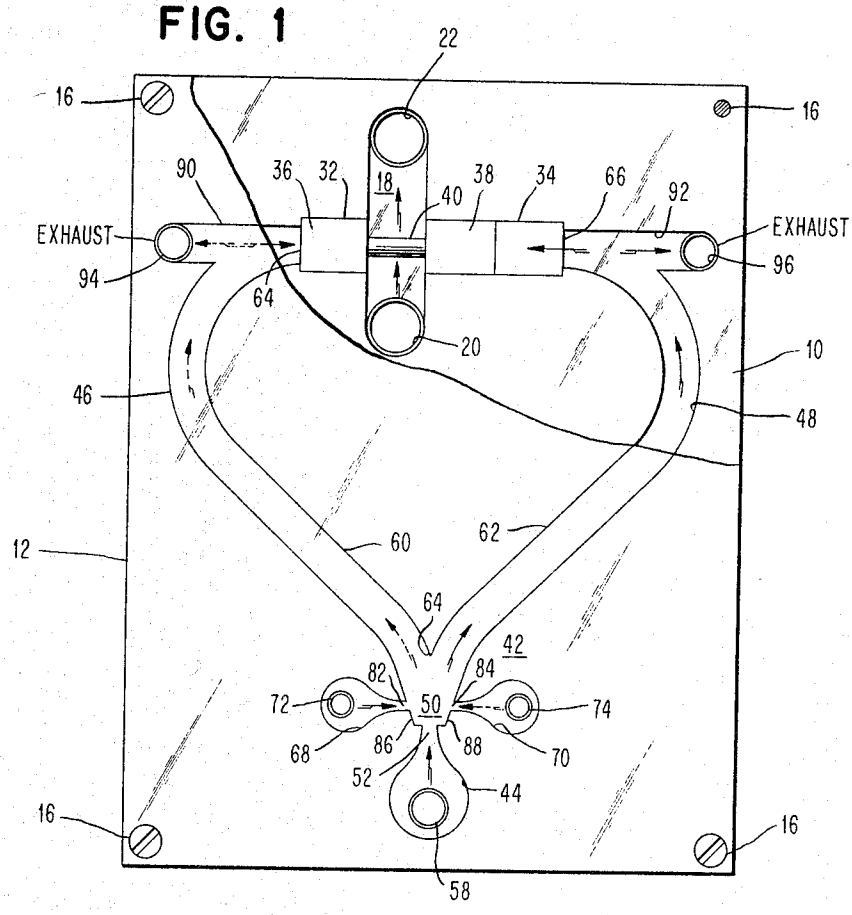
Nov. 1, 1966 E. U. SOWERS III 3,282,282

FLUID POWER OUTPUT DEVICE

Filed Feb. 18, 1964 2 Sheets-Sheet 1

FIG. 1



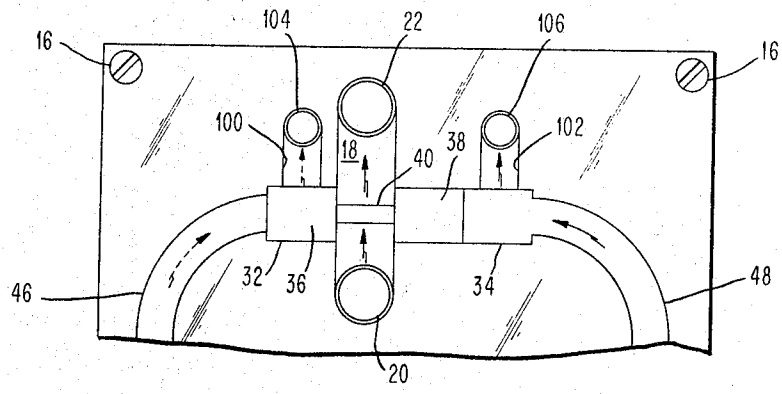


FIG. 3

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FLUID POWER OUTPUT DEVICE

Filed Feb. 18, 1964 2 Sheets-Sheet 2

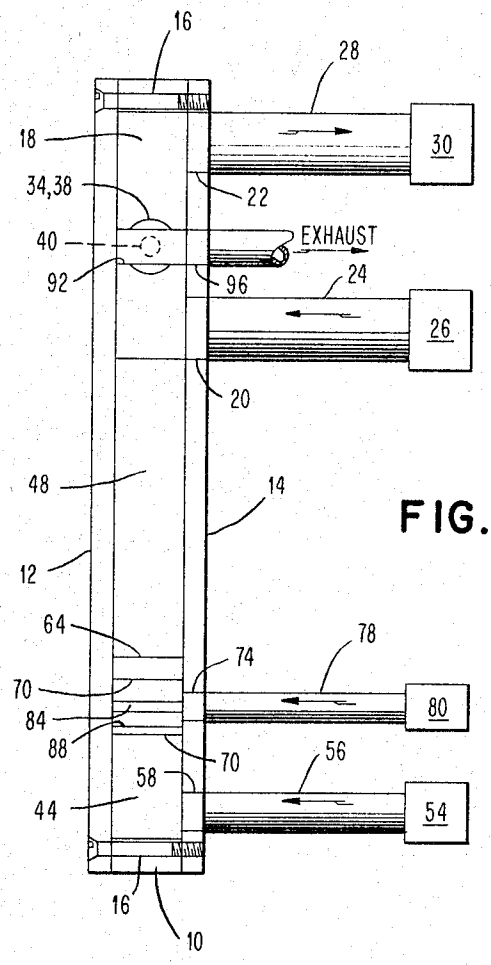


FIG. 2

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FLUID POWER OUTPUT DEVICE

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3 Claims. (Cl. 137—81.5)

The present invention relates to the field of fluid amplifiers, and particularly, to a fluid power output device which minimizes the power consumption of a fluid system.

Fluid amplifiers, as the term is now employed, operate upon the principle that a fluid power jet stream of relatively high energy may be deflected without losing its integrity generally and preferably by means of a fluid control stream of lesser energy. In general, a typical pure fluid amplifier includes a fluid interaction chamber wherein an entering power stream is deflected into either one of two output channels by means of a control stream impinging thereon at substantially a right angle. Certain types of fluid amplifiers exhibit bistable flip-flop characteristics in that power stream flow remains entirely in a selected output channel even after termination of the control input. Other types of fluid amplifiers, such as logical OR and NOR gates, can also exhibit a digital types of response without being bistable in nature. In some instances, the power stream output obtained from a pure fluid logic system must have sufficient energy to operate mechanical mechanism such as an output printer or the like. In the prior art it is customary to directly connect one output channel of the amplifier to the mechanical device while the other output channel is connected to exhaust the power stream back to the source of fluid pressure. The power stream flow is continuous no matter through which amplifier output channel it is directed, i.e., the power stream remains on even during the time that the mechanical mechanism is inoperative. In such a situation, the efficiency of the unit is considerably decreased since the power stream source performs work upon the fluid being exhausted. Consequently, if the energy in the power stream is required to be large because of the need for actuating a mechanical device, a considerable amount of power is wasted at various times in the system operation.

The present invention discloses means for producing large output fluid power from a fluid amplifier digital system only when it is actually required to perform some significant function. Instead of utilizing the power stream of a fluid amplifier to directly actuate mechanical elements of a large mass, a digital type fluid amplifier power stream of relatively low energy is used to move a mechanical valve element of relatively low mass to a position which either blocks or permits flow of a fluid stream of relatively large energy through a separate independent channel. This relatively high energy stream in turn provides the output fluid power necessary. Consequently, although the fluid amplifier power stream is continuously generated as usual, the power loss resulting from its constant operation is negligible compared to the power saved by blocking the flow of the high energy stream in the separate channel during those times when no significant output function need be performed.

It is therefore one object of the present invention to provide a fluid power output device which minimizes the power consumption of a fluid system.

Another object of the present invention is to provide means of producing relatively high fluid output power only when required.

A further object of the present invention is to provide a unique combination including a digital type of fluid amplifier whose output power stream controls the positioning of a spool valve element which in turn blocks

or permits flow of relatively high energy fluid in a separate channel.

These and other objects of the present invention will become apparent during the course of the following description to be read in view of the drawings, in which:

FIGURES 1 and 2 are the plan and side elevation views, respectively, of one embodiment of the present invention; and

FIGURE 3 is a plan view showing a modification of the embodiment in FIGURES 1 and 2.

Referring now to FIGURES 1 and 2, a preferred embodiment of the present invention will be described in which the output from a pure fluid digital type amplifier controls the position of a spool valve, which in turn blocks or permits flow of fluid in a channel leading to some utilization device such as a printer. The pure fluid amplifier channels, the valve seat, and the utilization fluid channel may be formed or molded in a body **10** of transparent plastic material or the like, with said channels having side walls extending entirely therethrough. The top and bottom walls of the channels are formed by plastic covers **12** and **14**, respectively, which are attached to body **10** by means of threaded fastening screws **16**. A fluid utilization channel **18** is provided having input and output ports **20** and **22**, respectively, which are drilled into cover **14** at right angles. High energy fluid under pressure is constantly supplied to port **20** via an external conduit **24** from a fluid pressure source **26**. The fluid flow in channel **18** exits from body **10** by means of port **22**, and from thence through external conduit **28** to a utilization device **30** which in turn may be comprised of mechanism actuated by the energy of the fluid stream. Fluid flow in channel **18** is governed by the position of a spool valve **32** which is slidably located in a valve seat channel **34** intersecting fluid channel **18**. As best shown in FIGURE **1**, the spool valve **32** is comprised of two end lands **36** and **38** which are connected by a center portion **40** of considerably reduced cross-sectional area. When valve **32** is in its leftmost position as shown in FIGURE 1, center portion **40** lies athwart fluid channel **18** and thereby permits substantial fluid flow in said channel from source **26** to utilization device **30**. On the other hand, if valve **32** is positioned in its rightmost position so that it abuts against the right end of channel **34**, then land **36** lies athwart channel **18** and completely blocks the flow of fluid therein. Therefore, energy may be selectively applied to utilization device **30** depending upon the position of valve **32**, there being no energy wasted from source **26** with said valve in its right hand position.

The positioning of spool valve **32** in turn is governed by the output from a digital type pure fluid amplifier generally indicated by **42**. This pure fluid amplifier is comprised of a power stream input channel **44** and two power stream output channels **46** and **48**. Power stream input channel **44** emerges into a fluid interaction chamber **50** via a nozzle **52**, so that a power jet stream is formed in the manner well known in the art. Power input channel **44** is supplied fluid under pressure from an external source **54** via conduit **56** and port **58** drilled at right angles to body **10**. The inner walls **60** and **62** of output channels **46** and **48** come together to form a divider knife edge **64** which is located on the axis of orifice **52**. Output channels **46** and **48** in turn respectively communicate with the left and right ends of valve seat channel **34** by means of fluid ports **64** and **66**.

As is well known by those skilled in pure fluid technology, a fluid power jet stream entering the interaction chamber of a digital type pure fluid amplifier can be deflected, without losing its integrity, so as to enter only one of its two output channels. That is to say, the absence or presence of power streams fluid in a particular power stream output channel can be representative of a discrete

control function or of a digital value in a number system. This deflection in turn is accomplished by an even lower energy control jet stream impinging upon the power stream at right angles thereto in the vicinity of the interaction chamber. In FIGURE 1, two control stream input channels **68** and **70** are provided each having an inlet **72** and **74**, respectively, from some external fluid source. In FIGURE 2, one such source **80** is shown for the control stream channel **70**, said source **80** possibly being another fluid amplifier whose power output stream is used as the control stream for amplifier **42**. Control channels **68** and **70** open into interaction chamber **50** via nozzles **82** and **84**. If a power jet stream issues from nozzle **52** into interaction chamber **50**, then a control stream issuing from channel **68** will deflect the power stream in the direction of the solid arrow so that said power stream flows into output channel **48**. On the other hand, if a control stream from channel **70** instead issues into interaction chamber **50**, it deflects the power stream from channel **44** into output channel **46** as indicated by the dotted arrow.

The digital type pure fluid amplifier **42** also has a bistable characteristic such that power stream flow in either output channel **46** or **48** is maintained even after termination of the initiating control stream. In other words, it is a fluid flip-flop device. This bistable characteristic may be conveniently provided by the so-called "boundary layer" phenomenon, well known to the prior art, which causes the power stream to automatically lock on to the outer side wall of a channel to which it is deflected. As an example, the temporary emission of control stream fluid from channel **70** pushes the power stream over to output wall **86** so that said power stream commences to flow in output channel **46**. The entrainment of fluid from the region between wall **86** and the power stream causes a reduction of pressure here which acts by itself to keep the power stream flowing in this path. The control stream from channel **70** may now be terminated without the power stream leaving output channel **46**. Consequently, the amplifier is stable for this output since no control stream need be continuously applied thereafter. When it is desired to divert the power stream into output channel **48**, a control stream is caused to flow temporarily from channel **68** which provides fluid to this region, increases the pressure therein, and thereby pushes the power stream into channel **48** where it locks on to outer wall **88**. The control stream in channel **68** may now be discontinued, but the power stream remains flowing in channel **48**. The formation of this boundary layer may be enhanced by slightly offsetting side walls **86** and **88** with respect to nozzle **52** in the manner shown in FIGURE 1.

Exhaust channels **90** and **92** are further provided for respective channels **46** and **48** in order to permit the escape of power stream mass flow in order to avoid a reversal of same within an output channel which in turn would result in fluid pressure appearing in both channels **46** and **48** at the same time. These exhaust channels, however are preferably constricted and/or oriented at an acute angle with the upstream power fluid so as to permit sufficient pressure to be built up for operating and moving the spool valve, and they exit from body **10** via ports **94** and **96**. Also, each exhaust channel prevents the back pressure from building up in the output channel wherein power stream flow occurs. For certain fluid amplifier configurations this back pressure relief is necessary to avoid undesirable switching of the power stream between output channels in the absence of control stream flow, since very often the boundary layer lock on effect, which provides power stream stability in an output channel, can be destroyed if said back pressure is above a certain threshold value.

Fluid flow in output channel **48** causes an unbalanced force to be applied to spool valve **32** such that it is moved to its leftmost position which thereby prevents fluid flow in channel **18**. On the other hand, power stream flow in channel **46** applies an unbalanced force on spool valve **32** in order to move it to its rightmost position so that land **36** completely blocks channel **18**. Since the spool valve body moves transverse to the high energy stream only a small pressure against its end is required to actuate it because there is no work done against the force of the high energy stream. This means that the relatively low energy of a typical fluid amplifier power stream is quite capable and admirably suited for operating this type of mechanical valve element. Thus, a relatively low energy power stream flow in either channel **46** or channel **48** causes the positioning of a valve **32** which in turn controls a relatively higher energy fluid stream in channel **18**. No additional valve biasing means need be provided here to maintain said valve in one position or the other. It will be noted that power stream flow in the fluid amplifier **42** usually is continuous no matter to which channel it is deflected. However, the loss of energy occasioned by this flow, when there is no need to energize the mechanism **30**, is relatively small compared to the energy supplied by source **26** which is itself not wasted when valve **32** is in its blocking position.

FIGURE 3 shows a slightly modified arrangement of the basic embodiment in which the exhaust channels **100** and **102** actually communicate with valve seat channel **34**. In this figure, an exhaust channel is not open to a power stream output channel **46** or **48** until spool valve **32** is correctly positioned. Such a configuration may be advantageous where the exhaust pressure exsting at a port **94** or **96** in FIGURE 1 might be of such low value that the stability of power stream flow in amplifier **42** of the boundary layer type would be affected because of unwanted low pressure feedback via the non-selected channel **46** or **48** to the chamber **50**. A more important reason, however, is that the FIGURE 3 arrangement prevents escape of the power stream mass flow until the spool valve is at least partially repositioned which thus permits the application of a higher initial actuating force to the valve.

Although preferred embodiments of the present invention have been shown and described, it is apparent that may modifications will occur to those skilled in the art without departing from the spirit of the invention as defined in the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A fluid device which comprises:

a first source of relatively high energy utilization fluid stream;

a utilization channel having an inlet connected to said first source and an outlet which in turn is adapted for connection with utilization means;

an elongated valve seat channel intersecting said utilization channel, said valve seat channel having first and second fluid ports at first and second ends thereof, respectively;

a spool valve member having first and second end surfaces which is slideably mounted in said valve seat channel with its first and second end surfaces exposed to said first and second fluid ports, respectively, and movable by fluid pressure selectively applied to its first and second end surfaces to a first position at one end of said valve seat channel wherein said spool valve member blocks flow through said utilization channel of said utilization fluid stream and movable to a second position at the other end of said valve seat channel wherein said spool valve member permits flow through said utilization channel of said utilization fluid stream;

a second source of relatively low energy power fluid stream;

a digital type fluid amplifier including a power stream input channel connected to said second source, and at least first and second power stream output chan-

nels respectively connected with said first and second fluid ports;

control means connected with said fluid amplifier for selectively directly its said power fluid stream into either of said first or second power stream output channels; and

first and second exhaust channels coaxial with the valve seat channel and respectively communicating with said first and second power stream output channels at locations immediately exterior to the respective end of said valve seat channel so that said exhaust channels are continuously operable to exhaust fluid from said valve seat channel and said power stream output channels at all times irrespective of the position of said spool valve member in said valve seat channel.

2. A fluid device of the type according to claim 1 wherein said fluid amplifier is of the boundary layer bistable type.

3. A fluid device according to claim 2 wherein said control means comprises selectively operable nozzle means.

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