

[54] **FLUIDIC FAILURE DETECTION SYSTEM**
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[22] Filed: **Nov. 23, 1970**

[21] Appl. No.: **91,732**

[52] U.S. Cl. **91/3, 91/388, 91/461**
[51] Int. Cl. **F15b 13/16, F15b 13/042**
[58] Field of Search **91/388, 363 A, 387, 91/461**

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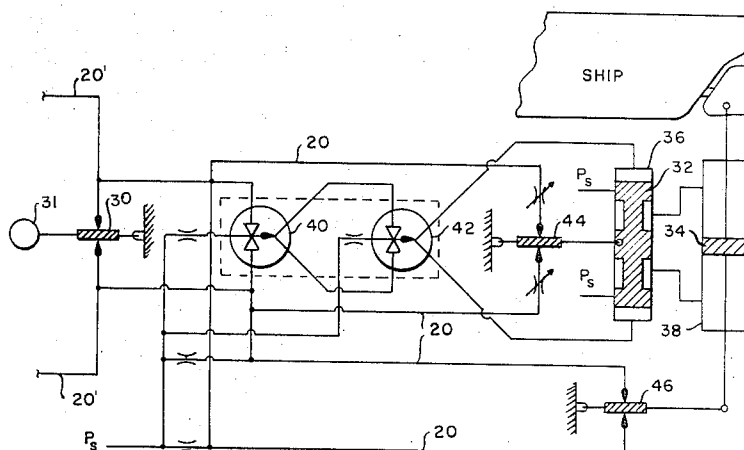
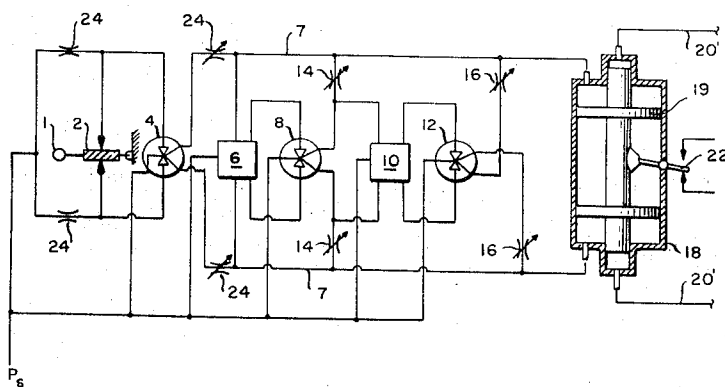
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[57] **ABSTRACT**

A fluidic failure detection system to be used in conjunction with the fluidic steering and diving control system. The detection system is a fluidic analog of the steering control system and duplicates what the control system is to do and then compares its output with that of the control system.

2 Claims, 2 Drawing Figures



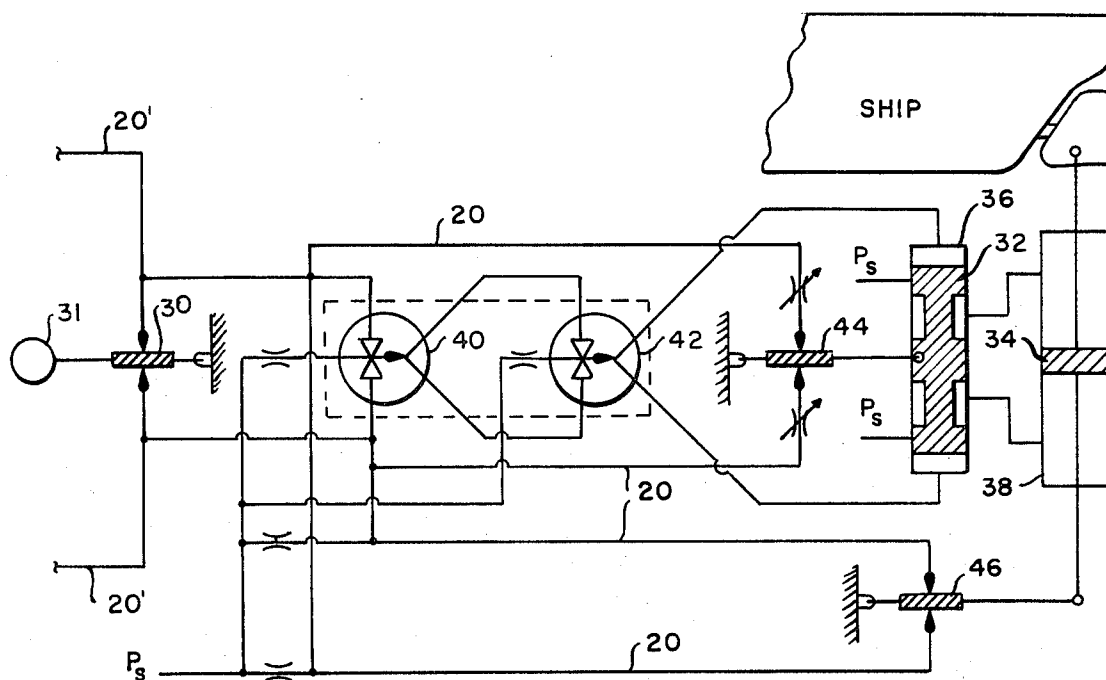


FIG. 1.

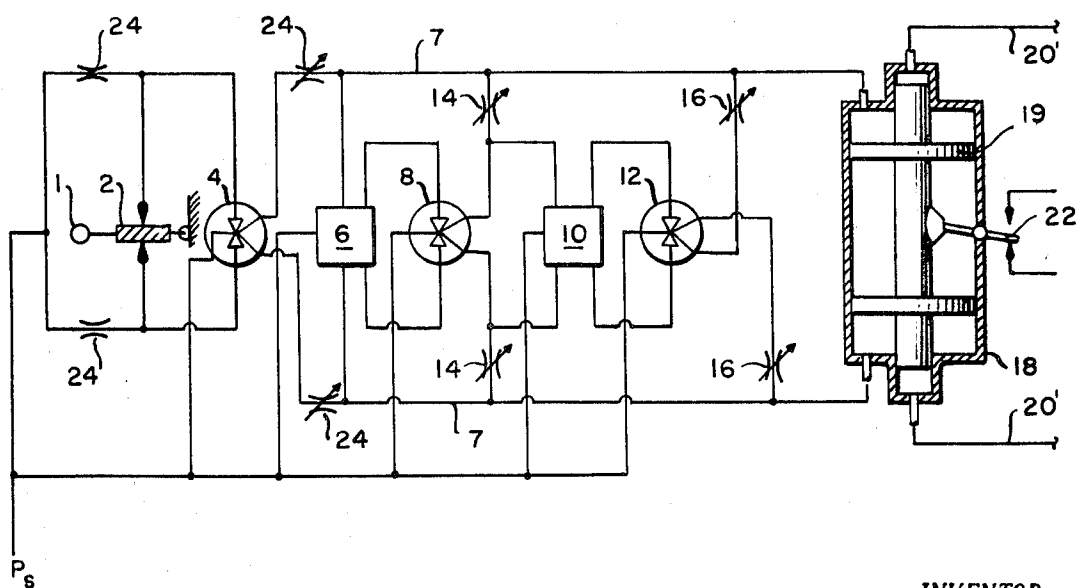


FIG. 2.

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FLUIDIC FAILURE DETECTION SYSTEM

The invention described herein may be manufactured and used by or for the Government of the United States of America for Governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention relates to a fluid operated system which utilizes the flow of a fluid so that the system performs functions which are analogous to functions now being performed by electronic components and systems, and relates more particularly to such a system employed for ship control failure detection.

The present electronic detection system is a complex computer system requiring skilled personnel to maintain and repair. Electronic systems and components are capable of performing such functions as detecting, amplifying and integrating a signal. However, it is also desirable that systems utilizing other than electronic components be developed to perform the same functions. While known mechanical systems will perform functions analogous to functions performed by electronic systems, these systems require large numbers of moving parts. Failure in any part usually results in improper operation or failure of the system.

The present invention was designed to operate with the fluidic steering control disclosed in Navy Case No. 51,229, U.S. Pat. application Ser. No. 75,594, filed Sept. 25, 1970.

SUMMARY OF THE INVENTION

The general purpose of the fluidic failure detection system is to have a means of sensing the proper performance of the fluidic steering and diving control system disclosed in U.S. Pat. application Ser. No. 75,594.

To attain this, the present invention provides a fluidic failure detection system composed of two fluidic integrators, (i.e., one simulating a control valve the other a control surface actuator), three operational amplifiers, an input flapper nozzle valve assembly and a mechanical comparator. The comparator will sense a deviation between the "error" signals of the fluidic steering and diving control system and the fluidic failure detection system. If there is a deviation, the comparator will activate an alarm either visual or audible, or both.

OBJECTS OF THE INVENTION

Broadly, therefore, it is an object of this invention to provide a fluid operated system which performs functions analogous to functions performed by existing electronic systems such as the system for navigation failure detection in this disclosure.

More specifically, it is an object of this invention to utilize a fluid operated system having a minimum of moving parts and having the distinct advantage of operating directly with the control system and not by relying on hydro-electric sensors to transmit signals to it. As a result, any element or part thereof in the fluidic control system can fail and the failure detection system will be able to sense such failure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic drawing of the fluid circuitry of the fluidic control system; as disclosed in U.S. Pat. application Ser. No. 75,594; and

FIG. 2 is a schematic drawing of the fluidic circuitry of the fluidic failure detection system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

With continued reference to the drawing, the fluidic failure detection system, FIG. 2, is an analog model of the fluidic control system, FIG. 1. The fluidic failure detection system has been designed, as will be described, to produce a pressure differential output directly proportional to the operating signal or "error" signal produced in the fluidic control system responsive to varying navigational commands. Both systems contain an input flapper nozzle valve assembly connected via control sticks 1 and 31 to receive identical input navigational commands. The failure detection system simulates the fluidic control system's operation with fluidic operational amplifiers and integrators. In the fluidic failure detection system the operational amplifiers are used for amplification purposes only. The control system effectively performs two integrations; one by movement of the spool 32 over a period of time, and another movement of the ram 34 over a period of time. These integrations are accomplished when the input flapper nozzle valve assembly 30 receiving a navigational command from control lever 31 activates the valve 36 and in turn the actuator 38. The fluidic failure detection system also accomplishes these two integrations but with commercially available fluidic integrators which create the same effect as the spool's motion and the actuator's motion. Such a fluidic integrator is disclosed in U.S. Pat. No. 3,534,755 to Urbanosky, patented Oct. 20, 1970. In the failure detection system the input signal from the input flapper nozzle valve assembly is processed by a first operational amplifier 4 which then feeds the rest of the circuit. In the fluidic control system the input signal is fed through amplifiers 40 and 42 to move the spool 32. The resulting movement of the spool 32 with respect to time is in essence an integration of the amplifier output flow. The fluidic failure detection system having received an input from the control stick 1 and processed it through a first operational amplifier 4 feeds this signal into a first integrator 6 which accomplishes the same effect as the spool 32 in the fluidic control system. In the fluidic control system, the spool's motion results in a flow to the actuator 38 and the resulting movement of the ram 34 with respect to time is essentially an integration of the spool's motion. The failure detection system accomplishes the same effect by taking the output of the first integrator 6 which corresponds to the spool 32 and amplifying it by a second amplifier 8 to feed a second integrator 10 which corresponds to the motion of the actuator 38. The output of the second amplifier 8 in the fluidic failure detection system is partially fed back into the failure detection system internal operational control lines 7 to partially cancel, depending on the magnitude of the initial input of input flapper nozzle valve assembly 2. This accomplishes the same thing as the spool flapper nozzle valve assembly 44 in the fluidic control system which is activated as the spool moves, thereby creating a signal negative to the positive input signal generated by input flapper nozzle valve assembly 30 which is fed into control lines 20 to cancel a portion of the input signal. The resultant of the input signal generated by 30 and the signals generated by 44 and 46 is defined as the operating signal of the fluidic control system. As the second integrator 10 in the fluidic failure detection system receives an input from the re-

maintaining output of the second amplifier 8, it too generates an output to a third amplifier 12 which is amplified and also fed back into the internal operational control line 7. This output will complete cancelling the initial input due to the input flapper nozzle valve assembly 2. This corresponds to the fluidic control system action where a negative signal generated by the actuator flapper nozzle valve assembly 46 is fed into the fluidic steering and diving control system control lines 20 to cancel the remainder of the positive input signal generated by input flapper nozzle valve assembly 30. The magnitude of error signal being cancelled by the output of the second operational amplifier 8 is controlled by the first set of fluidic variable restrictors 14. This is similar to adjusting the proportional band of the fluidic control system. The internal operational control lines of the fluidic failure detection system feed a comparator 18 which is capable of comparing the control line signals of the fluidic steering and diving control system with those of the internal operational control lines of the fluidic failure detection system. The comparator couples the internal operational two control lines 7 of the fluidic failure detection system with the two connecting control lines 20 of the fluidic steering and diving control system. If the outputs of the internal operational control lines and the steering and diving control lines are not equally opposed at the comparator then the pressure differential across the mechanical comparator moves the piston 19 of the comparator to trip the switch 22 that will indicate that failure has occurred.

Now that the analogy of the functions of the fluidic failure detection system and the fluidic control system have been pointed out, it will be advantageous in understanding the invention to further describe the fluidic failure detection system and its operation alone. The fluidic failure detection system has an input flapper nozzle valve assembly 2 which is connected to a helm control as on a ship. The input flapper nozzle valve assembly will generate a pressure differential proportional to the actual system "error" signal and feed this signal into a first operational amplifier 4. The first operational amplifier 4 will then process this input signal and apply it to the internal operational control lines 7 and the first integrator 6 connected to them. The first integrator 6 receiving this input signal will begin integrating at a given rate until its saturation level is obtained. The second operational amplifier 8 receives this output of the first integrator 6 and amplifies it. The output of the second operational amplifier 8 is divided into feeding the second integrator 10 and also in feeding a signal back into the internal operational control lines 7 through variable restrictors 14. The variable restrictors control the amount of error signal to be cancelled by the spool's integration simulated in the first integrator 6. The amount of the error signal fed from the second operational amplifier 8 into the second integrator 10 begins the simulated motion of the actuator 38 as in the fluidic control system. The second integrator 10 will begin integrating at a given rate and its output will be amplified through the third amplifier 12 and fed back also into the internal operational control lines 7. When the total error signal has been cancelled by both the output of the second amplifier 8 and the output of the third amplifier 12, the input to the first integrator 6 will be zero and the output of the first integrator 6 will be a constant value of saturation. This constant value will continue to be fed through the second amplifier 8 and

into the second integrator 10 which will continue to integrate at its given rate. When this integrated signal is fed back the error signal will become negative thus driving the first integrator 6 negatively to return its output from a saturated value back to a neutral or a zero value and when it obtains that value the output of the second integrator 10 will become a steady state value because of the nulled input into it. At this point the fluidic failure detection system would be simulating a final condition or a steady state condition for a given signal supplied to it and its output across comparator 18 would be similar and balanced by the output of the fluidic control system for a like command input.

In the fluidic failure detection system the final output is compared by means of the mechanical comparator 18 which compares the pneumatic fluidic failure detection system signal's output with the hydraulic oil operating signal of the fluidic control system through the differential area piston arrangement. The fluidic control system output is of a higher value in pressure than the failure detection system output therefore, the pneumatic pressure is applied to a larger area in cross-section on the comparator than is the oil pressure on a smaller area such that equilibrium can be attained if the two systems are functioning properly.

The fixed restrictors and the variable restrictors 24 are for system application and operational features and not so much in the actual systems application. The variable restrictors 14 and 16, however are important for feedback purposes as are those of the fluidic control system, item 46 and 44.

It will be apparent from the foregoing that the invention provides fluidic apparatus of novel and advantageous construction for sensing the proper performance of a fluidic steering and diving control system.

It is understood that the invention is not limited to the exact details of construction shown and described for obvious modifications will occur to persons skilled in the art. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A fluidic failure detection system which is an analog of a fluidic steering and diving control system, the diving control system being made up of a control valve, an actuator flapper nozzle valve, an actuator and a spool flapper nozzle valve and which is to be connected to a set of fluidic steering and diving control system control lines, comprising:

an input means to generate an input signal;

a first fluidic amplifier connected to said input means to amplify said input signal and to produce a first signal;

a first fluidic integrator connected to the output of said first fluidic amplifier to produce a second signal thereby creating an analog of the function of said control valve within said fluidic steering and diving control system;

a second fluidic amplifier connected to the output of said first fluidic integrator to amplify said second signal to produce a third signal; failure detection system internal operational control lines

one of said failure detection system internal operational control lines connecting the output of said second fluidic amplifier to feed back part of said third signal to cancel part of said first signal, thereby creating an analog of the function of said

spool flapper nozzle valve within said fluidic steering and diving control system;

a second fluidic integrator connected to the output of said second fluidic amplifier to receive the remainder of said third signal to produce a fourth signal thereby creating an analog of the function of said actuator within said fluidic steering and diving control system;

a third fluidic amplifier connected to the output of said second fluidic integrator to amplify said fourth signal producing a fifth signal, one internal operational control line also connecting the output of said third fluidic amplifier to the output of said first fluidic amplifier to feed back said fifth signal to cancel the remaining part of said first signal, thereby creating an analog of the function of said actuator flapper nozzle valve within said fluidic steering and diving control system; and

a comparator means connected to said internal operational control lines and adapted to be connected to said fluidic steering and diving connecting control lines, to compare the fluidic failure detection system and the fluidic steering and diving control operational system for deviations.

2. A fluidic failure detection system which is an analog of fluidic steering and diving control system, the diving and control system being made up of a control valve, an actuator flapper nozzle valve, an actuator and a spool flapper nozzle valve and which is to be connected to a set of fluidic steering and diving control system control lines, comprising:

an input means to generate an input signal;

a first fluidic amplifier for connected to said input means to amplify said input signal and to produce a first signal;

a first fluidic integrator connected to the output of said first fluidic amplifier for to produce a second signal;

a second fluidic amplifier connected to the output of said first fluidic integrator to amplify said second signal to produce a third signal; failure detection system internal operational control lines

one of said failure detection system internal operational control lines connecting the output of said second fluidic amplifier to feed back part of said third signal to cancel part of said first signal;

a second fluidic integrator connected to the output of said second fluidic amplifier to receive the remainder of said third signal to produce a fourth signal;

a third fluidic amplifier connected to the output of said fluidic integrator to amplify said fourth signal producing a fifth signal, said one internal operational control line also connecting the output of said third fluidic amplifier to the output of said fluidic amplifier to feed back said fifth signal to cancel the remaining part of said first signal; and

a comparator means connected to said internal operational control lines and adapted to be connected to said fluidic steering and diving connecting control lines to compare the fluidic failure detection system output and the fluidic steering and diving control operational system for deviations.

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