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(54) **Apparatus for controlling the flow of gas**

(57) A gas valve comprises a resilient valve member (14) which co-operates with a fixed annular valve seat. The valve member is mounted on a flexible and resilient arm (13) which is cantilevered at its outer end and biases the valve member to a closed position. The arm can be attracted by an electromagnet (15) so as to lift the valve member from its seat. The extent to which the valve opens varies with the current through the electromagnet. The electromagnet is housed, within a ferromagnetic body (2), and an axial tube (4) forming an integral part of the body constitutes a core for the electromagnet and gas inlet. The valve seat is formed around a gas outlet and constitutes part of a non-ferromagnetic cap (3) screwed onto the body. The resilient arm constitutes part of an apertured disk (12) of which a marginal part is trapped between the cap and the body.

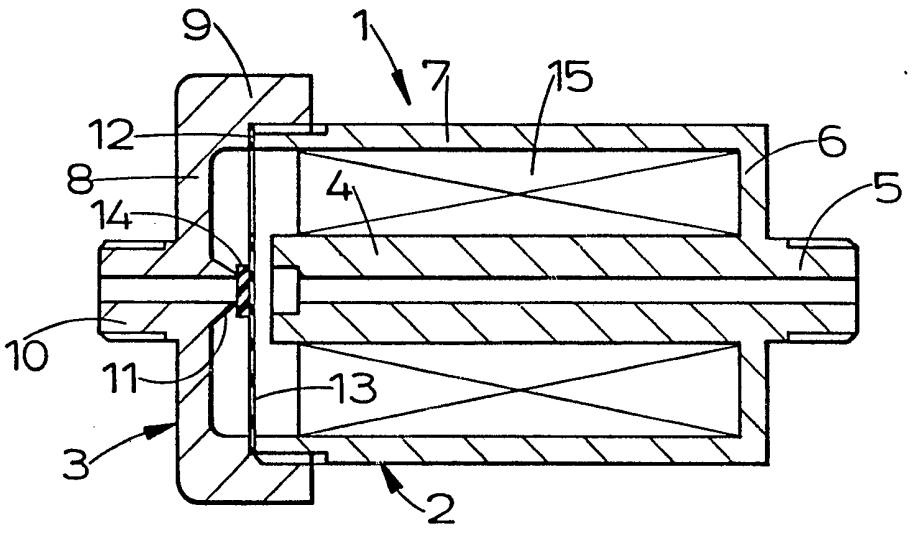


FIG. 1

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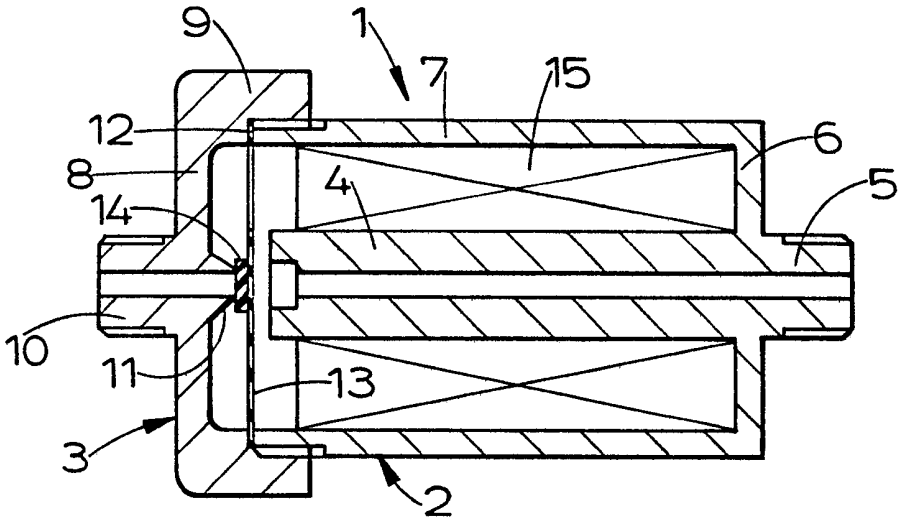


FIG. 1

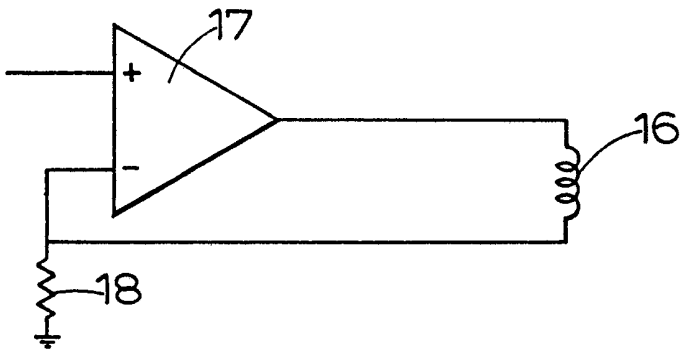


FIG. 2.

SPECIFICATION

Apparatus for controlling the flow of gas

This invention is concerned with apparatus for use in controlling the flow of gas. It is particularly, though not exclusively, applicable to the control of the flow of combustible gas.

An aim of the present invention is to provide apparatus for that purpose comprising a gas valve which can be of relatively simple construction and which can cause variations in the flow of gas, normally including cessation of flow, in response to electrical control signals.

The present invention consists in apparatus for controlling the flow of gas comprising a gas valve incorporating valve elements capable of relative movement so that they assume different relative positions and thus control the flow of gas along a path through the gas valve, spring means comprising a flexible and resilient arm operative to exert a bias tending to bring the valve elements into a first predetermined relative position or base position, and an electromagnet so arranged that the passage through the electromagnet of an electric current of a predetermined value causes the electromagnet to exert a magnetic force which opposes the bias and brings about relative movement between the valve elements to another predetermined relative position or operative position.

The valve elements preferably comprises a valve seat and a complementary valve member which can engage the valve seat; with such an arrangement at least one of the elements is preferably resilient so as to be capable of sealing against the other. In a preferred construction there is a fixed valve seat, through which the gas path extends, and a movable valve member; preferably the seat is rigid while the valve member is resilient. When the valve member engages the valve seat, this may serve to cut off the gas flow through the valve; alternatively there may be a bypass permitting some gas to flow even when the valve member engages the seat. The bypass may extend through one or both of the valve elements. The spring means is preferably such as to bias the valve member towards the valve seat, so that in the base position the valve member engages the valve seat. The arrangement could be such that in the base position the spring means exerts no residual force urging the valve member against the valve seat, but in a preferred arrangement the spring means does exert a force, in the base position, urging the valve member against the valve seat.

The valve elements, instead of comprising a valve seat and a valve member which can engage the valve seat, may be of other forms and may be such as to be incapable in use of assuming any relative positions such that the flow of gas is entirely cut off. In that case the gas valve would usually be used in series with a separate on/off valve.

The spring means preferably comprises a cantilevered arm, one end portion of which is anchored and the other end portion of which constitutes or is connected or coupled to one of the valve elements. The arm preferably constitutes part of plate formed with an opening into which the arm extends. Where the valve elements comprise a valve seat and a complementary valve member, the valve member is preferably mounted on said other end portion of the cantilevered arm. The arm is preferably made from a ferromagnetic material and in use responds to the magnetic force exerted by the electromagnet. When the arm is made from a ferromagnetic material the valve member may be of a non-ferromagnetic nature.

The apparatus preferably has a casing comprising a hollow body of ferromagnetic material with an end cap of non-ferromagnetic material. The gas valve preferably comprises a valve seat on the cap and a complementary valve member on said arm, the valve member engaging the valve seat when the valve elements are in their base position. The arm preferably comprises part of an apertured plate of which a marginal part is trapped between the end cap and the body. In each instance there may be a tubular core of ferromagnetic material inside the electromagnet, there being a path for gas through the bore of said core.

The gas valve is preferably such that the valve elements can assume any of a range of operative positions, which differ from one another in the extent to which they obstruct the flow of gas. To this end the arrangement is preferably such that variation in the electric current through the electromagnet causes corresponding variation in the relative positions of the valve elements. The arrangement is preferably such that a current of a certain value is preferably required to cause the gas valve to assume a position in which it is open to the maximum extent, any reduction in the current below said certain value bringing about partial closure of the gas valve.

Where accurate control of the relative positions of the valve elements is required, use is preferably made of feed-back circuitry for an electricity supply for the electromagnet, the circuitry, preferably incorporating one or more operational amplifiers, to ensure that when a signal of predetermined value is applied, the current through the electromagnet has an accurately predetermined corresponding value.

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

Figure 1 is a section through a gas valve embodying the present invention, and

Figure 2 is a simplified circuit diagram of a control circuit of a kind that can be used with a valve of the kind illustrated in Figure 1 and can, with the valve, constitute apparatus embodying the present invention.

The valve illustrated is intended for use in controlling the flow of combustible gas and is capable of cutting off the flow of gas completely and of modulating the flow of gas as may be

required in use. The valve has a casing 1 comprising a body 2 and a cap 3.

The body 2 is made from steel, which is ferromagnetic, while the cap 3 is made from an aluminium alloy, which is not ferromagnetic. The body 2 comprises an axial tube 4, one end portion of which is externally screw-threaded and constitutes a gas inlet 5. The bore of the other end portion of the tube 4 is of enlarged diameter, as shown. Adjacent to the gas inlet 5 is an outwardly directed end plate 6 of circular shape, the periphery of which is integrally joined to one end of a tubular outer wall 7. The other end part of the outer wall 7 is externally screw-threaded for engagement with the cap 3. The threaded end of the outer wall 7 extends a short way beyond the adjacent end of the axial tube 4.

The cap 3 comprises a circular plate 8 with an axially directed peripheral flange 9. For a part of its axial length the flange 9 is internally screw-threaded with a thread complementary to that on the outer wall 7 of the body 2. At the inner end of the thread inside the flange 9 there is formed an annular, planar shoulder. A tubular gas outlet 10 projects axially from a central part of the circular plate 8 and, like the inlet 5, is externally screw-threaded for ready attachment to gas piping or to other pieces of apparatus. The bore of the outlet 10 extends through the central part of the plate 8 and through a frusto-conical projection 11 on the inner surface of that plate. The end surface of the projection 11 is of annular planar shape and constitutes a valve seat. The distance (as measured in an axial direction) between the end plate 8 and the plane containing the valve seat is less than the distance between the end plate 8 and the plane containing the shoulder in the flange 9.

A marginal part of a valve disc 12 made from spring steel is tightly trapped between the shoulder in the flange 9 and the adjacent end surface of the outer wall 7. Like the body 7, the disc 12 is ferromagnetic. Much of the disc 12 is cut away, so that there only remains the marginal part of annular shape and an arm 13 which extends radially inwards from a location on the marginal part. The arm is of uniform width and extends a short way beyond the centre of the disc. The arm 13 carries a valve member 14 which is disposed at centre of the disc. The valve member is made from silicone rubber or alternatively may be made from some other resilient material.

The valve is illustrated as being in a closed position. In this position the valve disc 12 is flat, and the valve member 14 engages the valve seat on the projection 11. Nevertheless, the arm 13 has been prestressed in such a manner that in this closed position it positively urges the valve member 14 against the valve seat to ensure that the gas outlet 10 is truly sealed. In an alternative arrangement, the arm 13 is not prestressed but merely holds the valve member 14 by the valve seat without exerting any force. With such an arrangement the differential pressure of gas between the gas inlet and gas outlet may well be sufficient to urge the valve member against the valve seat and to ensure a satisfactory seal.

The valve seat and valve member 14 constitute the valve members referred to above, and the arm 13 constitutes the spring means also referred to above. The arm is both flexible and resilient and exerts a bias tending to bring the valve member to the closed position, which is thus, in this embodiment, the base position referred to above. It will be appreciated that the arm is in effect cantilevered from its outer end.

A coil 15, constituting an electromagnet, is fitted into the body 2, and largely occupies the interior space between the tube 4 and the outer wall 7. The coil 15 is mounted on a bobbin (not shown) of non-ferromagnetic material, an end portion of which extends axially a short distance beyond the end of the axial tube 4 towards the arm 13; but it does not extend as far as the arm when the arm is in the base position described above. Electric leads (not shown) for the coil 15 extend through a hole or holes in the body which is or are rendered gas-tight.

The valve operates in the following manner. When gas under pressure is applied to the gas inlet 5, it can enter the casing 1 but cannot escape through the gas outlet 10 as it is closed by the valve member 14. When an electric current of predetermined value is passed through the coil 15, however, the arm 13 is magnetically attracted towards the coil and the valve member is lifted from the valve seat, thereby allowing gas to flow through the gas outlet. The arrangement is such that by varying the value of the current through the coil the valve member can be held in a stable manner in any of a range of positions relative to the valve seat. As the distance between the valve member and the valve seat increases, the rate of flow of gas increases until the valve member is spaced from the valve seat by a distance equal or substantially equal to one quarter of the diameter of the bore of the hole in the valve seat. That relationship is one that is well-known in the art. It is therefore unnecessary for the valve member to be movable from the valve seat by a distance much, if any, greater that a quarter of the diameter of the hole in the valve seat. When the valve seat is shifted to this maximum necessary extent the arm 13 engages the projecting end of the bobbin on which the coil 15 is wound. This prevents the arm approaching the adjacent end of the axial tube 4 too closely, which is desirable for two reasons, first to prevent obstruction of the gas outlet hole at the end of the axial tube 4 and second to prevent the arm reaching an unstable position adjacent to the axial tube, in which position the rate of increase of the force exerted on the arm by the electromagnet as the arm approaches the magnet would be greater than the rate of increase in the bias exerted by the arm, so that the arm would tend to snap to a widely open position. If such a snap action were allowed to occur, there would have to be a considerable reduction in the current passing through the electromagnet before the arm would return to its

normal range of operating positions.

Thus, in this preferred arrangement the range of operating positions is such that if a certain minimum current is required to cause the valve to assume a position in which it is open to the maximum extent, any reduction in that minimum current brings about some closing movement of the valve.

The valve may well be used for adjusting the flow of gas to any flow rate within a range of normal flow rates of which the slowest rate is very considerably less than the fastest rate. For example the minimum flow rate may be such as to require the axial gap between the valve member and the valve seat to be about 0.0004 inches (0.01 mm), while the maximum flow rate may be such as to require that gap to be 0.05 inches or at least 0.03 inches (1.27 to 0.76 mm). To enable results such as this to be achieved it is necessary to control the current through the electromagnet very accurately. The necessary current control may be achieved with the aid of a feed-back circuitry employing one or more operational amplifiers, the arrangement being such that any unwanted fluctuation in the current through the electromagnet gives rise to a feed-back signal which causes the current to return substantially to its initial, desired value. Such an arrangement is illustrated in Figure 2, where the coil 16 of an electromagnet of a valve is connected to the output of an operational amplifier 17 and to the inverting input thereof, that inverting input being connected to earth through a resistor 18. This type of circuit and other types of circuit yielding similar results are well-known as such and will not be described in more detail here. The idea of using such circuits to control the current supplied to electromagnets in gas valves, however, is believed to be entirely new.

If valves of the kind shown in Figure 1 are made by mass-production methods, it is likely that the valves will differ slightly from one another so that the current required to open the valve to a predetermined extent will differ from the valve to valve. In order to overcome that difficulty, each valve preferably has associated with it its own electric circuit, which constitutes part of the apparatus and is trimmed during manufacture of the apparatus, so that every valve will open to the same extent when a given control signal is fed to the input of the associated circuit.

The valve may be so designed as to require only relatively little power to operate it, in which case the power may be supplied by a thermocouple or thermopile. In particular the valve may be used to control the supply of gas to a main burner provided with a pilot burner which, when lit, heats a thermopile to open the valve and is so positioned as to ignite gas from the main burner. Use of such a system would obviate the need to provide a magnetic flame-failure valve of the kind that is commonly in use at present and that requires the valve to be held open manually while a thermopile is heated.

Valves of the kind described may conveniently be used to control the flow of gas to the burners of domestic and other gas-burning appliances. Where several valves are employed in the same appliance they may conveniently be mounted side by side in a row on a common gas-supply manifold, with their axes mutually parallel and at right-angles to the longitudinal axis of the manifold.

Where valves of the kind embodying the present invention are used to control the flow of gas on a larger scale than that normally used in domestic fires, ovens and the like, it may be desirable to provide an electric control circuit such that the valve always opens relatively slowly but can be closed rapidly. The slow opening of the valve can be achieved with the aid of a ramp generator operative to supply a steadily increasing signal whenever it is operated.

Valves embodying the present invention may also be incorporated in thermostats. In a typical thermostat, suitable for use in a domestic cooker, a valve controls the flow of gas to a burner. An electric temperature sensor such as a platinum film detector is mounted adjacent to the burner and gives rise to an electrical signal dependent on the temperature. That signal, after being modified so that the temperature/signal graph is linear, is fed back to the control for the gas valve so as to cause the temperature to remain substantially constant. By adjusting the strength of the feed-back signal the temperature setting can be varied as desired. Alternatively, in the control of space heating, as for example by a gas fire or by gas-fired central heating, a thermosensitive device may be positioned at any suitable location and provide the necessary feed-back signal.

As the valves embodying the present invention require only electrical signals for their operation they can be positioned wherever the requirements of the gas supply and gas flow may dictate. The necessary controls, such as manually operable controls, time controls, temperature sensing devices, flame detecting devices, etc. may be connected to the apparatus by appropriate electric wires. If desired, however, the connection may be by way of signals transmitted from one plate to another without the intermediary of any wires; for example use may be made of infra-red signals, optical signals or even radio signals.

Numerous modifications to the apparatus illustrated may of course be made without departing from the scope of the present invention. For example, the gas inlet may extend through the cap 3 rather than through the axial tube 4, that tube being replaced by a solid rod.

CLAIMS

1. Apparatus for controlling the flow of gas comprising a gas valve incorporating valve elements capable of relative movement so that they assume different relative positions and thus control the flow of gas along a path through the gas valve, spring means comprising a flexible and resilient arm operative to exert a bias tending to bring the valve elements into a first predetermined

relative or base position, and an electromagnet so arranged that the passage through the electromagnet of an electric current of a predetermined value causes the electromagnet to exert a magnetic force which opposes the bias and bring about relative movement between the valve elements to another predetermined relative position or operative position.

2. Apparatus according to claim 1 in which the valve elements comprise a valve seat and a complementary valve member which can engage the valve seat.

3. Apparatus according to claim 2 in which at least one of the valve elements is resilient so as to be capable of sealing against the other.

4. Apparatus according to either of claims 2 and 3 in which there is a fixed valve seat, through which the gas path extends, and a movable valve member.

5. Apparatus according to claim 4 in which the seat is rigid while the valve member is resilient.

6. Apparatus according to any one of claims 2 to 5 in which the spring means is such as to bias the valve member towards the valve seat, so that in the base position the valve member engages the valve seat.

7. Apparatus according to claim 6 in which the spring means exerts a force, in the base position, urging the valve member against the valve seat.

8. Apparatus according to any one of the preceding claims in which the spring means comprises a cantilevered arm, one end portion of which is anchored and the other end portion of which constitutes or is connected or coupled to one of the valve elements.

9. Apparatus according to claim 8 in which the arm constitutes part of a plate formed with an opening into which the arm extends.

10. Apparatus according to either of claims 8 and 9 in which the valve elements comprise a valve seat and a complementary valve member, the valve being mounted on said other end portion of the cantilevered arm.

11. Apparatus according to any one of claims 8 to 10 in which the arm is made from a ferromagnetic material and in use responds to the magnetic force exerted by the electromagnet.

12. Apparatus according to any one of the preceding claims having a casing comprising a hollow body of ferromagnetic material with an end cap of non-ferromagnetic material.

13. Apparatus according to claim 12 in which the gas valve comprises a valve seat on the cap and a complementary valve member on said arm, the valve member engaging the valve seat when the valve elements are in their base position.

14. Apparatus according to either of claims 12 and 13 in which the arm comprises part of an apertured plate of which a marginal part is trapped between the end cap and the body.

15. Apparatus according to any one of claims 12 to 14 in which there is a tubular core of ferromagnetic material inside the electromagnet, there being a path for gas through the bore of said core.

16. Apparatus according to any one of the preceding claims in which the valve elements can assume any of a range of operative positions, which differ from one another in the extent to which they obstruct the flow of gas.

17. Apparatus according to claim 16 in which the arrangement is such that variation in the electric current through the electromagnet causes corresponding variation in the relative positions of the valve elements.

18. Apparatus according to claim 17 in which the arrangement is such that a current of a certain value is required to cause the gas valve to assume a position in which it is open to the maximum extent, any reduction in the current below said certain value bringing about partial closure of the gas valve.

19. Apparatus for controlling the flow of gas, substantially as hereinbefore described with reference to Figure 1 of the accompanying drawings.

20. Apparatus according to any one of claims 17 to 19 in combination with feed-back circuitry for an electricity supply for the electromagnet, the circuitry incorporating one or more operational amplifiers, to ensure that when a signal of predetermined value is applied, the current through the electromagnet has an accurately predetermined corresponding value.

21. Apparatus according to claim 20 in which the feed-back circuitry is substantially as hereinbefore described with reference to Figure 2 of the accompanying drawings.

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