

[54] PNEUMATIC MEMORY RELAY

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137/608; 235/201 ME; 251/61, 61.2

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[57] ABSTRACT

A memory relay has a poppet movable between two positions in a space of a relay housing. The poppet surfaces are arranged to sealingly engage a seat in each position, each seat bounding an input conduit arranged to receive a fluid under pressure. An output conduit is in communication with the space and the exterior of the housing. Means are provided for moving the poppet from one position to the other in response to the application of a set or reset signal to the relay whereby the pressure in one or the other input conduit is caused to appear at the output conduit. Bistable mechanical biasing means are provided for retaining the poppet in at least one position independently of the presence or absence of pressures in the input conduits.

30 Claims, 5 Drawing Figures

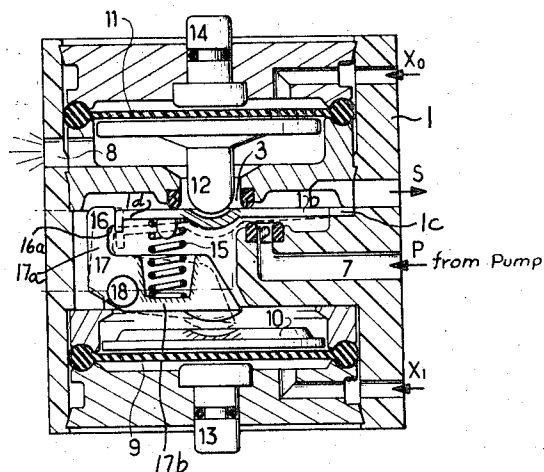
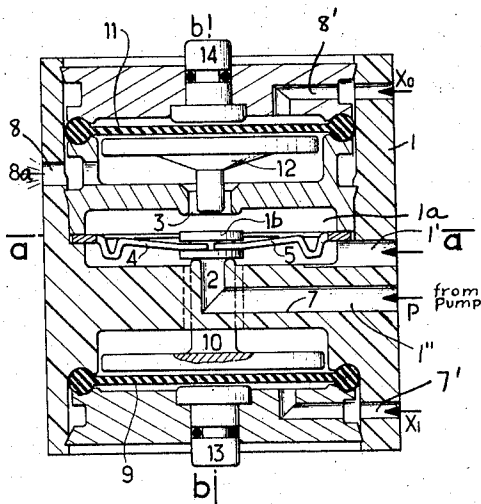


FIG.3

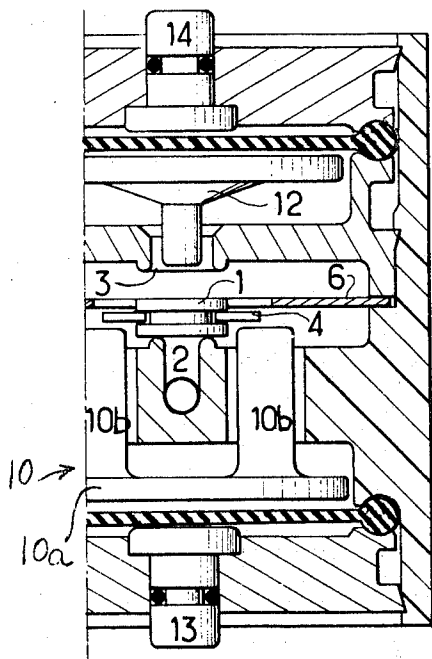


FIG.1

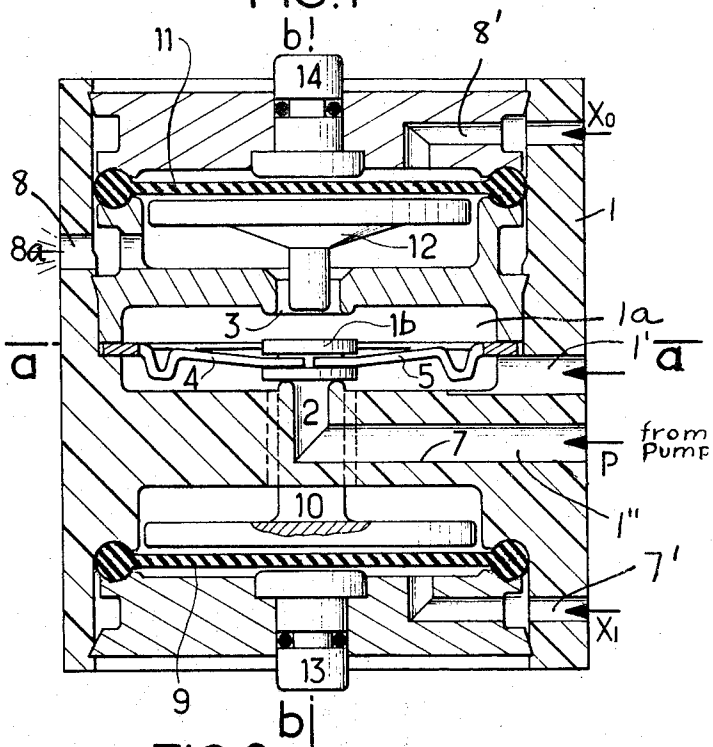


FIG.2

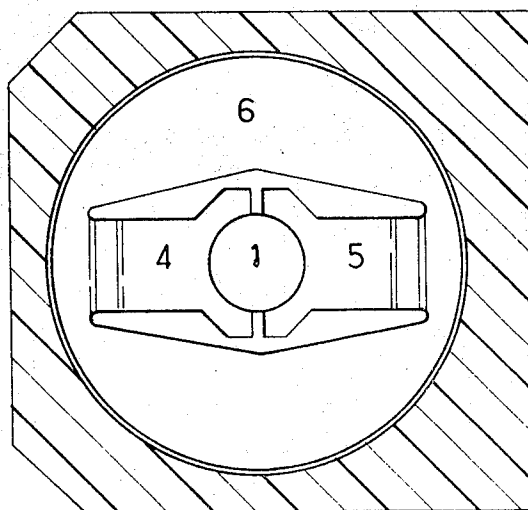


FIG. 4

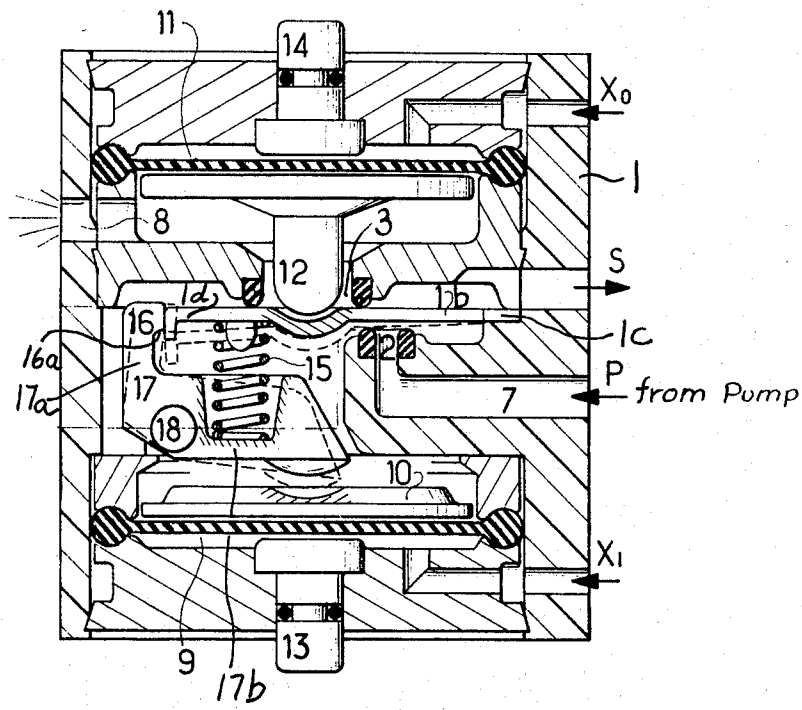
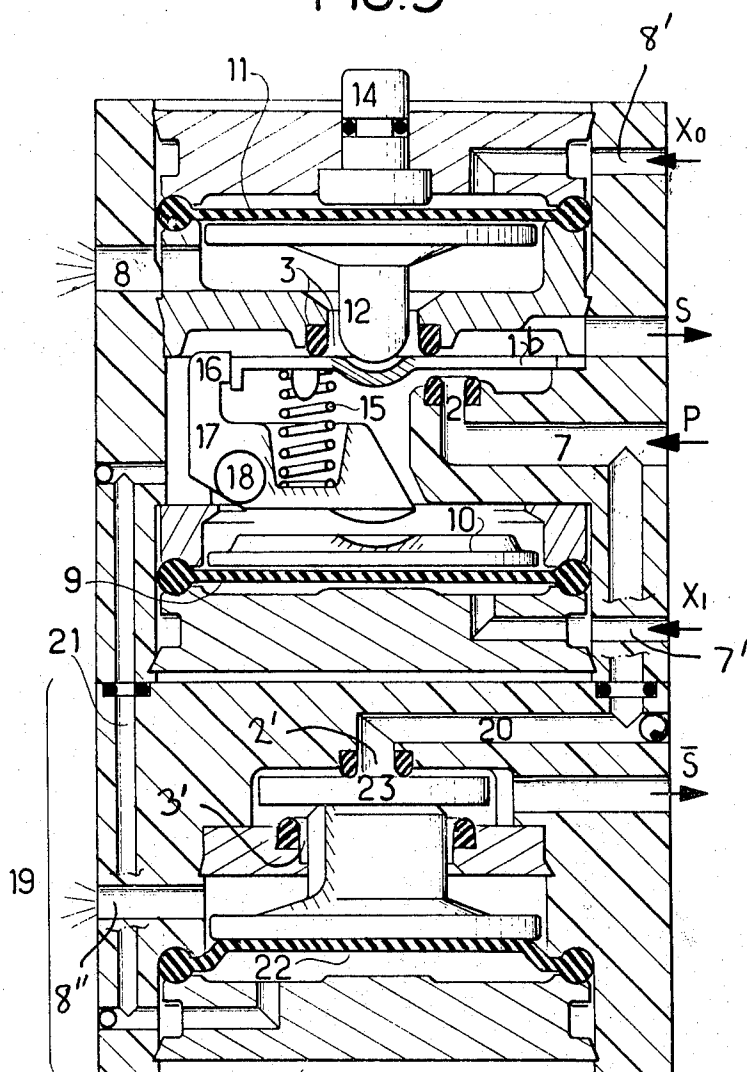


FIG. 5



PNEUMATIC MEMORY RELAY

BACKGROUND OF THE INVENTION

The present invention relates to a pneumatic control device for automatic systems, and more particularly to pneumatic relays which can be controlled by pneumatic pulses or signals and which have a memory or operate as a flip-flop, i.e., they retain the state set by a control pulse after the pulse has disappeared.

It is often required in industrial applications to utilize a pneumatic relay which operates as a flip-flop, i.e., can be alternately set to one of two stable states by pneumatic control pulses. A variety of such relays are already known. Most of the relays are of the spool-valve type, whereby pressurized fluid switching is achieved by the movement of a spool that slides under the action of control pressures which are applied at its ends. After the control pressures have disappeared, the spool can be maintained in the positions set by the control pressure pulses by the inherent friction present in the structure, i.e., the friction between the seals needed to seal the fluids and the relay, by mechanical locking (also called mechanical detent because of its detent effect) obtained by an elastic lock that deforms during the spool movement, or by magnetic means obtained by the action of magnets that are placed at both ends of the spool.

Generally, these spool valve memories are provided with two outputs. In the one state or position of the relay, one of the output ports is under pressure and the other output port is at or below this pressure. In the other spool position or state, the output conditions at the two output ports are reversed. In some cases, these memory relays are constructed with only one output. With the latter type, the two output pressure conditions appear at the single output alternately in response to the application of appropriate control pulses.

Spool valve relays, however, present disadvantages in that they are difficult to construct in mass production. The reason for this is that the operative elements of such relays must be constructed with high precision for proper and reliable operation of the parts and for satisfactory sealing. Additionally, their lifespan is limited and their cost, because of the required precision, is high.

Also known are poppet-type valve relays which allow switching by moving a poppet between two seats. The input pressures which are to be communicated to the output duct are provided at opposite sides of the poppet. Output relays of this type have the advantage that they only require very short strokes of the poppet to effect switching, so that very little wear takes place. Additionally, high precision is not required in the construction of such relays. However, poppets are not pressure-balanced, i.e., their position is affected by the action of the pressure of fluid utilized for effecting the switching, and thus different locking mechanisms must be employed to retain the poppet in a set condition. Locking mechanisms frequently require special, elaborate designs which increase the price of the relays. Finally, as two output relays are frequently required, the use of multiple poppets leads to complicated constructions because of the precision which is necessary to permit all the poppets to simultaneously close or engage the respective seats. Thus, while the input pressures to be switched to the output conduits are not in-

tended to change the state of the relay, once switching has been effected by a control pulse, the construction of the poppet valve relay frequently results in these input pressures undesirably switching the state of the relay.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a pneumatic memory relay which is not possessed of the disadvantages of similar relays known in the prior art.

It is another object of the present invention to provide a pneumatic relay of the type under discussion which is simple in construction and economical to manufacture, and which can be provided with one or two outputs.

It is still another object of the present invention to provide a relay of the above type which is adapted to maintain a desired state effected by an appropriate control pulse, subsequent to the removal of the pulse.

It is a further object of the present invention to provide a pneumatic relay as above described which includes simple mechanical locking means for maintaining the relay in a desired state.

It is still a further object of the present invention to provide a pneumatic relay which can be easily modified from a single-output relay to a double-output relay, in which the two respective outputs are complementary to one another.

According to the present invention, a pneumatic memory relay comprises a housing having a space interiorly therein. First and second input conduits are provided in said housing, said conduits respectively having outer ends accessible exteriorly of said housing and respectively having inner ends which communicate with said space. First and second seat means are respectively provided at said inner ends. An output conduit in said housing communicates with said space and with the exterior of said housing. Poppet means is arranged to move in said space between a first position in which it sealingly engages said first seat means and places said output conduit in communication with said second input conduit, and a second position in which it sealingly engages said second seat means and places into communication said output conduit with said first input conduit. First and second actuating means, including means for receiving set and reset signals, are provided for moving said poppet means to said second and first positions, respectively, in response to application of said set and reset signals. Retaining means are provided for retaining said poppet means in at least one of its positions absent the application of the respective signal.

According to the presently preferred embodiment, the retaining means comprises mechanical means in the form of bistable spring-type devices which cooperate with said poppet means to maintain the same in one or the other of said positions, said poppet means being substantially flat and having two flat surfaces each arranged to sealingly engage one of said set means.

According to a further feature of the present invention, an associated relay means has an auxiliary output conduit and cooperates with said above-mentioned memory relay and includes conduit means communicating with said first and second conduits as well as with said means for receiving said set and reset signals.

Means are provided in the associated relay means which cooperate with said conduit means for generating at said auxiliary output conduit an output signal which is complementary to that appearing at the first-mentioned output conduit so that two complementary signals normally appear at the two respective output conduits, alternately in response to the application of the set and reset signals.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side elevational cross section of a pneumatic relay with mechanical locking means in accordance with the present invention, the relay having one output;

FIG. 2 is a section taken on line 2—2 of FIG. 1;

FIG. 3 is a section of the embodiment shown in FIG. 1, taken on line b—b;

FIG. 4 is a side elevational cross section of another embodiment of the present invention, the relay having one output and a different mechanical locking means; and

FIG. 5 illustrates still a further embodiment of the relay as shown in FIG. 4, combined with an associated relay connected thereto to provide two outputs which are complementary to one another.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The single-output relay illustrated in FIG. 1 comprises a housing 1 having provided therein a space 1a. A poppet 1b is positioned in the space 1a and arranged to move between two positions, as will further be described hereafter. Seats 2 and 3 are provided at opposite sides of the space 1a and are each arranged to be engaged by one of the major surfaces of the poppet 1b when the latter is in one of the two positions. The seats 2 and 3 are preferably made from an elastomeric material, such as rubber, which is capable of at least partial deformation for providing a good seal when the poppet 1b comes into contact therewith. An inlet conduit 7 is provided in the housing 1 which has an outer end accessible exteriorly of the housing 1, and an inner end which is bounded by the seat 2 and communicates with the space 1a. The conduit 7 is arranged to receive fluid under a predetermined pressure. The pressure which normally exists in the conduit 7 is represented by the reference character P. Pressure P is provided by a permanent pressure supply (not shown). In the position of the poppet 1b as shown in FIG. 1, the lower surface of the poppet engages or makes contact with the seat 2 to thereby close or seal the inner end of the conduit 7. Retaining means, in the form of bistable biasing means 4, 5 are mounted in the housing 1, and arranged to urge said poppet means against the seat 2 when the poppet means is in a first position, i.e., the position shown in FIG. 1, and for urging the poppet 1b against the seat 3 when the poppet is in the other of its positions. More particularly, the biasing means as can best be seen from FIGS. 1-3, comprises a snap-over center plate spring

mounted in the housing and has holding portions 4, 5 for holding the poppet 1b. The holding portions 4, 5 are arranged to snap either to one or the other of the stable positions, after the poppet has been caused to pass through an unstable central position toward a stable position. In each stable position, the holding portions 4, 5 hold the poppet 1b against one of the seats 2, 3. As can be best seen in FIG. 2, the snap-over center plate spring can advantageously be constructed by punching a plate of spring material to provide two extending holding portions 4, 5 which are adapted to engage the poppet.

To effect a proper seal between the seats 2, 3 and the poppet 1b, it is preferred that at least either the seats or the poppet be made from a somewhat resilient material (for example, an elastomer). In the embodiment illustrated in FIGS. 1-3, the seats 2, 3 are made from a hard material while the poppet 1b is made of a plastic or resilient material. However, it is clear that the reverse arrangement is equally suitable and this is illustrated in FIG. 4. Insofar as the plate 6 is concerned, out of which the holding portions 4, 5 are formed, the material for the plate is preferably selected to be one which can resist fatigue due to many snapping actions. A material which is suitable for this purpose is beryllium-bronze, of the type which is commonly used for snap contacts in electric switches. With a snap-over spring of this type, the blades 4, 5 are deformed in such a manner that the forces generated as a result of the deformations of the holding portions as well as that of the poppet 1b itself, are sufficient to cause the poppet to abut against seats 2 and 3, respectively, with significant force. Additionally, the poppet is forced to move from its seat 2 abutment position to its seat 3 abutment position, and vice versa, in response to the deformation or bending of the holding portions 4, 5 once the poppet has passed through a central position between the two seats 2, 3. With the poppet 1b held by the holding portions 4, 5 in abutment with seat 2 as shown in FIG. 1, the pressure P does not appear in the relay beyond the conduit 17.

An output conduit 1' has an inner end in communication with the space 1a and an outer end opening at the exterior of the housing. The output conduit 1' is provided to communicate the pressure conditions in the space 1a to the exterior of the housing — output signal being represented by the reference character S. The inlet conduit 8 has an outer end communicating with the exterior of the housing 1, and its inner end communicates with the space 1a via a seat 3 which bounds the inner end of this conduit. With the position of the poppet 1b as shown in FIG. 1, it will be clear that the output conduit 1' is in communication with the inlet conduit 8 via the seat 3.

The conduit 8 is arranged to receive a fluid at a predetermined pressure. In accordance with the presently preferred embodiment of the invention, the conduit 7 is supplied with a fluid at a pressure above atmospheric pressure, while conduit 8 is placed at atmospheric pressure. To this purpose the inlet conduit 8 extends through the housing 1 and the exhaust port 8a of the conduit 8 is schematically illustrated as being in communication with the atmosphere.

With the poppet 8b in the lower position so that the conduits 8 and 1' communicate with each other, the memory relay is said to be in the "zero" state, i.e., the output S is at a relative pressure of zero. Stated in an-

other way, the "zero" state of the relay indicates that the pressure S at the outer or output end of the conduit $1'$ is atmospheric pressure.

The cross-sectional area of the seat 2 is smaller than the cross-sectional area of the seat 3 . The cross-sectional area of the seat 2 is made sufficiently small so that the pressure P acting on the poppet $1b$ over the area of the conduit or seat 2 , is insufficient to overcome the locking force or retaining force developed by the holding portions $4, 5$ so that the poppet $1b$ is maintained in abutment with the seat 2 despite the presence of the pressure P in the conduit 7 .

Actuating means are provided which can move the poppet from the position wherein it engages one seat to a position wherein it engages the other seat. The actuating means which is adapted to bring the poppet $1b$ into abutment against the seat 3 includes a conduit $7'$ arranged to receive fluid under pressure, and particularly to receive pneumatic pulses or signals X_1 , which will hereinafter be referred to as set signals. When a set signal is transmitted to the conduit $7'$, the pneumatic control pulse is applied to one side of a diaphragm 9 which is movable in an upward direction when viewed in FIG. 1. Upon the application of a set signal X_1 the diaphragm deforms upwardly and causes an actuating member 10 having a first portion $10a$ arranged to be engaged by the diaphragm 9 and a second portion configured in the form of a fork $10b$, to engage the poppet $1b$ and urge the same in an upward direction, as viewed in FIG. 1, against the retaining forces exerted on the poppet by the holding portions $4, 5$. The upward movement of the actuating member 10 causes the fork $10b$ to abut against the holding portions $4, 5$ and cause the same to move the poppet $1b$ towards the seat 3 . The thrust developed by the active area of the diaphragm 9 is greater than the thrust required to overcome the retaining forces exerted on the poppet $1b$ by the holding portions $4, 5$. Once the holding portions $4, 5$ have passed a central or neutral position, this being an unstable position, the holding portions $4, 5$ snap to the other side towards a new stable position wherein they apply forces to the poppet $1b$ to cause the latter to abut against the seat 3 . Advantageously, the diaphragm 9 is arranged to deform sufficiently so as to cause the bifurcated portion or fork $10b$ to move in upward direction, as viewed in FIG. 1, by a distance sufficient to urge the poppet $1b$ towards seat 3 until engagement has been effected. Once the upper surface of the poppet $1b$ has come into contact with the seat 3 , the inner end of the conduit 7 is now open and communicates with the space $1a$ and, therefore, with the output conduit $1'$. The pressure P is thereby transmitted to the output conduit $1'$ and the pressure S is equal to the pressure P . Now, however, the inner end of the conduit 8 which is bounded by the seat 3 is sealed and the conduit 8 is no longer in communication with the space $1a$. The pressure output S at the output conduit $1'$ now changes from the atmospheric pressure in conduit 8 to the pressure that prevails in conduit 7 . The memory relay is then said to be in the "state 1" or "set" position. With the relay in the "state 1" position, it is possible to switch the output S back from the pressure P to atmospheric pressure, by the application of a reset signal X_0 in conduit $8'$. A pneumatic pressure control signal X_0 applied in the conduit $8'$, as in the case of a pressure in conduit $7'$, operates on a diaphragm 11 which is arranged to deflect in the direction of the space $1a$. An

actuating member in the form of a piston 12 has a portion configured to pass into and extend through the seat 3 while having another portion which is adjacent to the diaphragm 11 . Upon deformation or flexing of the diaphragm 11 , the piston 12 is urged in a downward direction, as viewed in FIG. 1, the portion extending into the seat 3 and abutting against the poppet $1b$ to urge the same to move towards the seat 2 . The lifting of the poppet $1b$ from seat 3 is facilitated by making the cross-section of the diaphragm 11 as well as the cross section of the portion of the piston engaging therewith, greater than that of seat 3 . The holding portions $4, 5$ are advantageously made from a material which develop forces on the poppet $1b$ when engaged with the seat 3 which can easily be overcome by the piston 12 in response to movement of the diaphragm 11 and the thrust developed by the air pressure on the poppet $1b$.

Poppet $1b$ again passes the central or neutral position and, in response to the downward movement of the piston 12 , is forced to abut against the seat 2 where it is maintained by the forces imparted thereto by the spring or elastic holding portions $4, 5$ even after the signal X_0 has disappeared. The output S is then reconnected to the conduit 8 and the memory relay is again said to be in the state "zero." The output remains in this state after disappearance of the X_0 reset signal and only returns to the state "1" when a set signal X_1 appears. Because of this characteristic, the relay is said to have a memory since it retains its states indefinite, as long as no external control pulses are applied.

Push buttons 13 and 14 are manual overrides which permit changing the states of the memory relay by simple manual control. Upon depressing of the respective push button a force is exerted on a respective diaphragm 9 or 11 , which has the same effect as do the forces exerted by the pressures on diaphragms caused by the control signals X_1 and X_0 , respectively. Thus, push button 13 sets the memory to state "1" and push button 14 resets it to state "0."

The mechanical retaining means described in connection with FIGS. 1-3 may have the disadvantage that the holding portions $4, 5$ are subject to failure after repeated inversions as a result of fatigue. For some applications, and in particular where many inversions are anticipated, another type of locking may be preferred. FIG. 4 illustrates a second embodiment for mechanical retaining means which retains the poppet $1b$ in abutment against seats 2 or 3 in the absence of any external signals or in the event that the pressures in the housing are removed. In this embodiment, the poppet $1b$ is in the form of a substantially flat member which has a fixed portion $1c$ which is fixed to the housing 1 . In the presently preferred embodiment, the flat member is in the form of a flexible blade having a free portion $1d$ which is movable in upward and downward directions, as viewed in FIG. 4, while pivoting about the fixed portion $1c$. The solid outline of the flexible blade $1d$ represents the position where the flexible blade engages the upper seat 3 , while the dashed outline, or lower representation, depicts the flexible blade in its position when it engages the seat 2 . In the position illustrated in FIG. 4, therefore, the supply pressure P is transmitted to the conduit 7 and then via the seat 2 to the output conduit $1'$ where it appears as the output S . The relay is thus in the "state 1." A helical spring 15 maintains the free portion $1d$ in the upper position as

shown. The poppet 1b is also maintained in this position by the pressure differential which appears across the poppet, i.e., the pressure P below the seat 3, and a pressure lower than P at the seat 3.

The free portion 1d is movable in a downward direction against the action of the helical spring 15 if the force of the latter is overcome by the action of the piston 12. Thus, if a reset signal X_0 is applied to the diaphragm 11, it acts on the piston 2 which moves the flexible poppet blade from the seat 3 to the seat 2, thus communicating the output S with the conduit 8 via seat 3 and placing the memory relay in "state zero." Latching means are provided which are to utilized retain the free portion 1d in abutment against the seat 2. This latching means includes a bell crank 17 having a first arm 17a and a second arm 17b. The two arms are substantially displaced from one another by about 90°. The helical spring 15 abuts against the second arm 17b, the free end of said second arm being arranged for engagement with a piston 10. The bell crank 17 is pivoted about a pin 18. With this arrangement the lever can move between two angular positions, as to be described hereafter. The first arm is provided with engaging means in the form of a notch 16, at the free end thereof. When the piston 12 is urged in a downward direction, this causes the free portion 1d to move in a downward direction and to further compress the helical spring 15. This action increases the downward force applied against the second arm 17b —this increasing the clockwise moment, as viewed in FIG. 4, applied to the bell crank lever 17 about the pin 18. The notch 16 is provided with a bearing surface 16a, and as soon as the free portion 1d has moved to a position below the bearing surface 16a, the free portion is engaged by the notch 16 as the bell crank 17 moves slightly in the clockwise direction. The free portion 1d is held by the bearing surface 16a in the position illustrated by the dashed-outline. At this time, the helical spring 18 is compressed to its near maximum. In this locked state, the flexible blade 1b is in a stable condition, the action of the helical spring 15 and the bell crank 17 being capable of maintaining the position of the flexible blade 1d indefinitely if no further pneumatic signals are transmitted to the device. Thus, when the control signal X_0 disappears, the poppet blade remains locked and the state of the memory relay is kept.

To revert the memory relay back to the state "1," a signal X_1 applied to the diaphragm 9, urges the piston 10 in an upward direction, as viewed in FIG. 4, to thereby engage the free ends of the second arm 17b. The effect of the upward movement of the piston 1 causes the bell crank lever 17 to rotate in a counterclockwise direction while slightly further compressing the helical spring 15. When the bell crank 17 has rotated in a counterclockwise direction, through an angular distance sufficient to cause the surface 16a to disengage from the free portion 1d, the compressed helical spring 15 forces the flexible blade 1d to move in an upward direction to thereby disengage from the seat 2 and to bring it into engagement with the seat 3. With this latter movement the flexible blade 1b is further aided by the air pressure, and the output S is again equal to the pressure P to thereby place the memory relay into the state "1." It should be noted that the free portion 1d of the flexible blade 1b is arranged slightly below the unflexed blade position (dashed outline in FIG. 4). This insures that seat 2 is properly sealed while the free por-

tion 1d applies sufficient restoring force against the bearing surface 16a to maintain engagement.

In connection with the embodiment illustrated in FIG. 4, the push buttons 13 and 14 allow the manual switching of the memory relay, and in the absence of control signals X_1 and X_0 in a manner similar as that described in connection with the embodiment illustrated in FIGS. 1-3. Also, the description of features of the first embodiment which are common with features of the second described embodiment are equally applicable to the latter.

The locking mechanisms or retaining mechanisms can take different forms, as exemplified by the two described embodiments. All of the retaining means or locking mechanisms have the function of urging the poppet into one position wherein it abuts one seat, and for permitting the poppet to move into engagement with another seat upon the application of a control signal while maintaining the poppet against the second seat and only permitting the return of the poppet to the first seat upon the provision of a further control signal.

The locking mechanisms as described are exemplary but illustrate the principle and the advantages of utilizing such locking mechanisms. For one, the moving parts are not exposed to the exterior and their lifetime can be excellent if the locking mechanism has been properly designed and constructed. Additionally, because the locking mechanisms are at least partially surrounded by the fluids which the relay is intended to switch, friction is generally minimized and temperatures are stabilized during high frequency operations. Also, lubrication is frequently not necessary.

The above described memory relays with mechanical locking have the property that they keep their state even if the supply pressure P fails. In fact, the mechanical locking mechanisms maintain this state even in a complete absence of any pressure input or control. This property may be very advantageous in some automatic systems.

Two complementary signals are frequently utilized in automation systems. The memory devices which have just been described in conjunction with FIGS. 1-4, are single output memories. The single output S at the output of the conduit 1' is either in communication with the larger pressure P in the conduit 7 or with the lower or atmospheric pressure in the conduit 8. These input pressures, as described above, can selectively be applied to the output conduit 1' by the application of suitable set and reset signals to the conduit 7' and 8', respectively. The just described memory relay may be modified by connecting to the same a "NOT" relay in the form of a switch 19. In the embodiment of FIG. 5, the switch 19 has been connected to a memory relay as shown in FIG. 4. The switch 19 is in communication with the conduit 7 via a conduit 20. The pressure P taken from the input conduit 7 can be selectively applied to the output S and the output $\bar{S}$, which is the inverse or complement of the output S. The actual construction of the "NOT" relay is known and does not form part of the present invention. Conduit means are provided in the housing, this including the conduit 20 which is in communication with the conduit 7. Thus, the pressure P is simultaneously applied to conduits 7 and 20, the latter being bounded by a smaller cross-sectional seat 2'. Cooperating with a seat 3', a conduit 21 of the "NOT" relay is in communication with the

space 1a. When a control signal X_1 is applied to the conduit 7', the control pulse is applied to diaphragm 9. This sets the main relay and the pressure P appears in the space 1a as well as in the conduit 21. The pressure P acts on the diaphragm 22 to urge the same in an upward direction, as viewed in FIG. 5. This action forces the poppet 23 to open seat 3' and seal or close seat 2'—placing the output $\bar{S}$ at the atmospheric pressure of conduit 8'' or the output $\bar{S}$ is placed at the "0" level.

In the position illustrated in FIG. 5, the output S is at the pressure existing in the conduit 7—this being the pressure P. The conduit 21 is in communication with the space 1a which feeds the output conduit 1' so that the pressure P is applied simultaneously to the poppet 23 through the valve 2' as well as the diaphragm 22. However, because the area of the diaphragm 22 is greater than the cross-sectional area of the seat 2' the net force generated in such as to maintain the poppet 23 in abutment against the seat 2'. Accordingly, the output $\bar{S}$ is in communication with the conduit 8'' which is at a pressure lower than that of pressure P.

In the condition illustrated in FIG. 5, the basic memory relay is in the "1" state since the output $\bar{S}$ of the conduit 1' is at the "1" state, while the auxiliary output S is in the "zero" state. By applying a reset signal X_0 to the conduit 7', both poppets 1b and 23 are urged to engage the respective opposite seats and the basic memory relay output S is placed in the "zero" state, and the complementary $\bar{S}$ is placed in the "1" state.

The above described function, very much used in automation, has until now remained difficult and costly to use in pneumatic devices as compared with the memory functions obtainable with electrical or electronic devices. The pneumatic memory relays with mechanical locking mechanisms achieve the objects of this invention, while the relays are easy to construct and to miniaturize. A pneumatic relay of this type makes the use of pneumatic relays practical in many applications which have been up to this point impractical. It should be noted that during switching from one state to another, movement of the parts, and in particular movement of the poppets is reduced to a very small travel and this results in increased lifetime and dependability of the relays. Because no sliding seal is utilized the components can operate perfectly without any lubrication.

Finally, the construction of the relay does not require precautions for guiding and sealing and can be mass produced, for example, with the use of plastic molded parts, thus leading to a very low unit price.

According to another feature of the present invention the housing 1 is composed of molded plastic and the holding or mounting parts are press-fitted in the housing. The mounting parts are advantageously provided with annular sharp edges that achieve sealing and also firmly maintain the parts in the housing. With such sealing means, no threads are necessary, and the relay assumes a very compact form which can be built very economically. The present invention is not, however, limited to this construction and other economical methods of construction can also be used in the framework of the invention, as for example, assembling by riveting, snapping means made of elastic parts, or by ultrasonic welding of plastic parts.

It will be understood that each of the elements described above, or two or more together, may also find

a useful application in other types of pneumatic relays differing from the types described above.

While the invention has been illustrated as described as embodied in a pneumatic memory relays with mechanical locking means, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

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

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. A pneumatic memory relay comprising a housing having a space interiorly therein; first and second input conduits in said housing, said conduits respectively having other ends accessible exteriorly of said housing and respectively having inner ends each communicating with said space; means for establishing in at least one of said input conduits a predetermined fluid pressure different from atmospheric pressure; first and second seat means respectively provided at said inner ends; an output conduit in said housing communicating with said space and with the exterior of said housing; poppet means arranged to move in said space between a first position in which it sealingly engages said first seat means and places said output conduit in communication with said second input conduit, and a second position in which it sealingly engages said second seat means and places said output conduit into communication with said first input conduit; first and second actuating means including means for receiving set and reset signals for moving said poppet means to said second and first positions, respectively, in response to application of said set and reset signals; and retaining means for retaining said poppet means in at least one of said positions absent the application of the respective signal; wherein said first and second means are spaced from each other, said first seat means having an effective area through which said predetermined pressure can act on said poppet means when the latter is in said first position, said effective area being so selected that the force resulting on said poppet means by the action of said predetermined pressure is insufficient to overcome the retaining force exerted on said poppet means by said retaining means.

2. The relay defined in claim 1, wherein said retaining means comprises means operative after said poppet means has been moved to at least a predetermined one of said positions for maintaining said poppet means in said predetermined position even in the absence of the respective one of said set and reset signals and even in the absence of said predetermined fluid pressure.

3. A pneumatic relay as defined in claim 1, wherein said first seat means comprises resilient means defining an opening substantially free of obstructions.

4. A pneumatic memory relay comprising a housing having a space interiorly therein; first and second input conduits in said housing, said conduits respectively having outer ends accessible exteriorly of said housing and respectively having inner ends each communicating

ing with said space; first and second seat means respectively provided at said inner ends; an output conduit in said housing communicating with said space and with the exterior of said housing; poppet means arranged to move in said space between a first position in which it sealingly engages said first seat means and places said output conduit in communication with said second input conduit, and a second position in which it sealingly engages said second seat means and places said output conduit into communication with said first input conduit; first and second actuating means including means for receiving set and reset signals for moving said poppet means to said second and first positions, respectively, in response to application of said set and reset signals; and retaining means for retaining said poppet means in at least one of said positions absent the application of the respective signal; wherein said first and second input conduits are arranged to be connected to stronger first and weaker second sources of pressure respectively, and wherein said first and second seat means respectively bound said inner ends of said first and second input conduits, the inner end of said second input conduit having a cross sectional area greater than that of the inner end of said first input conduit.

5. The relay defined in claim 4; and further including means for establishing in at least one of said input conduits a predetermined fluid pressure different from atmospheric pressure, and wherein said retaining means comprises means operative after said poppet means has been moved to at least a predetermined one of said positions for maintaining said poppet means in said predetermined position even in the absence of the respective one of said set and reset signals and even in the absence of said predetermined fluid pressure.

6. A pneumatic relay as defined in claim 4, wherein said second actuating means comprises movable piston means arranged to at least partially extend through said second seat means on the application of a reset signal to thereby move said poppet means from said second to said first positions.

7. A pneumatic memory relay comprising a housing having a space interiorly therein; first and second input conduits in said housing, said conduits respectively having outer ends accessible exteriorly of said housing and respectively having inner ends each communicating with said space; first and second seat means respectively provided at said inner ends; an output conduit in said housing communicating with said space and with the exterior of said housing; poppet means arranged to move in said space between a first position in which it sealingly engages said first seat means and places said output conduit in communication with said second input conduit, and a second position in which it sealingly engages said second seat means and places said output conduit into communication with said first input conduit; first and second actuating means including means for receiving set and reset signals for moving said poppet means to said second and first positions, respectively, in response to application of said set and reset signals; and retaining means for retaining said poppet means in at least one of said positions absent the application of the respective signal; wherein said poppet means comprises a substantially flat member having one free portion and having another portion connected to said housing, said flat member being reversibly movable between said first and second posi-

tions in response to movement of said free portion respectively from said first toward said second seat means.

8. The relay defined in claim 7; and further including means for establishing in at least one of said input conduits a predetermined fluid pressure different from atmospheric pressure, and wherein said retaining means comprises means operative after said poppet means has been moved to at least a predetermined one of said positions for maintaining said poppet means in said predetermined position even in the absence of the respective one of said set and reset signals and even in the absence of said predetermined fluid pressure.

9. A pneumatic relay as defined in claim 7, wherein said other portion is pivotally connected to said housing.

10. A pneumatic relay as defined in claim 7, wherein said flat member comprises a flexible blade whose other portion is fixedly connected to said housing.

11. A pneumatic relay as defined in claim 10, wherein said retaining means comprises biasing means abutting against said free portion and urging said flexible blade toward said second position, and latching means for locking said flexible blade in said first position of the latter.

12. A pneumatic relay as defined in claim 11, wherein said latching means comprises a bell crank lever having first and second arms angularly displaced from one another by approximately ninety degrees, said lever being pivotally mounted in said housing for pivoting movement between two angular positions, said first arm including means for engaging said free portion in a first angular position when said flexible blade is in said first position in opposition to the forces imparted to said flexible blade by said biasing means, said means for engaging said free portion releasing the latter in a second angular position of said lever, whereby said biasing means urges said flexible blade to move toward said second position.

13. A pneumatic relay as defined in claim 12, wherein said biasing means comprises a helical spring compressed between said free portion and said second arm.

14. A pneumatic relay as defined in claim 13, wherein said free portion of said flexible blade is arranged to move slightly beyond the unflexed blade position of said free portion towards said first seat means when the remainder of said flexible blade is in said first position, and wherein said latching means comprises a notch formed in said first arm, said notch having a bearing surface for abutment against said free portion once the latter has moved slightly beyond said unflexed position.

15. A pneumatic relay as defined in claim 12, wherein said first actuating means comprises means for pivoting said lever to said second angular position, and wherein said second actuating means comprising means for pivoting said lever to said first angular position.

16. A pneumatic memory relay comprising a housing having a space interiorly therein; first and second input conduits in said housing, said conduits respectively having outer ends accessible exteriorly of said housing and respectively having inner ends each communicating with said space; first and second seat means respectively provided at said inner ends; an output conduit in said housing communicating with said space and with

the exterior of said housing; poppet means arranged to move in said space between a first position in which it sealingly engages said first seat means and places said output conduit in communication with said second input conduit, and a second position in which it sealingly engages said second seat means and places said output conduit into communication with said first input conduit; first and second actuating means including means for receiving set and reset signals for moving said poppet means to said second and first positions, respectively, in response to application of said set and reset signals; and retaining means for retaining said poppet means in at least one of said positions absent the application of the respective signal; wherein said first and second actuating means each comprise a movable actuating member having a portion configured to extend respectively through said first and second seat means and arranged to abut against said poppet means when the latter is in respectively said first and second positions; and diaphragm means adjacent to each actuating member and arranged to displace the latter into abutment with said poppet means in response to set and reset signals respectively, to thereby urge said poppet means to move from one position to another.

17. The relay defined in claim 16; and further including means for establishing in at least one of said input conduits a predetermined fluid pressure different from atmospheric pressure, and wherein said retaining means comprises means operative after said poppet means has been moved to at least a predetermined one of said positions for maintaining said poppet means in said predetermined position even in the absence of the respective one of said set and reset signals and even in the absence of said predetermined fluid pressure.

18. A pneumatic relay as defined in claim 16, further comprising first and second manual override button means slidably mounted on said housing and arranged to act respectively on said diaphragm means adjacent to each actuating member when said button means is depressed.

19. A pneumatic memory relay comprising a housing having a space interiorly therein; first and second input conduits in said housing, said conduits respectively having outer ends accessible exteriorly of said housing and respectively having inner ends each communicating with said space; first and second seat means respectively provided at said inner ends; an output conduit in said housing communicating with said space and with the exterior of said housing; poppet means arranged to move in said space between a first position in which it sealingly engages said first seat means and places said output conduit in communication with said second input conduit, and a second position in which it sealingly engages said second seat means and places said output conduit into communication with said first input conduit; first and second actuating means including means for receiving set and reset signals for moving said poppet means to said second and first positions, respectively, in response to application of said set and reset signals; and retaining means for retaining said poppet means in at least one of said positions absent the application of the respective signal; wherein one of two complementary output signals appears at said output conduit; and further comprising associated relay means cooperating with said memory relay and including conduit means communicating with said first and

second input conduits and said means for receiving said set and reset signals, said conduit means including an other output conduit; and means cooperating with said conduit means for generating at said other output conduit an output signal which is complementary to that appearing at the first mentioned output conduit.

20. The relay defined in claim 19; and further including means for establishing in at least one of said input conduits a predetermined fluid pressure different from atmospheric pressure, and wherein said retaining means comprises means operative after said poppet means has been moved to at least a predetermined one of said positions for maintaining said poppet means in said predetermined position even in the absence of the respective one of said set and reset signals and even in the absence of said predetermined fluid pressure.

21. A pneumatic memory relay comprising a housing having a space interiorly therein; first and second input conduits in said housing, said conduits respectively having outer ends accessible exteriorly of said housing and respectively having inner ends each communicating with said space; first and second seat means respectively provided at said inner ends; an output conduit in said housing communicating with said space and with the exterior of said housing; poppet means arranged to move in said space between a first position in which it sealingly engages said first seat means and places said output conduit in communication with said second input conduit, and a second position in which it sealingly engages said second seat means and places said output conduit into communication with said first input conduit; first and second actuating means including means for receiving set and reset signals for moving said poppet means to said second and first positions, respectively, in response to application of said set and reset signals; and mechanical retaining means automatically operative after said poppet means has been moved to said first position for maintaining said poppet means in said first position even in the absence of a reset signal by applying to said poppet means a purely mechanical retaining force holding said poppet means in said first position, and automatically operative after said poppet means has been moved to said second position for maintaining said poppet means in said second position even in the absence of a set signal by applying to said poppet means a purely mechanical retaining force holding said poppet means in said second position.

22. The relay defined in claim 21; and further including means for establishing in at least one of said input conduits a predetermined fluid pressure different from atmospheric pressure, and wherein said retaining means comprises means operative after said poppet means has been moved to at least a predetermined one of said positions for maintaining said poppet means in said predetermined position even in the absence of the respective one of said set and reset signals and even in the absence of said predetermined fluid pressure.

23. The relay defined in claim 21, wherein said mechanical retaining means comprises obstructing means automatically operative after said poppet has moved to a predetermined one of said two positions thereof for maintaining said poppet means in said predetermined position by obstructing the path of movement of said poppet means from said predetermined position to the other position of said poppet means.

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24. The relay defined in claim 23, wherein said obstructing means comprises a latch mechanism arranged to detain said poppet means in said predetermined position thereof, and release means responsive to receipt of one of said set and reset signals for unlatching said latch mechanism.

25. The relay defined in claim 21, wherein said obstructing means comprises an element movable to a position obstructing the path of movement of said poppet means from said predetermined position to the other position of said poppet means, and means automatically operative in response to receipt of a predetermined one of said signals for moving said element out of said path of movement of said poppet means.

26. The relay defined in claim 21, wherein said mechanical retaining means comprises bistable biasing spring means automatically operative after said poppet means has been moved to said first position for maintaining said poppet means in said first position even in the absence of a reset signal by applying to said poppet means a spring biasing force holding said poppet means in said first position, and automatically operative after said poppet means has been moved to said second position for maintaining said poppet means in said second position even in the absence of a set signal by applying to said poppet means a spring biasing force holding said poppet means in said second position.

27. The relay defined in claim 26, wherein said bistable biasing spring means comprises a single bistable biasing spring.

28. The relay defined in claim 27, wherein said single bistable biasing spring is composed of a single resilient element.

29. A pneumatic memory relay comprising a housing having a space interiorly therein; first and second input conduits in said housing, said conduits respectively

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having outer ends accessible exteriorly of said housing and respectively having inner ends each communicating with said space; first and second seat means respectively provided at said inner ends; an output conduit in said housing communicating with said space and with the exterior of said housing; poppet means arranged to move in said space between a first position in which it sealingly engages said first seat means and places said output conduit in communication with said second input conduit, and a second position in which it sealingly engages said second seat means and places said output conduit into communication with said first input conduit; first and second actuating means including means for receiving set and reset signals for moving said poppet means to said second and first positions, respectively, in response to application of said set and reset signals; and mechanical retaining means automatically operative after said poppet means has been moved to a predetermined one of said two positions thereof for maintaining said poppet means in said predetermined position even in the absence of the respective one of said set and reset signals by obstructing the path of movement of said poppet means from said predetermined position to the other position of said poppet means.

30. The relay defined in claim 29; and further including means for establishing in at least one of said input conduits a predetermined fluid pressure different from atmospheric pressure, and wherein said retaining means comprises means operative after said poppet means has been moved to at least a predetermined one of said positions for maintaining said poppet means in said predetermined position even in the absence of the respective one of said set and reset signals and even in the absence of said predetermined fluid pressure.

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