

[54] **APPARATUS FOR ESTABLISHING A VARIATION OF TIME DELAY BETWEEN INPUT AND OUTPUT FLUID SIGNALS**

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[51] Int. Cl. **F16k 31/145, F16k 47/12**

[58] Field of Search..... **138/43, 46; 137/505.38 505.36; 251/205, 61, 126, 325**

[56]

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[57]

ABSTRACT

Apparatus for establishing a variation of time delay between input and output fluid signals comprising a variable-circuit-length body and a pressure-activated body, said device being so constructed that a fluid signal applied to a power supply port on said first body may be delayed in time according to a variation of pressure in the pressure-activated body, said variable-circuit-length body being provided with spiral grooves for delaying the fluid signal.

5 Claims, 9 Drawing Figures

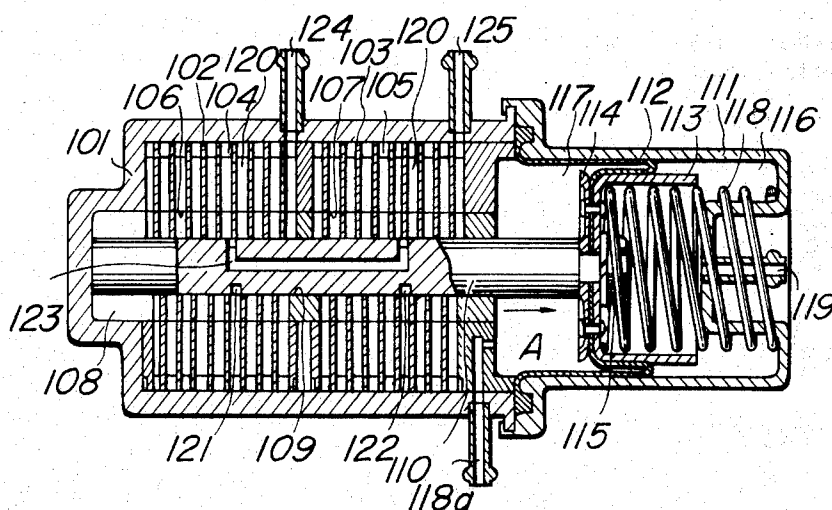


FIG. 1

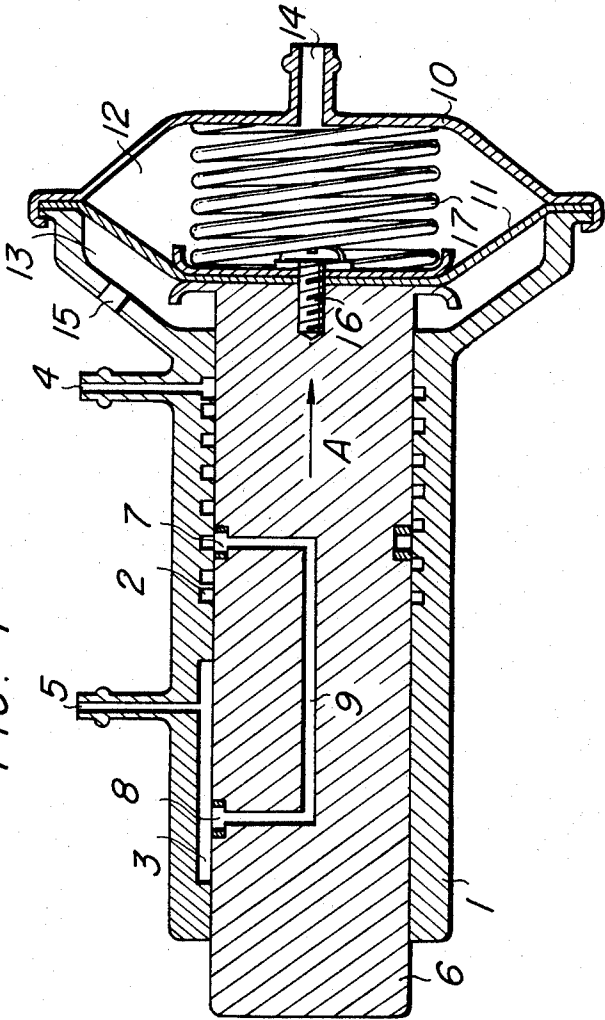


FIG. 2

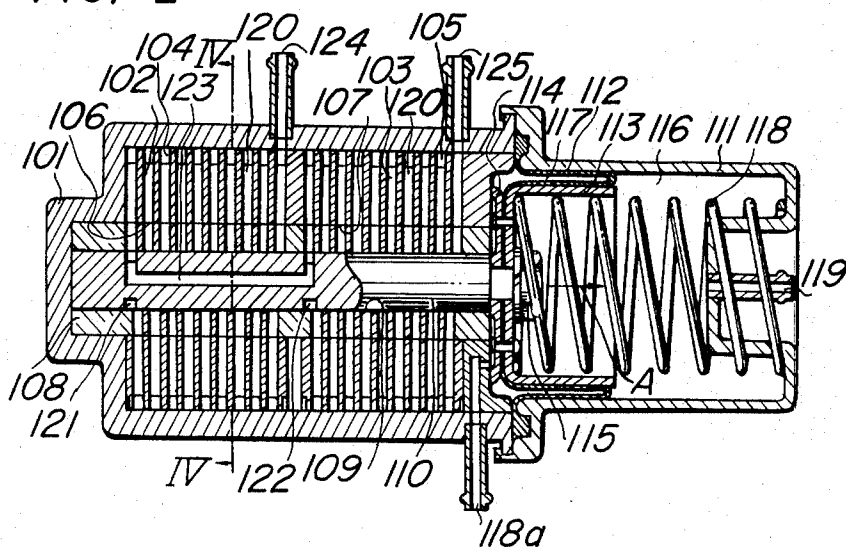


FIG. 3

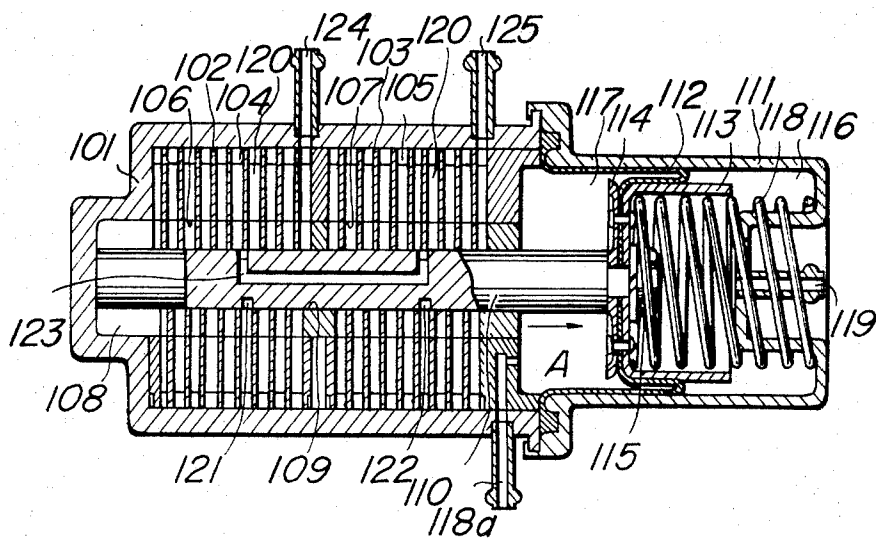


FIG. 4

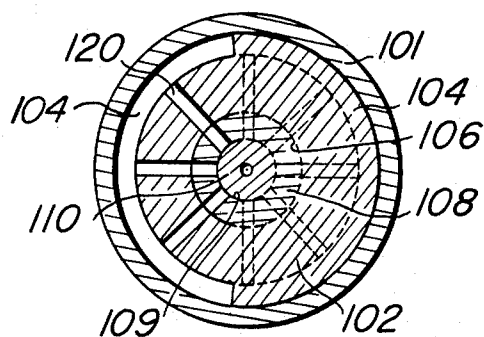
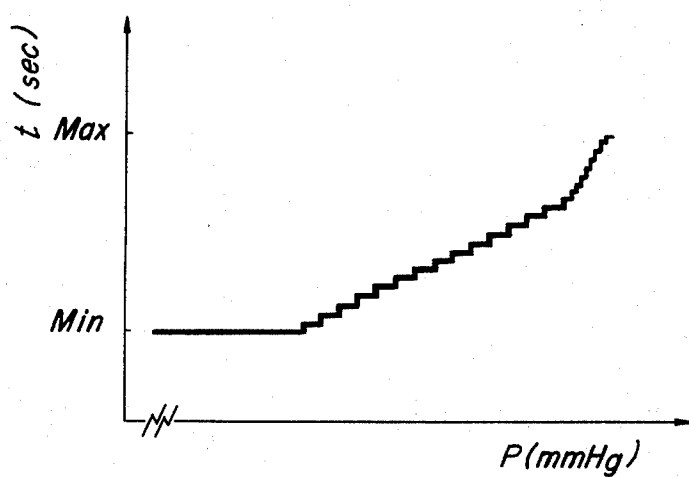
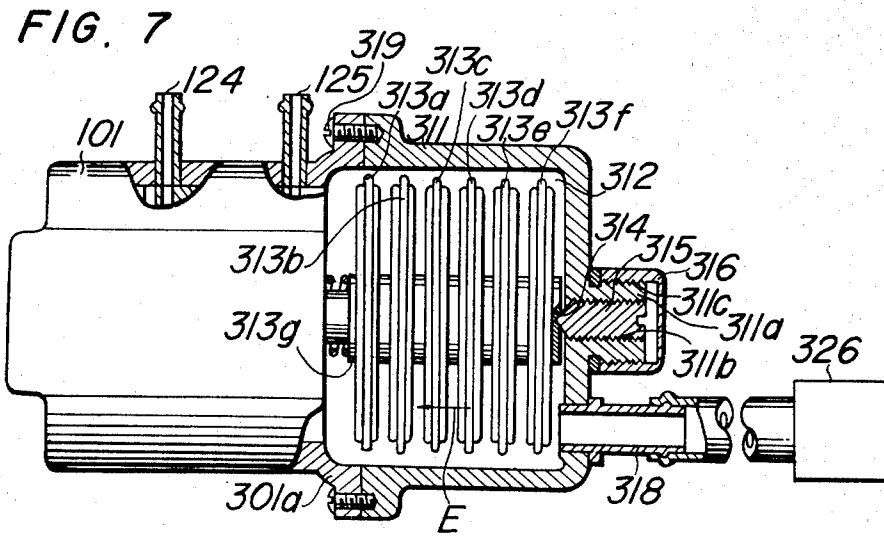
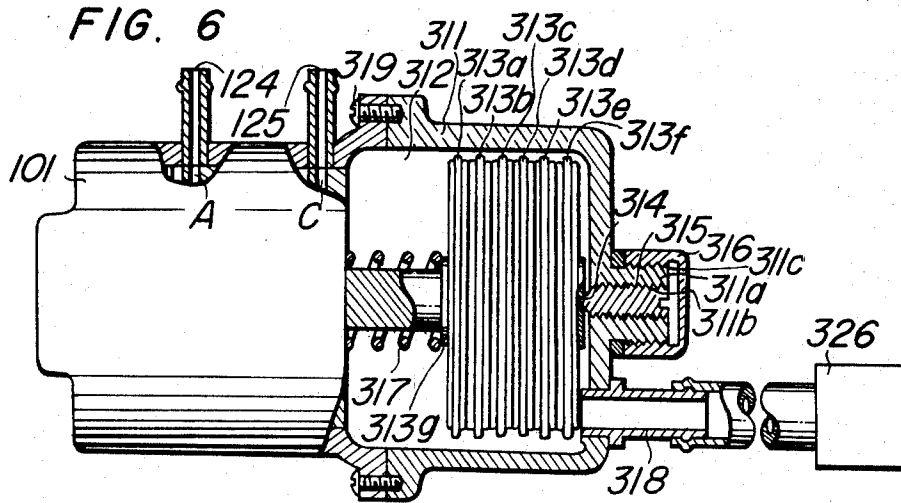
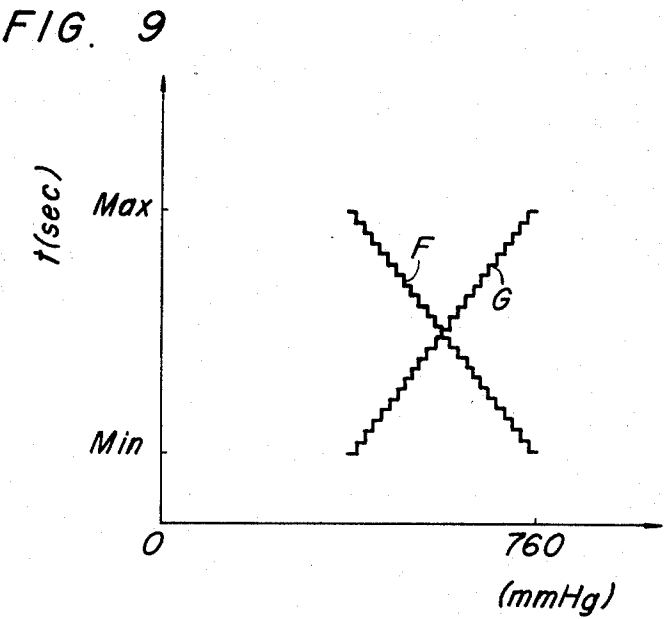
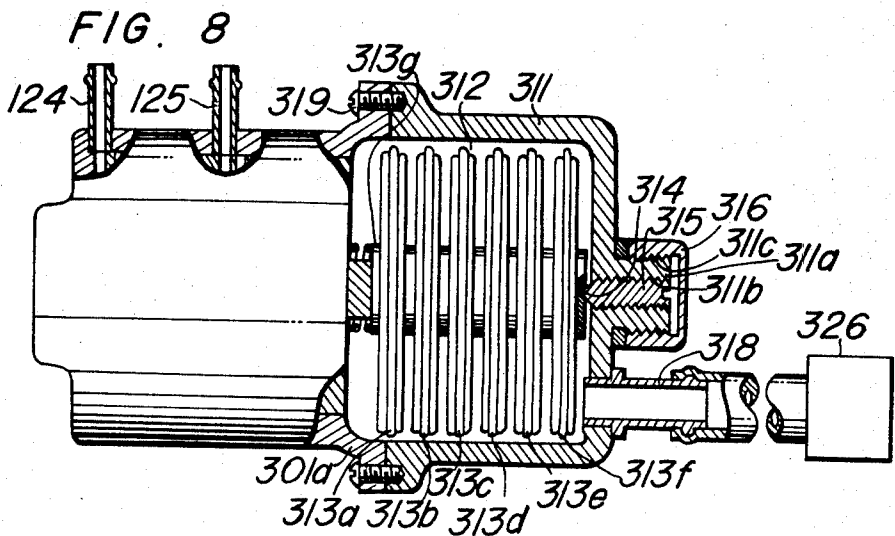


FIG. 5







APPARATUS FOR ESTABLISHING A VARIATION OF TIME DELAY BETWEEN INPUT AND OUTPUT FLUID SIGNALS

BACKGROUND OF THE INVENTION

The present invention relates to a pneumatic or hydraulic control system component and more particularly a device comprising a cylinder and a plunger fitted therein capable of varying the effective length of a pneumatic or hydraulic circuit within the device. More specifically the present invention relates to a device in which the effective length of a pneumatic or hydraulic circuit may be linearly varied so that the transmission of fluid pressure signal applied to one end of the device to the outlet port or power supply port thereof may be delayed in time.

The device in accordance with the present invention may be employed for example in a fuel feed control system of an internal combustion engine of the type directly atomizing the fuel and injecting it into the cylinders without use of a carburetor. However, it should be understood that the application of the present invention is not limited to the above control system. In general in the above fuel feed control system a fuel nozzle is aligned with a fuel recovery line or pipe in spaced-apart relation therewith in a manifold and a pressurized air nozzle is disposed at a right angle relative to the axis of the fuel nozzle and the fuel recovery line or pipe. A fluid control system or circuit includes a fluidic element such as a fluidic multivibrator having an input port, two control ports and two output ports. The multi-vibrator receives at its input port the air under pressure from an air compressor and is actuated in response to the signal representative of the engine r.p.m. Pressurized air supplied to the input port of the multi-vibrator is discharged from one of the two output ports when a signal representative of the engine r.p.m. is supplied to one of the two control ports. Then, a signal is applied to the other one of the two control ports with a time lag corresponding to the engine load (the throttle opening or the manifold vacuum), whereupon the pressurized air is discharged from the other one of the two output ports. The fuel under a constant pressure is supplied to the fuel nozzle at a constant flow rate and the air under pressure in the form of pulses from one of the two outputs ports of the multivibrator is supplied to the flow circuit so that the fuel sprayed through the fuel nozzle may be deflected and atomized by the air under pressure ejected through the air nozzle and supplied into the manifold.

The present invention provides a device by which a fluid signal to control a fluidic element such as the above-described multi-vibrator is delayed a time proportional, for example, to the manifold vacuum of an engine. In other words, the invention relates to a variable-circuit-length device which varies the length of a fluid path in accordance with a pressure differential between two fluids discharged from a fluidic element, upon detecting the pressures of said two fluids, for the purpose of delaying a fluid signal supplied to the fluidic element, a time proportional to said pressure differential, to control the operation of said fluidic element.

DESCRIPTION OF THE PRIOR ART

There have been known various types of fuel feed device for internal combustion engines. They are for example a carburetor utilizing the pressure drop in the carburetor venturi throat, a mechanical injection device which directly injects the fuel into the cylinders or intake manifold without use of the carburetor and an electronic fuel injection device having an electronic fuel injection control system.

In the suction type carburetor the fuel is generally metered through the pressure drop in the intake air passage by a fixed or variable venturi throat. In the fixed venturi throat type carburetor, separate systems or devices must be provided and selectively used depending upon the air velocities for a low, middle and high speeds so that the transition or change from one system to another will adversely affect the smooth operation of the engine. The variable venturi type carburetor may eliminate the defects of the fixed venturi type carburetor, but a throttle, variable venturi throat and a mechanism for actuating the variable venturi throat in response to the air flow rate must be machined with a higher degree of accuracy. In addition the mechanism is complex and the cost is expensive.

To overcome these problems, there has been proposed the fuel feed system of the type described above. In a variable-circuit-length device in accordance with the present invention a plunger is displaced in response to the pressure difference between the atmospheric pressure and the pressure in the intake manifold of an engine and to the opening of a throttle valve in the intake manifold so that the length of the path formed between the cylinder and the plunger may be varied to thereby displace the phase of the pulse from the multivibrator. Therefore the rate of the air under pressure injected into the intake manifold may be adjusted so that the fuel may be fed at an optimum fuel-air ratio in response to the change in speed and load of the engine.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, a spiral groove and an axial groove are formed in the inner surface of a cylinder or in the peripheral surface of a plunger slidable in the cylinder; ports for communicating with the spiral groove and the axial groove respectively are formed in the peripheral surface of the plunger or in the inner surface of the cylinder and are communicated with each other; and an inlet and outlet ports are formed at one end of the spiral groove and at one end of the axial groove respectively. Therefore when the plunger is displaced axially, the effective length of the spiral groove may be varied in proportion to the displacement of the plunger so that the fluid pressure signal applied to the inlet port or power supply port may be transmitted to the outlet port with a predetermined time delay which depends upon the effective length of the spiral groove.

According to another aspect of the present invention, a first and second spiral grooves are formed in the outer surface of a cylinder in axially spaced-apart relation with each other and a plurality of communication holes are radially drilled from the bottom land of each coil of the first and second spiral grooves so as to open

into the cylinder bore into which is fitted a plunger. The cylinder is enclosed by a casing. A first and second annular grooves are formed in axially spaced apart relation with each other in the peripheral surface of the plunger for communication with the radial communication holes of the first and second spiral grooves and are intercommunicated with each other by a communication line formed within the plunger. One ends of the first and second spiral grooves are communicated with an inlet and outlet ports respectively through the casing. Means is provided for causing the axial displacement of the plunger so that the effective lengths of the first and second spiral grooves are varied depending upon the displacement of the plunger. Therefore, the fluid pressure signal applied to the inlet port is transmitted to the outlet port with a time delay which is dependent upon the variable length of the first and second spiral grooves. Because of the axially spaced apart first and second spiral grooves and the radial communication holes opening into the cylinder bore, there is an advantage that the axial length of the device may be reduced but the maxima of the variable length may be increased.

According to another aspect of the present invention, a first and second spiral grooves are formed in the outer surface of a cylinder encased in a casing in axially spaced-apart relation with each other and a plurality of communication holes are radially drilled from the bottom land of each coil of the first and second spiral grooves to open into the cylinder bore into which is slidably fitted a plunger. A first and second axially-spaced-apart annular grooves are formed in the peripheral surface of the plunger for communication with the radial communication holes from the first and second spiral grooves of the cylinder. One ends of the first and second spiral grooves are communicated with an inlet and outlet ports respectively through the casing. To the free end of the plunger is connected one end of a bellows whose internal pressure is maintained at a predetermined absolute pressure and which is disposed in a second casing connected to a pressure source. Therefore, the plunger is displaced in response to the pressure difference between the pressure in the second casing and the absolute pressure in the bellows so that the effective length of the first and second spiral grooves may be varied in response to the pressure difference. As a consequence the fluid pressure signal applied to the inlet port is transmitted to the outlet port with a time delay depending upon the effective length of the first and second spiral grooves. In other words, by measuring this time delay the absolute pressure of the pressure source may be detected precisely. When such device is employed in sensing the absolute pressure in the intake manifold of an internal combustion engine for an automobile, the plunger is displaced in response to the absolute pressure difference between the internal pressure in the bellows and the pressure in the second casing and hence the pressure in the intake manifold without requiring any calibration whether the automobile runs along the low or high land where the atmospheric pressure is generally lower or higher than the level land. This arrangement has another advantage that the axial length of the device may be reduced while the maxima of the variable length of the first and second spiral grooves may be increased.

One of the objects of the present invention is to linearly vary the length of a hydraulic or pneumatic circuit so that the fluid pressure signal applied to one end thereof may be transmitted to the other end with a predetermined time delay.

Another object of the present invention is to linearly vary the length of a hydraulic or pneumatic circuit in response to an absolute pressure so that the fluid pressure signal applied to one end thereof may be transmitted to the other end with a time delay which is in proportion to said absolute pressure.

In order that the invention may be more clearly understood and readily carried into effect, the same will now be described more fully with reference to the accompanying drawings, in which:

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a longitudinal sectional view of a first embodiment of the present invention;

FIG. 2 is a longitudinal sectional view of a second embodiment of the present invention illustrating the plunger in position of providing the maximum circuit length;

FIG. 3 is a view similar to FIG. 2 illustrating the plunger displaced;

FIG. 4 is a cross sectional view taken along the line IV—IV of FIG. 2;

FIG. 5 is a graph illustrating the relation between the displacement of the plunger and a delay time;

FIG. 6 is a longitudinal sectional view of a third embodiment of the present invention;

FIG. 7 is a view similar to FIG. 6 illustrating the plunger in position for providing the maximum circuit length and hence the maximum delay time;

FIG. 8 is a longitudinal sectional view of a fourth embodiment of the present invention; and

FIG. 9 is a graph illustrating the relation between the displacement of the plunger and the delay time in the third and fourth embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, a cylinder 1 has a spiral groove 2 formed in the inner surface thereof and a longitudinal or axial groove 3 also formed in the inner surface thereof in the axial direction thereof. An input port 4 is in communication with the spiral groove 2 at its one end whereas an output port 5 is in communication with the longitudinal or axial groove 3. A plunger 6 is axially slidably fitted into the cylinder 1 and is provided with an annular port 7 formed in the outer peripheral surface thereof for communication with the spiral groove 2 of the cylinder 1 and also a port 8 for communication with the axial groove 3 of the cylinder 1. The annular port 7 and the port 8 are intercommunicated with each other through a line 9 formed in the plunger 6. A power cylinder 10 is fixed to one end of the cylinder 1 in coaxial relation therewith and a diaphragm 11 disposed in the power cylinder 10 divides the power cylinder into two chambers 12 and 13. The chamber 12 is in communication with a negative pressure source such as a manifold of an internal combustion engine through a negative pressure line 14 while the inner chamber 13 is in communication with the surrounding atmosphere through a port 15. It is noticed that the diaphragm 11 is

fixed to one end of the plunger 6 and is normally biased toward the left in FIG. 1 under the force of a coil spring 12 loaded in the outer chamber 12 between the power cylinder 10 and the diaphragm 11.

Next the mode of operation of the first embodiment with the construction described will be described. The fluid or air under pressure enters the input port 4 and is discharged from the output port 5 after having passed through a pneumatic circuit consisting of the spiral groove 2, the annular port 7, the line 9, the port 8 and the axial groove 3. In this case, the power transmission is delayed by a time required for the air under pressure to pass through the pneumatic circuit. In the pneumatic circuit, the length of the line 9 is constant so that it is seen that the overall length of the pneumatic circuit is dependent upon the length of the annular groove 2 from the input port 4 and the annular port 7 of the plunger 6. The pressure of the negative pressure source is transmitted through the pressure line 14 into the outer chamber 12 so that the diaphragm 11 is caused to move to the right against the spring 17 or to move to the left depending upon the pressure in the outer chamber 12. As a consequence the plunger 6 is also moved to the left or right and the displacement of the plunger 6 is in proportion to the pressure transmitted into the outer chamber 12.

For example when the pressure in the outer chamber 12 is less than the atmospheric pressure so that the plunger 6 is caused to move in the direction indicated by the arrow A, it is readily seen that the length of the annular groove 2 interposed between the input port 4 and the annular port 7 of the plunger 6 becomes shorter so that a delay time becomes shorter accordingly. On the other hand, when the pressure in the outer chamber 12 is increased, the length of the annular groove 2 between the input port 4 and the annular groove 7 is increased as the plunger 6 is moved to the left so that a delay time is accordingly increased.

In the first embodiment, the working fluid has been described as being the air under pressure, but it is understood that a gas or liquid may be also employed. In addition, the pressure difference between the atmospheric pressure in the inner chamber 13 and the pressure in the outer chamber 12 is employed for causing the axial displacement of the plunger 6, but it is understood that the outer chamber 13 may be communicated with another suitable pressure source so that a delay time may be varied in response to the pressure difference between the two pressure sources. Furthermore, the suitable mechanical and electromagnetic means may be employed for causing the axial displacement of the plunger 6. Furthermore, it is understood that the annular port 7 and the port 8 may be formed in the inner surface of the cylinder 1 while the spiral groove 2 and the axial groove 3 may be formed in the plunger 6.

Referring to FIGS. 2 and 3, within a housing or casing 101 are disposed a first and second grooved bodies 102 and 103 having the spiral grooves 104 and 105 formed in the peripheral surfaces thereof and coaxial hollow portions 106 and 107 respectively. The spiral grooves 104 and 105 are independent from each other and a cylinder 108 is fitted into the coaxially arrayed hollow portions 106 and 107. A plunger 110 is slidably fitted into a cylinder bore 109 coaxially formed in the

cylinder 108. A diaphragm cylinder assembly 111 is fixed to the housing or casing 101 coaxially and a diaphragm 112 has its periphery securely held between the joint surfaces of the cylinder 111 and the housing 101. The center of the diaphragm 112 is fixed to one end of the plunger 110 together with diaphragm supports 113 and 114 by means of a screw 115. Thus, the diaphragm 112 defines two separate chambers 116 and 117 within the diaphragm cylinder assembly 111 and is normally biased toward the left, that is, toward the inner chamber 117 under the force of a coil spring 118 loaded between the diaphragm 112 and the cylinder 111 within the outer chamber 116. The outer chamber 116 is in communication with a negative pressure source (not shown) through a pressure line 119 while the inner chamber 117 is in communication with the surrounding atmosphere through a port 119a.

FIG. 4 is a cross sectional view of the first grooved body 102 taken along its first spiral groove 104 (See FIG. 2) and it is seen that a plurality of communication holes or lines 120 are drilled from the bottom lands of the first and second grooves 104 and 105 of the first grooved body 102 through the grooved body 102 and the cylinder body 108 to the cylinder bore 109 thereof. As seen from FIGS. 2 and 3, the plunger 110 is provided with a first and second annular grooves or ports 121 and 122 formed in the outer peripheral surface thereof for communication with the communication holes or lines 120 from the first and second spiral grooves 104 and 105 respectively. These annular grooves or ports 121 and 122 are intercommunicated with each other through a communication line 123 formed in the plunger 110. An input port 124 is in communication with one end of the first spiral groove 104 through the housing 101 while an output port 125 is in communication with one end of the second groove 105 through the housing 101.

Next the mode of operation of the second embodiment with the construction described will be described hereinafter. The air under pressure enters the input port 124 and is discharged from the output port 125 after the air under pressure having passed through the pneumatic circuit consisting of the first spiral groove 104 of the first grooved body 102, the communication holes or lines 120, the first annular groove or port 121 of the plunger 110, the communication line 123 within the plunger 110, the second annular groove or port 122 of the plunger 110, the communication holes or lines 120 and the second spiral groove 105 of the second grooved body 103. It should be understood that the above pneumatic circuit is the shortest circuit between the input and output ports 124 and 125 and that the power transmission is delayed by a time required for the air under pressure to pass through the above pneumatic circuit. As in the case of the first embodiment, the summation of the lengths of the communication holes or lines 120, the first and second annular ports or grooves 121 and 122 of the plunger 110 and the communication line 123 therebetween is constant so that the overall length of the pneumatic circuit is varied depending upon a variable length which is the summation of the lengths of the first spiral groove 104 between the input port 124 and the communication bore or line 120 intercommunicating the first spiral groove 104 with the first annular groove or port 121 of the plunger 110 and

of the second spiral groove 105 between the output port 125 and the communication bore or line 120 communicating the second spiral groove 105 with the second annular groove or port 122 of the plunger 110.

When the plunger 110 is in the position shown in FIG. 2, the pneumatic circuit has the maximum length because the variable length is the summation of the overall lengths of the first and second spiral grooves 104 and 105, so that a delay time becomes the maximum.

The pressure of the negative pressure source such as an intake manifold of an internal combustion engine is transmitted to the outer chamber 116 of the diaphragm cylinder 111 through the pressure line 119 so that the diaphragm 112 is caused to move in the direction indicated by the arrow A' in FIG. 3 against the spring 118 due to the pressure between the chambers 116 and 117, the latter being at the atmospheric pressure. As a consequence the plunger 110 is also moved in the direction indicated by the arrow A' so that the first and second annular grooves or ports 121 and 122 of the plunger 110 communicate with other communication bores or lines 120. In other words depending upon the pressure difference between the chambers 116 and 117 and hence the displacement of the plunger 110, the lengths of the first and second spiral grooves 104 and 105 between the input port 124 and the first annular groove or port 121 and the output port 125 and the second annular groove or port 122 are varied. Hence the variable length of the pneumatic circuit is varied so that the overall length of the pneumatic circuit is varied or shortened, whereby a delay time is decreased accordingly.

The length L_2 of the pneumatic circuit (constant length + variable length) is decreased in stepwise as the displacement L_1 of the plunger 110 is increased. This means that a delay time caused by this device of the second embodiment is in proportion to the pressure in the outer chamber 116. This relation is shown in FIG. 4, in which the ladder-like curve is dependent upon the pitch and space of the spiral grooves. The gradient may be increased by suitable selection of the pitch and space.

As in the case of the first embodiment, instead of the air under pressure, a gas or liquid may be employed. The inner chamber 117 may be communicated with a suitable pressure source so that the plunger 110 may be displaced depending upon the pressure difference between two pressure sources. Other suitable mechanical and electromagnet means may be employed for causing the axial displacement of the plunger 110. In addition the first and second grooved bodies 102 and 103 and the cylinder body 108 may be fabricated as a unitary construction.

Referring to FIGS. 6 and 7 illustrating a third embodiment of the present invention, a first housing 101 (similar in construction to the housing 101 of the second embodiment) has a flange 301a through which bolts 319 are passed to secure thereto a second housing 311. In the chamber 312 of the housing 311 are disposed a plurality of metal bellows 313a-313f connected in series. The pressure within the bellows is maintained at 0 mm Hg. The bellows 313a is fixed at its end 313g to a plunger 310 and the bellows 313f has a blind hole 314 conical in cross section formed at its

end. The free end of an adjustment screw 315 screwed into an internally threaded hole 311b of a boss 311a is fitted into the blind hole 314 of the bellows 313f. A cover 316 is screwed over the externally threaded boss 311a. A coiled spring 317 wound around the plunger 310 is loaded between the free end of the cylinder body 308 and the end 313g of the bellows 313a. The chamber 312 is communicated through a pressure line 318 with a pressure source 326 which generates the pressure from 0 - 760 mm Hg and may be a vacuum pump.

When the pressure in the chamber 312 is 760 mm Hg, it overcomes the pressure (0 mm Hg) inside the bellows and the elastic forces of the bellows and spring so that the bellows are most contracted as shown in FIG. 6. As a consequence the plunger 310 is displaced to its rightmost position so that the pneumatic circuit in the device 301 has the shortest path or length (constant length + variable length) as described in the second embodiment with reference to FIGS. 2, 3 and 4. Consequently the delay time is shortest.

When the pressure in the chamber 312 is reduced the bellows expand by their own elasticity against the coiled spring 317 in the direction indicated by the arrow E as viewed from FIG. 7, so that the plunger 310 is also displaced in the direction indicated by the arrow E. The displacement of the plunger 310 is of course dependent upon the pressure difference between the pressure in the bellows and the pressure in the chamber 312. Therefore as in the case of the second embodiment, the variable length of the pneumatic circuit is increased so that the delay time is increased accordingly.

The relation between the pressure P mm Hg of the pressure source 326 and the delay time t seconds is indicated by the curve F in FIG. 9. It is seen that the delay time is decreased in stepwise as the pressure P is increased. In other words, the delay time between an input and output ports 324 and 325 is in proportion to the absolute pressure P of the pressure source 326 with a negative proportionality constant. In FIG. 9, Max and Min indicate the maximum and minimum delay time respectively.

In the third embodiment described above, the delay time is inversely proportional to the pressure P of the pressure source as indicated by the curve F in FIG. 9, but sometimes it is desired to have a delay time in proportion to the pressure P as indicated by the curve G in FIG. 9. The fourth embodiment illustrated in FIG. 8 is for attaining this delay-time and pressure relation.

In the fourth embodiment, the input port 124 is communicated with the end of the first spiral groove 104 whereas the output port 125 is communicated to the beginning end of the second spiral groove 105. The mode of operation is obvious so that no further description will be made.

The third and fourth embodiments of the present invention described above have a distinctive advantage that the absolute pressure of the pressure source such as an intake manifold of an internal combustion engine may be precisely measured as a delay time between the input and output ports 324 and 325. That is, regardless of the fact that an automobile is running on low or high land where the atmospheric pressure is lower than that on the low land, the absolute pressure in the manifold may be precisely detected with reference to the pres-

sure 0 mm Hg in the bellows 313a-313f as a delay time between the input and output ports 324 and 325.

When the diaphragm is employed instead of the bellows of the present invention in such a way that the pressure of the intake manifold is applied to one side of the diaphragm while the atmospheric pressure to the other side so as to displace the plunger connected to the diaphragm in response to the pressure difference between the atmospheric pressure and the pressure in the intake manifold, the atmospheric pressure is lowered on the low or high land so that the relative pressure difference sensed by the diaphragm and hence a delay time will not indicate precisely the absolute pressure in the intake manifold. As a consequence the device of the type employing the diaphragm requires the calibration depending upon whether the automobile is running on the low or high land. However, according to the third and fourth embodiments of the present invention the plunger 310 is displaced not by the pressure difference between the atmospheric pressure and a negative pressure but by the absolute pressure difference between the absolute pressure 0 mm Hg in the bellows and the negative pressure so that the defect encountered in the device of the type employing the diaphragm may be completely eliminated and the absolute pressure in the manifold may be precisely detected.

In the third and fourth embodiments, instead of the air under pressure any suitable gas or liquid may be employed. A number of series-connected bellows is not limited to six as shown in FIGS. 6, 7 and 8 and may be suitably selected. In addition the series-connected bellows may be intercommunicated with each other and the pressure inside the bellows is not limited to 0 mm Hg, but may be at a few mm Hg or at any value less than 760 mm Hg as needs demand. As in the case of the second embodiment, the first and second grooved bodies 302 and 303 and the cylinder body 308 may be fabricated as a unitary construction.

We claim:

1. Apparatus for establishing a variation of time delay between input and output fluid signals comprising:

- a variable-circuit length body and;
- a pressure-activated body; said variable-circuit-length body comprising
- a cylinder,
- a plunger slideably disposed therein, inlet and outlet ports disposed in said cylinder,
- a spiral groove in communication with said input port and formed between said cylinder and said plunger,

a passage in the cylinder in communication with said outlet port; said pressure-actuated body comprising:

two partitioned chambers, one of which communicates with a pressure source, said plunger secured to a displaceable partition member forming said partition chambers so as to be displaceable in response to the pressure difference between said two chambers;

said plunger being provided with a passage formed therein and having ports, one of which communicates with a part of said spiral groove and the other of which communicates with a part of said first mentioned passage in communication with said outlet port,

whereby the circuit length between said inlet and outlet ports may be varied in response to the displacement of said plunger and variation of time delay for the fluid signal between the inlet and outlet ports may be established.

2. Apparatus for establishing a variation of time delay between input and output fluid signals according to claim 1 wherein said first mentioned passage in communication with said outlet port is a groove which is formed in a part of the inner surface of said cylinder in the axial direction thereof and in hydraulically or pneumatically space-apart relation with said spiral groove.

3. Apparatus for establishing a variation of time delay between input and output fluid signals according to claim 1 further comprising a second cylinder disposed between said first cylinder and the plunger, first and second spiral grooves formed in the outer surface of said second cylinder, said inlet port being communicated with said second spiral groove, and radial bores drilled from the bottom end of each coil of said first and second spiral grooves so as to open into the cylinder bore of said cylinder into which is fitted said plunger.

4. Apparatus for establishing a variation of time delay between input and output fluid signals according to claim 3 further comprising: two spaced-apart annular grooves being formed in a peripheral surface of said plunger and interconnected with each other through the passage formed within said plunger so that the fluid pressure from said inlet port may be transmitted to said outlet port only through said passage in said plunger.

5. Apparatus for establishing a variation of time delay between input and output fluid signals according to claim 4 wherein the pitch of the coils of said spiral groove close to said outlet port is smaller than the pitch of the other coils.

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