Feb. 18, 1969

J. A. HERR

3,428,066

ELECTRICALLY CONTROLLED FLUID AMPLIFIER

Filed Feb. 19, 1965

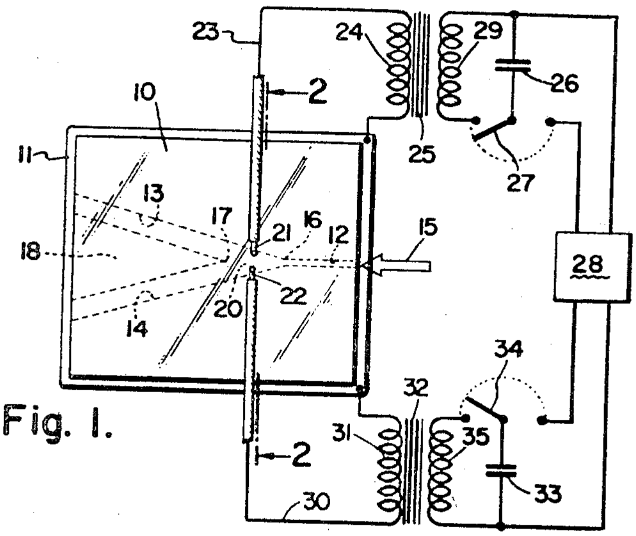

Fig. 1.

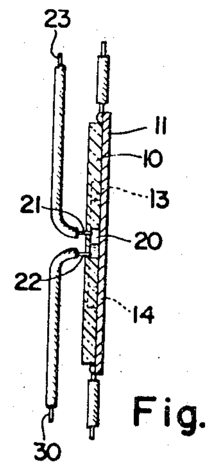

Fig. 2.

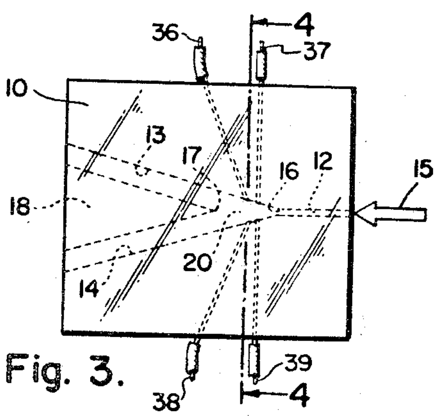

Fig. 3.

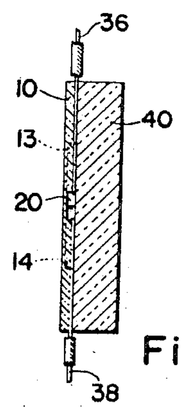

Fig. 4.

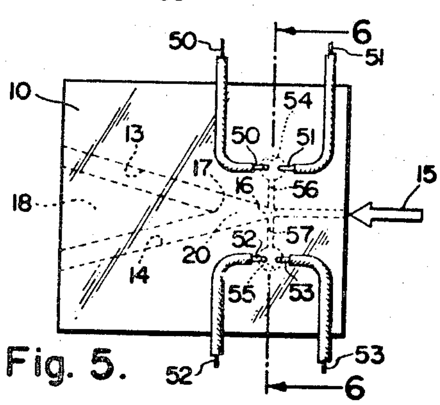

Fig. 5.

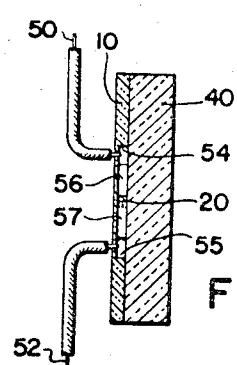

Fig. 6.

INVENTOR.

John A. Herr

BY

[signature]

ATTORNEY

WITNESS

[signature]

United States Patent Office

3,428,066
Patented Feb. 18, 1969

1

3,428,066
ELECTRICALLY CONTROLLED FLUID AMPLIFIER

John A. Herr, Garwood, N.J., assignor to The Singer Company, New York, N.Y., a corporation of New Jersey

Filed Feb. 19, 1965, Ser. No. 433,896
U.S. Cl. 137—81.5 2 Claims
Int. Cl. F15c *1/08, 1/14*

ABSTRACT OF THE DISCLOSURE

A fluid amplifier is described in which spark-gaps are formed by spaced wire pairs positioned in control chambers located on opposite sides of the power stream and these chambers are sealed except for connections to the interaction chamber just downstream of the power stream duct by control ducts having small cross-sectional area. These control ducts have a length at least equal to the maximum dimension of the control chamber. Unusual but consistent operation is observed in that spark discharge in a control chamber located on one side of the power stream causes deflection of the power stream towards the control chamber in which the spark discharge occurs.

This invention relates to fluid amplifiers and more particularly to pneumatic amplifiers for producing pneumatic output signals in direct response to electrical control signals.

Fluid amplifiers are a comparatively recent addition to the data processing and control system arts. These amplifiers are small, rugged and inexpensive. They may be constructed of plastic, metal or ceramic material, and basically comprise a plurality of fluid ducts formed within substantially solid bodies of material. For further information concerning the characteristics and mode of operation of fluid amplifiers, reference should be made to the publication entitled fluid Jet Control Devices, The A.S.M.E., New York, N.Y., 1962.

As explained in the aforementioned publication, fluid amplifiers heretofore known have required one or more control signal inputs for applying fluid control signals for producing fluid output signals. In order to control fluid amplifiers with electrical signals it has heretofore been necessary to apply the electrical signals to an electrically-actuated mechanical fluid valve. The fluid output signal from the valve is then applied to a control signal input of the fluid amplifier. It will be apparent that the inertia effect of the mechanical valve for converting the electrical control signals to fluid control signals inherently limits the response time of the amplifier and the output signals cannot follow rapidly changing input signals.

Attempts have been made to eliminate the need for valves as control elements in fluid amplifiers. For example, United States Patent No. 3,001,539 suggests the use of an electrically-controlled variable fluid resistance in the control ducts leading to a region of low pressure. The exact nature of this fluid resistance is not disclosed but apparently it changes value in response to a variable transverse voltage gradient. In another system disclosed in United States Patent No. 3,071,154 the power fluid stream is ionized as it enters the amplifier and the fluid then passes through an electrostatic or a magnetic field to cause deflection of the fluid to a desired output. A recent system disclosed in United States Patent No. 3,168,897 utilizes a spark discharge closely adjacent the power stream to deflect the stream in a direction away from the area of discharge.

The present invention utilizes an electrical spark discharge in a sealed chamber remotely located relative to the power stream and connected thereto by a duct of small cross-section to deflect said stream to a selected output duct. Devices built in accordance with the present invention do not require a source of fluid pressure for the control signal but derive this pressure directly from the energy of the spark discharge itself. The relative simplicity of the system of the present invention and its inherent ability to provide pressure pulses of short rise time and short duration set it quite apart from the prior art control devices for fluid amplifiers.

2

An object of this invention is to provide a fluid amplifier which does not require fluid control signals.

Another object of this invention is to provide a fluid amplifier having only one input stream called the power stream.

A further object of this invention is to provide a fluid amplifier having a fluid output signal which responds quickly to an electrical input signal.

A still further object of this invention is to provide fast-acting multistable switches responsive to electrical signals for producing fluid output signals.

A further object of this invention is to provide a system for converting electrical pulses into fluid pulses without the use of moving parts.

Other objects of the invention and its mode of operation will become apparent upon consideration of the following description and drawings in which:

FIG. 1 is a top plan view, partly schematic, of an amplifier constructed in accordance with the prior art,

FIG. 2 is a sectional view of the device of FIG. 1 taken substantially on line 2—2 of FIG. 1,

FIG. 3 is a top plan view of a modification of the embodiment of FIG. 1,

FIG. 4 is a sectional view of the device of FIG. 3, taken substantially on line 4—4 of FIG. 3,

FIG. 5 is a top plan view of an embodiment of this invention,

FIG. 6 is a sectional view of the device of FIG. 5 taken substantially on line 6—6 of FIG. 5.

The fluid amplifier shown in FIG. 1 comprises a top plate **10** preferably of insulating material the bottom surface of which is grooved in the Y configuration shown. A bottom plate **11**, preferably of electrical conducting material, is secured to said top plate **10** and forms with the grooved portion a power stream input duct **12** and two divergent power output ducts **13** and **14**. It will be understood that the plates **10** and **11** are sealed together so that a high velociyt fluid jet introduced at the end of the input duct **12**, as indicated by the arrow **15**, will be confined within the Y configuration shown.

It will be noted that the side walls of duct **12** diverge at a point **16** downstream thereof to form the side walls of the output ducts **13** and **14**. Further downstream, at point **17** defined by the end of a splitter **18**, the output ducts begin and the duct region between point **16** and **17** will be defined as the interaction chamber **20** and corresponds to the jet interaction chamber of prior art fluid amplifiers using control jets.

Conducting wires **21** and **22** are sealed into apertures in the top plate **10** and terminate substantially flush with the top wall of the interaction chamber **20** at positions equally spaced on either side of the centerline of the power stream input duct **12** and adjacent to the side walls of the chamber **20**. Wire **21** is connected by lead **23** to one end of the secondary winding **24** of a pulse transformer **25**, the other end of winding **24** being connected to the bottom conducting plate **11**. A condenser **26** is connected to a single-pole double-throw switch **27** so that it may be selectively charged from a D.C. voltage source **28** and discharged through the primary winding **29** of the pulse transformer **25**.

Similarly, wire **22** is connected by lead **30** to one end of the secondary winding **31** of a pulse transformer **32**, the other end of winding **31** being connected to the bottom plate **11**. A condenser **33** is connected to a single-pole double-throw switch **34** so that it may be selectively charged from the D.C. source **28** and discharged through the primary winding **35** of the pulse transformer **32**.

The configuration of FIG. 1 is that of a bistable amplifier and when a power stream **15** is introduced into duct **12**, it will, due to the turbulence effect of the splitter **18** tend to pass more into one of the output ducts, say **13**, than into the other output duct **14**. This tendency is regenerative and, due to the well-known "Coanda" effect, the stream will lock onto the side wall of duct **13** and the entire stream will issue from output duct **13** as a stable condition. If now, switch **27** is operated to discharge condenser **26** into primary winding **29**, a steep voltage pulse is supplied by the secondary winding **24** and applied between wire **21** and the plate **11**. This produces an electrical discharge or spark between wire **21** and plate **11** as spark-gap means and operates to deflect the power stream into the output duct **14** where due to the "Coanda" effect it locks onto the side wall of duct **14** where it remains as a stable condition in the absence of spark signals. The stream may selectively be switched back to the output duct **13** by operating switch **34** to produce a spark between wire **22** and plate **11**. Thus, by selective spark discharge located asymmetrically to the power stream in the interaction chamber, the power stream in duct **12** may be switched into a selected one of said output ducts **13** or **14** as desired and without the use of any fluid signal jets as conventionally required. This phenomenon of direct interaction between an electrical discharge and the input power stream, while not fully understood, is consistently repeatable and not random in nature. The response is very fast and would appear to result from a steep pressure wave generated by the electrical discharge, which wave deflects the power stream away from the wall to which it was attached.

While there is shown a specific means using a condenser discharge into a pulse transformer for obtaining the sparking potential it is to be understood that this invention is not so limited but includes within its scope any suitable means for obtaining a potential sufficient to produce an electric spark discharge in regions related to the main power stream in accordance with the teachings of this invention.

FIG. 3 shows a modification of the arrangement of FIG. 1 from which it differs only in the arrangement of the spark-gaps. In this case, wires **36** and **37** are brought into the amplifier from one side and terminate substantially flush with one side wall of the interaction chamber **20** to form a spark-gap extending along said wall. Similarly, wires **38** and **39** are brought into the amplifier from the opposite side of the amplifier and terminate substantially flush with the side wall of the interaction chamber **20** to form a spark-gap extending along said wall. The conducting plate **11** of FIG. 1 is replaced in FIG. 3 by an insulated plate **40** to maintain the wires **36, 37, 38** and **39** in insulated spaced condition. It will be understood that any suitable electrical source of sparking potential may be applied to wires **36** and **37** or to wires **38** and **39** to cause selective spark discharge across the spark-gaps defined above. The operation of the amplifier of FIG. 3 is the same as that of the amplifier of FIG. 1 above described.

In FIG. 5 is shown an embodiment of this invention in which the spark-gaps formed by wire pairs **50, 51** and **52, 53** are located in control chambers **54** and **55**, respectively, lying on opposite sides of and remote from the power stream duct **12** and connected to the interaction chamber **20** (just downstream of the duct **12**) by transverse ducts **56** and **57**. The chambers **54** and **55** are sealed except for the connections with ducts **56** and **57**. These ducts **56** and **57** are small in cross-sectional area but have a length at least equal to the maximum dimension of the control chambers **54** and **55**. In this case electric sparking potentials are applied to wires **50, 51** to cause spark discharge in chamber **54** and to wires **52, 53** to cause spark discharge in chamber **55** but the deflection effect on the power stream is just the reverse of that obtained in the case of the amplifiers of FIG. 1 and FIG. 3. That is, in order to deflect the power stream from output duct **14** to output duct **13** the spark discharge is made to occur in chamber **54** and for the opposite deflection, the spark discharge is made to occur in the chamber **55**. It is not understood why this observed reverse behavior occurs but it is a consistently repeatable effect and can be relied on to deflect the power stream as desired and with relatively small energy sparks. In the embodiment of FIG. 5, the wires **50, 51** and **52, 53** may preferably be brought fully into the chambers **54** and **55** respectively to form spark-gaps within the chambers as opposed to terminations flush with the wall as indicated to be preferable with the embodiments of FIG. 1 and FIG. 3.

From the above it will be perceived that there is provided in accordance with this invention novel and effective means for deflecting the power streams of fluid amplifiers by the action of a controlled electric spark discharge.

What is claimed is:

1. A fluid operated device comprising a power stream duct for receiving a power stream, a pair of output ducts having origins adjacent to the downstream end of said power stream duct, an interaction chamber located between said downstream end and said origins, sealed control chambers located remotely on opposite sides of and downstream of said power stream duct, a duct having a length at last equal to the maximum dimension of the control chamber and connecting each control chamber to said interaction chamber, and means for producing an electrical spark discharge in a selected one of said control chambers thereby to deflect said power stream to the one of said output ducts located on the same side of the power stream duct as the selected chamber in which said discharge occurs.

2. In a fluid amplifier of the wall-effect type having a power stream duct connected to a source of fluid power for producing a power stream, means forming a pair of output ducts for receiving said power stream, and means defining an interaction chamber located between said power stream duct and said output ducts including a pair of boundary walls associated respectively with said output ducts, improved control means for said amplifier comprising:

(a) a means defining a pair of sealed control chambers located remotely from and on opposite sides of said power stream,

(b) means defining a pair of ducts of small cross-sectional area, each duct connecting a respective one of said control chambers to said interaction chamber at a respective boundary wall,

(c) the length of each of said ducts being at least equal to the maximum dimension of said control chambers, and

(d) means located in each of said control chambers for producing an electrical spark discharge operable to switch the power stream into the output duct located on the same side of the power stream duct as the control chamber in which the spark discharge occurs.

References Cited

UNITED STATES PATENTS

3,071,154	1/1963	Caraill et al.	137—81.5
3,122,062	2/1964	Spivak et al.	137—81.5 X
3,168,897	2/1965	Adams et al.	137—81.5
3,263,695	8/1966	Scudder et al.	137—81.5
3,269,419	8/1966	Dexter	137—81.5

SAMUEL SCOTT, *Primary Examiner.*