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54 Improvements relating to operating control arrangements for fluidic devices.

57 A fluidic device operating arrangement which is especially for the remote control of a fluidic device in potentially explosive or electrically vulnerable environments comprises optical signal generating means and transducer means for converting the output derived from the optical signal generating means into a mechanical output either directly or through the intervention of further means to produce the requisite flow of operating fluid in the device for the operation thereof.

The transducer means may comprise a gas-filled light transmissive vessel which contains a small volume of fibrous material which undergoes very rapid heating and produces consequential expansion of the vessel walls for generating a mechanical pressure pulse which can be transmitted to the operating fluid fed to one or more control ports of the associated fluidic device.

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IMPROVEMENTS RELATING TO OPERATING CONTROL ARRANGEMENTS FOR FLUIDIC DEVICES

This invention relates to fluidic devices and relates more specifically to operating control arrangements for such devices.

Fluidic devices, such as fluidic analogue amplifiers and fluidic switches or gates, may be actuated by a pre-determined variable flow rate of operating fluid through one or more control ports of the device which in the case of a fluidic amplifier will cause the fluid output from the amplifier to be increased whereas in the case of a fluidic switch (e.g. monostable or bistable switch) would cause the fluid flow output from the switch to be diverted from one output port to another. These fluidic devices offer distinct advantages over the more conventional pneumatic or hydraulic devices (eg electrically operated) which embody diaphragms or equivalent and which are relatively large and slow to operate.

Changes in the flow rates of operating fluid in such fluidic devices which may include continuous variable flow in the case of a fluidic amplifier and short flow impulses in one or more of the control ports generated in response to short pressure pulses for the operation of fluidic switches are usually provided through a system of pipes, including fluid pressure pumps and valves for conveying and injecting the operating fluid into the fluidic devices. Such fluidic systems for the remote operation of mechanical equipment, such as pneumatic or hydraulic apparatus in aircraft, have hitherto been controlled by electric signals transmitted to electrical to mechanical transducers (e.g. piezo-electric devices) for actuating valves in the fluidic system over electrical conductors which may extend from the pilot's cockpit control panel to the rear of the aircraft. As is well known, such electrical conductors may be vulnerable to electrical pick-up from adjacent electric cabling and this may give rise to unwanted or mal-operation of the equipment being controlled. Moreover, the use of electrical signalling and control in or through potentially explosive environments, such as coal mines, gas and petrochemical plants, for the actuation of fluidic systems is extremely hazardous.

The present invention therefore provides an operating arrangement for fluidic devices which is especially, but not exclusively, for the remote control of such devices in potentially explosive or electrically vulnerable environments, such arrangements comprising optical signal generating means and transducer means for converting the output derived from the optical signal generating means into a mechanical output either directly or through

the intervention of further means in order to produce the requisite flow of operating fluid in a fluidic device for the operation thereof.

In carrying out the present invention the transducer means may comprise a gas-filled light transmissive vessel which contains a small volume of fibrous material or a plurality of vanes having high light absorbent properties whereby the fibrous material or vanes undergo very rapid heating and produce consequential expansion of the vessel walls for generating a mechanical pressure pulse which can be transmitted to the operating fluid fed to one or more control ports of associated fluidic devices.

Alternatively, the light from the light generating means may produce direct heating of a thin film or diaphragm which is caused to bend either due to the higher thermal expansion of the directly heated surface of the diaphragm relative to the other surface or due to the diaphragm being constructed from a plurality of layers of material having dissimilar thermal expansion coefficients (e.g. bi-metallic diaphragm).

In yet another alternative embodiment according to the present invention the light may be converted into electrical energy (this may be at the remote end of a remote control system in aircraft for example, in order to avoid vulnerability to electrical pick-up from adjacent cabling as explained earlier or to avoid electrical conductors passing through a potentially explosive environment) by means of an photo-electric transducer device such as for example a silicon or gallium arsenide device or gallium aluminium arsenide junction diode. The electrical output from these devices, in response to incoming light, may then be converted into mechanical energy by piezo-electric or other electro-mechanical (e.g. electro-magnetic) devices the mechanical outputs from which may produce the fluid pressure pulse in the operating fluid in the control port or ports of the fluidic device to produce actuation thereof.

The mechanical pressure signal produced by the optical signal acting on an optical-mechanical transducer or through optical-electrical and electro-mechanical transducers may be produced in the body of the fluidic device itself or the signal may be transmitted into the operating region of the fluidic device to produce a pressure pulse in the operating fluid of the device by a focussed or collimated acoustic wave or by means of a pressure-transmitting rod or anvil extending into the operating region of the fluidic device.

The mechanical pressure derived from mechanical movement of the opto-mechanical or

electro-mechanical transducer, as the case may be, may interact directly with the fluidic device or it may be utilised to displace biasing fluid resistors in order to control the fluid pressure levels actually applied to the fluidic device from the external fluid injection arrangement.

By way of example the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 shows a block schematic diagram of one operating control arrangement for a fluidic device;

Figures 2, 3 and 4 show various forms of opto-mechanical transducers for use in the Figure 1 arrangement;

Figure 5 shows a block schematic diagram of an alternative operating control arrangement for a fluidic device;

Figures 6 and 7 show alternative opto-mechanical transducer systems for use in the Figure 5 arrangement; and,

Figures 8, 9, and 10 show diagrams of fluidic devices which may be controlled by the arrangement of Figure 1 or Figure 5.

Referring to Figure 1 of the drawings, an optical signal source 1 will be arranged to produce optical signals for the control of a fluidic device 2 which may be remotely located from the optical signal source 1 and which may comprise a fluidic switch (e.g. bistable switch) as depicted in Figure 8 or Figure 9 or a fluidic amplifier as depicted in Figure 10. The optical control signals produced by the source 1 may be applied to an optical-mechanical transducer 3 either through an optical fibre 4, more particularly in the case of a remotely located fluidic device 2, or through a light focussing arrangement.

The optical to mechanical transducer 3 may, for example, comprise any of the transducers depicted in Figures 2 to 4.

In the case of the transducer of Figure 2 the light beam derived from the optical control signal source 1 (Figure 1) passes through the light transmissive wall 5 of a gas-filled vessel 6 containing a small volume of fibrous material 7 which has high light absorbency for the conversion of light energy into thermal energy. Although the vessel 6 shown in spherical it may be non-spherical to increase its compliance. The heat generated by the fibrous material 7 rapidly heats part of the gas filling of the vessel 6 and causes the wall 5 to expand thereby generating a pressure wave in the air or liquid 8 surrounding the vessel 6. This air or liquid 8 may be the operating fluid for controlling the fluidic device 2 (Figure 1). If air is the operating fluid then the vessel 6 could be dispensed with. By referring to Figure 8 it will be appreciated that the pressure wave produced by the transducer of Figure 2 may

be applied to fluid in the control port C2 to cause the fluid power stream FP to be switched from the output port O2 to the output port O1.

An alternative form of gas-filled optical-mechanical transducer is shown in Figure 3. In this transducer the vessel 9 which may be rectangular as shown contains a plurality of thin light absorbing vanes 10 which receive light from the optical control signal source 1 (Figure 1) through the light transmissive wall 11 of the vessel and respond by heating the gas filling of the vessel to thereby produce a pressure wave PW which is accordingly applied to the surrounding gas or liquid 12 which may constitute the operating fluid in one of the control ports of the fluidic device 2 (Figure 1).

Yet another embodiment is depicted in Figure 4 in which the optical control signals derived from the source 1 (Figure 1) fall on one side of a diaphragm 13. This diaphragm may be composed of a single material or it may comprise a plurality of layers of thermally dissimilar material having different coefficients of expansion. In either case the heat from the light signal causes the diaphragm 13 to bend in order to produce a pressure wave PX which can be applied to the operating fluid of the fluidic device 2 (Figure 1) to produce operation of the switch or a change in amplifier output in the case of a fluidic amplifier. As has already been mentioned, the pressure waves produced by the optical to mechanical transducers may be applied directly to the control fluid of the fluidics device 2 (Figure 1) or it could be applied to bias control resistors associated with the fluidics device.

The transducer may be embodied in the fluidics device itself in which case the body of the fluidics device may be light transmissive to allow the light signals to impinge on the optical mechanical transducer through the wall of the device.

Referring now to Figure 5 of the drawings, this control arrangement includes two transducers 14 and 15. The transducer 14 comprises an photo-electric transducer which produces an electrical output which in turn is fed to an electro-mechanical transducer 15.

Examples of such transducers 14 and 15 are depicted in Figures 6 and 7 of the drawings. In Figure 6 the light beam from the optical control signal source 1 (Figure 5) falls on a photo-voltaic detector 16 (e.g. silicon or gallium arsenide or gallium aluminium arsenide diode) the electrical output from which is fed to a piezo-electric transducer 17 for generating a corresponding mechanical pressure pulse PY. In the Figure 7 arrangement, however, the electrical output from the photo-voltaic detector 16 is applied to an electromagnetic transducer 26 to derive the pressure impulse PB for use in operating the fluidics device either directly or through fluidics control means

(e.g. bias resistors etc).

In the case of the arrangement of Figure 5 utilising electric means, the latter may be remotely located with the fluidics device in cases where the transmission path for the optical signal over the optical fibre 4 is a potentially explosive environment or an electrically intrusive path as previously explained.

In Figure 9 the fluidics device includes mechanical acoustic transducers 18 and 19 which are arranged for applying acoustic control signals to the respective control ports C1 and C2 for switching purposes. These transducers may receive their mechanical input 5 from the pressure waves generated by transducers such as illustrated in Figures 2, 3 and 4 or Figures 6 and 7.

The figure 10 fluidic proportional amplifier comprises a two-stage amplifier arrangement and has restrictions 20, 21, 22 and 23. In this case the incoming light signal may fall upon opto-mechanical transducers 24 and 25 in order to vary the restrictions 20 and 23 so as to bring about a change in the output of the amplifier.

Claims

1. An operating arrangement for fluidic devices comprising optical signal generating means and transducer means for converting the output derived from the optical signal generating means into a mechanical output in order to produce the requisite flow of operating fluid in a fluidic device for the operation thereof.

2. An operating arrangement as claimed in claim 1, in which the transducer means converts the output from the optical signal generating means directly into the mechanical output.

3. An operating arrangement as claimed in claim 2, in which the transducer means comprises a gas-filled light transmissive vessel which contains a small volume of fibrous material having high light absorbency which undergoes very rapid heating in response to the light output from the optical signal generating means so as to produce consequential expansion of the vessel walls for generating a mechanical pressure pulse for transmission to operating fluid fed to control port means of a fluidic device.

4. An operating arrangement as claimed in claim 2, in which the transducer means comprises a gas-filled light transmissive vessel which contains a plurality of vanes having high light absorbency whereby the vanes undergo very rapid heating and produce consequential expansion of vessel walls for generating a mechanical pressure pulse which can be transmitted to control port means of a fluidic device.

5. An operating arrangement as claimed in claim 2, in which the transducer means comprises a thin film or diaphragm which is heated directly by light from the light generating means and which bends accordingly to produce a pressure wave which can be applied to the operating fluid of a fluidic device.

6. An operating arrangement as claimed in claim 5, in which the diaphragm is constructed from a plurality of layers of material having dissimilar thermal expansion coefficients.

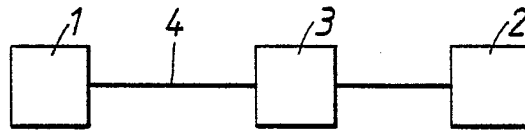
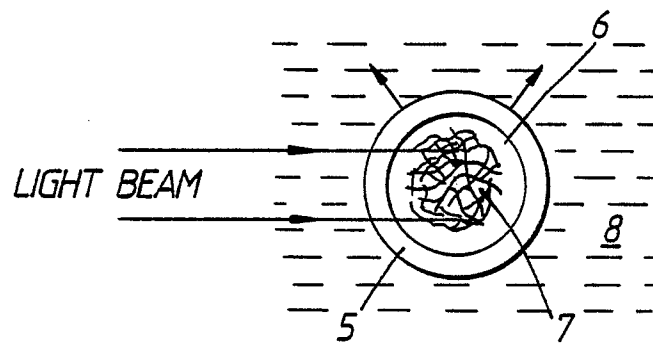
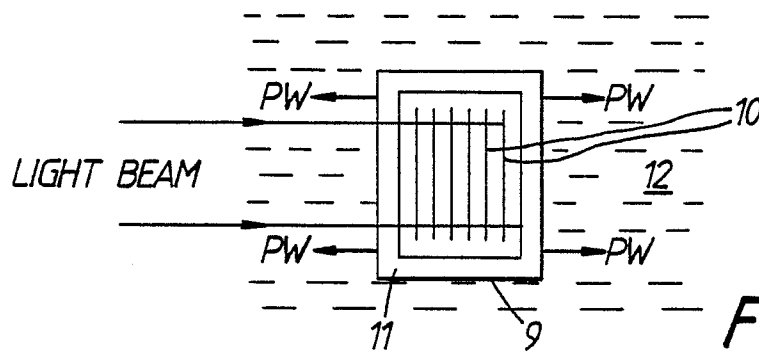
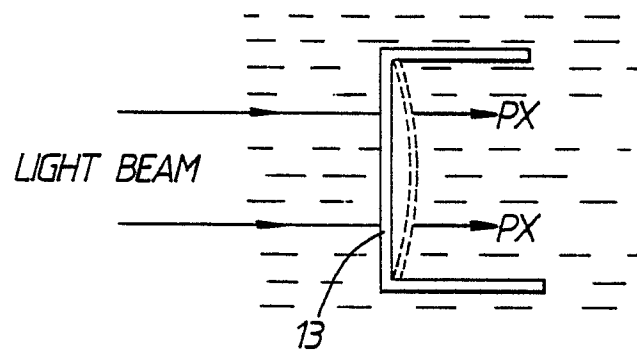
7. An operating arrangement as claimed in claim 1, in which the output from the light generating means is converted into electrical energy by means of a photo-electric transducer device (eg. a silicon or gallium arsenide device) and in which the electrical output from the photo-electric transducer device is converted into mechanical energy by an electro-mechanical device (eg. a piezo-electric or electro-magnetic device) the mechanical output from which produces a pressure pulse in operating fluid in control port means of a fluidic device.

8. An operating arrangement as claimed in claim 1, in which the mechanical output is produced in the body of a fluidic device to provide a pressure pulse in the operating fluid of the device by a focussed or collimated acoustic wave.

9. An operating arrangement as claimed in claim 1, in which the mechanical output is produced in the body of a fluidic device to provide a pressure pulse in the operating fluid of the device by means of a pressure-transmitting rod or anvil extending into the operating region of the fluidic device.

10. An operating arrangement as claimed in claim 1, in which the mechanical output from the transducer means interacts directly with the fluidic device.

11. An operating arrangement as claimed in claim 1, in which the mechanical output from the transducer means is utilised to displace biasing fluid resistors in order to control the fluid pressure levels actually applied to the fluidic device from an external fluid injection arrangement.

*FIG. 1.**FIG. 2.**FIG. 3.**FIG. 4.*

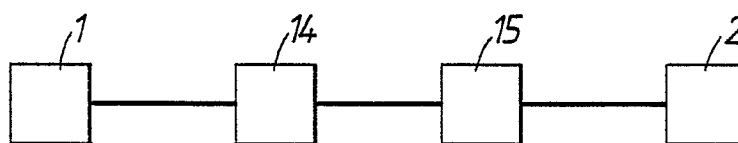


FIG. 5.

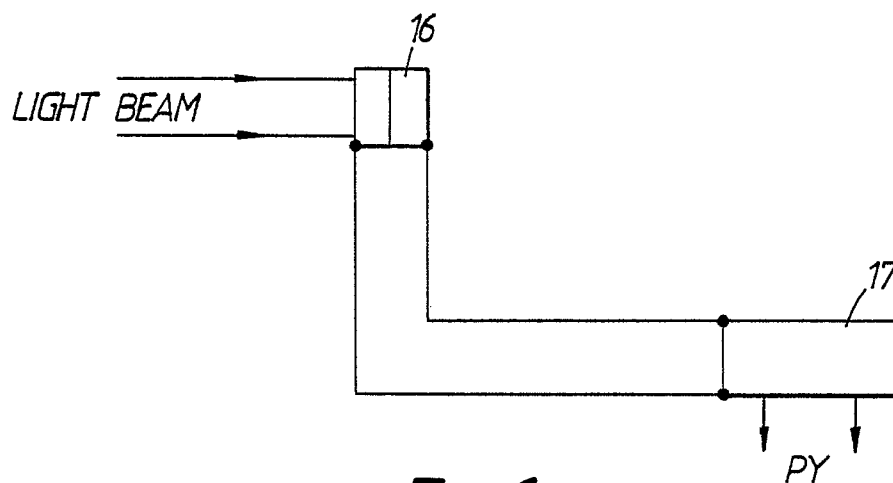


FIG. 6.

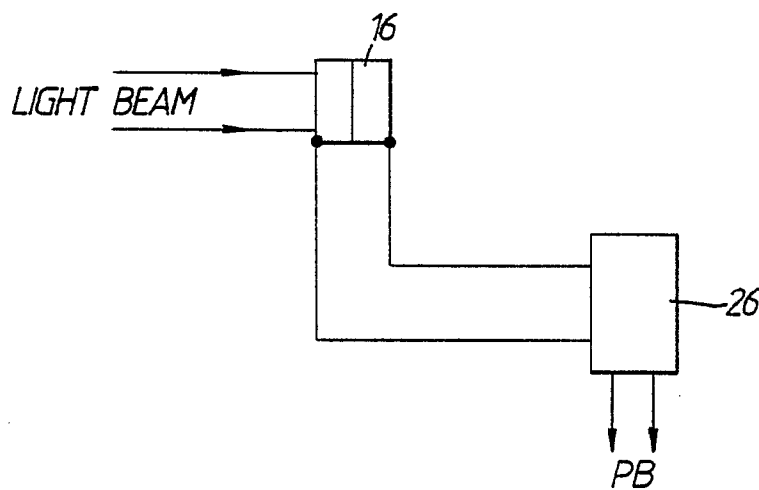
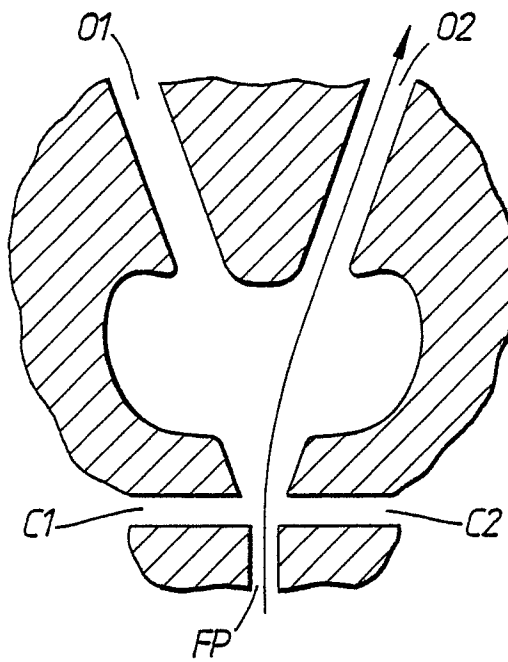
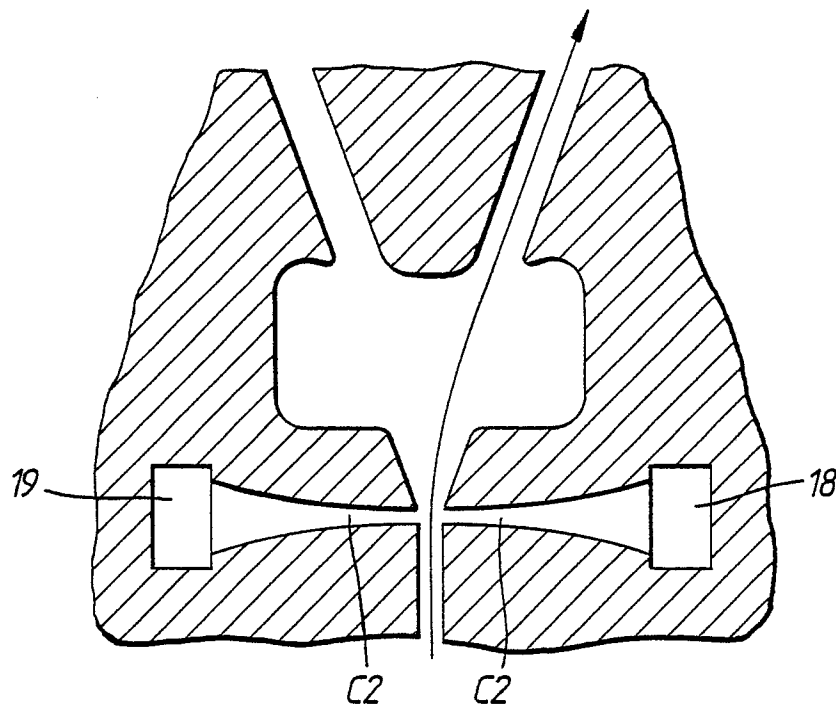


FIG. 7.

*FIG. 8.**FIG. 9.*

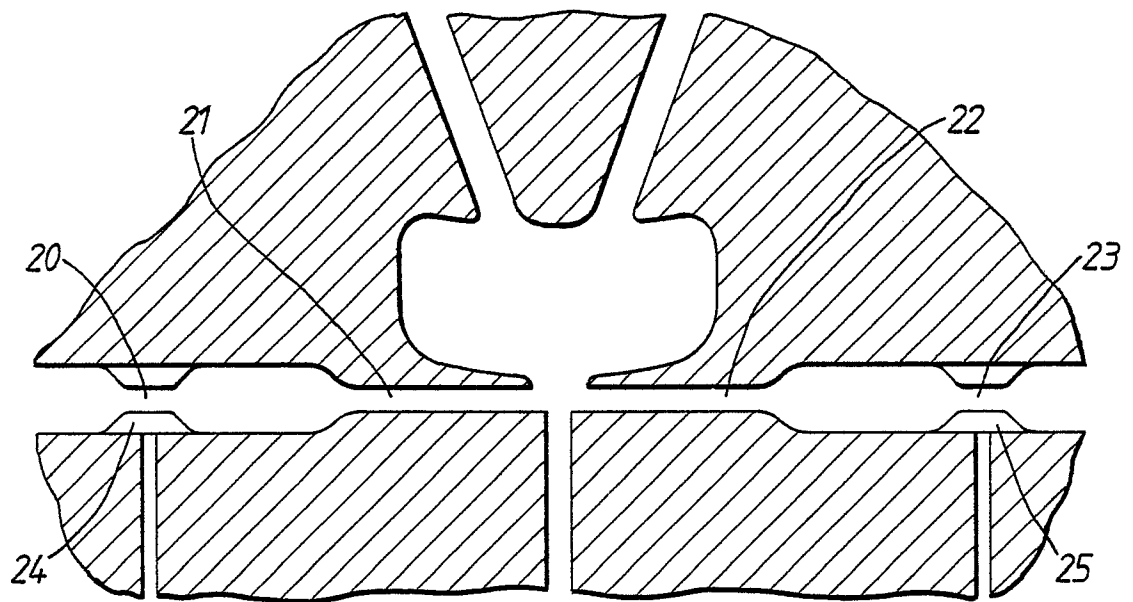


FIG.10.