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SWITCHING ARRANGEMENTS FOR FLUID AMPLIFIERS

Filed March 2, 1964

FIG. 1

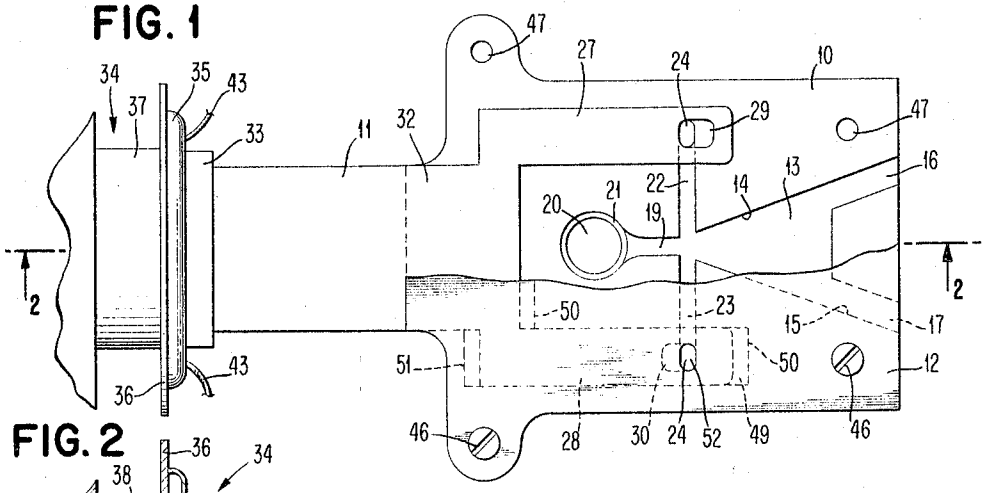



FIG. 2

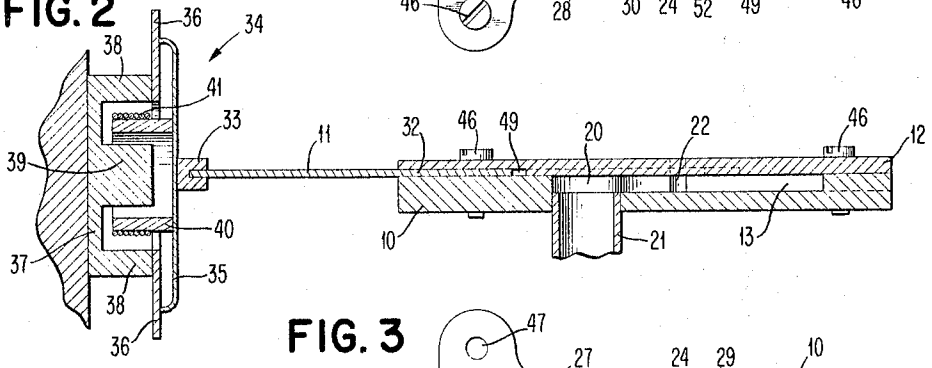



FIG. 3

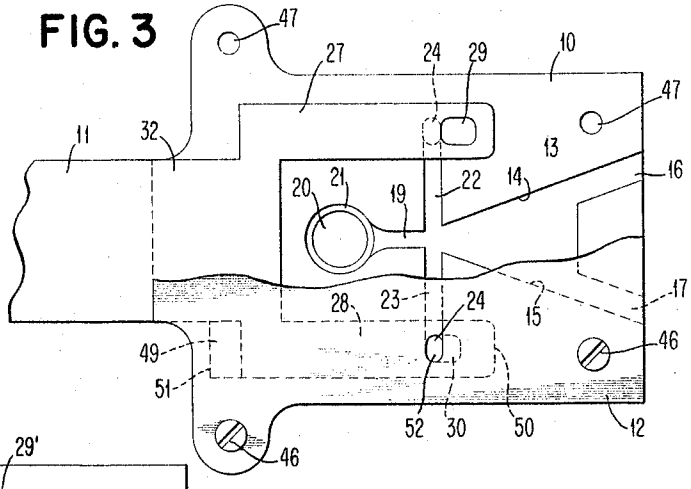
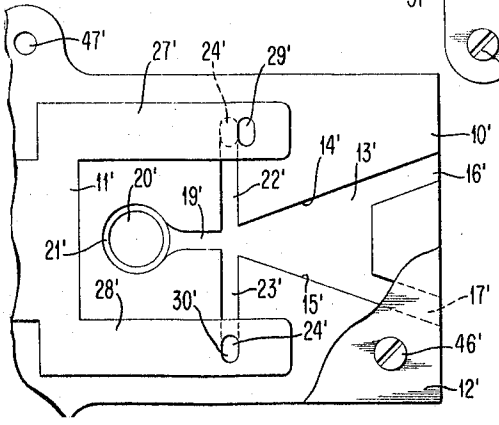



FIG. 4

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# SWITCHING ARRANGEMENTS FOR FLUID AMPLIFIERS

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The present invention relates generally to fluid devices and more particularly to improved arrangements for switching fluid amplifiers.

Fluid amplifiers of the type employing a jet of fluid under pressure wherein the jet is caused to adhere to either of two diverging side walls are well known in the art. Such an amplifier usually comprises a supply port located approximately at the apex of a chamber whose diverging side walls extend to two spaced outlet ports. A pair of control ports are positioned in the side walls in transversely aligned relation between the supply port and the outlet ports. The control ports are in communication with control passageways or conduits having valve means disposed therein.

In operation of such a fluid amplifier, the fluid jet issuing from the supply port adheres to one side wall of the chamber and passes outwardly to the corresponding outlet port. To switch the state of the amplifier, a control transverse pressure gradient is established between the control ports of sufficient magnitude and in a direction which causes the jet to move and adhere to the other side wall of the chamber. The fluid jet appears at the other outlet port and the fluid amplifier will remain in this state even after the control transverse pressure gradient is removed due to the boundary layer condition existing between the side wall of the chamber and the jet. To return the fluid jet to its initial state, a control transverse pressure gradient of sufficient magnitude in the opposite direction is established. The energy required to establish the controlling transverse pressure gradients is much less than the energy contained in the fluid jet and this is the reason the devices are designated fluid amplifiers.

Recently, fluid amplifiers of the above type have been employed as computer or data processing logic element where the presence or absence of a fluid jet at a particular port or ports is used to represent data, usually in the binary code. In any fluid system used to process information, it is necessary to couple mechanical or electrical signals to the fluid system. This is usually accomplished by connecting various control ports to sources of fluid under pressure via relative large and expensive relay or solenoid operated spool valves. Such valves are slow in operation and, as a consequence, the response of the overall system is limited to the response capabilities of the fluid valves. The inability to couple mechanical and electrical signals to fluid systems in a simple manner at a high rate of speed has limited the application of such fluid systems.

Briefly, the present invention is concerned with the provision of improved fluid amplifiers with particular reference to highly simplified and fast acting switching arrangements for coupling electrical and mechanical signals to the amplifiers for controlling the states thereof. A fluid amplifier constructed in accordance with the teachings of the present invention comprises a housing in which are formed a chamber and various ports and passageways. A pair of control ports and passageways are aligned transversely on opposite sides of the chamber. In order that control transverse pressure gradients can be established between the control ports and the passageways to determine the state of the amplifier, there is provided a generally U-shaped plate-like valving member which is guided for longitudinal movement in the housing.



The valving member has a pair of forwardly extending and transversely spaced arms. Each of the arms has a valving aperture therein which is adapted to cooperate with the end of one of the control passageways. The valving apertures are so positioned in relation to each other and the ends of the control passageways that in one position of the valving member one passageway is blocked and the other passageway is open. In a second position of the valving member, the arrangement is reversed with the one passageway open and the other passageway blocked. Also, if desired, the valving apertures can be designed to provide an intermediate position of the valving member between the first and second positions where the ends of the control passageways are in the same condition. A voice coil or other similar fast actuating electromechanical transducer is connected to the valving member for applying electrical signals to the fluid amplifier. Mechanical signals can be directly applied to the valving member.

It is the primary or ultimate object of the present invention to provide improved switching arrangements for fluid amplifiers wherein the state of a fluid amplifier is capable of being switched at a high rate of speed. The valving member is light in weight and is accurately guided for valving movement.

Another object of the invention is the provision of a fluid jet amplifier with improved switching arrangements that is characterized by its extreme simplicity in construction and operation. As will be hereinafter more fully apparent, a fluid jet amplifier is constructed from a minimum of simple and easily fabricated parts at a relatively low cost.

The foregoing and other objects, features 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 plan view of a fluid jet amplifier constructed in accordance with and embodying the teachings of the present invention;

FIGURE 2 is a side sectional view taken along the section line 2—2 of FIGURE 1.

FIGURE 3 is a plan view similar to FIGURE 1 showing the valving member in one of its valving positions; and

FIGURE 4 is a fragmentary plan view of a fluid jet amplifier depicting another embodiment of the present invention.

Referring now to the drawings, and initially to FIGURES 1–3 thereof, there is shown a fluid jet amplifier which comprises a housing member **10**, a valving member **11** and a cover member **12**. The housing member **10** is generally rectangular and has a chamber **13** formed therein. The chamber **13** is generally angular in shape and is defined by a pair of diverging side walls **14** and **15**. The side walls extend outwardly to fluid outlet ports **16** and **17**, respectively.

Positioned adjacent and slightly to the rear of the apex of the side walls **14** and **15** and communicating with the chamber **13** via inlet passageway **19** is an inlet port **20**. The inlet port **20** takes the form of a relatively large vertical bore which extends completely through the housing member. Received within the inlet port **20** is an end of a supply conduit **21** that extends to a source of fluid under pressure, not shown. Also formed within the housing member **10** are a pair of transversely extending control passageways **22** and **23** whose outer ends **24** are located adjacent the side edges of the housing member. The control passageways **22** and **23** are transversely aligned between the inlet port **20** and the outlet ports **16** and **17**. As will be later explained, a control transverse pressure gradient extending in a proper direction between the con-

trol passageways 22 and 23 can be employed to switch the state of the fluid amplifier.

The valving member 11 is relatively thin and characterized by its light weight. This member is generally U-shaped to provide a pair of forwardly extending and transversely spaced arms 27 and 28. Each of the arms 27 and 28 has a valving aperture 29 or 30 therein adjacent the end thereof. The valving apertures are offset with respect to each other and are approximately twice the size of the outer ends 24 of the control passageways 22 and 23. The reason for this arrangement will be fully discussed in following portions of the specification.

Spanning and joining the rear ends of the arms 27 and 28 of the valving member 11 is a trunk portion 32. The outer end of the trunk portion 32 is received in a tubular fitting 33 forming a portion of a voice coil assembly generally designated by reference numeral 34. As most clearly shown in FIGURE 2 of the drawings, the fitting 33 is connected to the center of a circular and flexible diaphragm 35 whose outer edge is glued or otherwise secured to an annular and relatively rigid supporting ring 36. The supporting ring 36 serves to support the diaphragm and is attached to the outer circular periphery of a permanent actuating magnet 37. The magnet 37 is generally cup-shaped and comprises a circular flange 38 and an outwardly projecting center leg 39.

Received in nesting relation between the center leg 39 and the circular flange 38 of the permanent magnet is an annular bobbin 40 having a coil wire 41 wrapped about the outer periphery thereof. The bobbin 40 is securely attached to the center of the diaphragm 35 by glue or other convenient attachment means. The overall arrangement of the voice coil assembly 34 is such that a pushing or pulling force is applied to the valving member 11 as long as the coil 41 is energized in response to electrical control signals applied over conductors 43.

The polarity of the electrical control signals will determine which direction the valving member 11 moves from its neutral position. When no control signal is applied to the coil 41, the valving member 11 assumes a neutral position as shown in FIGURE 1 of the drawings. In the illustrated embodiment, the resilience of the diaphragm 35 and its mounting are sufficient to return the voice coil assembly 34 and the valving member 11 to the neutral position. Additional biasing means may be incorporated to return the valving member to the neutral position if desired. The voice coil assembly is well known in the art and its construction will not be further described. Such assemblies have long been recognized as capable of high speed operation and faithful response as evidenced by their widespread use as electrical to mechanical transducers in loudspeaker and reproducing systems. The response of the voice coil assembly depends in part on its mechanical loading and it is noted the valving member is light in weight and easily moved.

The cover member 12 is the third part of the fluid jet amplifier and is rigidly attached to the housing member 10 by bolts 46 which are received in aligned threaded apertures 47 located adjacent the corners of the housing and cover members. The cover member 12 has a U-shaped recess 49 in its bottom surface which overlies and nestingly receives the U-shaped valving member 11. The recess 49 is approximately the same size as the valving member, although the longitudinal dimensions of the recess 49 are slightly greater than the corresponding dimensions of the valving member to permit longitudinal movement of the valving member. Certain surfaces of the recess 49, such as front walls 50 and back walls 51, limit the longitudinal movement of the valving member and define stop surfaces. A pair of transversely spaced vertical apertures 52 in the cover plate 12 overlie and are adapted to communicate with the ends 24 of control passageways 22 and 23 in the housing member.

Considering now the operation of the disclosed apparatus, it will be assumed that the valving member 11 is in its neutral position as shown in FIGURE 1 of the drawings and the high energy fluid jet issuing from inlet passageway 19 passes along and adheres to side wall 15. The fluid jet adheres to the side wall 15 due to the boundary layer condition existing and passes out through the outlet port 17. The fluid amplifier is in one of its stable states and will remain in this state since there is no control transverse pressure gradient existing which disturbs or alters the boundary layer condition and the adherence of the fluid jet to side wall 15. The control passages 22 and 23 are both vented to atmosphere since the valving apertures 29 and 30 in the arms 27 and 28 of valving member 11 interconnect the apertures 52 in the cover member 12 and the ends 24 of the control passageways 22 and 23 when the valve member is in the neutral position.



To switch the fluid amplifier to its other state, an electrical signal of the correct polarity is applied to coil 41 which causes the diaphragm 35 and valving member 11 to move to the right until the valving member abuts against the stop surfaces 50 defined by the front walls of the recess 49 in the cover member. At this time the position of the valving member is as shown in FIGURE 3 of the drawings. The control passageway 22 is blocked since valving aperture 29 no longer overlies the end 24 of this passageway. However, control passageway 23 is still vented to atmosphere since the valving aperture 30 is of such a length that it still overlies the end 24 of this control passageway. An equilibrium condition no longer exists, and a control transverse pressure gradient extends across the chamber 13 in a direction which causes the fluid jet to immediately switch and adhere to side wall 14 with the fluid jet passing through outlet port 16. The fluid amplifier will remain in its second state even after the electrical energizing signal is removed and the valving member returns to its neutral position. To return the fluid amplifier to its initial state, an electrical signal which causes the valving member to move rearwardly until the end 24 of the control passageway 23 is blocked while the control passageway 22 is vented to atmosphere is applied to the voice coil assembly 34.

A second embodiment of the invention is illustrated in FIGURE 4 of the drawings. In this embodiment, primed reference numerals are employed to designate the same or similar parts as shown in connection with the embodiment of FIGURES 1–3 of the drawings. The valving apertures 29′ and 30′ in the arms 27′ and 28′ of the valving member 11′ are smaller while still being offset. The arrangement is such that there is no neutral position of the valving member since in each of the two positions of this member one of the control passageways 22′ and 23′ is vented to atmosphere while the other control passageway is blocked. The fact that a control transverse pressure gradient exists across the chamber 13′ even after the fluid jet has switched and the electrical signal removed does not alter the operation of the amplifier since the control gradient is in a direction to maintain the fluid jet in its switched state. This embodiment is particularly useful if the apertures, not shown, in the cover member 12′ corresponding to apertures 52 are connected to sources of fluid under pressure, also not shown, rather than vented to atmosphere as set forth above. The use of transversely directed jets of fluid to control the state of a fluid amplifier is well known in the art. In this event, the control passageway 22′ or 23′ connected to its associated source of fluid under pressure as determined by the position of the valving member 11′, would have a fluid jet therein which controls the state of the fluid amplifier.

It should now be apparent that the objects initially set forth have been accomplished. Of particular importance is the provision of improved switching arrangements for fluid amplifiers which are capable of high speed operation. The valving member is formed from plastic or other suitable materal and is extremely light weight whereby the overall response of the voice coil assembly and the

valving member is quite high. Extremely simple but highly efficient and practical arrangements have been shown for coupling electrical and mechanical signals to fluid logic devices and systems. The apertures in the valving members are offset with respect to each other and the control passageways to obtain the valving action required upon actuation of the voice coils.

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. Fluid control apparatus to which pressurized fluid is adapted to be supplied comprising:

a housing having a pair of transmission channels formed therein for said fluid;

each of said transmission channels comprising a side wall and an outlet port;

an inlet port spaced from the outlet ports for directing fluid toward said transmission channels;

means to divert said fluid from one of said transmission channels to the other of said transmission channels;

said means to divert comprising a pair of transversely extending and spaced control passageways in said housing disposed on opposite sides of said transmission channels between said inlet port and said outlet ports;

said control passageways having transversely spaced end ports within said housing disposed on opposite sides and outwardly of said transmission channels;

means to selectively open and close said end ports comprising a generally thin and U-shaped valving member mounted for sliding movement within said housing in a direction generally normal to said control passageways;

said valving member having a pair of transversely spaced arms mounted within said housing and extending on opposite sides of said transmission channels in a direction transverse to said control passageways in generally blocking relation with respect to said end ports of said control passageways;

a valving aperture in each of said arms which in one related position of said valving member is adapted to communicate with the end port of the control passageway associated therewith;

said valving member having a trunk portion interconnecting said spaced arms and extending from said housing; and

means connected with said trunk portion for moving said valving member between valving positions.



2. Apparatus according to claim 1 further characterized by:

the valving apertures being offset with respect to said end ports of said control passageways whereby one of said end ports is in communication with its associated valving aperture and the other end port is blocked when said valving member is in a first position and said one of said end ports is blocked and said other end port is in communication with its associated valving aperture when said valving member is in a second position.

3. Apparatus according to claim 2 further characterized by:

said valving member having a neutral position between said first and second positions; and

said end ports of said control passageways both being in communication with said valving apertures in said arms when said valving member is in said neutral position.

4. Apparatus according to claim 2 further characterized by:

said means to move comprising an electromechanical transducer;

said transducer having a stationary magnetic field producing means and a wound coil assembly movable in the magnetic field of said producing means; and

means to connect said wound coil assembly to said extending trunk portion of said valving member.


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