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REPLY TO ATTN OF: GP

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U. S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code USI, the attached NASA-owned U. S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U. S. Patent No. : 3,493,004

Government or Corporate Employee : Government

Supplementary Corporate Source (if applicable) : NA

NASA Patent Case No. : XLA-07391

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:

Yes ☐ No ☒

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . . with respect to an invention of . . . "

Elizabeth A. Carter

Elizabeth A. Carter
Enclosure
Copy of Patent cited above

LOGIC AND GATE FOR FLUID CIRCUITS

Filed May 6, 1968

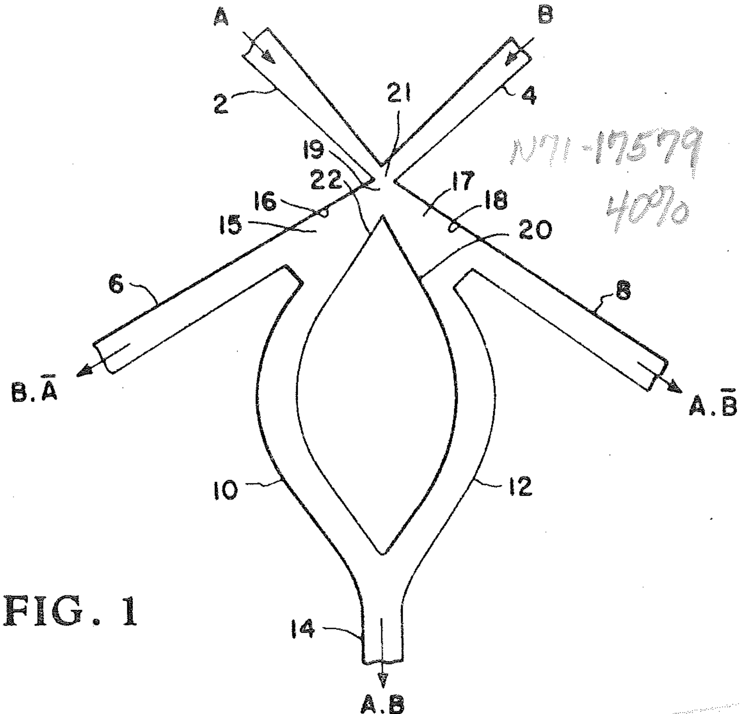

FIG. 1

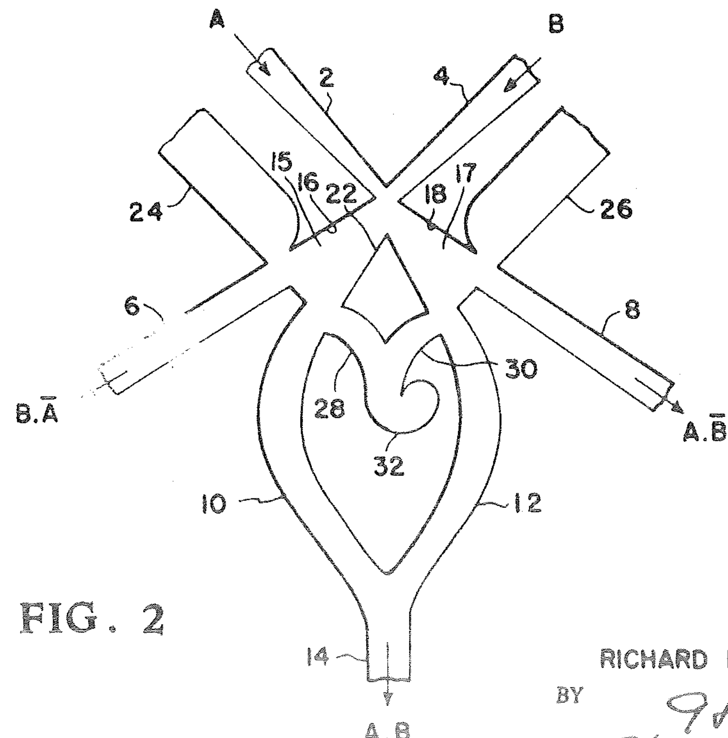

FIG. 2

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3,493,004

LOGIC AND GATE FOR FLUID CIRCUITS

Richard F. Hellbaum, Hampton, Va., assignor to the United States of America as represented by the Administrator of the National Aeronautics and Space Administration

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Int. Cl. F15c 1/08
U.S. Cl. 137—81.5 4 Claims

ABSTRACT OF THE DISCLOSURE

A logic AND gate having A and B inputs which each have a pair of outlets, with one of each of these joined together to form a common output. Each of the A and B inputs is arranged to produce a wall attachment with a wall for both its outlets, but is also arranged to have a preferential attachment to a wall of its unconnected outlet. The A and B inputs are connected to directly impinge on each other in a direction tending to produce a shift of each input signal from its preferred to its joined outlet, thus yielding a nonproportional AND output. Cross venting of the output chambers results in outputs insensitive to load.

This invention relates to a fluid logic element, and more particularly to a fluid AND gate.

Prior art AND gates are of many different configurations, but basically are of two different types, i.e., a fluid momentum type in which the two inputs are so arranged that when both signals are present, an exchange of momentum causes deviation of each signal stream into a common outlet to produce an AND output. A second type utilizes the wall attachment principle for both the AND output and each sole output, arranging the passages so that the flow is slightly monostable away from the AND output. A cross passage between the inputs is then provided so that when flow occurs in both inputs, the draw in the cross passages biases each input so that the jets are both switched to the common AND output.

While in general satisfactory, these devices suffer from some rather substantial disadvantages. The momentum exchange type of device produces an output varying proportionally with changes in input signal magnitude, generally an undesirable effect for the uses to which such devices are put. In addition, gross differences in the input signal levels may eliminate the AND output altogether. The second type of prior art AND gate suffers from the drawback that the switching from one output to the other must be accomplished by pressures a fraction of the magnitude of the primary signals, thus requiring high gain in the switching function. This in turn leads to sensitivity of the device to dimensional variations encountered in normal manufacturing processes, and hence, these devices tend to be relatively expensive. Both of these types also are sensitive to loads on the various outputs.

Therefore, it is an object of the present invention to provide an AND gate which produces an output that does not vary proportionately with changes in input signal magnitude.

It is a further object to provide an AND gate which may be manufactured without holding dimensions to excessively close tolerances.

It is yet another object to provide an AND gate which operates normally regardless of the level of loading of the output devices.

It is a further object to provide an AND gate which produces an output even though considerable disparity exists between the two input signals.

These and other objects of the invention which will become apparent upon a reading of the specification are accomplished by providing for each input passage a pair of output passages, and wall contours such that wall attachment will occur with flow through either output passage, but the design in such that a preference is felt by the input flow to attach to one of the outputs. The other output of each of the inputs are connected together to form a common output. The input passages are arranged so that flow through either input impinges on flow through the other when flowing along its preferred path, and in a direction to cause switching of both to the connected outlets, thus producing the AND output. Cross ventilation of both the output chambers eliminates sensitivity to loading of the AND output.

Referring now to the specification and particularly to the drawings, FIG. 1 is a schematic of the basic AND gate according to the present invention.

Shown in FIG. 2 is a schematic of another form of the AND gate according to the present invention.

In FIG. 1, passages **2** and **4** are the input signal passages for signals A and B, converging into each other at a substantial angle. Each of these input passages **2** and **4** has a pair of related output passages **6** and **10** and **8** and **12** respectively, downstream from the convergement, with **10** and **12** joined to form a common output **14**. Input passage **2** directs fluid signal A into an output chamber **17**, formed by the two sidewalls **18** and **20**. These sidewalls are contoured so that preferential wall attachment of the jet occurs with wall **18**. This may be accomplished in any number of ways, all well known in the flueric art, as by providing a wall contour **18** that deviates but slightly from the direction of the input flow A. Wall **20**, on the other hand, breaks away more sharply from input passage **2**, and flow must cross a gap **19** wider than that at **21**, so that as a result, if the signal A is uninfluenced by other factors, flow preferentially attaches to sidewall **18**. However, wall **20** is contoured sufficiently smoothly and continuously with respect to passage **2** that wall attachment of flow from input **2** will occur if the jet is influenced toward wall **20**, as will be explained further herein.

Input passage **4** directs fluid signal B into output chamber **15**, formed by the sidewalls **16** and **22**. These sidewalls are formed so as to have the same relationship with the input passage **4** as that discussed above with respect to input passage **2**. Therefore, fluid signal jet B will preferentially attach to wall **16**, but if influenced toward wall **22**, fluid wall attachment will occur with respect to this surface.

In operation, if either signal A or B is present without the other, no flow occurs in output **14**, but entirely in either output **6** or **8** depending on the signal present, thus producing the $A \cdot \overline{B}$ at **8** and the $B \cdot \overline{A}$ at **6**. Conversely, if flow occurs in both inputs **2** and **4**, the interaction of the jets A and B causes mutual influencing of the jets toward surfaces **20** and **22**, such that both jets now become attached to its respective inner wall **20** and **22**, and all of the flow now occurs in output **14**, and none in outputs **6** and **8**, thus yielding the AND function $A \cdot B$.

Analysis of this arrangement will show the several distinct advantages arising therefrom. Firstly, the output at **14** is nonproportional, since once the input jets are shifted from the outer walls, attachment to the inner walls **20** and **22** occurs and the flow is completely shifted from the outputs **6** and **8**. Secondly, differences in magnitude between the inputs A and B does not affect the mode of operation, since both the output paths of A and B in the

AND mode are combined to produce the AND output. Thirdly, since the entire A and B signal are exerted on each other to perform the switching function, the unit can be designed for comparatively low gain, with a considerable resultant lessening of fabrication tolerance requirements and therefore manufacturing costs.

A practical design of the AND gate according to the present invention is shown in FIG. 2. This unit incorporates the same basic configuration as that shown in FIG. 1, but has been vented so as to eliminate sensitivity to loads on the various outputs.

This has been accomplished by adding vents 24 and 26 to chambers 15 and 17, so that excess fluid may escape when outputs 6 and 8 are loaded or blocked rather than moving into output 14.

In addition, vent passages 28 and 30 have been added which join together as a common vent 32. This functions to provide complete ventilation when passages 10 and 12 are loaded or blocked. It has been found that the inclusion of a single side vent does not completely eliminate leakage into outputs 6 and 8 when loads are imposed on an output at 14. The central vent allows excess fluid to escape in both directions, thus minimizing leakage into outlets 6 and 8.

Therefore, it can be seen that an AND gate has been provided which produces a nonproportional AND output which may be inexpensively manufactured, and which is insensitive to loadings on the various outputs.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A logic AND gate comprising:

first and second inlet passages arranged to converge into each other, each of said inlets having a first and a second outlet passage downstream from said convergement;

means providing a fluid path from each inlet passage to its respective first and second outlet passage;

means for producing wall attachment flow from each of said inlets into its respective first outlet passage whenever flow occurs solely in said input passage;

means for producing wall attachment flow into said second outlet passages whenever flow occurs in both said inlet passages; and

means for providing a fluid connection between said second outlet passages, whereby a nonproportional AND output is provided.

2. The AND gate of claim 1 wherein said means for producing wall attachment flow into said second outlet passages includes a central wall member disposed downstream of said convergement and having surfaces running between each of said inlet passages and its respective second outlet passage.

3. The AND gate of claim 1 further including a vent outlet between each of said inlet passages and its respective outlet passages.

4. The AND gate of claim 1 further including vent means located on both sides of each of said fluid paths downstream of said convergement.

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