Dec. 13, 1966 H. P. CHABRIER ETAL 3,291,153

FLUID-ACTUATED OSCILLATORS

Filed Dec. 10, 1963 3 Sheets-Sheet 1

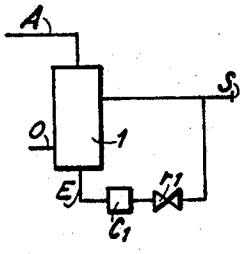

Fig. 1

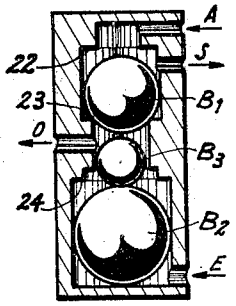

Fig. 2

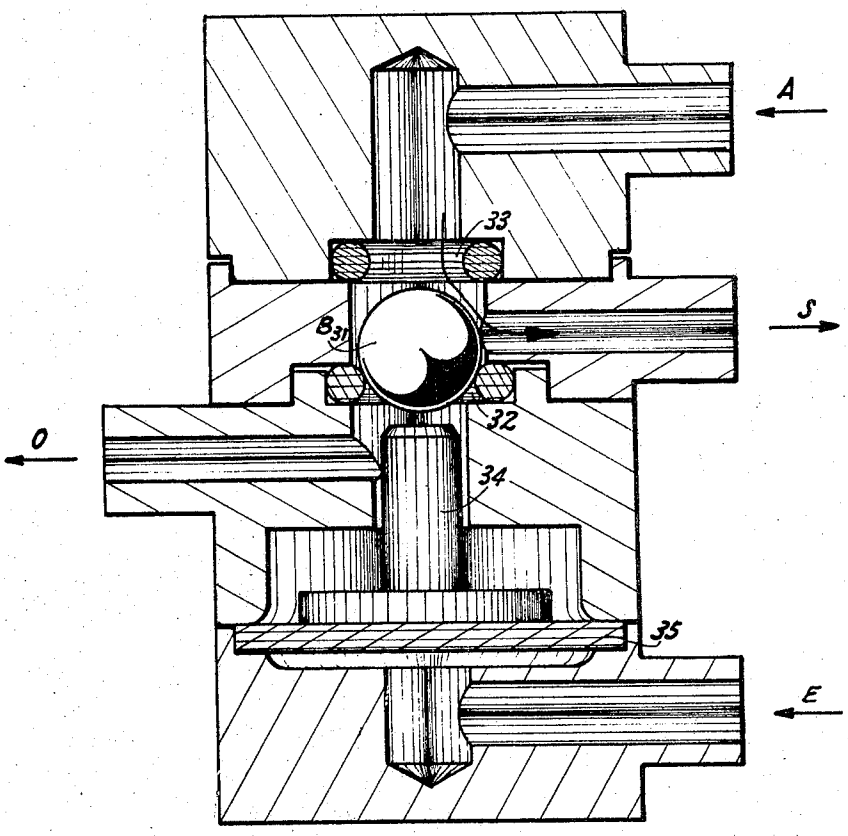

Fig. 3

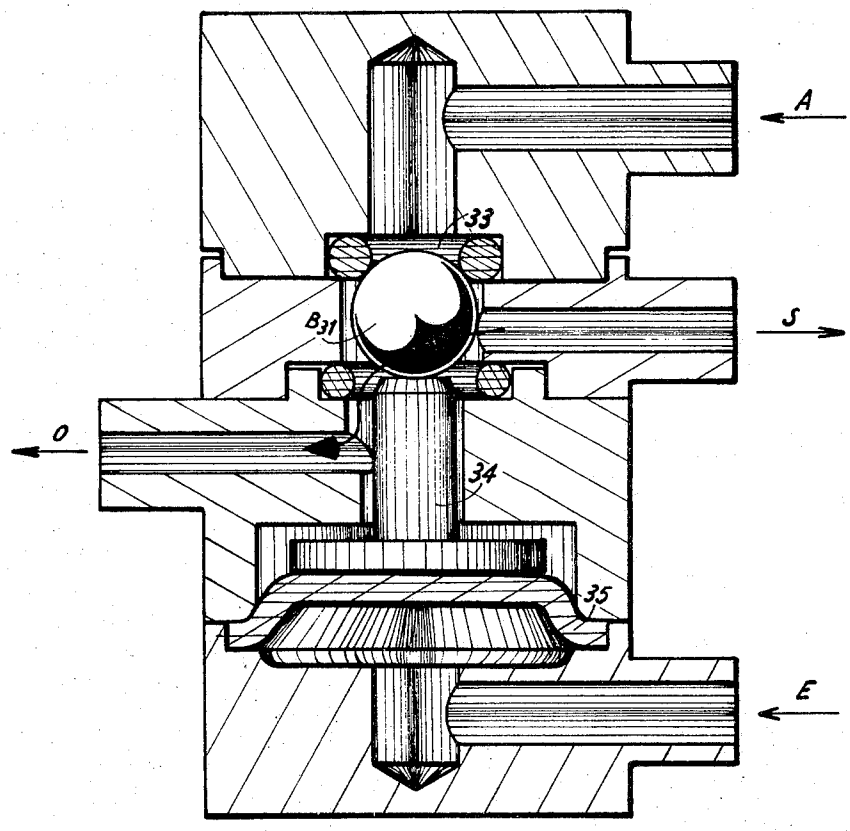
A
33
B31
S
O
34
35
E

Fig. 4

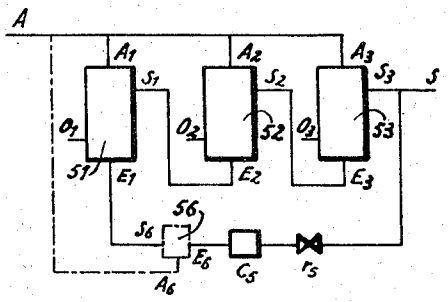
A
A1
A2
A3
S1
S2
S3
S
O1
O2
O3
S1
S2
S3
E1
E2
E3
56
S6
E6
C5
r5
A6

Fig. 5

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FLUID-ACTUATED OSCILLATORS

Filed Dec. 10, 1963 3 Sheets-Sheet 3

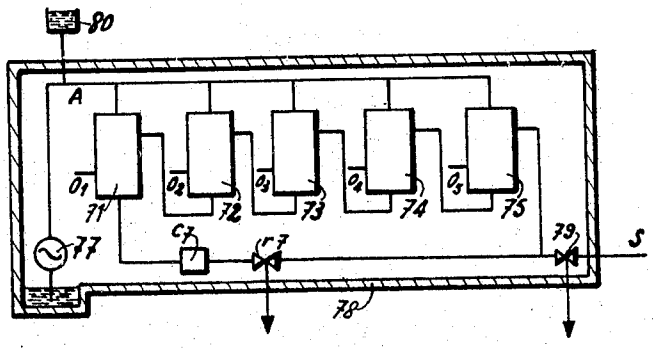

Fig. 6

United States Patent Office 3,291,153 Patented Dec. 13, 1966

3,291,153

FLUID-ACTUATED OSCILLATORS

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Claims priority, application France, Dec. 11, 1962, 918,142
2 Claims. (Cl. 137—624.14)

The present invention relates to oscillator arrangements actuated by a liquid or gas under pressure.

It is an object of this invention to provide a fluid-actuated oscillator of particularly single design which essentially consists of at least one valve of the type disclosed in the U.S. Patent No. 3,242,946 patented October 11, 1965, in the name of the applicants, for: "Fluid-actuated logical devices."

Such a valve is of the conventional general type comprising a hollow body provided with a supply inlet orifice in communication with a source of fluid pressure, an outlet orifice adapted for connection to a point of use, a reference pressure orifice, and a control pressure inlet, valve means movable between a first position connecting the supply inlet and outlet orifices, while disconnecting the outlet and reference pressure orifices and a second position connecting the reference pressure and outlet orifices, while disconnecting the supply inlet and outlet orifices.

According to the above mentioned patent this fluid-actuated valve has the feature that said hollow body has a chamber therein, with first, second, third and fourth mutually adjacent chamber portions having in the respective walls thereof the four respective orifices, at least two seatings and at least one spherical valve closing member in the chamber and adapted to seat against the seatings for closing the communication between the respective first, second and third chamber portions.

This particular feature of the said valve enables one to establish the communication either between the supply inlet and the outlet orifices, or between the outlet and the reference pressure orifices and to obtain the switching from one position to the other in a very simple way.

With the above mentioned object in view, the oscillator arrangement according to this invention further includes motor means of a remarkably simple design, responsive to fluid pressure from the control inlet orifice and operatively connected to said spherical valve closing member to move the latter from the first to the second position upon a predetermined increase in pressure at the control inlet orifice, and time delay means connecting the outlet orifice to the control inlet orifice.

It is another object of the present invention to provide an oscillator arrangement which is remarkably stable at comparatively low operating frequencies and which, for that purpose, consists of an odd number of at least three fluid actuated valves of the general type defined hereinabove, the supply inlet orifice of each of said valves being connected to the control inlet orifice of the next successive valve, the outlet of the last valve being connected via time delay means to the control inlet of the first valve.

These and other objects and features of the invention

will become clearly apparent from the following description.

In the accompanying drawing:

FIG. 1 is a block diagram of a particularly versatile oscillator arrangement embodying the present invention;

FIG. 2 shows an embodiment of a fluid-actuated valve adapted for use in the oscillator arrangement illustrated in FIG. 1;

FIG. 3 illustrates, in one of its stable operating positions, another embodiment of a valve adapted for use in the arrangement of FIG. 1;

FIG. 4 illustrates the valve of FIG. 3 in the stable operating position other than the one of FIG. 3;

FIG. 5 is a block diagram of another oscillator arrangement according to the invention; and

FIG. 6 illustrates a liquid-actuated oscillator arrangement according to this invention.

In FIG. 1 there is shown a fluid-actuated valve schematically illustrated as a rectangle 1 comprising a supply inlet A, a control inlet E, a reference pressure outlet O and an active outlet S. This valve is built in such a way that the pressure P_A of the fluid prevailing at the supply inlet A is transferred to the outlet S only when the control inlet E is not submitted to a pressure higher than a predetermined level.

In other words, this valve performs the $s=a.\bar{e}$ function.

The active outlet S of the valve 1 is connected to the control inlet by means of a line connected therein, preferably including means for delaying the fluid flow, such as a fluid "resistance" $r1$, a valve or duct capable of introducing a pressure drop, for instance, or a fluid "capacity" C_1, i.e. a buffer chamber.

The operation of the oscillator arrangement just described is as follows:

When the supply pressure A is established the fluid is discharged via S until the moment when the pressure wave issued from S, delayed by resistance (r) and capacity (C) reaches E with a level high enough for causing the interruption of the circuit AS and the establishment of the circuit OS. The latter is maintained until the moment when the pressure at E, issued from S, has been sufficiently decreased through discharge at O to stop the inhibition of the communication AS. As long as the supply A is maintained, a self-sustained oscillation is obtained.

Valve 1 of the arrangement of FIG. 1 will, for instance, be of the type which is illustrated in FIG. 2.

It comprises two balls of obturation B_1 and B_2, if required separated by a ball B_3 adapted for transmitting pressures without obturating any seating, a hollow body 21 comprising the seats 22, 23, 24 and orifices A, S, O and E in communication with fluid supply sources, not shown.

It is clear that a connection is established between either A and S, or between A and O, according to the pressure which is exerted at E on ball B_2, and transmitted by ball B_3 to ball B_1.

As a modification, valve 1 of the arrangement of FIG. 1 could also be of the type illustrated in FIGS. 3 and 4.

In this embodiment there is only one ball B_1 which is capable of obturating either seating 32 (in the position represented in FIG. 3) or seating 33 (in the position represented in FIG. 4). This ball is pushed by a rod 34

controlled by a flexible diaphragm **35** which is submitted to the pressure of the fluid exerted at E.

The device, as well as that of FIG. 1, embodies the function

$$s=a.\bar{e}$$

FIG. 5 illustrates an oscillator arrangement constituted by three valve units **51**, **52** and **53** supplied in parallel, the control inlet of each valve being connected to the active outlet of the preceding one, by means of a feedback loop comprising a capacity C_5 and a fluid resistance r_5 being connected between the general outlet S of the arrangement and the inlet E_1 of the first valve unit.

It should be observed that an oscillator arrangement of the type as illustrated in FIG. 5 comprises an odd number of valve units: this is a condition for the signal s_3 at the outlet S_3 to be the logical inverse of signal e_1, which is applied to inlet E_1. Besides, in order to obtain that the pressure transferred from S to E_1 be sufficiently high to switch valve **51**, in practice units **51**, **52** and **53** should be built so as to operate as amplifiers. This will be obtained by properly dimensioning these units, as explained in the patent application already referred to.

In comparison with the arrangement of FIG. 1, the one of FIG. 5 possesses the advantage of being more stable at comparatively low frequencies, not exceeding 1 Hertz, for instance, and of being more easy to adjust.

At frequencies not exceeding 0.1 Hertz it is advantageous, in view of obtaining a sharper turnover of the device, to connect in the feedback loop in series with capacity C_5 a device as illustrated in mixed line, together with its circuit connections, and indicated by reference numeral **56**, the function of which will be explained hereinafter.

This device will preferably consist of a bistable unit having a variable switching threshold level, either positive or negative, performing the function of delivering at its outlet S_6 a pressure having a rectangular waveform, said pressure being supplied from the common supply source A, as soon as the pressure at its inlet E_6, issued from the pressure in S, exceeds a predetermined threshold level, this threshold level being as close as desired to the common supply pressure.

Such a bistable unit will for instance consist of a direct acting amplifying relay as disclosed in the U.S. Patent No. 2,772,688, patented December 4, 1956, and illustrated in FIG. 1 of the said patent, under reference numeral **14**.

In case a negative threshold bistable unit is utilised means have to be provided for re-establishing the phase reversal between S and E_1. These means will, for instance, consist of a valve unit as the one of FIG. 1.

It is also possible to obtain a sharp switching at comparatively low frequencies by connecting between S and E_1 and even number of valve units supplied from the common source, the inlet of one unit being connected to the outlet of the preceding one, these units having such characteristics that the unit closest to E_1 switches when submitted to a pressure very close to the common supply pressure, without any modifications in the phase difference between S and E_1.

In this way the oscillation frequency of the system is better defined.

As the filling of capacity **5** follows an exponential law corresponding to a rate of increase which is the lower as the fluid flow through resistance **5** is the lower, the fact that it is possible to adjust by means of device **56** the threshold of operation at any predetermined and accurately defined level and to obtain the starting of the signal at S, and, consequently at E_1, at a time which is accurately defined and as delayed as desired.

The oscillator arrangement of FIG. 5 is apt to provide at outlets S_1, S_2 and S_3, as well pulsatory signals such as pressure signals without any flow, as a pulsatory flow of the supply fluid, this pulsatory flow being delivered under pressure.

In the latter case the arrangement behaves likes an adjustable pulsatory flow pump, the flow being determined by the supply pressure and by the delay due to the feedback loop r_5, C_5, **56**.

The arrangement of FIGURE 5, as well as the one of FIGURE 1, may be equipped with valve units of one of the two types respectively illustrated in FIGURES 1 and 3, or, more generally, of the general type which has been defined hereinabove.

FIGURE 6 illustrates an embodiment of liquid-actuated oscillator utilising for instance five valve units **71–75**. These valve units are supplied in parallel from rotary pump **77**, the inlet of each of them being connected to the outlet of the preceding one, and a feedback loop comprising a capacity C_7 and a fluid resistance r_7, connecting inlet E_1, of the first unit to outlet S of the whole arrangement.

Such an arrangement may be utilised as a periodic pressure oil generator. The oil flows along a closed circuit lost at the discharge orifices O_1 to O_5 being recovered at the bottom of the casing **78** of the assembly.

The arrangement may also be used as an alternating volumetric pump, a gate **79** in that case controlling the outlet flow and a charge tank **80** providing the oil supply.

It should be observed that oscillators according to this invention function correctly with both a compressible fluid, compressed air for instance, and with an incompressible fluid. In case of an incompressible fluid, the capacities will preferably consist of a chamber having slightly elastic walls, such as a bellows.

Without departing from the scope and spirit of the invention, some of the connections between valves other than the feedback loop between the outlet of the last one and the inlet of the first, may comprise fluid capacities or resistances. Also, some connections between the valve units may comprise devices which modify the form or the amplitude of the signal.

It may be necessary also to connect in the oscillating circuit some valve units, the presence of which in this circuit not modifying, however, the phase difference of the feed back pressure wave.

It is desired to recover the fluid that escapes via the orifices O, one may assemble the latter by means of a collector or direct them towards a tank out of which the fluid can be recovered.

The above description and the drawings should be taken in an illustrative sense only and not in a limiting sense.

Of course there are modifications to this invention which will fall within the scope and spirit thereof, and which will be apparent to those skilled in the art.

What is claimed is:

1. A fluid actuated oscillator comprising an odd number of at least three successive actuated valve units, each valve unit consisting of a hollow body having at least four orifices, a first orifice being an inlet orifice adapted for connection to a source of pressure, a second being an active outlet orifice adapted for connection to a point of use, a third being a reference pressure outlet, and a fourth being a control pressure inlet, valve means movable between a first position connecting the first and second orifices while disconnecting the second and third orifices and a second position connecting the second and third orifices while disconnecting the first and second orifices, motor means responsive to fluid pressure from the control inlet orifice and operatively connected to the valve means to move the latter from the first to the second position upon a predetermined increase in pressure at the control inlet orifice, the inlet orifice of each unit being connected to a common source of fluid pressure, the active outlet of each unit except the last being connected to the control inlet orifice of the next successive unit, the

active outlet of the last unit being connected via time delay means to the control inlet of the first unit.

2. A fluid actuated oscillator as claimed in claim 1, wherein said time delay means include a fluid resistance, a fluid capacitance and a bistable device having a predetermined fluid pressure switching threshold level.

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