clock contact 179, and wire 172 runs to the twelve o'clock contact 181, the four o'clock contact 182, and the eight o'clock contact 183. Any three of these contacts which are at the same position on each of the three dials will be picked up by the blades of said gang switch 184 and thus connected to wires 186, 187 and 188 respectively. For each additional motor, one more dial and one more contact on each dial should be added (not shown). When any one of switches 97, 151, 152, 153, or 154 is closed by the attendant picking up the respective one of nozzles 76 off of hook 123 current passes from 78 through 81, 159, 165, 200, 190, the respective switch 97, 151, 152, 153 or 154, parts 102, and 82 to 79, and coil 170 closes relay switch 185 starting the motor connected to wire 186 by completing the circuit 186, 185, 195, 194, 193, 102, and 82 to 79.

The motor whose pole is connected to wire 187 remains inoperative until the pressure difference in 156 is sufficient to drive mercury 53 into contact with wire 158, whereupon current travels from source 78 through 81, 159, 164, relay coil 167, wire 158, mercury 53, wire 189, wire 190, the closed one of switches 97 and 151 to 154, wire 102, and part 82 to source 79. This energizes solenoid 167 pulling switch 191 shut against the force of spring 192 completing the circuit between wires 193 and 187. The motor whose pole is connected to 187 is then energized by current starting from 78 and passing through 81, 159, the respective motor connected to line 187, switch 191, line 193, line 102, and circuit breaker 82 to source 79.

In a similar manner when the differential pressure in 156 becomes great enough so that the mercury climbs to a point where it contacts 157, a relay 168 is actuated in a similar manner to permit the motor which is connected to wire 188 to operate with its circuit being completed through relay switch 170, wires 194, 193, 102, and breaker 82 to source 79.

Figure 3 shows a differential pressure actuated electrical switch generally designated as 196 which can be substituted for the ones shown in Figures 1 and 2 by connecting pipes 197 and 198 to pipe 37 of Figures 1 or 2 at points 43 and 44 respectively. One advantage of the modification shown in Figure 3 is that it is readily adjustable, as by screwing cap 199 in or out on body 201 it is easy to vary the compression of compression spring 202. This will make the glass switch 195 containing

mercury 99 close the circuit first between wires 203 and 204, and then between wires 203 and 206, at different predetermined pressures, as the pressure in bellows 207 and 208 varies, and lever 209 rotates around the pivot at 211, tilting the glass switch 195.

In Figure 1, pumps 23 and 24 were centrifugal pumps, which reach a certain pressure and then allow liquid to slip, so that they never exceed a certain pressure. In Figure 2, however, the pumps may also be positive displacement pumps, such as piston pumps, or gear pumps, and therefore it is essential that there be a relief valve bypass 148 to discharge any excess pump capacity.

In operation, when one or more of the dispensing nozzles 76 is placed in operation, one pump will start and will continue to supply the dispensing nozzles until the combined flow through all the open nozzles exceeds a predetermined rate which will be near, but below the discharge capacity of said first pump. This increased flow through orifice 42 will cause an increased pressure drop across this orifice above a predetermined minimum which will close differential pressure switch 46 of Figure 1, 156 of Figure 2, or 196 of Figure 3 as to wires 49, 158 and 204 respectively, which will operate relay 88 of Figure 1, or 167 of Figure 2, as the case may be, starting a second pump. This second pump will continue to operate until the combined dispensing flow rate falls below the predetermined rate allowing the differential pressure switch to open. In Figure 2 where there is a third motor and a third contact 157 an even greater pressure differential will start the third motor and drive a third pump, and the devices of Figure 3 can be substituted for 156 of Figure 2 by connecting wires 203, 204 and 206 in place of wires 189, 158 and 157 respectively and connecting pipe 197 in place of 43 and 198 in place of 44 respectively to pipe 37 upstream and downstream of orifice 42 respectively.

It will be noted in Figure 1 that the current for both motors 28 and 29 returns through wire 91, switch 97 and wire 101 to wire 102. This is quite all right when small motors are involved, and actual service station installations like this have been made and are successful. With larger motors, however, it is not desirable to have all the motor current going out to the dispening points 70 and going through switch 97. Figure 2 shows that this can be avoided by the use of relay switches 170, 185 and 191 on separate return lines of the motors which bypass switches 97, 151, 152, 153 and 154 through wires 195, 194, 193 and 102, the current in line 190 being much smaller than the motor current in line 193 because of the high resistance of coils 167, 168 and 200 designed for this purpose.

Figure 4 shows how the wiring of parts 49, 51, 83, 88, 89, 91, 93, 97, 101, 102, 106, 118 and 119 of Figure 1 can be rearranged to keep the motor current out of switch 97 in the same manner as in Figure 3. A relay consisting of a coil 211 and a switch 212 biased open by spring 213 is added and the connections made as shown. Motor current goes through switches 119 and 212 only, while the ohmic resistance in coils 88 and 211 limit the current across switch 97.

In Figure 5 discharge line 37 is provided with a differential pressure indicating section 214 in place of the orifice plate 42 of Figure 1. When used in the system shown in Figure 1, valves 59 and 61 can be closed, or pipes 43 and 44 eliminated completely. Wires 49 and 51 of Figure 1 now lead in Figure 5 to a snap-action electrical switch generally designated as 216, and are connected when stationary contact 217 and the movable contact 218 are touching, and disconnected when contact 218 moves away from contact 217 as shown.

The housing 219 of switch 216 may be secured to pipe section 214 by any suitable bracket 221, and slideably mounted in a guide 220 on the housing is a switch actuating pin 222 having one end engaging snap-action spring 223 and the other end 224 being engaged and operated by adjustable screw 226 which is threaded in a hole in lever arm 227 of the vane type flow meter generally designated as 228, being secured thereto by lock nut 229. Guide 220 is preferably long enough and fits pin 222 close enough to make switch 216 explosion proof, and may contain suitable packing (not shown) to make it even more closely fitting and thereby more explosion proof.

The snap-action spring 223 carrying the movable contact 218 is shown further in Figure 7 where it will be seen to be a 3-bladed spring. The spring blade 223 is preferably made of suitable spring material, such as beryllium-copper alloy, and the contact 218 is made of any suitable switch contact point material, such as very pure silver, platinum, or the like.

Vane type flow meter 228 of Figures 5 and 6 comprises a nipple 231 threaded into hole 232 in pipe section 214, with a flexure tube 233 closely fitting the bore of said nipple. While flexure tube 233 could be soldered to nipple 231, it is preferred to merely have a close fit so that disassembly is possible by unscrewing stuffing box 234 containing packing 236 which acts to seal tube 233 fluid tight and at the same time provide sufficient friction to prevent fluid pressure in line 37 from forcing tube 233 out of nipple 231.

Operating lever arm 227 is provided with an enlarged intermediate cylindrical portion 237 which fits the interior of the upper portion of tube 233 and may be secured thereto by soldering. Lever 227 also has a lower reduced diameter portion 238, which may be non-circular in cross section and to which is secured a target, or flow restricting disk, 239 by any suitable means such as nuts and bolts 241.

While the flexure tube 233 can be used when cylindrical throughout its entire length, this is not preferred as too great a bending force is needed. To reduce the bending force required the upper portion of tube 233 below and adjacent cylinder 237 is mashed, or bent in at 242, preferably into actual contact with lever 238, although it will operate without being in contact with the lever. This bent in portion 242 makes flexure tube 233 much more flexible, and it will bend with less force on target 239. The axis of bending is also more closely controlled and is substantially in the center of bent portion 242 and normal to the plane of the drawing of Figure 5.

The operation of Figure 5 is believed obvious. The gasoline flows through pipe 37 in the direction indicated by the arrow, passing around target 239, which creates a differential pressure on opposite sides thereof, which differential pressure is a function of the velocity of the gasoline flowing thereby. This differential pressure acting over the area of target 239 creates a force which is a function of the velocity, being roughly proportional to the square of the velocity of the fluid within the conduit 37. This force bends tube 233 at 242 moving the top of lever arm 227 to the right by an amount which is also a function of the velocity, and in turn lever arm 227 acting through screw 226 and pin 222 presses against the center blade 243 of spring 223 tending to move contact 218 towards contact 217, which movement is inhibited by curved blades 244 having their ends resting in support 246 until the cantilever forces on 243 overcomes the vertical component supplied by 244 and contact 218 snaps over against the contact 217 with a rapid snap-action closing the switch and electrically connecting wires 49 and 51.

When the velocity of the fluid in 37 is reduced, the differential pressure across target 239 falls, and flexure tube 233, being resilient, tends to move target 239 upstream and to straighten out, moving the upper end of the lever 227 to the left reducing the pressure on pin 222 until the reverse action occurs when the cantilever force becomes less than the compression supplied by compression springs 244, and the spring snaps back against stop 247 as shown, spring 223 contacting stop 216 open-

ing the switch and electrically disconnecting wires **49** and **51**. Thus, it will be seen that there is definite predetermined velocity at which switch **216** operates, which can be set by adjusting screw **226** and lock nut **229**.

In Figures 8 and 9 pipe section **214**, switch **216**, pin **224**, screw **226** and lock nut **227** are the same as in Figure 5, but the target **239** is mounted on a different type of lever arm **248** and there is no flexure tube. Instead, the force created by the differential pressure on target **239** is opposed by a helical tension spring **249** having one end around groove **251** in arm **248**, and the other end attached to an eye **252** in a tension adjusting screw **253** mounted in a hole in bracket **254** and positioned by suitable lock nuts **255** and **256**. Bracket **254** is secured to pipe **214** by welding, or other means.

As shown best in Figures 9 and 10, a body **257** is threaded into hole **232**. Body **257** has a large threaded bore **258**, an intermediate diameter bore **259** in the walls of which radial slots **261** are cut, and a third small diameter bore **262** of a diameter somewhat greater than the diameter of lever **248**.

As shown in Figure 9 lever **248** has an enlarged intermediate cylindrical portion **263** in which is secured a radial pin **264** having ends extending into slots **261**. In the intermediate bore **259** an "O" ring **266** is provided. Ring **266** preferably lightly contacts the lower portion of lever **248**, the bottom of cylindrical portion **263**, and the wall and bottom of bore **259**. These parts are retained by gland **267** threaded in bore **258**. While the parts can be made so that pin **264** substantially fills slot **261** and is held against substantial movement by nut **267**, this requires very accurate fitting of parts, and it is preferred to have the parts loose as shown and employ a helical compression spring **268** between nut **267** and cylindrical portion **263** causing the latter to engage ring **266** as shown.

In Figure 11 a packing pivoted bearing is shown in which spring **268** of Figure 9 has been eliminated by having a modified gland **267A** press against the top of pin **264** compressing a modified O ring **266A** so that it is compressed only by cylindrical portion **263** and body **257**.

Another modification is shown in Figure 12, in which lever arm **269** is provided with an annular flange **271**, which may be integral or welded thereto, said flange being supported and held between resilient washers **272** and **273** held in stuffing box **274** by gland **276**. **277** is an anti-friction washer and body **274** is screwed in hole **232** of pipe **214**. Target **239** is secured to the lever **269** in the same manner as previously. While the tension spring **249** of Figure 8 may be employed in Figure 12, if washers **272** and **273** are resilient enough said spring **249** is unnecessary, as the washers will return the lever arm in a manner similar to the flexure tube **233** of Figure 5.

Packing ring **236**, O rings **266** and **266A**, and washers **272** and **273** can be made of any suitable resilient material, depending on the fluid being pumped, and when that fluid is hydrocarbon such as gasoline, I prefer to employ "Neoprene" (which is a trademark name for 2-chlorobutadiene 1,3), chloroprene rubber, or other synthetic elastomer resistant to decomposition by gasoline.

While an illustrative embodiment of the invention has been shown for purposes of illustration the invention obviously is not limited thereto.

Having described my invention, I claim:

1. An excess-flow operated snap-action electrical switch responsive to a small increase over a predetermined substantial rate of flow of fluid in a conduit, comprising in combination a resilient metal tube secured rigidly in cantilever relation at one end to said conduit in fluid tight communication with said conduit, a lever arm disposed in said tube with one end extending out of contact with said tube into said conduit and thereby being affected by a force which is a direct increasing function of said rate of flow, said lever arm being provided with an enlarged cylindrical portion fitting the interior of and sealed fluid tight to the other end of said tube, the wall of said tube intermediate said cylindrical portion and said conduit being flattened transversely to the axis of said conduit, said tube thereby supporting and fulcruming said lever and biasing said lever against fulcruming in response to said force, and an electric snap-action switch comprising a switch operator secured adjacent said tube, the end of said lever exterior of said tube being positioned adjacent said operator so that upon said flow increasing over said predetermined substantial rate of flow said force will overcome the biasing of said tube and said exterior end of said lever will contact said operator and actuate said switch.

2. The combination of claim 1 in which the exterior end of said lever is provided with an adjustable length contactor for varying its position of contact with said operator, the interior end of said lever in said conduit is provided with an enlarged area target to increase said force, and the tube is secured in said rigid cantilever relation by insertion of its end in a stuffing box secured to said conduit.

3. An excess-flow operated snap-action electrical switch responsive to a small increase over a predetermined substantial rate of flow of fluid in a conduit, comprising in combination a resilient metal tube having its inner end secured rigidly in fluid tight communication with said conduit, a lever arm disposed to fulcrum relative to said conduit, a first portion of said lever arm extending into said conduit and thereby being affected by a force which is a direct increasing function of said rate of flow, said lever arm being provided with an enlarged intermediate cylindrical portion fitting the interior of and sealed fluid tight to the outer portion of said tube, the wall of said tube intermediate said cylindrical portion and said conduit being flattened transversely to the axis of the conduit, said tube thereby biasing said lever arm against said fulcruming movement with a force proportional to the displacement of said lever arm in said movement, an electrical snap-action switch comprising a flexible spring blade secured at one end stationary relative to said conduit adjacent said lever arm, a stationary electrode spaced from said end of said blade, said blade having a movable electrode secured thereon spaced from said end of said blade disposed to move with said blade from a first position out of contact with said stationary electrode into a second position in contact with the same, means operatively connecting a second portion of said lever arm with said blade at a point spaced from said end of said blade, and means biasing said spring blade to suddenly move said movable electrode from one of said positions to the other as the rate of flow varies from one side of said predetermined rate to the other.

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