Aug. 24, 1965 R. W. VOCKROTH, JR 3,202,179

FLUID AMPLIFIERS

Filed Feb. 5, 1962

2 Sheets-Sheet 1

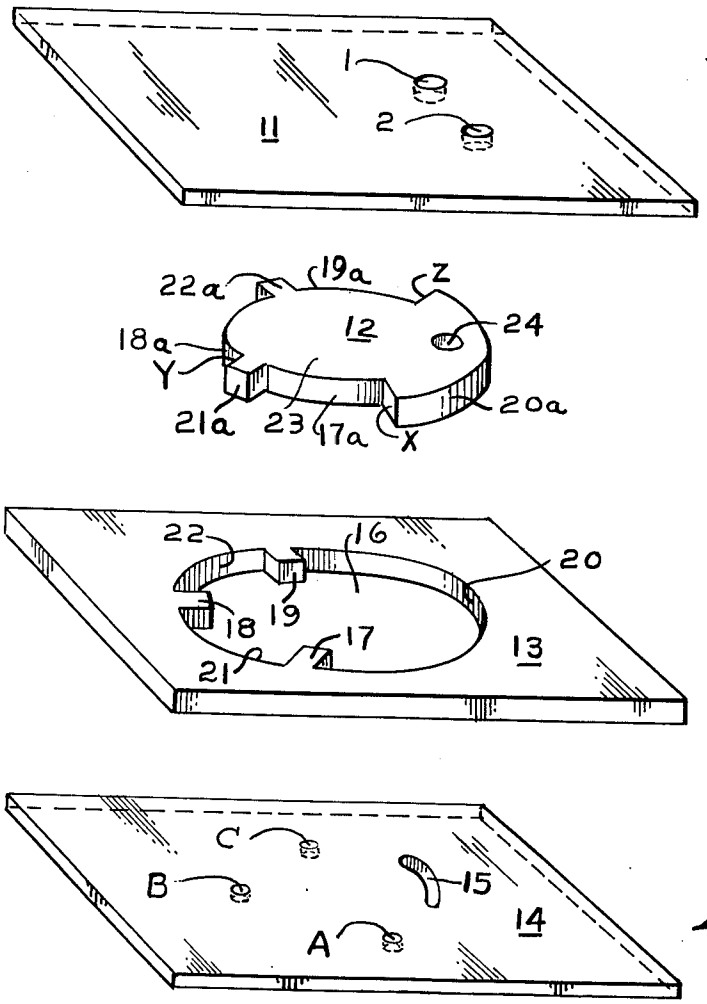


Fig. 1

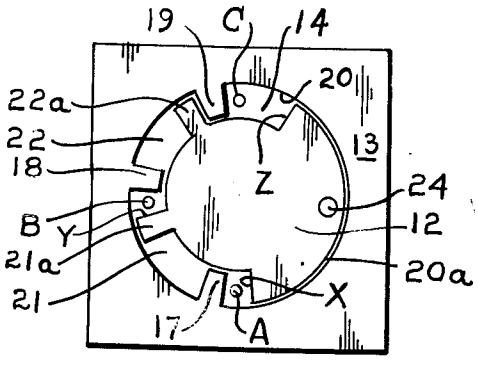


Fig. 2

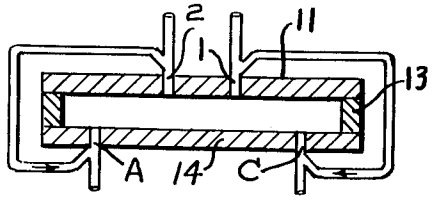


Fig. 3

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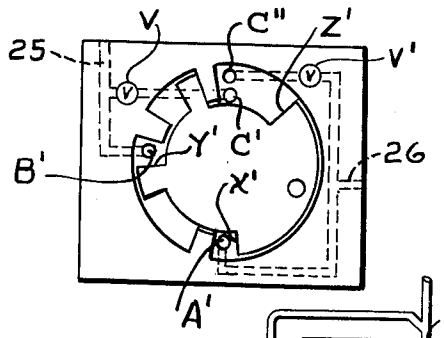
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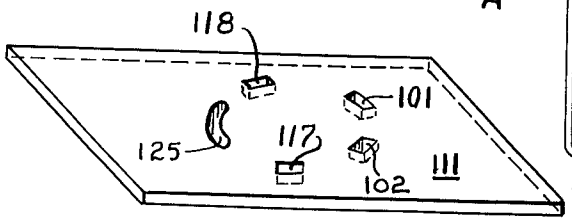
FLUID AMPLIFIERS

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2 Sheets-Sheet 2

Fig. 4





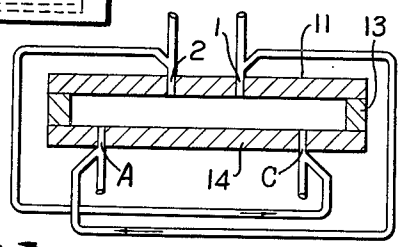


Fig. 3A

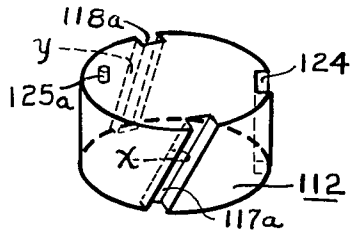
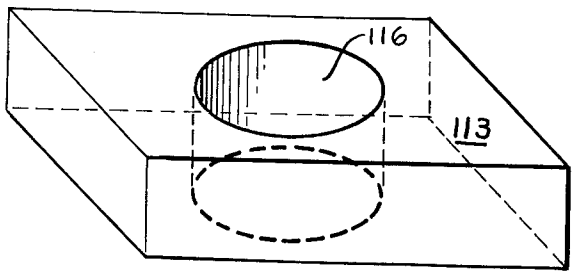


Fig. 5



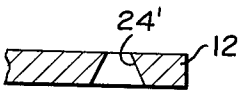
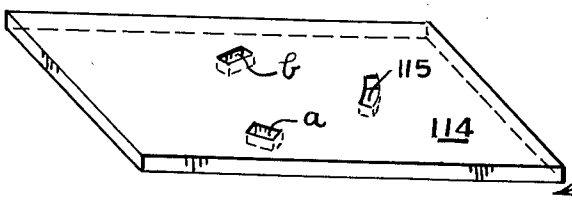


Fig. 2A



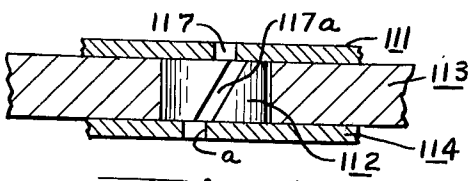


Fig. 6

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FLUID AMPLIFIERS

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Filed Feb. 5, 1962, Ser. No. 170,898
6 Claims. (Cl. 137—624.14)

This invention relates to fluid amplifiers and more particularly to devices by which a relatively high pressure and/or relatively high volume stream of fluid may be controlled or directed by a relatively low pressure fluid stream.

A fluid amplifier may not only be utilized to control a high pressure power stream of air or other fluid, such as by deflecting or switching such stream between "on" and "off" positions, but may also be constructed so as to perform the pneumatic counterpart of some of the more common electronic devices, such as the thyratron, oscillator, blocking oscillator, and binary counter circuit element.

It thus has been an object of my invention to provide an improved positive acting fluid amplifier.

A further object of my invention has been to provide a simplified construction for fluid amplifiers wherein a low pressure air stream may be utilized to positively control and deflect a high pressure air stream, irrespective of the continuity of the high pressure stream or control stream.

These and other objects of my invention will be more apparent to those skilled in the art from the following disclosure and accompanying drawings in which:

FIGURE 1 is an assembly drawing illustrating an embodiment of my invention;

FIGURE 2 is a top plan view of the assembled device of FIGURE 1 with the top cover plate omitted;

FIGURE 2A is a fragmental sectional view in elevation illustrating a tapered power channel formed in a rotatable actuator;

FIGURE 3 is a somewhat schematic sectional view in elevation, with the rotating actuator eliminated for purposes of clarity, illustrating various feedbacks which may be utilized with the device shown in FIGURE 2;

FIGURE 3A is a schematic sectional view in elevation similar to FIGURE 3, illustrating a modified form of feedbacks which may be utilized with the device shown in FIGURE 2;

FIGURE 4 is a plan view with the cover plate omitted, similar to that shown in FIGURE 2, illustrating various input connections which may be utilized to produce a two-legged "and gate" unit;

FIGURE 5 is an assembly drawing of a further embodiment of my invention; and,

FIGURE 6 is a fragmental side elevational view in section of the assembled device shown in FIGURE 5.

Referring now to the drawings and particularly FIGURES 1 and 2, the actuator assembly comprises a cover plate **11**, a rotatable or oscillatable actuator **12**, an actuator housing **13**, and a bottom plate **14**. The thickness of the actuator **12**, which is the only movable part of the assembly, is a few thousandths of an inch less than the thickness of the housing, so that the actuator is free to rotate in performing its switching functions. The cover plate, actuator housing, and bottom plate, are hermetically sealed together by any suitable means, with the rotatable actuator positioned therewithin.

The bottom plate **14** is provided with at least one power input opening or passageway **15** extending therethrough, which may be of an arcuate shape, and a plurality of control inlet ports, input passageways or orifices A, B, and C. The actuator housing **13** is provided with a circular recessed portion **16** having a plurality of divider

lugs or stop abutment portions **17**, **18**, and **19**, extending radially inwardly, which in effect produce arcuate segments or sectors **20**, **21**, and **22** therebetween.

The rotatable actuator **12** comprises a disc-like body portion **23** having a plurality of arcuately spaced-apart peripheral recessed portions **17***a*, **18***a*, and **19***a* which form a plurality of radially extending lugs or projections **20***a*, **21***a*, and **22***a* therebetween. As shown in FIGURE 2, the lugs or projections **20***a*, **21***a*, and **22***a* are adapted to cooperably rotate within the arcuate segments or sectors **20**, **21**, and **22** respectively, when the rotatable actuator **12** is operably positioned within the actuator housing **13**. The side wall portions of lugs **20***a* and **21***a* are provided with pressure responsive surfaces or reaction areas X, Y, and Z, which are in communication with control input passageways A, B, and C, respectively.

A power channel **24** extends through the rotatable actuator **12**, and is positionable for communication with a power input passageway. When a single arcuate power input passageway is utilized such as **15**, the power channel is in constant communication therewith. The top cover member **11** is provided with a first power output orifice or passagway **1**, and a second power output orifice or passageway **2** which, depending upon the orientation of the rotatable actuator **12**, are in alternate communication with the power channel **24**. A pair of power input passageways, in alignment with power output passageways **1** and **2**, may be substituted for the single arcuate passageway **15**. The stop abutment portions **18** and **19** limit the travel or amount of rotation of projection **22***a*, and accordingly function as end stops for the oscillatable actuator **12** to position the channel **24** in selective alignment with output passageway **1** or **2**.

When the actuator **12** is in the position shown in FIGURE 2, the power stream supplied at a suitable power input passageway such as **15** is directed through the power channel **24** and outwardly through power output passageway **2**. A control pressure supplied at either input A or B would react against pressure responsive surfaces or reaction areas X or Y, respectively, and cause the actuator **12** to rotate counterclockwise and switch the power stream, passing through power channel **24**, from power output passageway **2** to output passageway **1**. Such a fluid amplifier represents an "or gate" configuration as may be utilized in digital computers.

If the shapes of the power channel **24** and the power output channels **1** and **2** were changed, and the control pressures were applied simultaneously at inputs A, B, and C, then the wave form of the air pressure at the power outputs plotted against time could be made to represent a process which acts as a function of variables A, B, and C. Further, scaling may be accomplished by either providing constrictions, such as valves, in the lines leading to these control inputs, or by shaping the actuator at manufacture so that the surface areas acted upon by the control pressures are unequal.

FIGURE 3 is a schematic illustration showing how the device of FIGURE 2 may be made into an oscillator. By providing feed-back lines from the power output passageway **1** to control input orifice C, and from power output passageway **2** to control input orifice A, the device of FIGURE 2 may be made into an oscillator whose frequency may be varied and/or unbalanced by suitable constrictions or plenum chambers in the feedback lines. In operation, a power stream directed outwardly through power outlet **2** is partially fed back into control input passageway A where it reacts against pressure responsive surface X to rotate the actuator **12** in a counterclockwise direction and switch the stream to power outlet orifice **1**. However, as the stream egresses from power outlet **1**, a portion is fed back into control input orifice C where it

reacts against pressure responsive surface Z and rotates the actuator clockwise to switch the power stream back to power outlet passageway 2, with the cycle continuously repeating itself. Control input orifice B is of course unnecessary and is omitted in this configuration. If only one feedback line were present, the device would become a blocking oscillator whose pulse duration could be controlled by a suitable constriction or plenum chamber within the line.

If the shape of the actuator shown in FIGURE 2 were constructed in a non-symmetrical fashion so that the surface area Z, acted upon by a control input at C, is greater than the area acted upon by an input at orifice A or B but less than the sum of areas X and Y, and a control pressure is always present at input C, then an "and gate" construction would be represented. Neither a control input at orifice A nor B alone could switch the power stream output 2 to power output 1, however, a control input at both A and B could overcome the force exerted by the control input at C.

FIGURE 4 respresents a two-legged type of an "and gate" construction. The pressure reaction area Z' is larger than either of the pressure reaction areas X' or Y'. An input passageway **25** communicates with input orifices B' and C', which in turn communicate with pressure reaction areas Y' and Z', respectively. A second input passageway **26** communicates with input orifice A' and C'', which in turn communicate with pressure responsive surface areas X' and Z' respectively. When a control pressure is supplied at either input **25** or input **26** alone, the pressure at Z' holds the actuator in the clockwise rotated position, because the area Z' is greater than the area X' or Y' acted upon by the inputs. However, when a control pressure is supplied at both input passageways **25** and **26**, the combined areas of X' and Y' are greater than the area Z', and accordingly the actuator is rotated counterclockwise, thus shifting the power stream to the other power output passageway. Check valves V, V' are positioned within the control lines to orifices C' and C'' to prevent cross flow between input passageways **25** and **26**.

The two-legged "and gate" device has a slightly different operation than the standard "and gate" construction. In the latter construction, there is always a control pressure present at input C, resulting in the clockwise rotation of the actuator **12** when control input pressures at orifices A and/or B are idle; whereas in the former device, a control input pressure is not necessarily always present at orifices C' and C'', and accordingly when a control pressure is supplied at both input passageways **25** and **26** and then released, the actuator is rotated to its counterclockwise position and remains there until a single pulse is supplied at either of the input passageways. This feature may be utilized to function as a "memory" device on the order of a magnetic core in a computer core memory.

A pneumatic counterpart of a thyratron may be created by tapering the power channel **24**, of FIGURE 2 in the manner shown at **24'** in FIGURE 2A, so that the side wall portions of the channel taper inwardly or converge toward the outlet end, thus producing a channel having a larger diameter adjacent the power input orifice **15** than power output orifices **1** or **2**. Once the power channel is in communication with one of the power outputs and a power stream is applied to the power input passageway, the power stream will react against the sides of the tapered power channel if it should move off center to lock the actuator in position, so that further control inputs will not have enough force to rotate the actuator to the other power ouput while the power stream is being passed through the tapered power channel.

A further embodiment of a pneumatic counterpart of a thyrotron may be produced by reversing the feedback lines of FIGURE 3 in the manner shown in FIGURE 3A, so that the feedback line from output orifice **1** communicates with control input orifice A, and the feedback line from

output orifice **2** communicates with control input orifice C. Accordingly, when the power channel **24** is in alignment with output orifice **2**, a large feedback pressure flowing into control input orifice C would react against pressure responsive surface Z to lock the actuator in position so that a small control input pressure at input orifice A, reacting on pressure responsive area X, would be insufficient to rotate the actuator. A similar situation would, of course, exist when the power channel **24** is in communication with outlet orifice **1**, wherein a large feedback pressure communicating with input orifice A would prevent a small control input pressure at input orifice C from rotating the actuator.

Referring now to FIGURES 5 and 6, a further modification of a pneumatic or fluid amplifier embodying my invention is shown. The assembly, like the device shown is FIGURE 1, consists of a top cover plate **111**, a rotatable actuator **112**, an actuator housing plate **113**, and a bottom plate **114**. The bottom plate is provided with at least one power input passageway such as arcuate passageway **115**, and a pair of control input passageways or orifices *a*, *b*. The actuator housing **113** has a cylindrical recessed portion **116**, within which the rotatable actuator **112** is positionable for predetermined arcuate rotation.

The rotatable actuator **112** is provided with a pair of inclinded control channels **117***a*, **118***a*, having surface reaction areas *x*, *y*, respectively. A power channel **124**, which may be in constant communication with an arcuate input passageway such as **115**, extends vertically within a peripheral surface of the actuator **112**, and is adapted to alternately communicate with power outlet ports or passageways **101** and **102** formed through the cover plate **111**. A plurality of control outlet ports **117** and **118**, formed in the cover plate **111**, are positioned to communicate with control channels **117***a* and **118***a* respectively. An arcuate slot **125**, formed in the cover plate **111** is adapted to receive a travel limiting pin **125***a*, extending upwardly from the top surface of the rotatable actuator **112**, which limits the arcuate rotation thereof.

In operation, a power stream entering the power input **115** passes through the power stream channel **124** and out through one of the two power outlet orifices **101**, **102**, depending upon the orientation of the actuator **112** at that moment. When a control stream is directed through either control input orifice *a* or *b* in the bottom of the cover plate **114**, the impingement of such stream upon the surface reaction area *x* or *y* causes the actuator **112** to rotate through an arc limited by the travel limiting pin **125***a* riding within the slot **125**. As shown, a control stream supplied to the control channel **117***a* positions the actuator so that the power stream channel **124** is in communication with power output orifice **102**, whereas a control stream supplied to control channel **118** positions the actuator in its counterclockwise-most position with the power channel **124** in communication with power outlet **101**. The power control channels, as shown in FIGURE 6, are never completely blocked off at the control input and control output orifices.

Although I have disclosed the now preferred embodiments of my invention it will be apparent to those skilled in the art that various changes and modifications may be made thereto without departing from the spirit and scope thereof as defined in the appended claims.

I claim:

1. A fluid amplifier comprising, a housing body having a top cover plate, an actuator housing plate with a recessed portion formed therewithin, and a bottom plate all hermetically sealed together; an oscillatable plate-like actuator positioned within the recessed portion of said housing plate for limited rotation therewithin; said housing plate having a plurality of lug portions extending radially inwardly of said recessed portion; a plurality of control input orifices extending through said bottom plate and communicating with said recessed portion intermediate the radially extending lug portions; outwardly ex-

tending projections formed on said oscillatable actuator projecting between said lugs and having pressure responsive surface areas in communication with said control input orifices; a power stream channel formed in said actuator in constant communication with a power input orifice formed through said bottom plate and positionable for selective individual communication with a plurality of power output passageways formed in said top cover plate; and said pressure responsive surface areas being selectively energized by fluid pressure supplied at a predetermined control input orifice to rotate said actuator and position said power channel in communication with a desired power output passageway.

2. A pneumatic oscillator comprising a housing body having a central recessed portion with an oscillatable actuator positioned therewithin, a power channel formed in said oscillatable actuator in constant communication with a power input orifice and positionable for alternate communication with a pair of power output orifices, means for limiting the degree of rotation of said oscillatable actuator so that at each of its end limits the power channel is in alignment with one of the power output orifices, a pair of opposing fluid pressure reaction areas formed on said oscillatable actuator, a control input orifice in communication with each of said reaction areas, and feedback means extending from each of said power output orifices to the control input orifice in communication with the pressure responsive reaction area which tends to rotate the actuator in the direction necessary to position the power channel in communication with the other power output orifice.

3. A pneumatic counterpart of a thyratron comprising a housing body having a central recessed portion with a rotatable actuator positioned therewithin, a tapered power channel formed in said rotatable actuator with a relatively large diameter inlet end in constant communication with a power inlet port and a relatively small diameter outlet end positionable for preselected individual communication with a plurality of power outlet ports, pressure responsive reaction means for rotating said actuator to position said power channel in communication with a preselected power outlet orifice, and side wall portions of said tapered power channel converging toward its outlet end to such a degree that a power stream acting against such side wall portions locks the actuator in position and prevents a pressure responsive reaction means for rotating said actuator while the power stream is flowing through said power channel.

4. A two-legged and gate fluid amplifier comprising, a housing body having a central recessed portion with a disc-like rotatable actuator positioned therewithin, said actuator having a plurality of pressure responsive reaction areas designed to rotate the actuator in opposite directions between two predetermined end points, a power channel formed in said actuator in constant communication with a power input orifice and rotatable between said end points for selective alternate communication with a pair of power output orifices, two of said pressure responsive reaction areas having substantially equal surface areas and positioned so as to facilitate the rotation of said actuator in one direction; a third of said pressure responsive areas having a larger surface area than either of said first mentioned surface areas taken singularly, but smaller than their combined surface areas, and positioned to facilitate the rotation of said actuator in an opposite direction; a first control input passageway in communication with one of said substantially equal surface reaction areas and said third surface reaction area; and a second control input passageway in communication with the other of said substantially equal surface areas and said third surface reaction area so that when a control pressure is supplied at either control input passageway the actuator will be urged to rotate in said opposite direction, whereas when control pressures are supplied at both input passageways the actuator will be urged to rotate in said one direction.

5. An and gate type of fluid amplifier comprising, a housing body member enclosing a rotatable actuator positioned for limited oscillation within a recessed portion formed in said housing body member, a plurality of arcuately spaced apart lug portions extending radially inwardly of said recessed portion, a plurality of outwardly extending projections formed on said rotatable actuator projection between said lug portions, pressure responsive reaction areas formed on said projections, a plurality of said reaction areas being responsive to fluid pressure to rotate said actuator in one direction and at least one of said reaction areas being responsive to fluid pressure to rotate said actuator in an opposite direction, a power stream channel formed in said actuator in constant communication with a power input orifice and positionable for selective individual communication with a plurality of power output passageways, and means communicating with said reaction areas for selectively energizing individual pressure responsive reaction areas with fluid pressure to rotate said actuator and position said power channel in communication with a desired power output passageway.

6. A pneumatic counterpart of a thyratron comprising, a housing body having a central recessed portion with a rotatable actuator positioned therewithin; a first and second power output passageway formed in said housing body, a power channel formed in said rotatable actuator communicable with a power input means and selectably alternately communicable with each of said power output passageways; a pair of pressure responsive surface reaction areas on said rotatable actuator for rotating said actuator in opposite directions; a pair of control input orifices, one of said orifices communicating with one of said pressure responsive reaction areas for supplying fluid pressure to rotate said actuator in one direction and position said power channel in alignment with said first power output passageway, and the other of said orifices communicating with the other of said pressure responsive reaction areas for supplying fluid pressure thereto to rotate said actuator in an opposite direction and position said power channel in alignment with said second power output passageway; a feedback passageway communicating between said first power output passageway and said one control input orifice, and a second feedback passageway communicating between said second power output passageway and said other control input orifice so that when the power channel is in alignment with either of said output passageways, a feedback pressure acting through a control input orifice locks the actuator in position and prevents a small control input pressure supplied to an opposing reaction area from rotating said actuator.

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