Feb. 25, 1969 E. E. METZGER 3,429,322

TURBULENCE AMPLIFIER SYSTEM

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FIG. 1

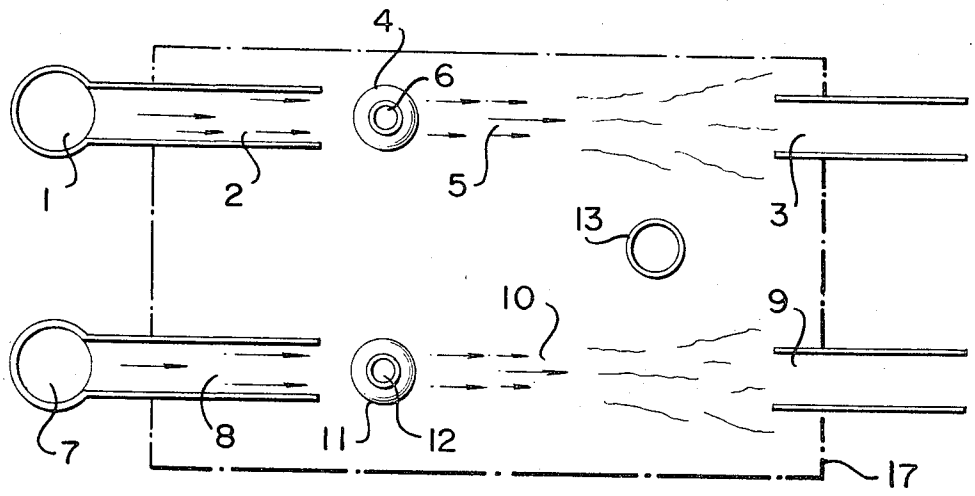
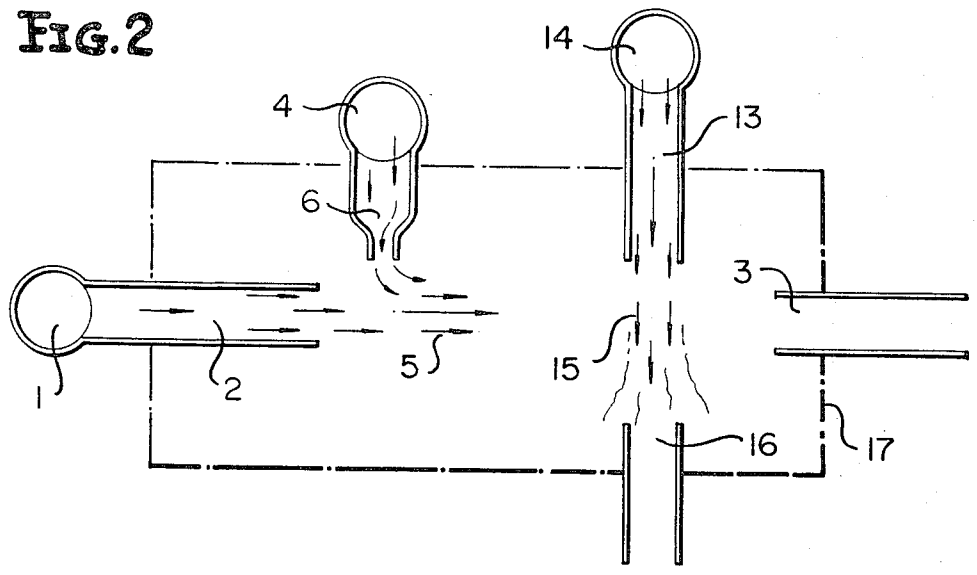


FIG. 2



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TURBULENCE AMPLIFIER SYSTEM

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ABSTRACT OF THE DISCLOSURE

A turbulence amplifier system wherein a control stream is employed to produce turbulence in a power stream which, when rendered turbulent, produces turbulence in still a further power stream. The degree of turbulence produced in both power streams is a function of the single input control stream.

The present invention relates to fluid elements, and more particularly, to pure fluid turbulence amplifiers.

Turbulence amplifiers, in general, are well known in the art of pure fluid amplification. With a supply pressure of a few hundredths of a lb./in.^{2} and a power nozzle about $\frac{1}{25}$ inch in diameter, an air-operated turbulence amplifier at sea level pressure can accomplish power gains of 100 and higher. This type of amplifier device with its extremely low operating power requirements, excellent gain, high level of amplification and many other unique properties is well suited for use in logic circuits and as a primary sensor of low velocity fluid streams and low energy acoustic waves.

In the turbulence amplifier of the type with which the present invention is concerned, a laminar power stream is developed by using a relatively long inlet tube or nozzle when the stream is at a sufficiently low velocity. With the flow being initially sufficiently laminar, the submerged power stream can be projected a distance of over one hundred times the diameter of the inlet tube or nozzle before it becomes turbulent. The eventual turbulence of the power stream is believed to result from the growth of vorticity and turbulence in the boundary layer regions of the submerged power stream as it progresses through surrounding static fluid.

In the usual turbulence amplifier, a single receiving duct is placed downstream of the power nozzle with the entrance just within the region of laminar flow of the power stream. An appreciable static pressure recovery, which is a function of the average velocity of the stream, is possible in this receiving duct and this static pressure constitutes the output signal of the amplifier. It is known that a relatively weak control signal from a suitably placed control nozzle will cause otherwise laminar flow in the boundary layer regions of the power stream to become turbulent at the entrance of the receiving duct. Strong mixing of the fluid in the boundary layer regions takes places, the energy initially contained within the narrow stream being distributed over a much enlarged cross-sectional area and thus the pressure signal detectable in the receiving duct is greatly reduced. As the control signal becomes stronger, the point of initial disturbance moves upstream toward the power nozzle exit and since the relative disturbance in the boundary layer regions becomes greater with increased distance of projection, the stream is distributed over even a larger area at the receiving duct entrance with the pressure signal in said receiving duct thus being further reduced. It is desirable in many cases to use a turbulence amplifier because of its ability to detect and amplify weak control signals such as acoustical waves. However, the use of turbulence amplifiers has been limited because normally only a single output signal is obtainable from this type of device.

In accordance with the present invention, there is provided a turbulence amplifier in which several output signals may be derived from a single input signal. When the term input signal is employed herein, it refers to the use of a relatively weak control signal to produce turbulence in an initially laminar stream. The present invention makes use of the fact that the spreading of a laminar stream is only approximately one-twenty-second as great as a turbulent stream. Consequently, one laminar stream may be employed to induce turbulence in a second laminar stream only when the first stream is rendered turbulent. Thus, a single control signal employed to produce turbulence in one stream effectively produces two or more output signals. Consequently, a turbulence amplifier is provided in which only a single control signal is coupled to the device and coupling of the control signal to multiple power streams is effected by a power stream wholly internally of the apparatus thereby eliminating intricate external cross-couplings between various power and control passages.

It is an object of the present invention to provide a turbulence amplifier in which a single control stream directed against a single laminar stream may produce turbulence in multiple initially laminar streams to provide plural output signals in response to the single control stream.

It is another object of the present invention to provide a turbulence amplifier operated as a NOR gate wherein there is provided a NOR output passage as well as other passages indicating which of one or both input signals have been applied to the NOR apparatus.

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawing, wherein:

FIGURE 1 is a front view in elevation of the apparatus of the present invention; and

FIGURE 2 is a top view of the apparatus of FIGURE 1.

Referring specifically to FIGURES 1 and 2 of the accompanying drawings, the apparatus comprises a first source of fluid **1** adapted to supply fluid at a low Reynolds number to a supply tube **2**. The tube **2**, when taken in conjunction with the Reynolds number of the fluid, is of such a length as to produce laminar flow in a stream **5** issued thereby.

Downstream of and coaxial with the tube **2** is a fluid receiver **3**. The receiver **3** is positioned such relative to tube **2** that, in the absence of a control signal, the stream **5** is laminar when it arrives at receiver **3** and a large proportion of the stream flows into the receiver.

A control signal source **4** is adapted to supply a low level control flow through a passage **6** which flow impinges upon the stream **5** and produces turbulence therein. Turbulent spreading of the stream in response to a control signal greatly reduces the flow to the receiver **3**.

A second source of fluid under pressure is connected to supply fluid to a second tube **8**. Alternatively, the source **1** may supply fluid to both of the tubes **2** and **8**. A fluid receiver **9** is located relative to tube **8** as receiver **3** is located relative to tube **2**. A second source **11** of control signals is connected through a passage **12** so as to issue fluid against a stream **10** issued by tube **8** and render it turbulent so as to reduce flow to the receiver **9**.

The tubes **2** and **8** are spaced apart such that turbulent spreading of the power streams **5** and **10** issued thereby do not affect one another. Thus, if passage **6** issues fluid, the stream **5** does not spread sufficiently to impinge upon the stream **10** and vice versa.

A third tube **13** is supplied with fluid from a source **14** or alternately from the source **1**. A receiver **16** is coaxial with and located downstream of the tube **13** at a location such that, when a power stream **15** issued by the tube **13** is turbulent, the flow thereto is greatly reduced relative to the condition when the stream **15** is laminar.

The tube **13** is positioned such that turbulent spreading of the stream **15** does not affect the streams **5** and **10**. This is accomplished by placing the egress end of tube **13** just a short distance from a plane passing through the adjacent surfaces of the tubes **2** and **8** and receivers **3** and **9**. Under these circumstances, the stream **15** issued by tube **13** cannot spread sufficiently to impinge upon streams **5** and **10** issued by tubes **2** and **8** before the former stream is beyond the range of the latter streams.

The tube **13** is symmetrically located relative to tubes **2** and **8** and downstream therefrom. The downstream location of tube **13** is such that, if either of the streams **5** and **10** is rendered turbulent, turbulent spreading causes fluid to impinge upon the stream **15** and renders this latter stream turbulent.

In operation, if no control signals are supplied to the system, all of the receivers **3**, **9** and **16** receive maximum pressure signals. If now the source **4** supplies fluid to tube **6**, the stream **5** is rendered turbulent, rendering the stream **15** turbulent. The signals supplied to receivers **3** and **16** are materially reduced while the signal supplied to receiver **9** is unaffected.

Similarly, if source **11** issues fluid through tube **12**, the receivers **9** and **16** receive reduced signals while tube signal supplied to receiver **3** is unaffected.

Thus, the receiver **16** provides a NOR output function in that a high level signal is developed therein when neither the source **4** nor the source **11** produces signal flows. In addition to the NOR function, the apparatus provides at the receivers **3** and **9** an indication of which of the sources **4** or **11** is active.

It will be noted that various signal functions are all interrelated within a single enclosure such as defined by the dashed line designated by reference numeral **17** in both FIGURES 1 and 2. It is apparent that other than for signal and supply sources, the unit is wholly contained requiring no interconnection of elements except by means of laminar power streams all contained within the enclosure.

It is apparent that the apparatus of the present invention increases the fan-out obtainable with turbulent amplifiers. In the usual turbulent amplifier, it may be possible, for instance, to operate 10 additional amplifiers from the output flow to one of the receivers. If, in the present invention, only the streams **5** and **15** are developed, for instance, a single input signal drives two power streams and a fan-out of 20 may be achieved. By employing additional power streams driven by the stream **5**, additional fan-out may be achieved and, more importantly, a separate power stream may be provided for each further device to be driven.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations of the details of construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

What I claim is:

1. A turbulence amplifier system comprising means for producing a first laminar power stream, means for selectively inducing turbulence in said power stream to produce turbulent spreading without substantial deflection thereof, means for producing at least one second laminar power stream, said second power stream being positioned such as to be out of the path of said first power stream when laminar and to be in the path of said first power stream when it has achieved a predetermined degree of turbulent spreading without substantial deflection thereof, whereby said second power stream is rendered turbulent.

2. A turbulence amplifier system comprising means for producing a first laminar power stream, means for selectively inducing turbulence in said power stream to produce turbulent spreading without substantial deflection thereof, a first fluid receiver generally aligned with said first power stream, means for producing at least one second laminar power stream, a second fluid receiver generally aligned with said second power stream, said second power stream being positioned such as to be out of the path of said first power stream when laminar and to be in the path of said first power stream when it has achieved a predetermined degree of turbulent spreading without substantial deflection thereof, whereby said second power stream is rendered turbulent.

3. A turbulence amplifier system comprising means for producing a first laminar power stream, means for selectively inducing turbulence in said power stream to produce turbulent spreading thereof, a first fluid receiver generally aligned with said first power stream, means for producing at least one second laminar power stream, a second fluid receiver generally aligned with said second power stream, means for selectively inducing turbulence in said second power stream to produce turbulent spreading thereof, means for producing a third laminar power stream, a receiver for said third power stream, said third power stream being located out of the paths of said first and second power streams when laminar and to be in the path of said first and second power streams when either have achieved a predetermined degree of turbulent spreading whereby said third power stream is rendered turbulent by either of said first and second power streams.

4. A turbulence amplifier system comprising means for producing a first laminar power stream, means for selectively inducing turbulence in said power stream to produce turbulent spreading thereof, means for producing at least one second laminar power stream, means for selectively inducing turbulence in said second power stream to produce turbulent spreading thereof, means for producing a third laminar power stream, a receiver for said third power stream, said third power stream being located out of the paths of said first and second power streams when laminar and to be in the path of said first and second power streams when either have achieved a predetermined degree of turbulent spreading whereby said third power stream is rendered turbulent by either of said first and second power streams.

5. A turbulence amplifier system for providing first and second fluid output signals having pressures which vary in inverse proportion to the magnitude of a variable input signal, said system comprising:

means for producing a first laminar power stream;

a first fluid receiver generally aligned with said first power stream and positioned to receive said first power stream when laminar;

means responsive to said input signal for inducing turbulence in said power stream to produce turbulent spreading thereof in proportion to the magnitude of said input signal while said power stream remains substantially undeflected;

means for producing a second laminar power stream;

a second fluid receiver generally aligned with said second power stream and positioned to receive said second power stream when laminar, said second power stream being positioned out of the path of said first power stream when laminar and in the path of said first power stream when turbulent, so as to produce turbulent spreading of said second power stream in proportion to the turbulent spreading of said first power stream.

6. The system according to claim **5** wherein said means for inducing turbulence comprises means for issuing a control stream which angularly intercepts said first laminar power stream upstream of said first fluid receiver, said control stream having a pressure which is proportional to the magnitude of said variable input signal.

7. A turbulence amplifier system for performing a NOR logic function in response to first and second binary input signals, said system comprising:

means for producing a first laminar power stream;

means responsive to said first binary input signal for inducing turbulence in said power stream whenever said first binary input signal is in a binary one state;

means for producing a second laminar power stream;

means responsive to said second binary fluid input signal for inducing turbulence in said second power stream whenever said second binary input signal is in a binary one state;

means for producing a third laminar power stream;

a receiver for said third power stream generally aligned therewith and positioned to receive said third power stream when laminar, said third power stream being located out of the paths of said first and second power streams when said first and second power streams are laminar and being in the paths and rendered turbulent at said receiver by said first and second power streams when either has been rendered turbulent;

whereby said receiver for said third power stream provides a fluid output signal as said NOR function of said first and second binary input signals.

8. The system according to claim 7 wherein said means for inducing turbulence in said first and second power streams comprises means for issuing respective first and second control streams which angularly intercept the flow of said first and second laminar power streams respectively, the pressure of said control streams being sufficient to induce turbulence in their respective power streams without deflection thereof whenever said first and second binary input signals respectively are in the binary one state, the pressures of said control signals being insufficient to cause turbulence in said power streams when said binary input signals are in the binary zero state.

9. A turbulence amplifier system comprising:

tube means for producing a first laminar power stream;

means for selectively inducing turbulence in said power stream to produce turbulent spreading thereof;

a first output tube in axial alignment with said tube means and spaced therefrom at a distance to receive a predetermined portion of said first laminar power stream when laminar and less than said predetermined portion of said power stream when turbulent and undeflected;

second tube means for producing a second laminar power stream;

a second output tube in axial alignment with said second tube means and spaced therefrom at a distance to receive a predetermined portion of said second laminar power stream when laminar and less than said predetermined portion of said second power stream when turbulent and undeflected;

said second power stream being positioned out of the path of said first power stream when laminar, and to be in the path of and rendered turbulent by said first power stream when it has achieved a predetermined degree of turbulent spreading without substantial deflection.

10. The system according to claim 9 further comprising:

third tube means for producing a third laminar power stream;

means for producing turbulence in said third power stream to produce turbulent spreading thereof;

wherein said second power stream is further positioned to be out of the path of said third power stream when laminar and to be in the path of said third power stream when it has achieved a predetermined degree of turbulent spreading.

11. The system according to claim 10 wherein said means for inducing turbulence in said first and third power streams comprises means for issuing respective first and second control streams which angularly intercept the flows of said first and third laminar power streams respectively.

12. The system according to claim 9 wherein said means for inducing turbulence comprises means for issuing a control stream which angularly intercepts the flow of said laminar power stream.

13. A fluid amplifier utilizing laminar-turbulence phenomena comprising:

(a) first and second supply tubes having predetermined parameters capable of producing laminar streams,

(b) means to feed fluid through the supply tubes with a specified velocity relative to said parameters at which there are produced first and second main streams having laminar flow patterns which are projected from the supply tubes,

(c) an output tube in axial alignment with said second supply tube and spaced therefrom at a distance to receive the projected laminar second main stream,

(d) a control tube having an inlet and an outlet, said tube disposed to convey a control stream along a path which angularly intercepts the flow of the projected laminar first main stream between the supply and output tubes,

(e) means to feed a unidirectional fluid to the inlet of the control tube with a velocity producing a control stream having sufficient energy to create turbulence in the projected first main stream while said first main stream remains in a substantially undeflected state; and

(f) said supply tubes being located relative to one another such that said second main stream is remote from the path of said first main stream whin said first main stream is laminar and lies in the path of said first main stream when said first main stream is turbulent rendering said second main stream turbulent at a point therein in advance of the output tube, whereby the pressure at the output tube is reduced to a value below that produced when the stream is laminar.

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