United States Patent

[11] **3,633,392**

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[21] Appl. No. **7,167**
[22] Filed **Jan. 30, 1970**
[45] Patented **Jan. 11, 1972**
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[54] **FLUIDIC COMBINATION LOCK**
14 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** ..... **70/275,** 137/81.5, 235/201 PF
[51] **Int. Cl.** **E05b 51/02;** F15c 1/12
[50] **Field of Search** ..... 70/262, 263, 275; 137/81.5; 235/201 FS, 201 PF

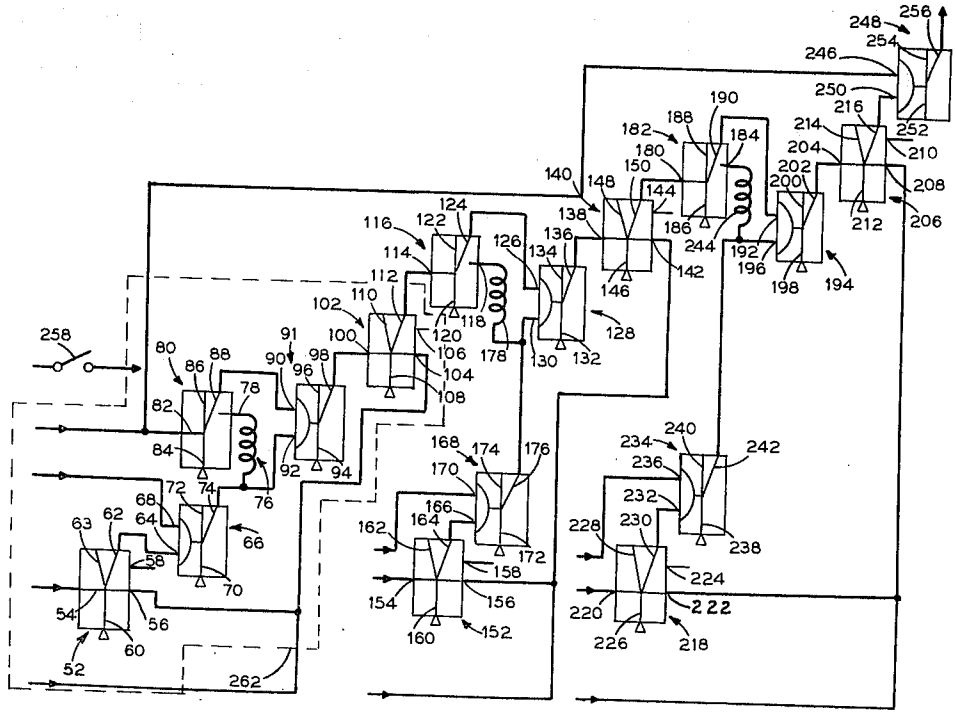
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ABSTRACT: This invention relates to a fluidic device for determining the occurrence of a predetermined sequence of digits of a rotatable dial and the direction of rotation of the dial to control selectively the operation of a lock on a door.



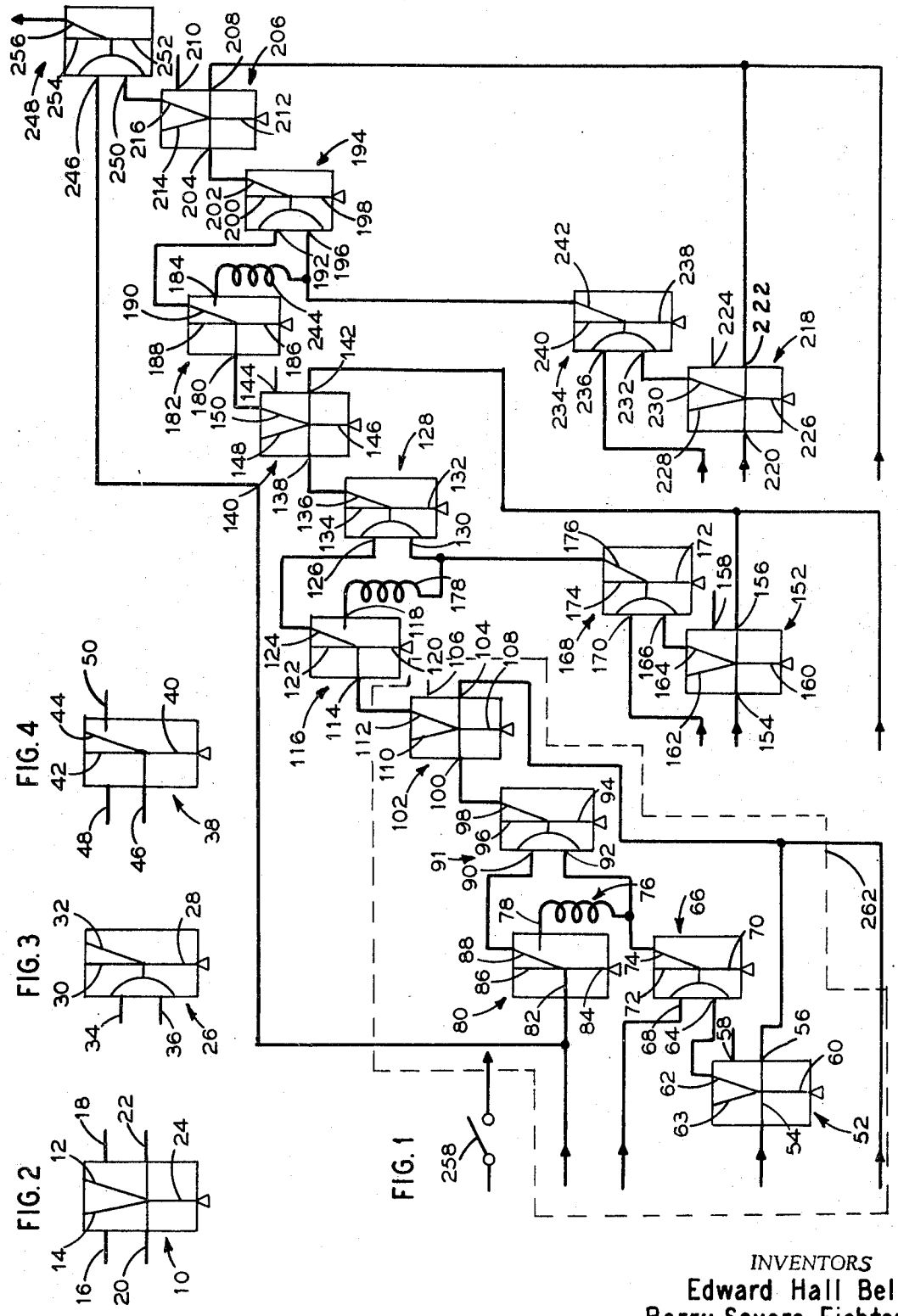


FIG. 1

FIG. 2

FIG. 3

FIG. 4

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FLUIDIC COMBINATION LOCK

This invention relates generally to a fluid device requiring no moving mechanical parts for the operation thereof and, more particularly, relates to a method and apparatus of using fluid logic elements to control selectively the operation of a combination lock.

The term fluidics refers to the use of interacting fluid flows to perform switching and logic operations. Fluidic devices and which have no moving parts other than the moving streams of fluid are capable of performing logical operation in a manner similar to the manner that such logical operations are performed by electronic components. Initially, devices which controlled high-energy fluid streams by means of low-energy fluid streams were developed and referred to by the term fluid amplifiers. Fluid amplifiers can be of the momentum or stream interaction type of amplifier, or of the boundary layer type of amplifier. In the stream interaction or momentum interchange amplifier, a power nozzle feeds a stream of fluid into an interaction area or chamber. A control nozzle feeds and directs a stream of control fluid to impinge upon and deflect the power stream away from its normal path.

There is a conservation of momentums between the two streams and, therefore, the power stream is deflected when impinged upon by the control fluid stream from its original direction of flow through an angle which is a function of the momentum of the power stream and the momentum of the control stream. Thus, a low-energy stream of control fluid can be utilized to urge a high-energy stream of power fluid toward or away from a desired area or receiving aperture system to constitute an amplification. Thus, in an analog amplifier, the delivery of energy by a high-energy power stream of fluid to an outlet orifice or utilization device is controlled by a low-energy control flow of fluid.

In addition to fluid amplifiers, other fluid devices have been developed which, because of their apparent similarities to well known electronic devices are called fluidic oscillators, fluidic multivibrators, fluidic AND gates, fluidic OR gates, fluidic NOR gates, fluidic flip-flops and the like.

The advantages of fluid devices over their equivalent electronic elements is well known. For example, fluid devices require no moving parts, are not subject to being burned out, are not subject to external influences, are easier and more economical to construct, require a very minimum of servicing for repair or replacement and are capable of operating under virtually all extreme environmental conditions such as temperature and vibration.

It is an object of the present invention to provide a new method and apparatus for selectively controlling the operation of a combination lock.

It is also an object of this invention to provide a combination lock controlled selectively by a fluid network.

It is another object of this invention to provide a combination lock that will not open when the fluid control network is destroyed.

It is still another object of this invention to provide a fluidic combination lock that is economical to build and reliable in operation.

These and further objects and advantages of the present invention are achieved, in general, through the use of fluidic logic components coupled to detect the occurrence of a predetermined sequence of events such as the direction of rotation and positioning of a dial to a predetermined combination of numbers to control the operation of a locking means.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawing wherein:

FIG. 1 is schematic of structure in accordance with the principles of this invention;

FIG. 2 is an illustration of a fluidic flip-flop used as a component of the schematic of FIG. 1;

FIG. 3 is an illustration of a fluidic AND gates used as a component of the schematic of FIG. 1; and

FIG. 4 is an illustration of a fluidic inhibited OR gate used as a component of the block diagram of FIG. 1.

Referring now to FIG. 2, there is illustrated a fluidic flip-flop **10** having output channels **12**, **14**, control channels **16**, **18**, **20**, **22**, and power input channel **24**. Application of a power fluid stream to the power input channel **24** causes the power fluid stream to pass through either output channel **12** or **14** depending upon the symmetry of the flip-flop **10**. If, for example, the power stream is passing through and emerging from the output channel **14** and a control input such as a fluid pulse is applied to either of the control channels **16** or **20**, the power stream will be switched from the output channel **14** to the output channel **12** and will continue to pass through output channel **12** even after the control input pulse at the channel **16** or **20** has stopped. This is due to the well known "Coanda" effect whereby the power stream is attached to the sidewall of the particular channel in which it happens to be. The power stream is caused to unlock only by the application of a control pulse of sufficient magnitude.

The operation of the fluidic flip-flop **10** is as follows: assume that the flip-flop is in its initial state, that is, with a power stream being supplied to the channel **24** and each of the control channels being in their "**0**" state. In this condition it will be assumed that the zero output channel **12**, of the flip-flop receives and passes the power stream. Continuing, if a control stream is now fed to control channel **16** or **20**, the power stream will pass through channel **12**. If a control stream is fed to control channel **18** or **22**, the power stream will pass through channel **14**. If the power stream is passing through channel **12**, it will continue to do so, even without the presence of any control signals, until a control signal is fed to control channel **18** or **22**. In a similar manner, if the power stream is passing through channel **14**, it will continue to do so, even without the presence of any control signals, until a control signal is fed to control channel **16** or **20**.

Referring now to the AND-gate **26**, there is a power input channel **28**, power output channels **30**, **32**, and input control channels **34**, **36**. The power output channel **32** is the AND output channel and the power output channel **30** is the AND output channel. In operation, the presence of a control stream simultaneously in both of the control channels **34**, **36** will cause the power stream to pass from the power input channel **28** to and through the power output channel **32**. Under all other instances the power stream will be directed through the power output channel **30**. Thus, the absence of a control stream on either or both of the control channels **34**, **36** will cause the power stream to pass through the power output channel **30**.

Referring now to the inhibited OR-gate **38**, there is a power input channel **40**, power output channel **42**, **44**, and input control channels **46**, **48** and **50**. In operation, a power stream is fed to the power input channel **40**. Now, assuming the various combination of applications of control streams to the various input control channels, the absence of a control stream in channels **46**, **48** and **50** will cause the power stream to pass through power output channel **42**; the presence of a control stream in input control channel **48** only will cause the power stream to pass through power output channel **44**; the presence of a control stream in input control channel **46** only will cause the power stream to pass through power output channel **44**; the presence of control stream in input control channels **46** and **48** only will cause the power stream to pass through power output channel **44**; the presence of a control stream in input control channels **48** and **50** only will cause the power stream to pass through power output channel **42**; and, the presence of a control stream in each of the input control channels **46**, **48** and **50** will cause the power stream to pass through power output channel **42**.

Referring now to FIG. 1, there is illustrated a schematic of structure in accordance with the principles of this invention. A fluidic flip-flop **52** supports control stream channels **54**, **56**,

58; power stream input channel 60; and power stream output channels 62, 64. Power stream output channel 62 is connected to feed a control stream channel 64 of fluidic AND-gate 66 having control stream channel 68, power stream input channel 70; and a power stream output channels 72, 74.

Power stream output channel 74 is coupled to feed, through a fluid time delay (which can take the form of a coil) 76 the control stream channel 78 of an OR-gate 80 having control stream channel 82, power stream input channel 84, and power stream output channels 86, 88.

The power stream output channel 88 is coupled to feed a control stream channel 90 of a fluidic AND-gate 91 having a control stream channel 92, a power stream input channel 94, and power stream output channels 96, 98.

The control stream channel 92 is coupled to the power stream output channel 74 of fluidic AND-gate 66.

The power stream output channel 98 of fluidic AND-gate 91 is coupled to feed a control stream input channel 100 of a fluidic flip-flop 102 having control stream input channels 104, 106; power stream input channel 108; and power stream output channels 110, 112.

Control stream input channel 56 of fluidic flip-flop 52 is coupled to control stream input channel 104 of fluidic flip-flop 102. Power stream output channel 112 of fluidic flip-flop 102 is coupled to feed control stream input channel 114 of fluidic inhibited OR-gate 116 having control stream input channel 118; power stream input channel 120, and, power stream output channels 122, 124.

Power stream output channel 124 is coupled to feed control stream input channel 126 of fluidic AND-gate 128 having control stream input channel 130, power stream input channel 132, and power stream output channels 134, 136.

Power stream output channel 136 of fluidic AND-gate 128 is coupled to feed control steam input channel 138 of fluidic flip-flop 140 having control stream input channels 142, 144; power stream input channel 146, and power stream output channels 148, 150.

A fluidic flip-flop 152 supports control stream input channels 154, 156, 158; power stream input channel 160; and, power stream output channels 162, 164. Power stream output channel 164 is coupled to a control stream input channel 166 of fluidic AND-gate 168 which supports channel 172; and, power stream output channels 174, 176.

Power stream output channels 176 is coupled through a fluid time delay 178 to control stream input channel 118 of fluidic inhibited OR-gate 116; and directly to control stream input channel 156 of fluidic flip-flop 152 is coupled to control stream input channel 142 of fluidic flip-flop 140.

Power stream output channel 150 of fluidic flip-flop 140 is coupled to feed control stream input channel 180 of fluidic inhibited OR-gate 182 having control stream input channel 184, power stream input channel 186, and power stream output channels 188, 190.

Power stream output channel 190 is coupled to feed control stream input channel 192 of fluidic AND-gate 194 having control stream input channel 184, power stream input channel 186, and power stream channels 188, 190.

Power stream output channel 190 is coupled to feed control stream input channel 192 of fluidic AND-gate 194 having control stream input channel 196, power stream input channel 198; and power stream output channel 200, 202.

Power stream output channel 202 is coupled to feed control stream input channel 204 of fluidic flip-flop 206 having control stream input channels 208, 210; power stream input channel 212, and power stream output channels 214, 216.

A fluidic flip-flop 218 supports control stream input channels 220, 222, 224; power stream input channel 226, and power stream output channels 228, 230. Power stream output channel 230 is coupled to feed control stream input channel 232 of fluidic AND-gate 234 having control stream input channel 236, power stream input channel 238; and power stream output channels 240, 242.

Power stream output channel 242 is coupled to feed control stream input channel 184 of fluidic OR-gate 182 through a fluid time delay 244, and to feed directly the control stream input channel 196 of the fluidic AND-gate 194.

The control stream input channel 222 of the fluidic flip-flop 218 is coupled to the control stream input channel 208 of the fluidic flip-flop 206.

The control stream input channel 82 of the fluidic OR-gate 80 is coupled to an input channel 246 of a fluidic AND-gate 248 having a control stream input channel 250, a power stream input channel 252, and power stream output terminal 254, 256.

The power stream output terminal 256 of the fluidic AND-gate 248 is coupled to activate a door lock release which can be either of the mechanical or electrical type.

A stream of fluid such as air is fed through a lock switch 258 which selectively controls the flow of fluid to the control stream input channels 58 of fluidic flip-flop 52, the channel 106 of fluidic flip-flop 102, the channel 158 of fluidic flip-flop 152, the channel 144 of fluidic flip-flop 140, the channel 224 of fluidic flip-flop 218, and the channel 210 of the fluidic flip-flop 206. A stream of fluid referred to as the timer is fed to the channel 82 of the fluidic inhibited OR-gate 80 and to the channel 246 of the fluid AND-gate 248.

In the operation of this invention it shall be assumed that the rotatable dial of a combination lock is constructed to provide a stream of fluid for each of the various numbers on the dial, and that the stream of fluid representative of predetermined numbers is fed to the network of FIG. 1, the network of FIG. 1 having been designed to provide a fluid flow at the channel 256 of the fluidic AND-gate 248 when the dial is oriented through the preselected combination.

The control stream input channel 68 of the fluidic AND-gate 66 is coupled to receive a flow of fluid when the dial of the combination lock is positioned on the number 3; the control stream input channel 54 of the fluidic flip-flop 52 is coupled to receive a flow of fluid when the dial of the combination lock is positioned on the number 4; the control stream input channel 56 of the fluidic flip-flop 52 is coupled to receive a flow of fluid when the dial of the combination lock is positioned on the number 2; the control stream input channel 170 of the fluidic AND-gate 168 is coupled to receive a flow of fluid when the dial of the combination lock is positioned on the number 6; the control stream input channel 154 of the fluidic flip-flop 152 is coupled to receive a flow of fluid when the dial of the combination lock is positioned on the number 5; the control stream input channel 156 of the fluidic flip-flop 152 is coupled to receive a flow of fluid when the dial of the combination lock is positioned on the number 7; the control stream input channel 236 of the fluidic AND-gate 234 is coupled to receive a flow of fluid when the dial of the combination lock is positioned on the number 9; the control stream input channel 220 of the fluidic flip-flop 218 is coupled to receive a flow of fluid when the dial of the combination lock is positioned on the number 0; and, the control stream input channel 222 of the fluidic flip-flop 218 is coupled to receive a flow of fluid when the dial of the combination lock is positioned on the number 8.

The network of FIG. 1 provides an output flow of fluid from the channel 256 of the fluidic AND-gate 248 when the following sequence of events occurs:

a. Lock switch 258 is turned off;
b. Timer is turned on;
c. Digit 4 then digit 3 is obtained on the dial. It is to be noted that with a dial this procedure would be used to determine the direction of rotation of the dial.
d. Digit 5 and then digit 6 is obtained;
e. Digit 0 and then digit 9 is obtained; and
f. The timer must continue to run during the entire coding sequence.

The lock switch 258 resets and holds in the reset position all of the fluidic flip-flops of the network to inhibit or prevent any coding sequence from becoming valid. When a flow of fluid

which indicates the occurrence of the digit 4 is obtained at channel 54 of the fluidic flip-flop 52, an output is obtained at the channel 62 of fluidic flip-flop 52 which is fed to the input channel 64 of fluidic AND-gate 66. When a flow of fluid which indicates the occurrence of the digit 3 at the channel 68 of fluidic AND-gate 66, fluidic AND-gate 66 will switch to provide an output at channel 74.

The output of the fluidic AND-gate 66 is fed to input channel 92 of the fluidic AND-gate 91 and to the inhibit channel 78 of the fluidic inhibited OR-gate 80. The inhibit channel 78 of the fluidic OR-gate 80 is coupled through a coil which functions as a time delay to allow both fluidic AND-gate 91 and fluidic flip-flop 102 to switch before the output from channel 88 of fluidic OR-gate 80 is removed by the inhibiting action of fluidic OR-gate 80.

The timer which was on first, if the correct sequence had been followed, would have switched fluidic OR-gate 80 to the channel 88 prior to the fluidic flip-flop 52 being actuated.

It can be seen that if the timer is not activated prior to the occurrence of a signal at channel 74 of fluidic AND-gate 66, the output at channel 112 of fluidic flip-flop 102 will never be obtained. The fluidic flip-flop 52, fluidic AND-gate 66, fluidic inhibited OR-gate 80, fluidic AND-gate 91 and fluidic flip-flop 102 provides a basic combination 262 which can detect the occurrence of an event and which can be cascaded with similar combinations to form a coding sequence where, if any one of the outputs required from any of the stages of the combinations is not obtained, the following stages of the combination cannot perform the desired logic.

If digit 4, then digit 3 is obtained, but the dial is moved past the digit 3 to digit 2, then the flow of fluid representative of digit 2 will be fed to channel 56 of the fluidic flip-flop 52 to reset both of the fluidic flip-flops 52 and 102 by feeding fluid to channel 56 of fluidic flip-flop 52 and channel 104 of fluidic flip-flop 102.

It is to be noted that the combination 262 can be cascaded into as large a control network as desired.

In the final stage of the fluidic AND-gate 248 checks to determine that the timer is still running and that the correct logic sequence has been performed before providing a valid output at the channel 256.

The output obtained at channel 256 of the fluid AND-gate 248 can be used to drive a cylinder or any other fluidic interface device to free or unlock a controllable locking device.

The description of the operation of the components positioned within the area designated by the reference numeral 262 is similar to and applied equally well to the cascaded combinations illustrated in FIG. 1 and, therefore, to avoid repetition of descriptive matter, a further duplicate explanation will not be here presented.

Obviously, many modifications and variations of the present invention are possible in the light of the above teaching. It is, therefore, to be understood that the invention may be practical otherwise than as specifically described herein.

We claim:

1. In a combination lock, a fluidic logic device for determining the occurrence of a predetermined sequence of digits comprising first means to detect the digit selected, and second means coupled to detect the order of selection of digits.

2. The structure of claim 1 including means coupled to detect the selection of a digit other than the digit required.

3. The structure of claim 2 including means to disable said second means to prevent said first and second means from performing the logic desired.

4. The structure of claim 3 comprising timer means coupled to permit said first and second means from initiating the generation of a desired output signal.

5. The structure of claim 4 wherein serial first means comprises a fluidic AND gate.

6. The structure of claim 5 wherein said second means comprises a fluidic flip-flop coupled to feed said fluidic AND gate.

7. The structure of claim 6 wherein said means to disable said fluidic flip-flop comprises a lock switch to reset and hold said flip-flop in the reset position.

8. In a combination lock, a fluidic logic device for determining the occurrence of a predetermined sequence of digits comprising a first fluidic flip-flop coupled to respond to the occurrence of a first digit, a fluidic AND gate coupled to said first fluidic flip-flop to indicate the occurrence of a second digit, a fluidic inhibited OR gate, a second AND gate coupled to receive a signal from said first AND gate and said inhibited OR gate, and a second fluidic flip-flop fed by said second AND gate to feed a fluid to a lock release means.

9. The combination of claim 8 including fluid time delay means coupled to the inhibit channel of said inhibited OR gate.

10. The combination of claim 9 including timer means coupled to condition said fluidic flip-flop fed by said second AND gate to generate an output.

11. The combination of claim 10 wherein said first fluidic flip-flop is coupled to be repositioned to indicate the selection of an undesired digit.

12. The combination of claim 11 including a lock switch to reset and hold said first and second fluidic flip-flops in their reset position.

13. In a combination lock, a fluidic logic device for determining the occurrence of a predetermined sequence of digits comprising first means to detect the digit selected, and second means coupled to detect the sequence of digits selected.

14. In a combination lock, a fluidic logic device for determining the occurrence of a predetermined sequence of digits comprising a first fluidic flip-flop coupled to respond to the occurrence of a first digit, a fluidic AND gate coupled to said first fluidic flip-flop to indicate the occurrence of a second digit.

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