April 4, 1967 W. F. VOIT, JR 3,312,238

MONOSTABLE FLUID LOGIC ELEMENT AND ACTUATOR

Filed Dec. 24, 1964 2 Sheets-Sheet 1

FIG. 1

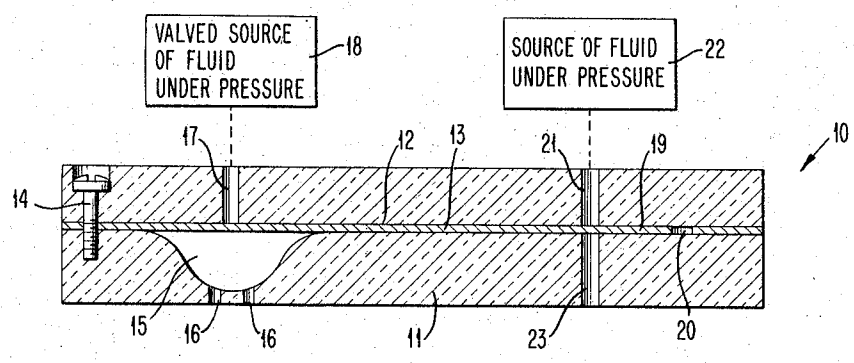


FIG. 2

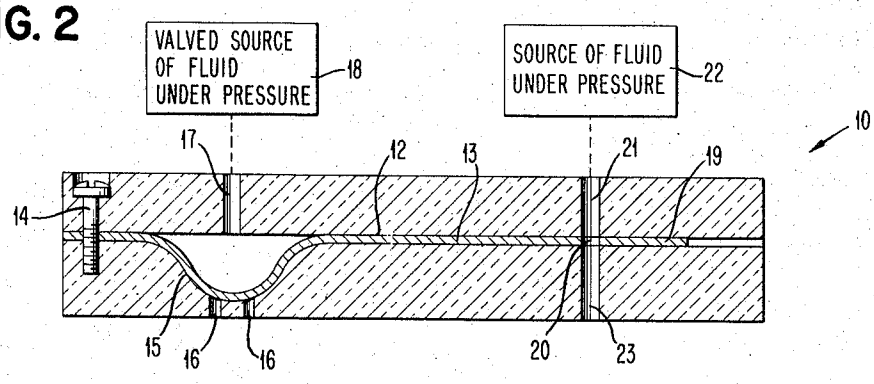
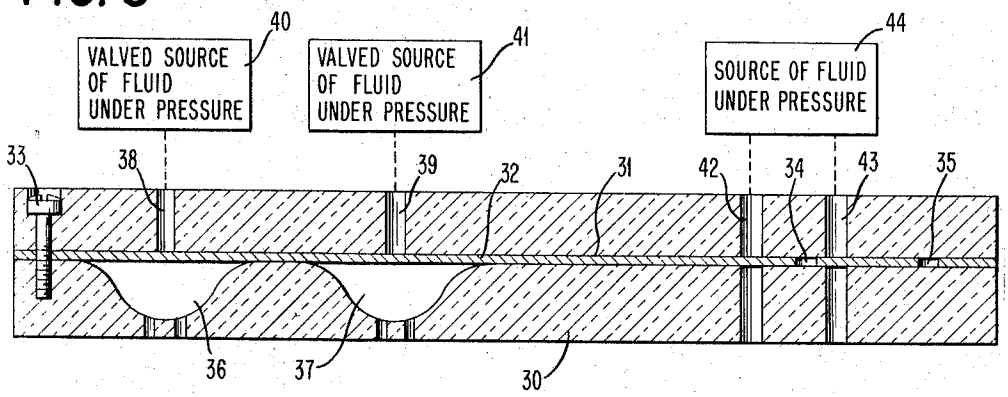


FIG. 3



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MONOSTABLE FLUID LOGIC ELEMENT AND ACTUATOR

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FIG. 4

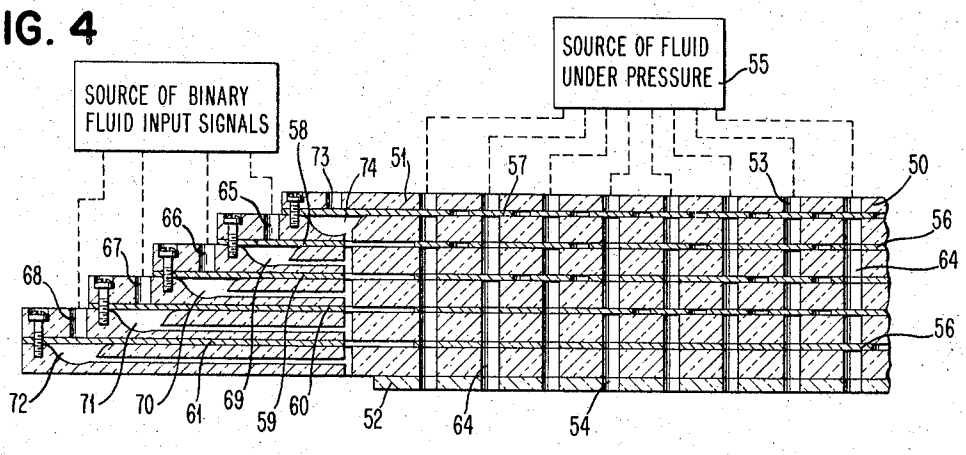


FIG. 5

DECIMAL OUTPUT	1	2	3	4	5	6	7	8	9	10
TAPE 58	0	X	0	X	0	X	0	X	0	X
TAPE 59	X	0	0	X	X	0	0	X	X	0
TAPE 60	X	X	X	0	0	0	0	X	X	X
TAPE 61	X	X	X	X	X	X	X	0	0	0

63 (above column 1) 62 (TAPE 58) 62 (TAPE 60) 63 (below column 4)

FIG. 6

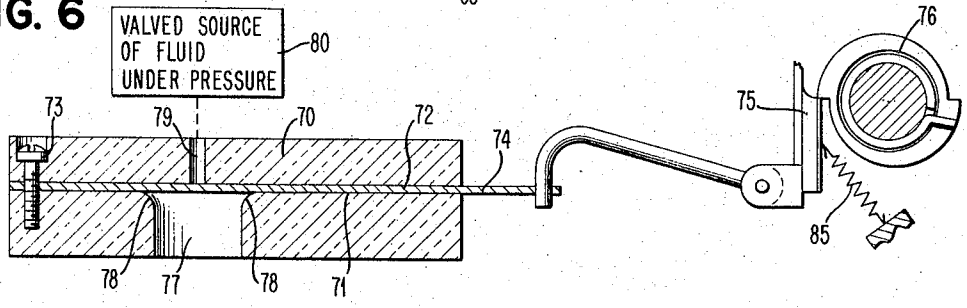
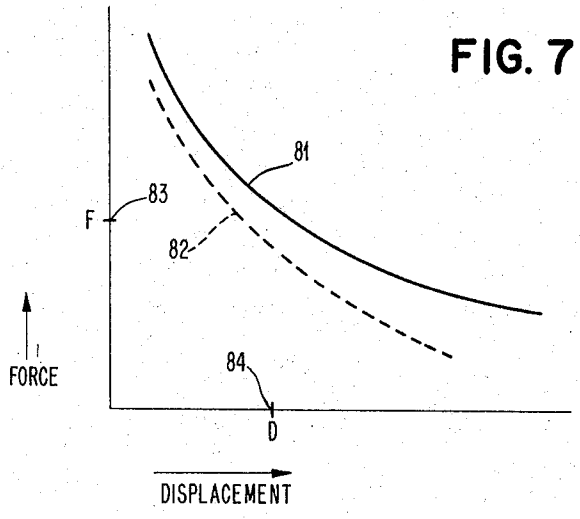


FIG. 7



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MONOSTABLE FLUID LOGIC ELEMENT AND ACTUATOR

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Filed Dec. 24, 1964, Ser. No. 421,032
27 Claims. (Cl. 137—552.5)

The present invention relates generally to the logic and actuator arts and more particularly to the provision of fluid elements each having a single stable state which are capable of being used as actuators for mechanical apparatus and of performing various logic operations of the type usually accomplished by electrical components.

Recently, much interest has been evidenced in the possible use of various fluid operated elements to perform logical functions normally associated with electrical components. One such fluid element is the fluid jet amplifier wherein a stream of fluid issuing from a nozzle is directed to either of a pair of outlet ports. The fluid jet is switched between the outlet ports by appropriately directed pressure gradients applied transversely across the fluid jet between the spaced nozzle and the pair of outlet ports. The pressure gradients are provided through the use of fluid control streams, vacuums, electrical discharges or the like. The fluid jet amplifier is a bistable device in that the fluid jet will remain directed toward a particular outlet port even though the controlling transverse pressure gradient is removed due to the boundary layer condition existing between the fluid jet and the adjacent side wall of the outlet port.

Fluid elements of the type mentioned above are relatively fast acting, occupy a minimum of space and can be fabricated at a low cost using conventional plastic molding techniques. The fluid elements can be interconnected to perform complex logic functions and are highly reliable in the sense they do not wear out and require replacement as do conventional electrical components. While these advantages have been widely recognized, several problems have somewhat limited the use of such fluid elements. A relatively large volume source of fluid under pressure is required since fluid is continuously moving through the fluid jet amplifiers and exhausted during standby conditions. Also, fluid jet amplifiers are load sensitive devices and various vents must be provided adjacent the outlet ports so that such amplifiers are not capable of performing much work.

Briefly, this invention is concerned with the provision of highly improved fluid logic and actuator elements. The basic fluid element comprises a strip or tape of flexible material which is received in an elongated slot in a housing. One end portion of the tape is stationarily mounted or anchored with respect to the housing and the other end portion of the tape is free to move in the elongated slot. A cavity is formed in the housing adjacent one side of the slot and an actuating port communicates with the slot on the opposite side of the tape from the cavity. A pressure gradient is created between the actuating port and the bottom of the cavity whereby the portion of the tape overlying the cavity is forced into the cavity and the free end portion of the tape moves in the slot in the housing. The material forming the tape, its mounting and dimensions, in combination with the dimensions and shape of the cavity, are selected so that when the pressure gradient is removed the tape returns to its original position.

The free end portion of the tape of the fluid element can be provided with properly positoned apertures that cooperate with inlet and outlet ports in the housing. Various pairs of inlet and outlet ports representing different conditions are in communication with each other or blocked depending on whether the tape is in its actuated or initial at rest condition. A plurality of tapes can be arranged in a single housing in generally overlying relation. The apertures in the tapes are positioned or coded in a manner to provide for the accomplishment of relatively complicated logic functions, such as converting signals from one code to a different code.

The fluid element of the present invention also provides a transducing means for directly actuating mechanical elements in response to applied fluid signals. The movable free end portion of the tape is directly attached to a mechanical device to be moved. The mechanical device is actuated in response to the application of the pressure gradient across the tape which causes the same to move into the cavity in the housing.

It is the primary or ultimate object of the present invention to provide fluid elements capable of performing logic functions and/or serving as actuators for directly applying actuating forces to mechanical devices. The fluid elements each comprise a strip or tape of flexible material which is movable longitudinally in a slot in a housing in response to applied fluid signals. A cavity is formed in the housing adjacent the slot and the applied fluid signal forces the tape into the cavity to cause the longitudinal movement of the tape in the slot.

Another object of invention is the provision of a fluid element which is monostable and returns to its initial state when the fluid actuating signal is removed. The material, size and mounting of the tape are such that the tape automatically returns from the cavity in the housing to its initial flat condition when the fluid input signal is removed.

Yet another object of the invention is to provide a fluid element that can be readily combined with other generally similar fluid elements to perform complicated logic functions. In one illustrated embodiment of the invention, a plurality of the strips or tapes are arranged in overlying relation. Apertures corresponding to logic functions to be performed are provided in the movable ends of the strips for controlling the flow of fluid between various inlet and outlet ports.

Still another object of the invention is the provision of fluid elements capable of being interconnected to perform complicated logic functions wherein relatively low volume fluid supply means are required. The fluid elements are relatively fluid tight and fluid, other than normal leakage, is not continuously exhausted during standby operations as is the case with conventional fluid jet amplifiers.

A further object of this invention is the provision of a fluid element or transducer adapted to be directly connected to and actuate mechanical elements. The force-displacement curve associated with the actuator is such that a large force is available during the initial movement of the tape. This characteristic matches very closely the actuating requirements of a high mass load, such as the cycle clutch latch in a typewriter, for example.

Still a further object of the invention is to provide a logic element and/or actuator having the characteristics above described which is extremely simple in construction and operation. The elements are formed employing conventional plastic molding techniques at low cost. The fluid logic elements are highly reliable in operation and do not wear out as do analogous electrical components.

The foregoing and other objects and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention as illustrated in the accompanying drawings.

In the drawings:

FIGURE 1 is a side sectional view showing a fluid ele-

ment constructed and operated in accordance with the teachings of the present invention;

FIGURE 2 is a side sectional view showing the fluid element of FIGURE 1 in its actuated and transient state;

FIGURE 3 is a side sectional view of another fluid element embodying the teachings of this invention;

FIGURE 4 is a side sectional view of a decoding device illustrating the manner in which the fluid elements may be combined to perform complicated logic functions;

FIGURE 5 is a schematic chart in which the tapes employed in the decoding device of FIGURE 4 are laid out in side-by-side relation to better illustrate the cooperation of the tapes with each other in performing the decoding function;

FIGURE 6 is a side perspective view of a fluid element illustrating its use as a fluid-to-mechanical transducer for actuating a mechanical device; and

FIGURE 7 is a graph depicting the force versus displacement relationship for the tape of a fluid element during the actuation thereof.

Referring now to the drawings, and initially to FIGURES 1 and 2 thereof, the reference numeral **10** designates generally a fluid element embodying the teachings of this invention. The fluid element comprises a housing **11** of plastic or other similar material which is formed with an opening to provide a generally thin and rectangular elongated slot **12**. Received within the slot **12** is a flexible rectangular strip or tape **13** of plastic or metal, such as "Mylar" or strip steel for example. The tape **13** is anchored to the housing **11** at one end by bolt **14** or any other convenient means and its other end is free to move in the slot **12**.

Formed in the housing **11** adjacent the anchored end of the tape **13** is a generally U-shaped cavity **15** which communicates with the slot **12**. The bottom of the cavity **15** is exhausted to atmosphere by a pair of exhaust ports **16**. Provided in the housing **11** on the opposite side of the slot **12** and tape **13** from the cavity **15** is an actuating port **17** which is in communication with a valved source of fluid under pressure represented schematically at **18** in the drawings.

When fluid pressure is applied to actuating port **17**, a force is exerted on the surface of tape **13** adjacent the actuating port and a pressure gradient exists in a direction extending transversely of the tape. This pressure gradient immediately causes the tape to be deflected into and conform to the shape of the cavity **15** as is clearly shown in FIGURE 2 of the drawings. The cavity **15** has approximately the same width dimension as that of the portion of the tape **13** received within the cavity so that fluid leakage is maintained at a minimum during and does not markedly effect the speed of operation of the device. The free end portion **19** of the tape **13** moves through a linear distance corresponding directly to the length of tape required to conform to the bottom contour of the cavity **15**. The exhaust ports **16** prevent the entrapment of fluid and the build up of fluid pressure between the bottom of the cavity **15** and the tape **13** so that the tape moves very quickly and smoothly into the cavity.

The movement of the tape **13** into the cavity **15** is caused by a pressure gradient which extends transversely of the tape as explained above. It should be understood at the outset that the pressure gradient can be created in various ways, including applying a fluid input pulse to one side of the tape **13** while exhausting the cavity **15** as employed in connection with the illustrated embodiments of the invention. Alternately, the exhaust ports **16** can be normally blocked and fluid under pressure always supplied to the actuating port **17**. A condition of pressure equilibrium would then exist because of the nominal clearance between the edges of the tape and the cavity. The tape **13** would remain in its unactuated state until the exhaust ports **16** are opened to create the tape deflecting pressure gradient. Still another manner of providing the pressure gradient extending transversely of the tape **13** to deflect the same into the cavity is to apply vacuum to the exhaust ports **16**.

A highly important aspect of this invention is that the fluid element is a monostable device since it has a single stable state (the unactuated or initial state shown in FIGURE 1 of the drawings) and a transient unstable state (the actuated state shown in FIGURE 2 of the drawings) which exists only as long as an actuating pressure gradient extends transversely of the tape **13** to hold the same deflected in the cavity **15**. As soon as the source of fluid under pressure **18** is effectively disconnected from the actuating port **17**, the tape **13** automatically returns to its initial and flat condition without external assistance of any kind.

Experiments have shown that if the fluid element is properly designed and the tape correctly mounted, there is sufficient energy stored in the deformed portion of the tape tending to straighten the tape which overcomes its mass, the frictional forces acting thereon and any other fluid forces acting thereon when the free end portion of the tape is used as a valving element. In several successfully operating constructed embodiments of the invention, the tape employed was a piece of "Mylar" plastic having a thickness of three mils and a width of .312 of an inch. The cavity was approximately .80 of an inch long and .165 of an inch deep at its deepest point. The thickness of the tape is selected so that the time required for the tape to automatically return to its initial and stable state is approximately the same as the time required to deflect the tape into the cavity. As a general rule, when the thickness is increased, the resetting action occurs at a faster rate. Thus, the design of the thickness of the tape provides a means for controlling the automatic resetting of the fluid element. Fluid elements having the dimensions set forth above are actuated and automatically reset within time intervals in the range of three to six milliseconds.

Critical aspects of the design of a fluid element are the thickness dimension and mounting of the tape considering the use projected for the fluid element, the material forming the tape and its other dimensions and the size and shape of the cavity. It has been found that if the tape is rigidly attached to the housing at both ends and the tape has a relatively thin thickness dimension, automatic resetting will not occur. This has resulted in the development of various fluid elements employing tapes which have at least two stable states and are bistable. Such devices are disclosed and more information concerning their design and operation is contained in my co-pending patent applications Ser. Nos. 420,928 and 429,929, entitled "Bistable Fluid Logic Element" and "Fluid Display and Converter Device," both filed concurrently with this application and both assigned to the assignee of the present invention. The latter application issued as Patent No. 3,263,922 on Aug. 2, 1966.

The fluid element can be employed in a wide variety of applications, such as a logic element and/or an actuator for a mechanical device. The free end portion **19** of the tape **13** is provided with an aperture **20**. Also, the housing **11** has an inlet port **21** which is connected with a source of fluid under pressure **22** and an outlet port **23** leading to a fluid sensitive device, not particularly shown. When the fluid device is in its unactuated and stable state, the aperture **20** in the movable end portion **19** of the tape is not aligned with inlet and outlet ports **21** and **23**. These ports are effectively blocked and no fluid under pressure is directed to the fluid sensitive device connected to outlet port **23**. However, when the valved source of fluid under pressure **18** is actuated and the tape **13** is forced into the cavity **15**, the aperture **20** in the free end portion of the tape move into alignment with inlet and outlet ports **21** and **23**. Fluid under pressure is supplied to the fluid sensitive device as is illustrated in FIGURE 2 of the drawings. The aperture **20** preferably has a shape which permits the greatest fluid flow in the shortest length of

tape, such as an elongated slot extending transversely across the surface of the tape.

Experiments have shown that the fluid element of this invention is generally fluid tight and a minimum of leakage occurs when the tape is employed as a valving element. This is an important advantage in many applications since fluid is not continuously flowing through and being exhausted in both states of the fluid element as is the case with other fluid logic elements, such as fluid jet amplifiers. This permits the pumps or other means defining the sources of fluid under pressure to be of substantially reduced size and capacity compared to those required for use with prior art fluid logic elements when performing the same functions or accomplishing the same results.

It should be apparent that the use of the movable end portion **19** of the tape **13** as a valving member can take various forms. The aperture **20** can be positioned so the inlet and outlet ports **21** and **23** are in communication when the fluid element is in its unactuated and stable state. In this event fluid is blocked from the fluid sensitive output device only during the transient state of the fluid element when the tape **13** is maintained in the cavity **15**. More than a single pair of inlet and outlet ports can be formed in the housing and more than one valving aperture can be provided in the movable end portion of the tape as required to perform complicated valving functions, such as opening a plurality of fluid circuits while concurrently closing other fluid circuits. This makes the fluid elements of the present invention particularly useful in performing logic operations in parallel since many fluid channels can be controlled by a single tape.

Another monostable fluid element is shown in FIGURE 3 of the drawings. This device has a plurality of transient stable states and can be employed to perform more complicated valving functions. A housing **30** has a slot **31** formed therein which slidably receives a tape **32** of strong and flexible material. The tape is anchored at one end in the housing by bolt **33** and has a pair of spaced valving apertures **34** and **35** in the movable end portion of the tape. The housing has a pair of generally U-shaped cavities **36** and **37** formed therein in series relation adjacent the slot **31**. These cavities have the same size in that each will receive the same length of tape when the same is deflected. Actuating ports **38** and **39** are provided in the housing and are connected to the individually actuatable valved sources of fluid under pressure **40** and **41**. Spaced pairs of inlet and outlet ports **42** and **43** are also formed in the housing **30** and the inlet ports are connected to a source of fluid under pressure **44** while the outlet ports lead to pressure sensitive output devices, not shown.

In the unactuated and stable state of the fluid element as shown in FIGURE 3 of the drawings, the apertures **34** and **35** are not aligned with pairs of inlet and outlet ports **42** and **43**. If fluid under pressure is applied to either of the actuating ports **38** or **39**, the tape **32** is forced into the corresponding one of the cavities **36** or **37** and the aperture **34** in the movable end of the tape moves into alignment with the pair of ports **42**. At this time the tape **32** has not moved sufficiently to cause aperture **35** to become aligned with the pair of inlet and outlet ports **43** and these ports remain blocked. This operation corresponds to the logical "exclusive OR" function in that either of two inputs, but not both, will provide a particular type of output. If at any time fluid under pressure is simultaneously applied to the actuating ports **38** and **39**, the tape **32** is moved into both of the cavities **36** and **37** so that the aperture **34** moves to the left past the pair of ports **42** while the aperture **35** moves into aligned relation with the pair of ports **43**. This defines a second transient state which provides an output when all of a number of input signals are present and corresponds generally to the logical "AND" condition. Regardless of the combination of fluid input signals applied to the input ports **38** and **39** and the type of output signals produced, the tape **32** returns to its initial flat condition and the fluid element is in its unactuated stable state when all of the input signals are removed as is the condition represented in FIGURE 3 of the drawings. While a series of two cavities **36** and **37** have been described in connection with this embodiment of the invention, it should be understood that three or more cavities could be employed depending on the results required for any given application.

Any number of the basic fluid elements described above can be combined in almost unlimited fashion to perform complicated logic functions. An example of this is shown in FIGURES 4 and 5 of the drawings wherein a binary to decimal converter is illustrated. The converter comprises a housing **50** having spaced upper and lower walls **51** and **52**. The walls are provided with ten pairs of vertically aligned and spaced inlet and outlet apertures **53** and **54**. The outlet apertures **54** represent the ten integers of the decimal system and are connected with fluid sensitive devices, not shown, while fluid under pressure is supplied to the inlet apertures from source **55**. Between the upper and lower walls **51** and **52** of the housing are formed five slots **56** which receive the five tapes **57–61**. The tape **57** is a gating tape while tapes **58–61** correspond to the first four orders of the binary numbering system. A plurality of valving and coding apertures **62** and **63**, respectively, are provided in the tapes **58–61** while interconnecting passageways **64** are formed in the housing **50**.

The over-all operation of the binary to decimal converter is that fluid signals corresponding to the binary representations of a number to be converted are supplied to appropriate ones of the actuating ports **65–68**. The corresponding ones of the tapes **58–61** are forced into their associated cavities **69–72**. After the selected binary tapes have been set, a fluid gating signal is applied to actuating port **73** and gating tape **57** is moved due to its deflection into cavity **74**. The positioning of the valving and coding apertures **62** and **53** in the tapes is such that a fluid passageway exists between the inlet and outlet apertures **53** and **54** corresponding to the decimal equivalent of the binary fluid input signals. A fluid output signal is passed to the appropriate pressure sensitive output device to complete the conversion operation. When the gating and binary fluid input signals are removed from the selected actuating ports **65–68** and **73**, the tapes **57–61** automatically return to their initial unactuated states without the use of resetting means of any kind.

The arrangement of the valving and coding apertures **62** and **63** in the tapes **58–61** is shown schematically in FIGURE 5 of the drawings. The symbol X indicates a valving aperture **62** in a tape which moves into fluid passing alignment with the associated pair of inlet and outlet apertures **53** and **54** when the tape is deflected into its cavity. The symbol O designates a coding aperture in a tape which moves from alignment with the associated pair of inlet and outlet apertures **53** and **54** when the tape is moved to its transient state in response to an applied fluid signal. For those desiring a complete description of the mathematical basis of the positioning of the valving and coding apertures **62** and **63** in the tapes, reference is made to U.S. Patent 2,904,070, issued Sept. 15, 1959, entitled, "Multi-Port Selector," and assigned to the assignee of this invention. The binary to decimal converter can be expanded to convert binary numbers greater than ten by the provision of more tapes, additional coding and valving apertures in the tapes and more pairs of inlet and outlet apertures. It should be clearly understood that the binary to decimal converted shown in FIGURES 4 and 5 of the drawings is intended to be representative only of a wide variety of complicated logic functions which can be accomplished when the fluid elements of this invention are employed. For example, a two dimensional switching matrix is easily fabricated where two groups of tapes with

appropriate valving apertures therein are disposed in overlying relation at right angles with respect to each other. Coincident energization or deflection of a tape from each of the tape groups is required to obtain an output fluid pulse as will be understood by those skilled in the art.

The fluid element can be used as a transducer for converting a fluid input signal into a mechanical movement which is employed to actuate a mechanical element. This is shown in FIGURE 6 of the drawings where a housing **70** is formed with an elongated slot **71**. Received within the slot **71** is a rectangular tape **72** whose one end is anchored to the housing by bolt **73** while its free end portion **74** extends from the housing and is connected directly to the mechanical element to be actuated. In the illustrated embodiment, the mechanical element is a latch **75** employed to hold a cycle clutch **76** of a typewriter in its unactuated condition. When the latch **75** is moved, the cycle clutch **76** is released and engages so that the typewriter is driven through a printing cycle. At the end of the cycle, the latch **75** re-engages and the apparatus is again ready to be actuated in response to a fluid input signal.

Formed in the housing **70** adjacent the anchored end of the tape **72** is a cavity **77** whose lower end is completely open and exhausted to atmosphere. The upper edges **78** of the cavity **77** are rounded or contoured to assist in the deflection of the tape into the cavity. An actuating port **79** is provided in the housing at a point opposite the cavity and is in communication with a valved source of fluid under pressure **80**. The bottom of the cavity **77** is completely open rather than contoured as are the cavities shown in the other embodiments of the invention since it is only necessary to move the latch **75** a predetermined distance to initiate a cycle of operation. In the other embodiments where coding and valving apertures are provided in the free end portions of the tapes, it is desirable to accurately control the extent of movement of the tapes in order that the valving operations are properly performed. The rounded upper edges of the cavities employed in all of the examples have been found to be of particular value and assistance in causing the tapes to quickly move into the cavities in a smooth manner when fluid actuating signals are applied.

A representative force-displacement curve **81** for a tape of a fluid element is depicted in FIGURE 7 of the drawings. The force or pull exerted by the tape is greatest during its initial movement and then decreases smoothly as the displacement increases. This is particularly useful when actuating a mechanical element having a large mass and a force-displacement curve like that shown at **82**, such as cycle clutch latch **75**. The high initial force enables the latch **75** to be accelerated rapidly from rest and as the velocity of the latch increases the available force decreases. More force is available for use in actuating a mechanical element than is required to operate or move the tape initially and in this sense the fluid element is a force amplifier. For example, if a force F represented at **83** on the graph of FIGURE 7 of the drawing is required to deflect the tape into the cavity, a higher force is exerted by the tape until a displacement D as indicated at **84** has occurred. This is explained by the fact that large movements of the tape do not occur until it has been deflected a considerable distance into the cavity. When the source of fluid under pressure **80** is actuated to remove fluid under pressure from the actuating port **79**, the tape **72** returns to its initial flat condition and returns the latch **75** to its original position. If desired, a spring **85** can be incorporated to assist in the return movement of the tape and the latch.

It should now be apparent that the objects initially set forth have been accomplished. Of particular importance is the provision of fluid elements each having a single stable state which are capable of being used as actuators and of performing various and complicated logic functions. The fluid elements are fast acting and characterized by their extreme simplicity in construction and operation. They can be manufactured at low cost using conventional plastic molding techniques and are highly reliable. The devices are monostable and automatically reset themselves so that complicated resetting arrangements are not required. Further, the fluid elements are relatively fluid tight and fluid is not continuously exhausted and flowing through a logic system during standby conditions as is the case with fluid jet amplifiers.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A fluid element comprising:
a housing having an elongated slot therein;
an elongated tape of flexible material movably received in said slot;
means stationarily anchoring one end of said tape relative to said housing;
at least one actuating cavity formed in said housing adjacent said slot for receiving said tape;
a source of input signals;
output means carried by a movable portion of said tape spaced from said cavity; and
means responsive to the input signals for creating a pressure gradient extending transversely of said tape for deflecting the same into said actuating cavity and causing movement of said tape in said slot to shorten the overall effective length thereof and to move said output means.

2. Apparatus according to claim **1** further characterized by:
said tape being relatively stiff and resilient; and
said tape, actuating cavity and slot being designed and formed of materials so that said tape automatically returns to its initial position from said actuating cavity when said transversely extending pressure gradient is removed.

3. Apparatus according to claim **1** further characterized by:
said ouput means comprises valving means carried by a movable portion of said tape;
conduit means for transferring energy disposed adjacent said movable portion of said tape; and
said valving means cooperating with said conduit means when said tape is in one of its positions.

4. Apparatus according to claim **1** further characterized by:
said output means comprises a valving aperture formed in a movable portion of said tape;
a pair of inlet and outlet ports formed in said housing on opposite sides of said slot and communicating therewith; and
said valving aperture interconnecting said pair of inlet and outlet ports when said tape is in one of its positions.

5. Apparatus according to claim **1** further characterized by:
said cource of input signals comprises a source of fluid under pressure; and
said means responsive to said input signals comprises an actuating port formed in said housing and communicating with said slot adjacent to and on the opposite side of said tape from said actuating cavity.

6. Apparatus according to claim **1** further characterized by:
said actuating cavity being U-shaped in cross sectional shape.

7. A fluid element comprising:
a housing having an elongated slot therein;
an elongated tape of flexible material movably received in said slot;

means stationarily anchoring one end of said tape relative to said housing;

an actuating cavity formed in said housing adjacent said means for anchoring and communicating with said slot;

a source of fluid input signals;

means responsive to said fluid input signals comprising an actuating port in said housing communicating with said slot adajcent to and on the opposite side of said tape from said actuating cavity for creating a pressure gradient extending transversely of said tape for deflecting the same into said actuating cavity to shorten the overall effective length of said tape;

valving means carried by a movable portion of said tape spaced from said cavity;

conduit means for transferring energy disposed adjacent said movable portion of said tape; and

said valving means cooperating with said conduit means when said tape is in at least one of its positions.

8. Apparatus according to claim **7** further characterized by:

said valving means comprises a valving aperture in said movable portion of said tape spaced from said cavity; and

said conduit means comprises a pair of inlet and outlet ports formed in said housing and communicating with said slot.

9. Apparatus according to claim **7** further characterized by:

said means responsive to said fluid input signals comprises an exhaust port communicating with the bottom of said actuating cavity.

10. Apparatus according to claim **7** further characterized by:

said tape being relatively stiff and resilient; and

said tape, actuating cavity and slot being designed and formed of materials so that the tape automatically returns to its initial position from said actuating cavity when said transversely extending pressure gradient is removed.

11. A fluid element comprising:

a housing having an elongated slot therein;

an elongated tape of flexible material movably received in said slot;

means stationarily anchoring one end of said tape relative to said housing;

an actuating cavity formed in said housing adjacent said means for anchoring and communicating with said slot;

a source of fluid input signals;

means responsive to said fluid input signals comprising an actuating port in said housing communicating with said slot adjacent to and on the opposite side of said tape from said actuating cavity for creating a pressure gradient extending transversely of said tape for deflecting the same into said actuating cavity to shorten the overall effective length of said tape;

output means carried by a movable portion of said tape spaced from said cavity;

sensing means disposed adjacent said movable portion of said tape for detemining the presence or absence of said output means;

said output means being in sensing relation with said sensing means when said tape is in at least one of its positions.

12. A fluid element comprising:

a housing having an elongated slot therein;

an elongated tape of flexible material movably received in said slot;

means stationarily anchoring one end of said tape relative to said housing;

a plurality of actuating cavities formed in said housing disposed adjacent said slot for receiving portions of said tape;

a source of input signals associated with said cavities;

output means carried by a movable portion of said tape spaced from said cavity; and

means responsive to the input signals for creating pressure gradients extending transversely of said tape for deflecting the same into selected ones of said actuating cavities and causing movement of said tape in said slot to shorten the overall effective length of said tape and to move said output means.

13. Apparatus according to claim **12** further characterized by:

said plurality of actuating cavities being positioned adjacent said means for anchoring in longitudinally aligned series relation along said slot.

14. Apparatus according to claim **12** further characterized by:

at least two of said plurality actuating cavities being the same size.

15. Apparatus according to claim **12** further characterized by:

all of said plurality of actuating cavities being the same size.

16. Apparatus according to claim **12** further characterized by;

said tape being relatively stiff and resilient; and

said tape, plurality of actuating cavities and slot being designed and formed of materials so that said tape automatically returns from at least one of said actuating cavities when the transversely extending pressure gradient associated with said one of said actuating cavities is removed.

17. A fluid element comprising:

a housing having an elongated slot therein;

an elongated tape of flexible material movably received in said slot;

means stationarily mounting one end of said tape relative to said housing;

a plurality of actuating cavities formed in said housing adjacent said slot for receiving portions of said tape;

a source of input signals associated with said actuating cavities;

means responsive to the input signals for creating pressure gradients extending transversely of said tape for deflecting the same into selected ones of said actuating cavities and causing movement of said tape in said slot to a plurality of positions to shorten the overall effective length of said tape;

valving means carried by a movable portion of said tape spaced from said cavities;

conduit means for transferring energy disposed adjacent said movable portion of said tape; and

said valving means cooperating with said conduit means when said tape is in at least one of said positions.

18. A fluid element comprising:

a housing having an elongated slot therein;

an elongated tape of flexible material movably received in said slot;

means stationarily mounting one end of said tape relative to said housing;

a plurality of actuating cavities formed in said housing adjacent said slot for receiving portions of said tape;

a source of input signals associated with said actuating cavities;

means responsive to the input signals for creating pressure gradients extending transversely of said tape for deflecting the same into selected ones of said actuating cavities and causing movement of said tape in said slot to a plurality of positions to shorten the overall effective length of said tape;

output means carried by a movable portion of said tape spaced from said cavities;

sensing means disposed adjacent said movable portion of said tape for determining the presence or absence of said output means; and

said output means being in sensing relation with said

sensing means when said tape is in at least one of said positions.

19. A fluid element comprising:
a housing having an elongated slot therein;
an elongated tape of flexible material movably received in said slot;
means stationarily mounting one end of said tape relative to said housing;
a pair of actuating cavities formed in said housing adjacent said slot for receiving portions of said tape;
a source of input signals associated with said actuating cavities;
means responsive to the input signals for creating pressure gradients extending transversely of said tape for deflecting the same into selected ones of said pair of actuating cavities and causing movement of the tape in said slot to a pair of positions to shorten the overall effective length of said tape;
valving means carried by a movable portion of said tape spaced from said cavities;
conduit means for transferring energy disposed adjacent said movable portion of said tape; and
said valving means co-operating with said conduit means when said tape is in at least one of said pair of positions.

20. Apparatus according to claim 19 further characterized by:
said valving means co-operating with said conduit means when said tape is deflected in either but not both of said pair of actuating cavities.

21. Apparatus according to claim 19 further characterized by:
said valving means cooperating with said conduit means when said tape is deflected into both of said pair of actuating cavities.

22. A fluid element comprising:
a housing having a plurality of elongated slots therein;
a plurality of elongated tapes of flexible material movably received in said slots;
means stationarily anchoring one end of each of said tapes relative to said housing;
at least one actuating cavity formed in said housing and disposed adjacent each of said slots for receiving a portion of the associated tape to shorten the overall effective length of said associated tape;
a source of input signals;
output means carried by a movable portion of each of said tapes spaced from the actuating cavity associated therewith; and
means responsive to the input signals for creating pressure gradients extending transversely of said tapes for deflecting selected ones of said tapes into their associated actuating cavities to move the corresponding ones of said output means.

23. Apparatus according to claim 22 further characterized by:
said output means comprises valving means carried by movable portions of said tapes;
conduit means for transferring energy disposed adjacent said movable portions of said tape; and
said valving means permitting the transfer of energy via said conduit means when a selected pair of said tapes are deflected into their associated actuating cavities.

24. A fluid element comprising:
a plurality of elongated flexible tapes;
each of said tapes being movably received in a slot;
means stationarily anchoring one end of each of said tapes;

an actuating cavity disposed adjacent each slot for receiving a portion of the associated tape;
a source of input signals;
means responsive to the input signals for deflecting selected ones of said tapes into their associated actuating cavities to shorten the overall effective lengths of said selected ones of said tapes;
each of said tapes carrying valving means on a movable portion thereof spaced from the associated actuating cavity;
a plurality of conduit means for transferring energy disposed adjacent the movable portions of said tapes; and
said conduit means transferring energy in a manner corresponding to the deflection of said tapes into said actuating cavities in response to said input signals.

25. Apparatus according to claim 24 further characterized by:
at least one of said tapes being relatively stiff and resilient; and
said one of said tapes and its associated actuating cavity being designed so that this tape automatically returns from said associated actuating cavity to its initial position when said means responsive is not operative to deflect this tape.

26. A fluid element comprising:
a housing having an elongated slot therein;
an elongated tape of flexible material movably received in said slot;
means stationarily anchoring one end of said tape relative to said housing;
an actuating cavity formed in said housing adjacent said slot for receiving portions of said tape;
a mechanical element to be moved;
means for connecting the other end of said tape to said mechanical element;
a source of input signals; and
means responsive to the input signals for creating a pressure gradient extending transversely of said tape for deflecting the same into said actuating cavity and causing movement of said tape in said slot to shorten the overall effective length of said tape and movement of said mechanical element.

27. Apparatus according to claim 26 further characterized by:
said source of input signals comprises a source of fluid under pressure; and
said means responsive to said input signals comprises an actuating port in said housing adjacent to and disposed on the opposite side of said tape from said actuating cavity.

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