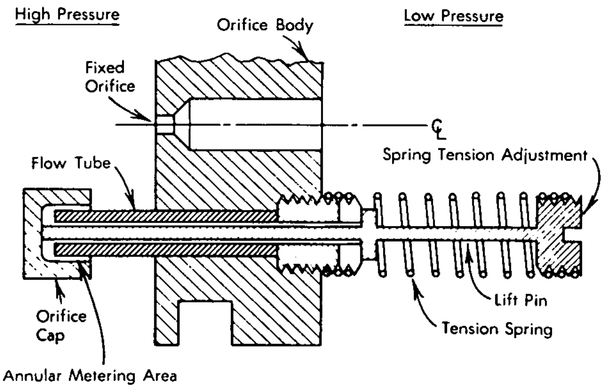
NASA TECH BRIEF

Ames Research Center

Pressure Sensitive Gas Flow Meter

The problem:

To maintain a steady flow rate of gas as the supply pressure from a storage system decreases.



ON/OFF Orifice Shown in ON Condition

The solution:

A pressure regulator which increases the flow area in discrete steps as the upstream pressure falls. Definitely sized orifices are opened in sequence to maintain relatively constant flow rate as the pressure differential across the regulator falls.

How it's done:

The valve control plate shown in the diagram consists of a fixed orifice and a controllable orifice that is merely a spring-loaded cap over a tube. A lift pin normally keeps the orifice cap away from the opening of the flow tube, but the gas pressure on the high pressure side of the control plate presses the orifice cap against the flow tube and only the fixed orifice controls gas flow. When the high pressure decreases to the point where the spring tension allows the orifice cap to move away from the end of the flow tube, the orifice cap gradually allows more gas to escape from the flow tube to compensate for the reduced gas flow through the fixed orifice.

The acceptable pressure variation at the operating terminus of the gas line determines the number of individual orifices required in the regulator. For example, in order to provide appropriate pressure for the thruster nozzle in an attitude control system, if a multitank storage system allows a 4:1 pressure variation, then *n* orifices in the regulator will provide a downstream pressure variation of $(4)^{1/n}$. Hence, two orifices give a 2:1 thrust variation; three a 1.59:1 variation; four, a 1.415:1 variation, etc. The number of orifices dictates their size, and each must be sized differently if the pressure ratio from one step to the next is to be constant. Thus, if the pressure ratio is 1.415 (four orifices), the area of the second orifice is such that $1.415A_1 = A_1 + A_2$. The area of the third orifice is such that $1.415(A_1 + A_2) = A_1 + A_2 + A_3$, and similarly for the fourth.

For pressure at the thruster varying from 345 kN/m² (50 psia) minimum to 489 kN/m² (71 psia) maximum (1.415 ratio), the orifice diameters vary from $A_1 = 0.0381$ cm (0.015 inch), always open, to $A_4 = 0.0345$ cm (0.0136 inch) at 1951 kN/m² (283 psia) to provide 0.76 N (0.17 pound) of thrust with a specific impulse of 75 seconds and a 0.75 discharge coefficient from a starting pressure of 5520 kN/m² (800 psia).

When the upstream pressure falls from 5520 kN/m² (800 psia) to about 3930 kN/m² (570 psia), the tension spring on one orifice is so adjusted to lift

(continued overleaf)

the cap off its tube and allow flow to occur, re-establishing the downstream pressure to its initial value. The second on/off orifice is adjusted to open at 2758 kN/m^2 (400 psia) and the third one at 1965 kN/m^2 (285 psia). In this way, the downstream pressure varies in a sawtooth manner from approximately 483 to 345 kN/m^2 (70 to 50 psia), in four steps, as the upstream pressure falls from 5520 to 1379 kN/m^2 (800 to 200 psia).

When the supply line to the flow meter is opened, the pressure on the upstream side of the metering orifices rises very rapidly to the value of the supply pressure. The pressure on the downstream side of the orifices takes a relatively much longer time to reach equilibrium since the downstream volume is being filled through the small metering orifices while at the same time it is being exhausted through the thruster. Similarly, when the supply line is closed, the pressure at the thruster nozzle has an appreciable decay time because as the low pressure gas bleeds out, it is being replenished from the high pressure side.

Notes:

1. The following documentation may be obtained from:

   National Technical Information Service
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.95)
   Reference: NASA CR-73231 (N69-13310),
   New Functional Redundancy Approaches for Attitude Control Thruster Systems

2. No additional documentation is available. Specific questions, however, may be directed to:

   Technology Utilization Officer
   Ames Research Center
   Moffett Field, California 94035
   Reference: B72-10049

Patent status:

No patent action is contemplated by NASA.

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