

1

3,525,263

SUPERVISORY APPARATUS

John G. Rupert, St. Anthony Village, Minn., assignor to Honeywell Inc., Minneapolis, Minn., a corporation of Delaware

Filed Dec. 23, 1968, Ser. No. 786,309

Int. Cl. G011 7/16

U.S. Cl. 73-419

6 Claims

ABSTRACT OF THE DISCLOSURE

A fluid pressure ratio sensor which is free from the disadvantages of diaphragms, O-ring seals, etc. The pressures are supplied on faces of pistons or vanes to cause movement of an assembly to a position determined by the ratio of the pressures. The pistons or vanes are contained in a housing which is vented to the atmosphere through a diffuser. The pressures being measured must be such that choked flow through the diffuser occurs.

BRIEF SUMMARY OF THE INVENTION

This invention relates to the field of supervisory apparatus and more particularly to apparatus responsive to the ratio between two fluid pressures, the fluids in question being substantially perfect gases. The pressures of which the ratio is to be determined are supplied to a housing and cause movement of a member therewithin to a position determined by the ratio of the pressures. Means are also included for making evident, outside the housing, the position of the member moving therewithin. Two embodiments shown translational movement of the member, while the movement in the third embodiment is rotational.

A principal object of the invention is to provide apparatus for giving more accurate indication of pressure ratio than has been heretofore possible. Various other objects, advantages and features of novelty which characterize the invention are pointed out with particularity in the claims attached hereto and forming a part hereof. However, for a better understanding of the invention, its advantages and objects attained by its use, reference should be had to the sub-joined drawing, which forms a further part hereof, and to the accompanying descriptive matter, in which there are shown and described certain illustrative embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWING

In the drawing, FIG. 1 is a longitudinal cross-section of one embodiment of the invention, FIG. 2 is a longitudinal section of a first modification of the invention, and FIG. 3 is a sectional view of a second modification of this invention.

DETAILED DESCRIPTION

Referring first to FIG. 1, one embodiment of my invention is shown to comprise an elongated hollow housing 10 containing first and second chambers 11 and 12 respectively which are in end-to-end communication. Egress of fluid from chamber 11 takes place through a converging-diverging diffuser 13, the throat area of which is designated by A_0 .

Movable axially in housing 10 is a member 14 which comprises first and second pistons 15 and 16 rigidly united by a shaft 17. Chamber 11 varies in cross-sectional area from end to end and the variation is preferably non-linear. Its smallest area is materially greater than that of chamber 12, which is of constant cross-sectional area. Piston 16 fits chamber 12, although leakage past this piston does not degrade the accuracy of the instrument. The area of piston 15 is less than the smallest cross-

2

sectional area of chamber 11, to leave an annular space, of area designated by A, between the edge of the piston and the wall of the chamber, the area A varying with the axial displacement of member 14. The area of piston 15 is designated as A_1 and that of piston 16 is designated as A_2 ; the cross-section of shaft 17 is so small as to be negligible.

Pressure taps 20 and 21 are provided to give ingress of pressure fluid to chambers 11 and 12 respectively at the ends thereof remote from diffuser 13.

An extension 22 of shaft 17 passes through an opening in housing 10 and carries graduations 23 outside the housing, which may be read with respect to an index 24 suitably mounted adjacent the graduations.

In use the pressures P_1 and P_2 whose ratio is to be determined are supplied to taps 20 and 21 respectively. The larger pressure is supplied to tap 20, and must be sufficient to result in choked flow of fluid out through diffuser 13. A pressure P_0 appears in chamber 11 to the right of piston 15 as seen in the figure, and for choked flow through the diffuser this pressure P_0 is independent of ambient pressure outside the housing. The flow past piston 15 may or may not be incompressible.

In response to pressure P_0 acting to the left on piston 15, to pressure P_1 acting to the right on piston 15 and to the left on piston 16, and to pressure P_2 acting to the right on piston 16, member 14 takes an equilibrium position in the housing, varying P_0 as it does so because of the variation in annular area A. When this equilibrium position is reached, the following relation exists:

$$(P_1 - P_0)A_1 = (P_2 - P_0)A_2 \quad (1)$$

The following relations are well known:

(a) For choked flow through diffuser 13

$$\dot{m} = K \frac{P_0}{T_0} A_0 \quad (2)$$

where

$$K = \sqrt{\frac{k}{r} \left(\frac{2}{k+1} \right)^{\frac{k+1}{k-1}}}$$

(b) For incompressible flow past piston 15

$$P_1 - P_0 = \frac{1}{2} \rho V^2 \quad (3)$$

and

$$\dot{m} = \rho A V \quad (4)$$

(c) For perfect gas

$$\frac{P_0}{\rho} = R T_0 \quad (5)$$

In these relations $\dot{m}$ is mass rate of flow, T_0 is absolute temperature, ρ is gas density, V is gas velocity, R is the unusual gas constant, and $k = C_p/C_v$, the ratio of specific heats, which is 1.4 for air.

Solution of Equations 1 through 5 gives the following relation:

$$P_1/P_2 = \frac{A_2/A_1 [1 + 4.28(A/A_0)^2]}{A_2/A_1 [1 + 4.28(A/A_0)^2] - 1} \quad (6)$$

which may be generalized as

$$P_1/P_2 = f(A_2/A_1, A/A_0) \quad (7)$$

All the quantities on the right hand side of Equation 7 are constant except A, and this may be made to vary arbitrarily with X, the displacement of member 14, by suitably configuring the wall of chamber 11, so that Equation 3 becomes:

$$P_1/P_2 = f(X)$$

While the indication of the quantity X is shown in FIG. 1 as a visual reading of graduations 23 against index 24, it will be realized that extension 23 may alter-

natively actuate, or comprise a portion of, any suitable mechanical, electrical, optical or fluidic read-out device, either local or remote.

Referring now to FIG. 2, a second embodiment of the invention is shown to comprise a housing 40 containing first and second chambers 41 and 42 respectively which are in end-to-end communication. Egress of fluid from chamber 41 takes place through a converging-diverging diffuser 43, the throat area of which is designated by A_0 .

Movable axially in housing 40 is a member 44 which comprises first and second pistons 45 and 46 which move unitarily and which may conveniently be integral. In this modification of the invention, both chambers are of uniform cross-sectional area, chamber 42 being the smaller, and pistons 45 and 46 fit their respective chambers. The area of piston 45 is designated by A_1 and that of piston 46 is designated by A_2 .

Pressure taps 50 and 51 are provided to give ingress of pressure fluid to chambers 41 and 42 respectively at the ends thereof remote from diffuser 43.

An extension 52 of member 44 passes through an opening in housing 40 and carries graduations 53 outside the housing which may be read with respect to an index 54 suitably mounted adjacent the graduations.

A bore 55 is formed in piston 45 extending parallel to the axis of member 44, but spaced laterally therefrom, and a tapered projection 56 extends from housing 40 to pass through bore 55. The bore is larger than the largest cross section of the projection, to define an annular area A which varies with the position X of the member in the housing, and the taper of projection 56 may be made non-linear if desired.

It will be readily apparent that the equations derived for the first embodiment apply equally well to the second embodiment if the same conditions are imposed.

The third embodiment of the invention, shown in FIG. 3, is clearly analogous to that of FIG. 1: the motion occurring is one of rotation rather than of translation. Here a housing 60 is shown to have a first chamber 61 and a second chamber 62 which are in communication and are shown to be of uniform depth. Egress of fluid from chamber 62 takes place through a converging-diverging diffuser 63, the throat area of which is designated by A_0 .

Movable in housing 60 is a member 64 having a pair of vanes 65 and 66 projecting into the chambers from a hub 67. Member 64 is pivoted for rotation about an axis perpendicular to the paper and passing through the center of hub 67, part of which fits closely in a recess formed in the housing.

Pressure taps 50 and 51 are provided to give ingress of pressure fluid to chambers 61 and 62 respectively.

Hub 67 is extended outside of housing 60 to actuate an index 73 angularly with respect to graduations 74 on a suitably mounted member 75.

Chamber 63 includes a surface 71 which is configured to depart from a circular cylinder by an amount which varies with the angular displacement of vane 65, in any desired linear or non-linear relationship.

Chamber 62 has a circularly cylindrical surface 72 which cooperates with the end of vane 66 in the manner that the wall of chamber 12 cooperates with piston 16 of FIG. 1.

In FIG. 3 the area between vane 65 and the adjacent wall of housing 60 is designated A and the areas of vanes 65 and 66 are designated A_1 and A_2 respectively. The equations given in connection with FIG. 1 obviously apply to this second embodiment of the invention as well.

The foregoing description and the drawing are illustrative of my invention, which I now claim as follows:

1. In combination: a housing;
- a diffuser affording egress of fluid from said housing;
- first means, spaced from said diffuser, for affording ingress of fluid to said housing;
- second means, spaced beyond the last named means from said diffuser, for affording ingress of fluid to said housing;

a member movable in said housing and including a first portion, located between the first ingress means and said diffuser for subjection to fluid pressure through said first ingress means, and a second portion, located between the first and second ingress means for subjection to fluid pressure through said second ingress means;

means co-acting with said first portion of the movable member to provide a path for fluid from said first ingress means to said diffuser which is variably restricted as said member moves in said housing, whereby to produce a variable pressure within said housing adjacent said diffuser; and

means for making evident, outside said housing, the position taken by said member therewithin as a result of the fluid pressures acting on said member;

whereby when the fluid pressure supplied at first ingress means is greater than that supplied at said second ingress means the position of said member in said housing is a measure of the ratio of the first fluid pressure to the second fluid pressure.

2. In combination: an elongated housing having a longitudinal axis;

a diffuser at one end of said housing to afford egress of said fluid therefrom;

first means, spaced along the axis of said housing from said diffuser, for affording ingress of fluid to said housing;

second means, located beyond said diffuser from said first means, for affording ingress of fluid to said housing;

piston means movable in said housing along said axis and including a first portion, located between the first ingress means and said diffuser for subjection to fluid pressure from said first ingress means, and a second portion, located between the first and second ingress means for subjection to fluid pressure through said second ingress means;

means associated with said housing and co-acting with said first portion of said piston means to provide a path for fluid, from said first ingress means to said diffuser, which is variably restricted as said member moves in said housing, so as to produce a variable pressure within said housing adjacent said diffuser and acting on said first portion of said piston means; and

means actuated by said piston means and extending through said housing for making evident, outside said housing, the axial position taken by said piston means therewithin as a result of the fluid pressures acting on said piston means;

whereby when the fluid pressure supplied at said first ingress means is greater than that supplied at said second ingress means the position of said member in said housing is a measure of the ratio of the first fluid pressure to the second fluid pressure.

3. In combination: an elongated housing having a longitudinal axis and including first and second chambers in end-to-end communicating relation;

a diffuser at one end of said housing to afford egress of fluid from said first chamber;

a first pressure port for affording ingress of fluid to said first chamber at a point remote from said diffuser;

a second pressure port for affording ingress of fluid to said second chamber at a point remote from said diffuser;

means unitarily movable in said housing along said axis and including a first piston located, in said chamber, between said first pressure port and said diffuser, for subjection to fluid pressure through said first port and to the fluid pressure adjacent to said diffuser, and a second piston located, in said second chamber, between said pressure ports, for subjection to fluid pressure through said ports;

5

means, including a wall of said first chamber, co-acting with said first piston to provide a path for fluid, from said first pressure port to said diffuser, which is variably restricted as said member moves axially in said housing, so as to produce a variable pressure within said chamber adjacent to said diffuser; and

means actuated by the movable means, and extending through said housing, for making evident outside said housing the axial position taken by said piston means therewithin as a result of the fluid pressures acting on said pistons;

whereby when the fluid pressure supplied at said first ingress means as greater than that supplied at said second ingress means, and is such that the fluid flow through said diffuser is choked, the position of said member in said housing is a measure of the ratio of the second fluid pressure to the first fluid pressure.

4. In combination: an elongated housing having a longitudinal axis and including a first chamber, of a cross-sectional area which decreases with distance along said axis, in end-to-end communication with a second chamber, of the same cross-sectional area at all points along the axis, the area of said second chamber being less than the smallest area of said first chamber;

a diffuser at one end of said housing to afford egress of fluid from said first chamber at a point remote from said second chamber;

a first pressure port for affording ingress of fluid to said first chamber at a point remote from said diffuser;

a second pressure port for affording ingress of fluid to said second chamber at a point remote from said diffuser;

means unitarily movable in said housing along said axis and including a first, larger piston located, in said first chamber, between said first port and said diffuser, for subjection to fluid pressure through said first port and to the fluid pressure adjacent to said diffuser, and a second, smaller piston located, in said second chamber, between said pressure ports, for subjection to fluid pressures through said ports, said first piston and the adjacent wall of said chamber co-acting to provide a path for fluid, from said first pressure port to said diffuser, which is variably restricted as the piston moves axially in the chamber so as to provide a variable pressure within said second chamber adjacent to said diffuser, the movable means positioning itself axially in said housing to balance the pressures acting on said pistons; and

means actuated by said movable means and extending through said housing for making evident, outside said housing, the axial position taken by said movable means therewithin.

5. In combination: an elongated housing having a longitudinal axis and including first and second chambers in end-to-end communication along said axis, the cross-sectional area of the said second chamber being less than that of said first chamber;

a diffuser at one end of said housing to afford egress of fluid from said first chamber;

a first pressure port for affording ingress of fluid to said first chamber at a point remote from said diffuser;

6

a second pressure port for affording ingress of fluid to said second chamber at a point remote from said diffuser;

a member unitarily movable in said housing along said axis and including a first, larger piston located, in said first chamber, between said first port and said diffuser, for subjection to fluid pressure through said first port and to the fluid pressure adjacent to said diffuser, and a second, smaller piston located, in said second chamber, between said pressure ports, for subjection to fluid pressure through said ports, said member positioning itself axially in said housing in response to the pressure on said pistons;

means, including a bore in said first piston and a tapering projection extending therethrough from said housing, for providing a path for fluid, from said first port to said diffuser, which is variably restricted as said member moves axially in said housing, so as to produce a variable pressure within said second chamber adjacent to said diffuser; and

means actuated by said member and extending through said housing for making evident, outside said housing, the axial position taken by said member therewithin as a result of the fluid pressures acting on said pistons.

6. In combination: a housing;

a chamber in said housing including a first, larger portion and a second, smaller portion in communication therewith;

a rotatable member including a long vane extending into said first portion, a short vane extending into said second portion, and means for causing simultaneous rotation of said vanes in said chambers, the second portion of said chamber being configured to agree with the path of the end of said short vane;

a first pressure port in said housing communicating with said chambers to subject one face of said short vane and one face of said long vane to a first fluid pressure;

a second pressure port in said housing communicating with said chamber to subject the other face of said short vane to a first fluid pressure;

a diffuser in said housing affording egress of said fluid from said chamber adjacent the other face of said long vane, the first portion of said chamber being configured for cooperation with the end of said long vane to provide a passage, for flow of fluid from said first source to said diffuser, which is variably restricted as said member rotates in said chamber in response to the pressures on the faces of said vanes; and

means actuated by said rotatable member for making evident, outside said housing, the rotated position of said member therein;

whereby when the fluid pressure supplied at said first ingress means is greater than that supplied at said second ingress means the position of said member in said housing is a measure of the ratio of the first fluid pressure to the second fluid pressure.

References Cited

UNITED STATES PATENTS

3,348,417 10/1967 Hitzelberger ----- 73-407

DONALD O. WOODIEL, Primary Examiner