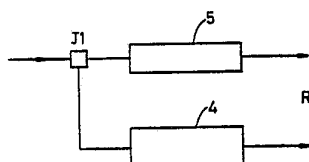
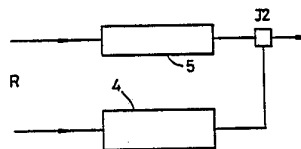
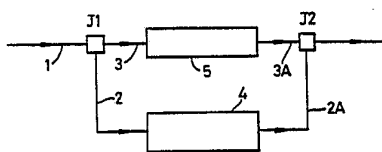




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(54) Title: FLOW CIRCUIT AND FLOW METER**(57) Abstract**

A flow circuit for a flow meter comprises a fluid flow line having an upstream junction or reservoir at which the fluid flow is divided into an inlet stream to a fluidic meter and an inlet stream to a laminar by-pass resistor, and a downstream junction or reservoir at which an outlet stream from the fluidic meter and an outlet stream from the by-pass resistor are recombined, in which the combined operating characteristics of the junctions (if present) and the by-pass resistor are selected and matched to the operating characteristics required of the flow meter, such that the relative magnitude of the two fluid streams changes over the required operating range, whereby, at high fluid flow rate, at the top of the required flow range, the greater proportion of the fluid passes through the by-pass resistor, while at low fluid flow rate, at the bottom of the flow range, the greater proportion of the fluid passes through the fluidic meter. The invention also includes a flow meter comprising a fluidic meter (4) for placing parallel with a laminar flow by-pass resistor (5).

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FLOW CIRCUIT AND FLOW METER

This invention relates to a flow circuit for a flow meter which extends the operating range of a flow meter, particularly although not exclusively for gas metering, and to a flow meter incorporating such a circuit. The flow meter
5 could be a fluidic flow meter, a vortex shedding meter, a turbine meter etc.

The useful operating range of a fluidic flowmeter can be limited by the specification of an upper limit to the pressure drop across the meter when operating at its maximum
10 required flowrate. This effectively sets a limit on the maximum meter size. Because the flow meter has a lower limit of operating Reynolds number, below which the meter does not function, fixing the meter size sets a minimum operating flowrate for the meter for a given fluid. There is thus a
15 conflict between the need for a large meter at high flow rates, and a small meter at low flow rates, and one proposed solution is described in GB 2172966 - to have two meters and a valve switching between them - but this is relatively expensive and impractical.

20 A basic object of the present invention is to provide a flow circuit and a flow meter in which the operating range is significantly extended.

According to a first aspect of the present invention there is provided a flow circuit for a flow meter, the circuit
25 comprising a fluid flow line having an upstream junction or a fluid reservoir from which the fluid flow is divided into an inlet stream to a fluidic meter and an inlet stream to a

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laminar by-pass resistor, and a downstream junction or a fluid reservoir at which an outlet stream from the fluidic meter and an outlet stream from the by-pass resistor are recombined, in which the combined operating characteristics of the junctions and the by-pass resistor are selected and matched to the operating characteristics required of the flow meter, such that the relative magnitude of the two fluid streams changes over the required operating range, whereby, at high fluid flowrate, at the top of the required flow range, the greater proportion of the fluid passes through the by-pass resistor, while at low fluid flowrate, at the bottom of the flow range, the greater proportion of the fluid passes through the fluidic meter.

A second aspect of the invention is directed to a flow meter incorporating the above defined circuit. Hence, in accordance with this second aspect, there is provided a flowmeter comprising a fluidic meter placed in parallel with a laminar flow by-pass resistor.

In contrast to prior art proposals of by-pass fluid flow metering in which a small fluidic meter is placed in parallel with a large meter and the small meter is used to infer the total flow, with the intention that both flows should increase proportionally if possible, the present invention departs from this teaching and achieves the opposite result by forcing the two flows (by-pass and meter) to change disproportionately, and the choice of two different types of resistance is essential to this principle. Thus, the flowmeter in accordance with the invention is, most

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advantageously, automatically self-switching.

In practice, at the maximum specified flowrate the overall pressure drop across the circuit is still set by the maximum pressure drop specification. However, at the maximum flow condition, most of the fluid passes through the by-pass resistor, so the flow meter can be made smaller than an equivalent independent meter taking all the flow. Conversely, at lower flows, the by-pass resistor has a relatively high resistance compared with the fluidic meter, so that most flow passes through the meter. This system effectively increases the measurement range of the flowmeter. This smaller meter size, combined with the fact that at low flows most of the fluid passes through the meter, effectively reduces the minimum operating flowrate of the circuit at which the meter still functions, below that for an equivalent, larger, independent meter. An alternative explanation of the circuit function is to consider a fixed size of flow meter. At the minimum meter operating point the flow through the biasing circuit is slightly higher than that through the meter alone, due to the small fraction of flow through the by-pass resistor. At the maximum pressure drop condition, however, the circuit flow is much higher than for the meter alone, because most of the flow now passes through the by-pass. Provided the proportional gain in flow at the maximum operating point is greater than that at the minimum operating point, the biased by-pass circuit results in a net increase in operating flow ratio.

To produce the desired effect, the resistance to flow

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through the by-pass must be less than that through the meter at high flows but more than the meter at low flows. Consider flow resistance in terms of an Euler number, defined as pressure drop divided by fluid dynamic head within an element.

5 The Euler number of a fluidic flow meter is typically close to unity at the maximum flow condition, rising somewhat as the flowrate decreases. A good by-pass resistor requires an Euler number which is low at high flow, but which rises quickly as flowrate decreases. Such a characteristic is

10 displayed by parallel plates or by a laminar pipe resistor. Use of a bundle of multiple laminar pipe resistors enables the number, diameter and length of such pipes to be optimally selected and matched to the meter. Careful design at the inlet and outlet of the resistor to minimize inlet and exit

15 losses at the maximum flow condition may be important. In this respect radial or axial flow diffusion may be employed to reduce exit losses.

The accompanying drawings, show, by way of example, in Figures 1a, 1b, and 1c three basic designs of the flow circuit

20 in accordance with the invention and in Figures 2, 3, 4 and 5 end view, a front view, a plan view and an enlarged nozzle detail respectively of a flowmeter in accordance with the invention.

The flow circuit of Figure 1a comprises a fluid flow

25 line 1 having an upstream junction J1 (or in Fig. 1b, the reservoir R), where the flow is divided into two streams 2 and 3, whereby a fraction of the fluid flows as an inlet stream 2 to a fluidic flow meter 4, and the remainder flows as an inlet

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stream 3 to a laminar by-pass resistor 5. Downstream of these two flow devices 4, 5 the two fluid streams 2A, 3A recombine at downstream junction J2 (or in Fig 1c, the reservoir R), prior to leaving the metering circuit. The resistor may for instance consist of a bundle of small tubes or a number of parallel plates to provide the desired laminar flow characteristics

The design of junctions J1 and J2 are also important in effecting the proportion of by-pass flow. The junctions can be designed to bias flow through the by-pass at high flows, by utilising the fluid momentum as either a directed jet or vortex. Any such biasing function will be much reduced at the low flows, where it is unfavourable, due to the increased viscous losses. The simplest design for J1 would be a full bore "T" piece, with the side connection to the meter. Forming J1 as a suitable jet pump would incur some extra pressure loss, but assist the bias action. At J2 the outflow from the resistor could tend to oppose meter flow across a "T"-piece, with the flow out through the side connection. Alternatively, a more sophisticated opposed jet with central radial diffusion could be used. Another option for J2 is as a form of vortex amplifier with the by-pass flow acting as control of the meter outflow.

To improve compactness the junctions, by-pass resistor and fluidic meter could be integrated into a single body.

In the embodiments of Figures 1b and 1c are illustrated the possibilities of supply being flow or to a reservoir R, e.g. the atmosphere, in contrast to the employment of two

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junctions J1 and J2.

Tests have been conducted with a fluidic 'target meter' oscillatory flowmeter of Figures 2 to 5 having a nozzle width of 1.4 mm, placed in parallel with a bundle of 57 laminar tubes of 1.8 mm diameter as a by-pass resistance. At 200 Pa pressure drop, the maximum flowrate was 5.1 m³/h (so the system was not optimally sized for 6 m³/h). Nevertheless, the minimum flow detected was 0.03 m³/h, giving a flow range of 170. For instance, this system showed great improvement over the meter alone (0.073 m³/h and range 82).

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CLAIMS

1. A flow circuit for a flow meter, the circuit comprising a fluid flow line having an upstream junction, or a fluid reservoir, at which the fluid flow is divided into an inlet stream to a fluidic meter and an inlet stream to a laminar by-pass resistor, and a downstream junction, or a fluid reservoir, at which an outlet stream from the fluidic meter and an outlet stream from the by-pass resistor are recombined, in which the combined operating characteristics of the junctions and the by-pass resistor are selected and matched to the operating characteristics required of the flow meter, such that the relative magnitude of the two fluid streams changes over the required operating range, whereby, at high fluid flowrate, at the top of the required flow range, the greater proportion of the fluid passes through the by-pass resistor, while at low fluid flowrate, at the bottom of the flow range, the greater proportion of the fluid passes through the fluidic meter.

2. A flowmeter comprising a fluidic meter placed in parallel with a laminar flow by-pass resistor.

3. A flowmeter as claimed in Claim 2, wherein the by-pass resistor is a parallel plate resistor.

4. A flowmeter as claimed in Claim 2, wherein the by-pass resistor is a pipe resistor.

5. A flowmeter as claimed in Claim 4, wherein the pipe resistor comprises a bundle of pipes.

6. A flowmeter as claimed in any one of Claims 2 to 5, comprising an upstream junction to divide the flow into two

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streams, or an upstream reservoir to supply two streams, whereby a part of the flow is conveyed to the fluidic flow meter and the remaining part is conveyed to the laminar by-pass resistor.

7. A flowmeter as claimed in Claim 6, comprising a downstream junction to recombine the flows, or a downstream reservoir to receive the two flows, from the fluidic flow meter and the laminar by-pass resistor.

8. A flowmeter as claimed in Claim 6, wherein the upstream junction is a full bore 'T' piece with the side connection to the meter.

9. A flowmeter as claimed in Claim 6, wherein the upstream junction is formed as a jet pump.

10. A flowmeter as claimed in Claim 7, wherein the downstream junction is a 'T'-piece, with the outflow from the resistor tending to oppose meter flow across the 'T'-piece, with the flow out through the side connection.

11. A flowmeter as claimed in Claim 7, wherein the downstream junction is constituted by an opposed jet with central radial diffusion.

12. A flowmeter as claimed in Claim 7, wherein the downstream junction is constituted by a vortex amplifier with the by-pass flow acting as control of the meter outflow.

13. A flowmeter as claimed in any one of Claims 7 to 12, wherein the junctions, by-pass resistor and fluidic meter are housed within a single body.

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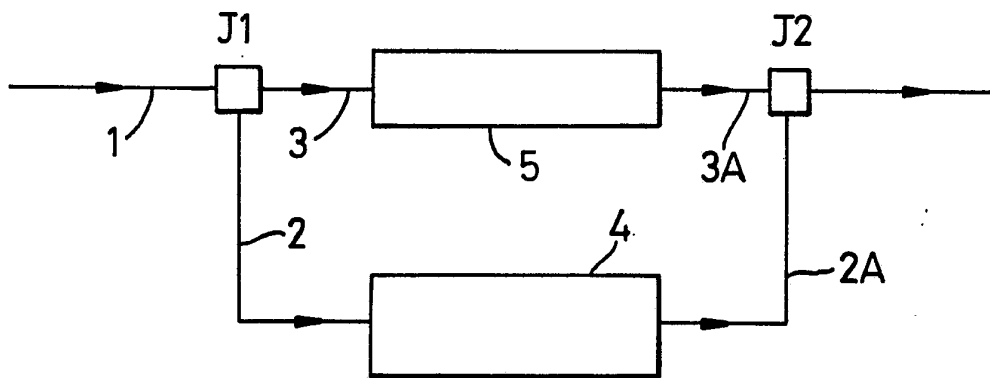


Fig. 1a

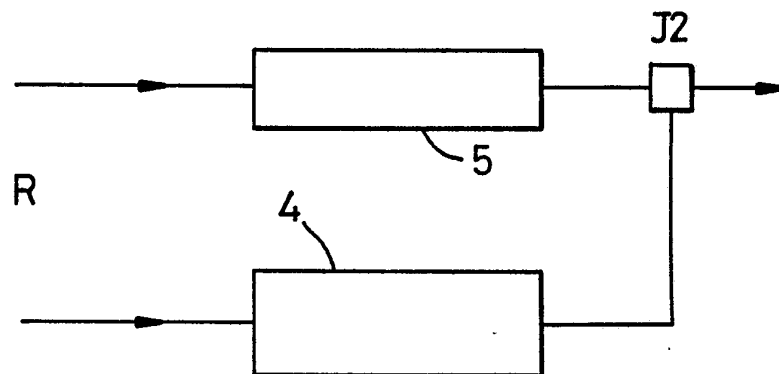


Fig. 1b

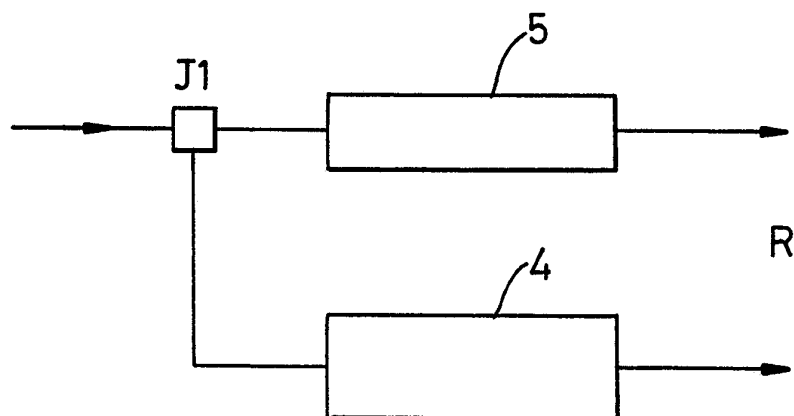


Fig. 1c

SLOT FOR PLATES=0.55mm
GAP THICKNESS=0.95mm

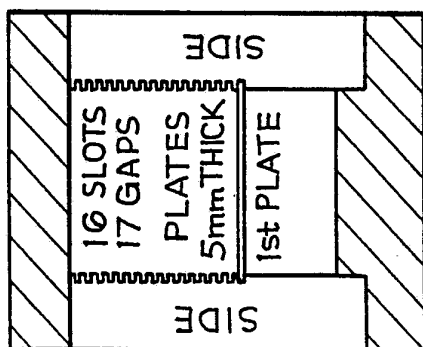


Fig. 2

SIDES SLOTTED TO TAKE
16 → 110mm LONG PLATES

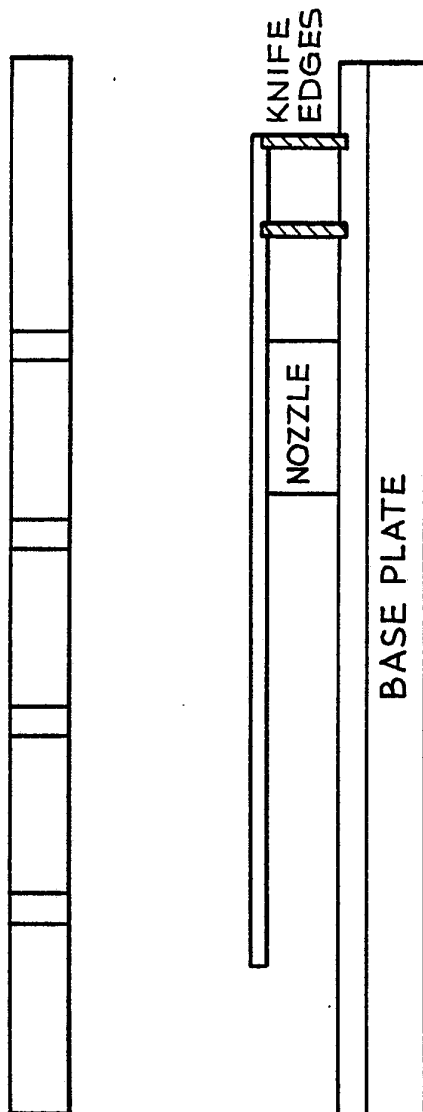


Fig. 3

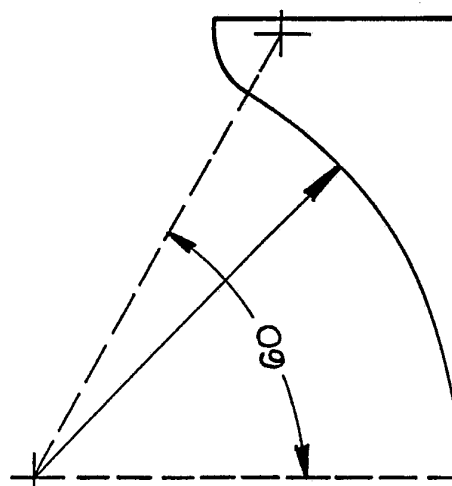


Fig. 5
NOZZLE DETAIL

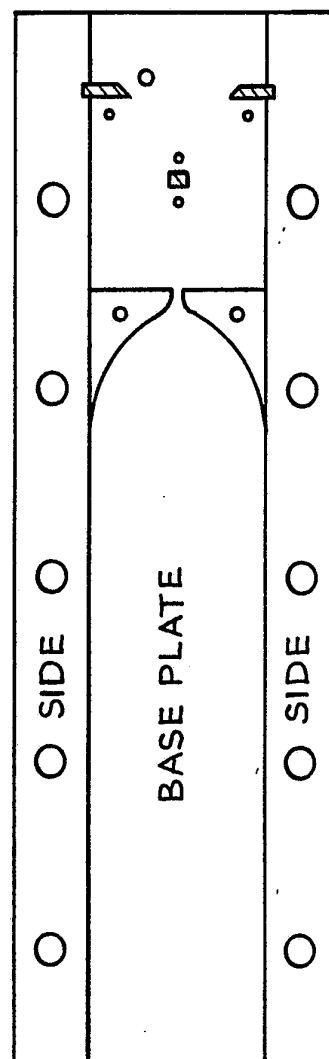


Fig. 4

INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 93/00498

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int.Cl. 5 G01F1/32; G01F7/00; G01F15/00		
II. FIELDS SEARCHED		
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III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category ¹⁰	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	US,A,4 610 162 (OKABAYASHI) 9 September 1986 see claim 1; figures 1-4 ---	1,2,13
A	EP,A,0 393 938 (JEAVONS ENGINEERING) 24 October 1990 see page 2, line 45 - page 3, line 17; figures 1,2 ---	1,2,13
A	US,A,4 800 754 (KORPI) 31 January 1989 see column 3, line 63 - column 4, line 16 see column 5, line 38 - column 7, line 4; figures 1A-3B ---	1,2,13
A	US,A,4 461 173 (OLIN) 24 July 1984 see the whole document ---	1,2,4,8, 10,13
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¹⁰ Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
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A	EP,A,0 129 012 (MKS INSTRUMENTS) 27 December 1984 see page 6, line 12 - page 7, line 24; figures 1-7 -----	1

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.**

GB 9300498
SA 71224

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
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11/06/93

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US-A-4800754	31-01-89	None	
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EP-A-0129012	27-12-84	US-A- 4522058	11-06-85
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