Sept. 15, 1964 B. J. GREENBLOTT 3,148,691

FLUID CONTROLLED DEVICE

Filed June 7, 1962

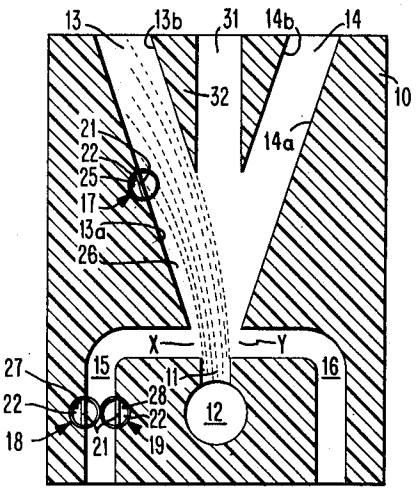



FIG. 1

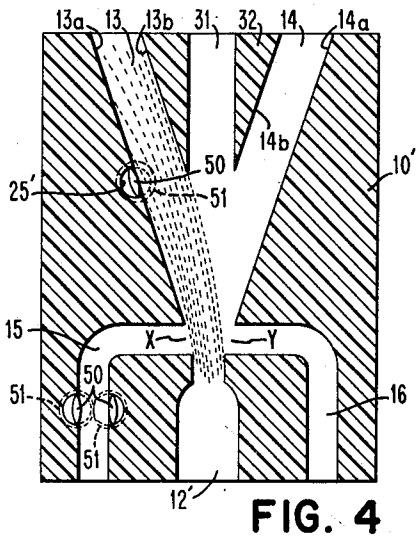



FIG. 4

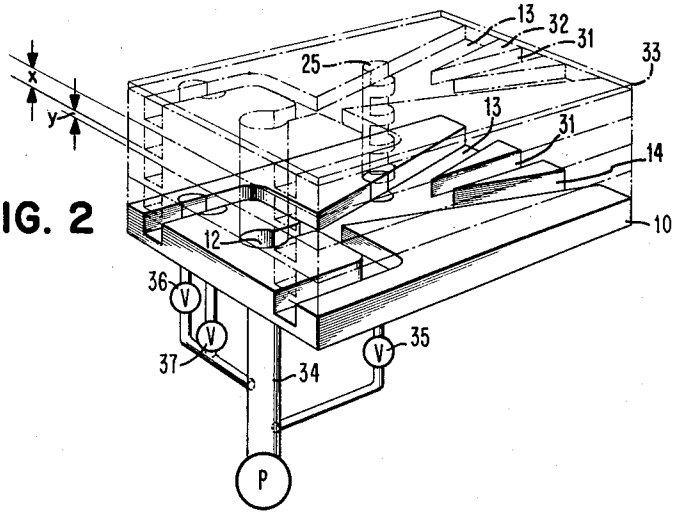



FIG. 2

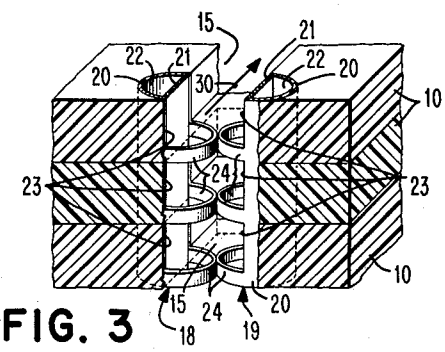



FIG. 3

INVENTOR

BERNARD J. GREENBLOTT

BY Henry E. Otto Jr.

ATTORNEY

United States Patent Office 3,148,691 Patented Sept. 15, 1964



3,148,691

# FLUID CONTROLLED DEVICE

Bernard J. Greenblott, Binghamton, N.Y., assignor to International Business Machines Corporation, New York, N.Y., a corporation of New York

Filed June 7, 1962, Ser. No. 200,703
8 Claims. (Cl. 137—81.5)

This invention relates to devices for controlling switching of a fluid power stream selectively into a plurality of outlet passages. The invention relates, more particularly, to devices of the so-called "fluid amplifier" type which employ fluid pressure actuated flexible, expandable or displaceable members to control switching of the power stream without commingling of the control pressure fluid with that of the stream.

"Fluid amplifier" devices are so named because a low energy pressure fluid control signal can control and switch a high energy fluid power stream to produce an output signal of higher energy level than the control signal. In fluid amplifier devices heretofore proposed, a fluid power stream, after leaving a nozzle, is switched selectively to one or the other of two outlet passages. This may be done by supplying pressure fluid continuously, or as a pulse, to one of the control ports at the exit end of said nozzle to enlarge the "separation bubble" adjacent the wall of one of the outlet passages until the stream is diverted to the other outlet passage. Or, switching may be effected by closing the other control port so that the fluid that is flowing in through said one control port from the atmosphere or some other source will create a sufficient fluid pressure unbalance adjacent the exit end of the nozzle to enlarge the "separation bubble" and effect switching of the stream to said other outlet.

In arrangements where it is desired to effect switching in response to supply of pressure fluid to a control port either continuously or as a pulse, the control pressure fluid thus supplied to the control port will, of course, be admitted to and commingle with the pressure fluid of the stream. There are instances where this may be undesirable. For example, the control pressure fluid may contain poisons, noxious or corrosive fumes or ingredients, or be otherwise contaminated, such as found in the manufacture of steel, paper or chemicals. Or, the control pressure fluid may contain foreign matter, such as card dust or chips, which might clog a control apparatus if permitted to mix with the fluid jet of the main stream.

One object of this invention is therefore to provide an improved fluid controlled device wherein switching of the fluid power stream from one outlet passage to another can be accomplished by a control pressure fluid without commingling of the control pressure fluid with the fluid power stream.

Another object is to provide a fluid control system wherein a control pressure fluid supplied to a single conduit can simultaneously switch the fluid power streams in a plurality of superposed fluid amplifier devices without commingling of the control pressure fluid with any of said streams.

Still another object is to provide a fluid amplifier device wherein one or more members are flexed, expanded or displaced by fluid under pressure fully or partially to constrict the control port adjacent a particular outlet to cause a fluid power stream to be switched into said outlet.

A further object is to provide a fluid amplifier device wherein a fluid power stream is switched from one outlet passage to another by fluid pressure effected displacement of flexible member in a direction outwardly from the wall of said passage.

Another object is to provide a fluid amplifier device



wherein the effective areas of the respective control ports are so related that switching of the fluid power stream to a desired outlet will require selective supply of pressure fluid to one (or, if preferred, concurrent supply of pressure fluid to both) of two tubes associated with a particular control port.

According to these objects, the fluid controlled device embodying the invention comprises a member comprising flexible, displaceable or expandable means which is actuated by fluid under pressure to move outwardly from the wall of an opening and, by interfering with the passage of fluid therethrough, effect either direct or indirect switching of a fluid power stream to another outlet. The member may be a generally rigid tube with paritions or the like that are flexed, expanded or displaced by a control pressure fluid. Or the member may be substantially entirely resilient, like a balloon.

According to one embodiment of the invention, one such member is disposed along a control port and normally retracted within or substantially flush with the wall of such port. Or, two such members may be arranged at opposite transverse sides of such control port, with their expandable means normally retracted or rendered ineffective so as to permit substantially unconstricted flow of pressure fluid through the control port. With these arrangements, when pressure fluid is supplied to one or both of these members, the expandable means of these members will move generally transversely of the direction of flow of fluid through the control port to constrict such flow. Where two such members are associated with a single control port, the effective area of that control port may be so related to that of another control port as to require a supply of pressure fluid to either one or both of the members to switch the fluid power stream; i.e., require either a logical "OR" or a logical "AND" relation to effect switching of the stream to another outlet.

According to a modification of the invention, a member of the type above described may be deployed along and normally substantially flush with the outer wall of an outlet passage (rather than along the wall of a control port). Upon supply of pressure fluid to such member, the "separation bubble" adjacent said outer wall will be enlarged sufficiently to divert the stream away from said wall and into another outlet passage.

With either of these embodiments, the fluid controlled devices may be superposed such that a single member passing through all such devices may effect concurrent switching of the respective fluid streams in each such device.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of fluid controlled devices embodying the invention, as illustrated in the accompanying drawing, wherein:

FIG.1 is a vertical section view of a fluid controlled device embodying two variations of one embodiment of the invention;

FIG. 2 is a perspective view, partly in phantom, showing how a plurality of devices of the type shown in FIG. 1 may be superposed and interconnected by rigid tube-like control members with expandable or displaceable portions, so as to be capable of concurrent control by pressure fluid from one or more sources;

FIG. 3 is an enlarged perspective view of a pair of the tube-like control members arranged side-by-side along opposite transverse walls of the respective superposed devices; and

FIG. 4 is a section view, like that of FIG. 1, but showing a fluid controlled device constructed according to two variations of a different embodiment of the invention in that it employs inflatable balloon-like control members (rather than rigid tube-like members with expandable or displaceable portions).

*Description—FIGS. 1 to 3*

The fluid controlled device constructed according to this embodiment of the invention comprises a housing **10** providing a nozzle **11**. A fluid power stream is supplied from an inlet **12** through the nozzle **11** and thence selectively into either of two outlet passages **13**, **14** that open through the exterior of the housing. As illustrated, the passages **13**, **14** are in part defined by divergent outer walls **13***a*, **14***a* which are set back or offset from the exit end of the nozzle. Also, control ports **15**, **16** extend from the exterior of the housing and at their inner ends have mouths that open through the outer walls **13***a*, **14***a*, respectively, at the exit end of the nozzle. The control ports **15**, **16** are shown to be of equal effective areas with their outer ends open to the atmosphere.

Because the outer walls **13***a*, **14***a* are set back from the exit end of the nozzle **11**, a low pressure region will be created at X when the fluid power stream is directed into passage **13**. This will tend to maintain the stream "locked on" to wall **13***a* by so-called "boundary layer control" and thus maintain the stream diverted into passage **13** even if both control ports **15**, **16** have unconstricted communication with the atmosphere. The power stream can be switched to passage **13** by momentarily constricting or blocking control port **15**, while leaving control port **16** open to atmosphere without restriction. This would be equivalent to supplying a "pressure fluid pulse" to control port **16** while leaving control port **15** open to the atmosphere. Similarly, since wall **14***a* is likewise offset, a low pressure region will be created at Y when the fluid power stream is directed into passage **14**; and this will tend to maintain the stream "locked on" to wall **14***a* once the stream is directed into said passage. The device as thus far described constitutes a bistable fluid amplifier with "lock on."

According to this embodiment of the invention, switching of the stream from passage **13** to passage **14** is effected by supplying fluid under pressure to a hollow member **17**; and switching of the stream from passage **14** back into passage **13** is effected by concurrently supplying fluid under pressure to two side-by-side arranged hollow members **18**, **19**.

These members **17**, **18**, **19** are identical in structure. As best shown in FIG. 3, each of these members comprises a rigid tubular casing **20** which may be formed of metal. Each tubular casing is longitudinally divided into two substantially semicircular parts by a flexible, expandable or displaceable diaphragm or partition **21** suitably bonded or otherwise sealingly secured to opposite sides of the inner wall of the casing. At one side of each partition **21** is an elongated semicircular chamber **22** for receiving a control pressure fluid. At the other side of each partition, each member **17**, **18**, **19** has a plurality of axially spaced cut-outs or windows **23** separated by intervening ribs **24**. The axial length of each window corresponds to the depth *x* (FIG. 2) of the control ports and passages. The thickness *y* (FIG. 2) of each rib **24** corresponds to the total height or thickness of the housing **10** less the depth of the control ports and passages.

Member **17** passes through aligned bores **25** extending through the respective housings **10** of each device. Each bore **25** provides a semicircular recess in the corresponding outer wall **13***a*. Member **17** is rotationally oriented in these bores **25** such that each partition **21** forms part of the wall **13***a* of a respective passage **13**. Hence, the windows **23** provide openings permitting the fluid of the respective power streams normally to flow along the corresponding walls **13***a* without impedance or interference. The member **17** is preferably disposed at a point along each wall **13***a* at or just beyond the downstream end of a separation bubble indicated at **26**.

Members **18**, **19** pass through aligned bores **27**, **28**, respectively, extending through the respective housings



**10** of each device. These bores provide semicircular recesses which face each other and are formed in opposite walls of the control port **15**. Members **18**, **19** are so oriented rotationally within these bores that their respective partitions **21** form part of the oppositely arranged walls of control port **15**. So long as the pressure of fluid in chambers **22** of the members **18**, **19** is equal to or less than that in the control port **15**, each partition **21** will permit fluid to flow freely through said control port from atmosphere to the region at X. Arrow **30** (FIG. 3) shows how such flow is accomplished, in each device, between the oppositely arranged partitions **21** and through the facing cut-outs or windows **23**.

An escape port **31** is provided in a flow divider **32** to release excess pressure fluid from the power stream and assure reliable switching of the stream between the passages **13**, **14**. As illustrated, this escape port is open to atmosphere and is disposed between the divergent inner walls **13***b*, **14***b* of the respective passages **13**, **14**; however, additional escape ports may be employed, if desired. The escape port(s) assure that if there is some form of impedance (such as a restriction or piston, not shown) at the downstream end of passage **13** and/or **14**, no adverse pressure gradient will be created which is sufficient to cause the fluid jet stream to leave the wall of such passage.

*Operation*

Assume that a plurality of superposed fluid controlled devices embodying the invention are stacked as shown in FIG. 2; that the various devices are securely staked to each other by the members **17**, **18**, **19**; that one end of the stack is sealed off by an imperforate end plate **33**; and that a pump P supplies fluid under pressure via a pipe **34** to the inlet **12** of each device. Assume also that control valves **35**, **36**, **37** are interposed between the pump P and the chambers **22** of the respective members **17**, **18**, **19** to control selective supply of control pressure fluid to such chambers.

Assume now that the valves **35**, **36**, **37** are positioned to vent the respective chambers **22** in members **17**, **18**, **19**; and that the fluid power stream in each device is directed into the passage **13** of such device. To switch the power stream from passage **13** to passage **14**, valve **35** is actuated to supply control pressure fluid to chamber **22** of member **17**. This pressure fluid will flex, expand or displace the partition **21** in a direction away from each wall **13***a*. This, in turn, will enlarge the separation bubble **26** sufficiently, at its downstream end, to cause the streams in each device to be directed simultaneously away from the corresponding walls **13***a* and diverted into the corresponding passages **14**. As soon as the streams are switched, chamber **22** of member **17** may be vented via valve **35**. The stream will remain "locked on" to wall **14***a* by "boundary layer control," as previously described.

To switch the stream back into passage **13**, valves **36**, **37** are concurrently actuated to supply control pressure fluid to the chambers **22** of members **18** and **19**. As the partitions **21** of these members are flexed, displaced or expanded toward each other, they will constrict flow through the control port **15** sufficiently to prevent flow of air from the atmosphere to region X. As previously explained, this will create an unbalance in fluid pressures in the control ports **15**, **16** with the higher (atmospheric) pressure being in the control port **16**. This will enlarge the separation bubble **26** at its upstream end sufficiently to switch the stream into passage **13**. Thereafter, the stream will remain "locked on" to wall **13***a* in the manner already described, even if the chambers **22** of members **18** and **19** are subsequently vented by valves **36** and **37** and fluid at the same reference pressure (illustratively assumed as atmospheric) is permitted to flow into both ports **15** and **16** concurrently.

It will thus be seen that by constructing and orienting the members **17**, **18**, **19** in the manner above described,

two useful results are achieved. First, these members provide a rigid casing **20** that can readily pass through the aligned bores **25** in a stack of superposed fluid controlled devices, and thereby securely stake said devices together. Secondly, when a control pressure fluid is supplied to the chamber **22** in any one of these members **17, 18, 19**, the corresponding partition **21** will be deflected or expanded simultaneously in all of the devices. Thus, concurrent switching of the respective fluid power streams in all of the devices may be effected by a superatmospheric control pressure fluid that cannot commingle with the pressure fluid of the respective streams. Thus, liquid power streams may be switched by supplying a gaseous type of control pressure fluid to an appropriate one of the control chambers **22**; and conversely.

*Description and Operation—FIG. 4*

The fluid controlled device constructed according to this embodiment differs from that shown in FIGS. 1 to 3 primarily in that expandable or resilient members **50** are substituted for the members **17, 18** and **19**.

The members **50** are like balloons and will be collapsed as shown when no control pressure fluid is supplied thereto. Upon selective supply of control pressure fluid to these members, they will expand or be displaced in a manner generally similar to the partitions **21** of the members **17, 18, 19** and for the same purpose. The housing of each device constructed according to this embodiment may be identical with the housing **10**; or, if preferred, it may be modified slightly to provide a housing **10'** having, instead of the bores **25**, semicircular member-accommodating openings **25'** that pass completely through the housing. In such case, by providing a suitable recess in the upper or lower side of each housing **10'**, O-ring type seals **51** may be compressed between adjacent devices and around each opening **25'**. This, desirably enables the control ports **15** and the passages **13** of the respective devices to be sealed off from each other. This arrangement would be especially useful where it is desired to effect concurrent switching of a number of power streams that are supplied with fluid under pressure through lateral inlets **12'** from separate sources (rather than from the common source P).

It should be understood, with respect to both embodiments above described, that the walls **13***a*, **13***b* need not necessarily be set back from the sides of the nozzle **11** to provide "lock on." A separation bubble **26** will be provided even without such setback. However, the pressure gradient between regions X and Y existing when the power stream is directed into either passage **13** or **14** will be influenced, among other things, by the angle at which the walls **13***a*, **14***a* diverge from the exit end of the nozzle. In other words, such gradient will increase as the angle increases and tends to enlarge the separation bubble **26**. However, the offset or setback is preferred to provide a somewhat increased pressure gradient for a given angle of divergence of the walls **13***a*, **14***a* from the axis of the nozzle **11**.

If preferred, switching of the power stream in each device may be effected by supplying pressure fluid to one of the members **18** or **19** (or alternatively, to one of the members **50** in control port **15**), rather than to both such members concurrently. This can be achieved, for example, by employing partitions **21** or members **50** which are flexed or expanded a greater degree by the control pressure fluid, or by reducing the width of the control port **15**.

Moreover, it will be understood that fluid at some reference pressure other than atmospheric may be supplied to the control ports **15** and **16** of each device; and/or reference pressures supplied to one set of control ports (such as **15**) may differ from those supplied to another set (such as **16**); and/or the effective areas of these ports may be dissimilar. If the control ports **15** are connected to a source of fluid at a higher reference pressure than the control ports **16**, or if the effective area of the ports **15** exceeds that of the ports **16** though connected to the same reference pressure, the streams in the respective devices will be biased into the corresponding passages **14**. In such case, the devices will be of the monostable type, and member **17** or the member **50** along wall **13***a* may be eliminated. Similarly, by providing monostable devices wherein the streams are biased into the respective passages **13**, the members **18, 19** or the members **50** in the control port **15** may be eliminated.

Finally, it will be apparent that members of the type of **17, 18, 19** and/or **50** may be associated with and extend through other control ports (such as **16**) or other passages (such as **14**) of the respective devices.

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 controlled apparatus comprising:
a plurality of superposed fluid controlled devices each having an inlet for issuing a corresponding fluid stream and at least two divergent outlet passages into which such stream is selectively switchable,
at least one hollow member having a substantially rigid perforate casing passing through all of the said devices and serving to secure said devices rigidly together,
a flexible element associated with each member and forming part of the wall of one of the passages of each such device, and
means for supplying a control pressure fluid to a chamber defined between the casing and each such element to effect concurrent flexure of all of said elements to divert the respective streams in each device concurrently from said one passage to a corresponding other passage without commingling of the control pressure fluid with the fluids of the respective streams.

2. A fluid controlled apparatus comprising:
a plurality of superposed fluid controlled devices each having an inlet for issuing a corresponding fluid stream and a plurality of outlet passages into which such stream is selectively switchable, and a plurality of control ports all normally concurrently supplied with fluid at a reference pressure and each opening through the wall of a corresponding outlet passage,
a hollow member having a generally rigid casing passing through all of said devices and serving to secure said devices together,
a movable partition within the casing and cooperating with said casing to define an elongated chamber, said partition forming part of a wall of a particular one of the control ports in each device, and
means for supplying a control pressure fluid to said chamber to constrict flow of such reference pressure fluid through the corresponding one control ports of each device and thus cause the stream in each device to be diverted into that particular passage with which said one control port is associated without commingling of the control pressure fluid with the fluids of the respective streams.

3. The combination according to claim 2, wherein
an additional one of said members is disposed beside the first-mentioned member such that the respective partitions of both members form part of substantially opposite walls of said one control ports of the respective devices, and
wherein fluid under pressure must be supplied concurrently to the respective chambers in each member to constrict flow through the said one control ports sufficiently to effect switching of the streams in each device.

4. A fluid controlled switching device comprising
means providing an inlet for issuing a fluid stream, and

a plurality of outlet passages into which the stream is selectively divertable, at least one of said outlet passages having a divergent outer wall adjacent the exit end of the inlet configured to provide a separation bubble adjacent such outer wall when the stream is directed into such passage,

a member comprising flexible means associated with the outer wall of said one passage to provide a flexible surface sealingly isolated from said one passage, and

means for directing pressure fluid against said surface to move said flexible means to enlarge said separation bubble and thereby effect diversion of the stream from said one passage into another of the passages.

5. The combination according to claim 4, wherein said member is expandable and balloon-like.

6. The combination according to claim 4, including

means providing control ports opening through one of the walls of each outlet passage substantially at the exit end of the inlet and normally supplied with fluid at a reference pressure, and

at least one element associated with at least one of the control ports and displaceable by fluid under pressure to so constrict flow of such reference pressure fluid through said one control port as to cause the stream to be diverted into the corresponding passage by the action of the reference pressure fluid supplied via the remaining control ports.

7. A fluid controlled apparatus comprising

a plurality of superposed substantially flat devices each having an inlet for issuing a respective fluid stream, and a plurality of outlet passages into which such stream is selectively switchable, at least one of said outlet passages having an outer wall that diverges from the exit end of the inlet to provide a separation bubble adjacent said wall when the stream is directed into such one passage,

a common flexible element extending through all of said devices and exposed through openings in the corresponding diverging outer wall of each device



at a point in proximity of where each separation bubble is provided,

means including said element for defining a common chamber sealingly isolated from all said passages, and

means for supplying pressure fluid to said chamber to move said flexible element to enlarge said separation bubble and thereby effect concurrent switching of the stream in each device from said one passage to a corresponding other one of the passages.

8. A fluid controlled apparatus comprising

a plurality of superposed substantially flat devices each having an inlet for issuing a respective fluid stream, and a plurality of diverging outlet passages into which such stream is selectively switchable, and a plurality of control ports all normally supplied with fluid at a reference pressure and each opening through the wall of a corresponding outlet passage near the exit end of the inlet,

a common flexible element extending through all of said devices and exposed through a wall of a respective one of the control ports of each device,

means including said element for defining a common chamber sealingly isolated from all said passages, and

means for supplying pressure fluid to said chamber to move said flexible element to concurrently constrict flow of reference pressure fluid through all of said one control ports and thereby cause switching of the stream in each device into those outlet passages associated with said one control ports.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 1,230,007 | Milliken | June 12, 1917 |
| 2,898,078 | Stephenson et al. | Aug. 4, 1959 |
| 2,984,448 | Koplin | May 16, 1961 |
| 3,001,539 | Hurvitz | Sept. 26, 1961 |
| 3,005,533 | Wadey | Oct. 24, 1961 |
| 3,030,979 | Reilly | Apr. 24, 1962 |