1410376

PATENT SPECIFICATION

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(54) A FLUIDIC MEMBRANE PNEUMATIC DEVICE

(71) We, INSTITUT PROBLEM UPRAVLENIA (AVTOMATIKI I TELEMEKHANIKI), of Profsojuznaya ulitsa 81, Moscow, and ZAVOD "TIZPRIBOR", of Krasno-Proletarskaya ulitsa 2/4, Moscow, both Union of Soviet Socialist Republics both Corporations organised and existing under the laws of the Union of Soviet Socialist Republics, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a fluidic membrane pneumatic device suitable for use in various pneumatic operated automatic systems.

A fluidic membrane pneumatic device is known which includes fluidic modules and membrane amplifiers. Each module comprises a stack of assembled functional plates, each plate having one side provided with corresponding pneumatic fluidic elements, i.e. with passages and apertures for the performance of AND, OR, or "Inhibition" logic functions and having the other side provided with passages for connection of said fluid elements with one another *via* openings provided through the plates. Each module also comprises membrane-type two-stage direct YES and inverse NO amplifiers, each stage of these amplifiers including nozzles.

This fluidic membrane pneumatic device is a combination of passive fluidic modules (having a working pressure range from 0 to 100—200/mmH_2O) and membrane-type amplifiers building this pressure up to the level employed by industrial installations, i.e. to a range from 0 to 1.4 kg/cm².

The passive fluidic modules are capable of performing various logic functions from the Boolean class.

The modules may be in the form of functional plates having one side impressed with a necessary combination of fluidic elements appropriate for the performance of the desired logic function, such as AND, "Inhibition", or OR.

The opposite side of each plate has cut or impressed therein passages for connection between the fluidic elements. The plates have covers attached thereto at both sides and thus form independent fluid modules. The bottom cover of such a fluidic module has inputs with a corresponding throttling means and outputs. The throttling means are provided for reduction of pressures within a range employed by industrial installations to a lower range, i.e. to the working range of the fluidic modules. Each output of the fluidic module is a low-pressure one and has to be connected to the low-pressure input of a membrane-type pneumatic amplifier. Pneumatic amplifier incorporates two stages, namely the first stage which is a pressure amplification stage and the second stage which is a power amplification stage. Thus, there is derived at the output of the membrane amplifier a signal within a pressure range employed by industrial installations. The membrane-type amplifier may be either of a direct-action type or of an inverse-action type, the first stage of the amplifier being in both cases a direct-action one, while the second stage of a direct-action amplifier is a direct-action stage and of an inverse-action one an inverse-action stage.

This conventional device has the following disadvantages.

Firstly, the creation of each new functional plate having its own combination of AND, OR or "Inhibition" fluidic logic elements requires production of a new stamping die, i.e. there is no standarad design of the functional plates.

Secondly, the connection passages establishing communication between the fluidic elements of each plate are produced, for example by milling, individually for each circuit plate.

Thirdly, the first stage of the membrane-type amplifier is a pressure-consumption one, i.e. it continuously consumes compressed air; it features an indistinct switch-type (on-off) characteristic and is susceptible to self-oscillation.

Fourthly, both nozzles of the second stage of the membrane-type amplifier have the same diameters, which also causes indistinct switch-type characteristics of the membrane amplifier and impairs the swiftness of action of the pneumatic fluidic membrane device as a whole.

According to the present invention there is provided a fluidic membrane pneumatic device, comprising a fluidic module including a functional plate, or a stack of assembled functional plates, each said plate having two fluidic logic elements formed on one side thereof so connected as to realize a selected one of a preselected group of logic functions, this connection being effected by additional passages formed on the other side of each said plate for communicating with said fluidic elements through said plate; wherein the additional passages of each plate include all passages necessary to achieve any of said logic functions, the selected logic function being realizable by forming appropriate respective openings through said plate; and a two-stage membrane-type fluid amplifier of direct action or inverse action, each stage of said amplifier having nozzles of different diameters, the first stage of said amplifier being an inverse-action stage, and the second stage being an inverse-action stage in the case of said amplifier being a direction-action amplifier and being a direct-action stage in the case of said amplifier being an inverse-action amplifier.

It is desirable that said two fluidic elements of said functional plate, of which each includes two inlet passages, two inhibition passages and one outlet passage should be associated with additional passages for interconnecting said outlet passages of said fluidic elements with each other and with one of said inhibition passages of each said fluidic element, and also for connecting the outlet passage of each said fluidic element with one of said inlet passages of the other one of said fluidic elements.

It is also preferable that said two fluidic elements of said functional plate, of which each includes four inlet passages and one outlet passage, should be associated with additional passages for connecting said outlet passage of said fluidic elements with each other and with one of said inlet passages of each one of said fluidic elements, and also for connecting said outlet passage of each said fluidic element with another one of said inlet passages of the other one of said fluid elements.

It is also preferably that said two fluidic elements of said functional plate, of which each includes two inlet passages, two inhibition passages and one outlet passage, should be associated with additional passages for connecting said outlet passages of said fluidic elements with each other and with one of said inhibiting passages inlet passage of the other one of said fluidic elements, and for connecting said outlet passage of each said fluid element with the other one of said inlet passages of said other fluid element.

The herein disclosed fluidic membrane pneumatic device constitutes a basic design for creation of all kinds of fluid logic devices including fluidic modules incorporating but three types of functional plates whereby the number of dies necessary for manufacture of such plates is considerably reduced. The two-stage membrane amplifiers are of a structure ensuring that the first stage of these amplifiers consumes practically no pressurized air, and both stages have each a pair of nozzles of different diameters, which improves the switch-type characteristic of the amplifiers and speeds up the action of the fluidic pneumatic device, as a whole.

The present invention will be now described in more detail, by way of example only, with reference to the accompanying drawings, in which:—

Figure 1 is a diagrammatic general view of a fluidic membrane pneumatic device;

Figure 2 is a diagrammatic representation of a fluidic element adapted for realization of a logic function

$$y_1=(x_1 \ Vx_2) \ . \ \overline{(x_3 \ Vx_4)};$$

Figure 3 is a diagrammatic representation of a fluidic element for realization of a logic function

$$y_2=(x_1 \ Vx_2) \ . \ (x_3 \ Vx_4);$$

Figure 4 shows a functional plate accommodating two fluidic elements each performing the above function y_1;

Figure 5 shows a functional plate accommodating two fluidic elements each performing the above function y_2;

Figure 6 shows a functional plate accommodating a fluidic element performing the above function y_1 and another fluidic element performing the above function y_2;

Figure 7 illustrates diagrammatically the structure of a direct-action membrane-type amplifier;

Figure 8 illustrates diagrammatically the structure of an inverse-action membrane-type amplifier; and

Figure 9 is a circuit representation of a flip-flop with independent inputs, based on the fluidic membrane pneumatic device.

The fluidic membrane pneumatic device shown in Figure 1 is an air-operated device and comprises a fluidic logic module 1 with external inlet and outlet passages (not shown). The module has any required number of functional plates 2 assembled into a stack and separated by gaskets 3, a top cover 4 and a bottom cover 5 associated with filters and a throttling gasket 6, and a two-stage membrane-type fluid amplifier 7. The module 1 and the amplifier 7 are mounted on a support panel 8. The external outlet of the fluid module 1 is connected *via* a passage 9 to the two-stage amplifier 7.

The functional plates 2 of the module 1 incorporate fluidic logic elements of two types. Figure 2 of the appended drawings illustrates a fluidic element 10 of the first type, including two inlet passages 11 and 12 (x_1 and x_2), two inhibiting passages 13 and 14 (x_3 and x_4) and a single outlet passage 15 (y_1).

The output passage 15 extends along the axis of symmetry of the inlet passages 11 and 12. The fluidic element 10 performs logic operation

$$y_1=(x_1 \ Vx_2) \ . \ \overline{(x_3 \ Vx_4)},$$

where x_1, x_2, x_3, x_4 are input signals and y_1 is an output signal, Figure 3 illustrates a fluidic element 16 of the other type, having four inlet passages 17, 18, 19 and 20 (x_1, x_2, x_3, x_4) and an outlet passage 21 (y_2). The outlet passage 21 extends along the axis of symmetry of the two pairs of the inlet passages 17, 18 and 19, 20.

The fluidic element 16 performs logic operation

$$y_2=(x_1 \ Vx_2) \ . \ (x_3 \ Vx_4),$$

where y_2 is the output signal.

In principle, with the use of the two types of fluidic elements, 10 and 16, it is possible to make up three types of functional plates. A functional plate including two fluidic elements 10 is illustrated in Figure 4. Figure 5 illustrates a functional plate having two fluidic elements 16, and Figure 6 illustrates a functional plate with a single fluidic element 20 and a single fluidic element 16. On the three plates (Figures 4, 5 and 6) solid lines indicate, respectively, the fluid elements 10 and 16 per se, impressed in the face side of the plates, whereas dotted lines indicate additional passages made in the opposite side of these functional plates.

Appropriate arrangement and interconnection of the external inlet and outlet passages of the fluid module 1 is effected with the help of vertical openings 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33 extending through the plates. In the areas of eventual desired intersection of the fluidic elements 10 and 16 with additional connection passages thin partitions 34 are left on manufacturing the blank of the functional plate.

As the fluidic module 1 is being assembled from the functional plates in accordance with a required logic function, internal communication between the respective fluidic elements 10 and 16 is effected through the vertical openings already provided, as well as through openings made by breaking through the appropriate partitions 34. The two fluidic elements 10 (Figure 4) provided on the functional plate each include two inlet passages 35 and 36, two inhibiting passages 37 and 38 and a single outlet passage 39. In this case, additional passages interconnect the outlet passages 39 and the inhibiting passage 38 of each one of the two fluid elements 10; additional passages further connect the outlet passage 39 of each fluidic element 10 with the inlet passage 36 of the other fluidic element 10.

The two fluid elements 16 (Figure 5) provided in the functional plate include each four inlet passages 40, 41, 42 and 43 and a single outlet passage 44. In this case, additional passages connect the two outlet passages 44 with each other and further connect them to the inlet passage 43 of each fluid element 16 and to the inlet passage 41 of the other fluid element.

The fluid elements 10 and 16 (Figure 6) provide on the functional plate include two inlet passages 35, 36, two inhibition passages 37, 38 and a single outlet passage 39 (element 10) and four inlet passages 40, 41, 42 and 43 and a single outlet passage 44 (element 16). In this case additional passages connect the two outlet passages 39 and 44 with each other and connect them to the inhibiting passage 38 of the fluidic element 10 and to the inlet passage 43 of the fluid element 16; other additional passages connect the outlet passage 39 of the element 10 with the inlet passages 41 of the element 16 and further connect the inlet passage 44 of the element 16 with the inlet passage 36 of the element 10.

Figure 7 illustrates a direct-action two-stage fluidic membrane-type amplifier, while Figure 8 illustrates a similar amplifier of inverse action. The amplifiers each include two stages, a first stage 45 amplifying the pressure of the output signal, and a second stage 46 amplifying the power of the signal.

The stage 45 is identical in both types of amplifiers. It comprises two nozzles: a nozzle 47 for bleeding the pressurized air into ambient atmosphere and a nozzle 48 for supplying the feed pressure (passage 57). The stage 45 features an inverse characteristic, that is when a signal at the input (passage 53) thereof attains its maximum value, its output (passage 58) signal is equal to zero. To improve the operational characteristic of the stage 45 and to prevent any possibility of self-oscillation, the diameter of the nozzle 47 is greater than that of the nozzle 48.

Positioned intermediate of the nozzles 47 and 48 is a perforated membrane 49 having mounted thereon a flapper 50 connected by a rod 51 with a control membrane 52. Input pressure from the fluidic module 1 is introduced *via* a passage 53. A chamber 54 is connected *via* a passage 55 to the ambient atmosphere, and a chamber 56 is connected by a passage 57 to the feed pressure supply source (not shown). The stage 46 of the direct-action amplifier (Figure 7) has an inverse characteristic, i.e. when a maximum pressure signal is supplied to the input thereof *via* the passage 58, the pressure at its output passage 59 equals zero. The stage 46 is connected *via* a passage 63 to the feed pressure supply source.

The stage 46 of the inverse-action amplifier (Figure 8) is a direct-action one, i.e. when the pressure signal at an input passage 58 is at its maximum, the output signal at the output passage 59 also attains its maximum value. The stage 46 includes two nozzles of different diameters, viz. a nozzle 60 for bleeding the pressurized air into ambient atmosphere *via* a passage 61 and a nozzle 62 for supplying the pressurized air *via* a passage 63. A flapper 64 is positioned opposite to the nozzle 62 and is connected by a rod 65 to a membrane 66. The diameter of the nozzle 62 is greater than that of the nozzle 60, which adds to the switch-type (on-off type) characteristic of the membrane-type amplifier and speeds up the action of the fluidic membrane pneumatic device as a whole. The stage 46 differs from the stage 45 in that the nozzle 60 for bleeding the pressurized air into ambient atmosphere *via* the passage 61 and the nozzle 62 for supplying the pressurized air *via* the passage 63 have greater diameters than the nozzles 47 and 48 respectively.

As an example of a practical embodiment of the fluidic membrane pneumatic device, there is schematically illustrated in Figure 9 a flip-flop with independent inputs and with a predetermined logic. The flip-flop and the logic circuit include a fluidic element 10 and a fluidic element 16, i.e. their structure is based on the functional plate of the third type. The feedback connection of the flip-flop, formed by the passage 53, the outlet passage 59 and the through opening 26 incorporates a direct-action two-stage amplifier 7.

The reference numerals indicating the openings, the inlet and outlet passages and the passages of the membrane-type amplifier in Figure 9 are the same as those indicating the corresponding positions in Figures 6 and 7.

The described pneumatic device of the fluidic membrane type has a standardized design of the functional plates of the fluidic module thereof and incorporates a consumption-free membrane-type two-stage amplifier offering a distinct switch-type characteristic. A membrane amplifier can be of a "direct action" or "inverse action" type. A direct action amplifier (Figure 7) performs the YES operation i.e. the signal at its output 59 is 1 when the input 58 is also 1. An inverse action amplifier (Figure 8) performs the NO operation i.e. the output 59 is 1 when the input 58 has 0.

WHAT WE CLAIM IS:—

1. A fluidic membrane pneumatic device, comprising a fluidic module including a functional plate, or a stack of assembled functional plates, each said plate having two fluidic logic elements formed on one side thereof, so connected as to realize a selected one of a preselected group of logic functions, this connection being effected by additional passages formed on the other side of each said plate for communicating with said fluidic elements through said plate; wherein the additional passages of each plate include all passages necessary to achieve any of said logic functions, the selected logic function being realizable by forming appropriate respective openings through said plate; and a two-stage membrane-type fluid amplifier of direct action or inverse action, each stage of said amplifier having nozzles of different diameters, the first stage of said amplifier being an inverse-action stage, and the second stage being an inverse-action stage in the case of said amplifier being a direction-action amplifier and being a direct-action stage in the case of said amplifier being an inverse-action amplifier.

2. A fluidic membrane pneumatic device as claimed in claim 1, wherein each one of said two fluidic elements of each one of said functional plates has two inlet passages, two inhibiting passages and a single outlet passage, said additional passages establishing connection of said outlet passages of said two fluid elements with each other and with one of said inhibiting passages of each said fluidic element and said additional passages further connecting said output passage of each said fluidic element to one of said inlet passages of the other one of said fluidic elements.

3. A fluid membrane pneumatic device as claimed in claims 1 and 2, wherein each one of said two fluidic elements of at least one of said functional plates has four inlet passages and a single outlet passage, said additional passages connecting said outlet passages of said fluidic elements to each other and to one of said inlet passages of each said fluidic element and said additional passages further connecting said outlet passage of each said fluid element with another one of said inlet passages of the other one of said fluid elements.

4. A fluid membrane pneumatic device as claimed in claim 1, 2 and 3, wherein each one of said fluid elements of at least one of said functional plates has two inlet

passages, two inhibiting passages and a single outlet passage, said additional passages connecting said outlet passages of said fluid elements to each other, to one of said inhibition passages of one of said fluid elements and to one of said inlet passages of the other one of said fluid elements and said additional passages further connecting said outlet passage of each said fluid element with the other one of said inlet passages of the other one of said fluidic elements.

5. A fluidic membrane pneumatic device, as claimed in any one of the preceding claims, substantially as described herein above with reference to the appended drawings, Figures 1 to 9.

MARKS & CLERK,
Agents for the Applicants.

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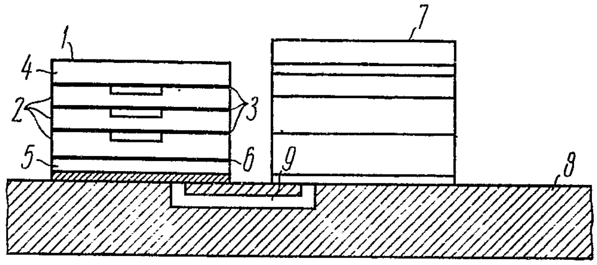

FIG. 1

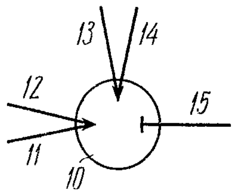

FIG. 2

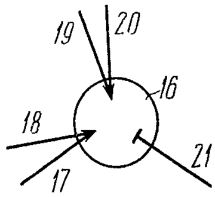

FIG. 3

1410376 COMPLETE SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 2

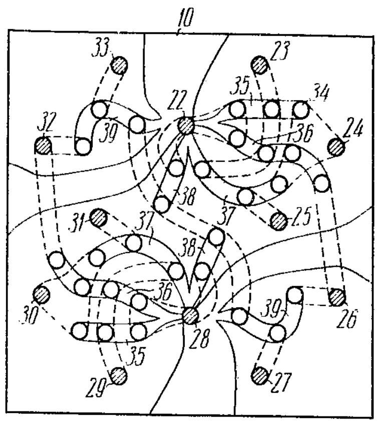

FIG. 4

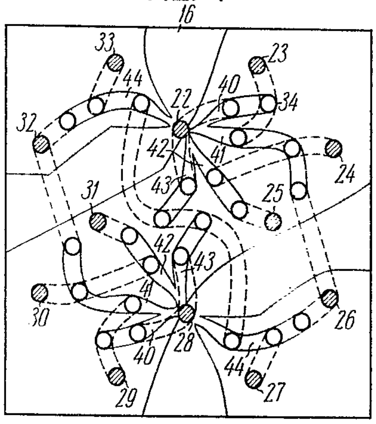

FIG. 5

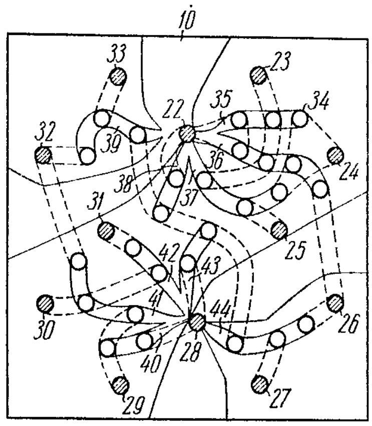

FIG. 6

1410376 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

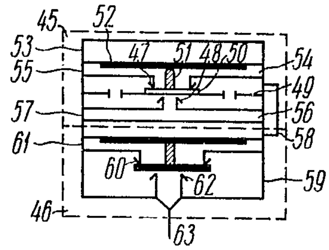

FIG. 7

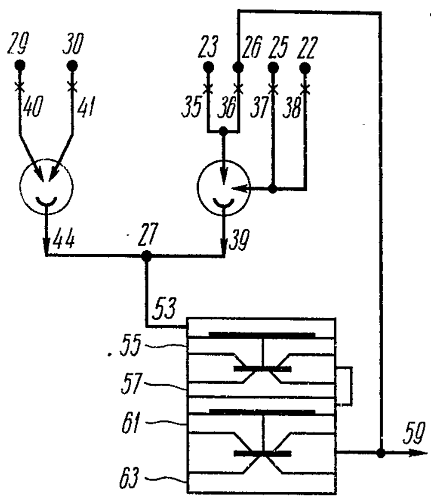

FIG. 9

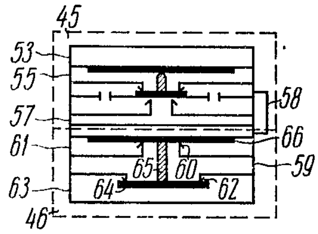

FIG. 8