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(54) Title: PRESSURE BASED MASS FLOW CONTROLLER

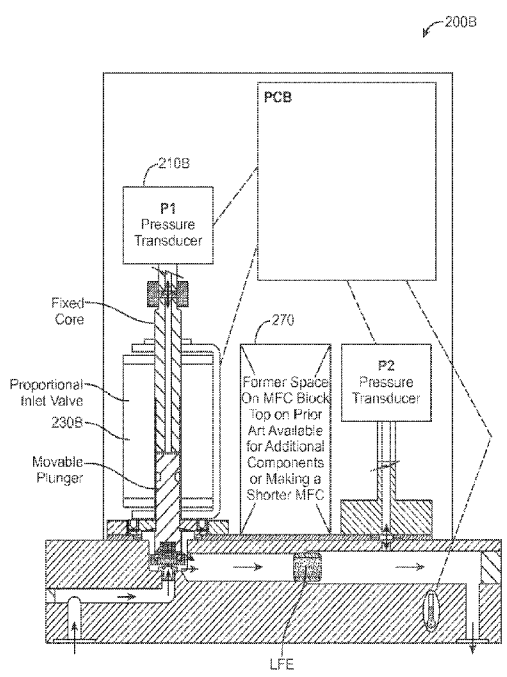

FIG. 2B

(57) Abstract: A mass flow controller (MFC) has a standard envelope with an enclosure and a corresponding base. A pressure transducer is communicatively coupled to a process gas in a proportional inlet valve without being physically coupled to the base. The space formerly occupied by the pressure transducer is available for additional component integration, or reduction of the standard envelope size. A second pressure transducer is located remotely and shared by multiple MFCs. A relief valve can quickly relieve a PI pressure of a PI volume of process gas. A first laminar flow element (LFE) and a second LFE and in series high conductance valve configured in parallel to produce a wide-range MFC that maintains accuracy.

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International application No.
PCT/US13/58828

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - G01P 5/14 (2014.01)
USPC - 702/50; 73/1.25
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8): F16K 17/06; G01F 1/50; G01P 5/14; G05D 7/06; G01F 1/44 (2014.01)
USPC: 137/462, 486, 487.5, 505; 73/861; 702/50; 73/1.25

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
MicroPatent (US Granted, US Applications, EP-A, EP-B, WO, JP, DE-G, DE-A, DE-T, DE-U, GB-A, FR-A); Google; Google Scholar; ProQuest; IP.com; keywords: pressure, transducer, mass flow control, laminar flow, relief valve, control, valve, temperature

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	Applicant Admitted Prior Art; figure 1; paragraph [031]	22 ---- 1-3, 21
Y	US 6,116,269 A (MAXSON WR) September 12, 2000; figure 5; column 6, lines 35-45	1-3, 21
A	US 6,539,968 B1 (WHITE W. W. et al.) April 1, 2003; figure 2; column 4, lines 30-35, 40-65; column 5, lines 1-20, 25-45, 40-50);	1-9, 21-22
A	US 2010/0200083 A1 (KOUCHI M. et al.) August 12, 2010; paragraphs [0028], [0033]	1-9, 21-22
A	US 6,026,834 A (AZIMA F. et al.) February 22, 2000; entire document	1-9, 21-22
A	US 7,292,945 B2 (WARGO C. et al.) November 6, 2007; entire document	1-9, 21-22
A	US 5,259,424 A (MILLER C. E. et al.) November 9, 1993; entire document	1-9, 21-22
A	US 4,096,746 A (WILSON F. P. et al.) June 27, 1978; entire document	1-9, 21-22
A	US 4,427,030 A (JOUWSMA W. et al.) January 24, 1984; entire document	1-9, 21-22

☐ Further documents are listed in the continuation of Box C. ☐

* 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 application or patent 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 when the document is taken alone
"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

Date of the actual completion of the international search	Date of mailing of the international search report
17 March 2014 (17.03.2014)	07 APR 2014
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Shane Thomas PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT PCT/US2013/058828 07.04.2014

International application No.
PCT/US13/58828

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
-***-Please See Supplemental Page-***-

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-9, 21-22

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

International application No.
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-***-Continued from Box No. III: Observations where unity of invention is lacking-***-

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: claims 1-9, 21-22 are directed toward a mass flow controller with an orifice continuously bleeding to a non-process location.

Group II: claims 10-20 are directed toward a mass flow controller with laminar flow elements.

The inventions listed as Groups I-II do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons.

The special technical features of Group I include an orifice to reduce bleed down time of transients between gas flows by continuously bleeding at least a portion of process gas from the PI volume to a non-process location (which is not present in Group II).

The special technical features of Group II include a relief valve physically coupled to the base to reduce bleed down time of transients between gas flows by venting at least a portion of process gas at PI pressure; a second pressure transducer external to the enclosure; wherein the second pressure transducer is accessed by one or more MFCs; a first laminar flow element (LFE) that maintains a percent of reading accuracy over a first dynamic range; and a second LFE in series with a high conductance valve to control activation of the second LFE, the second LFE configured in parallel to the first LFE and maintaining a percent of reading accuracy over a second dynamic range, wherein, when both the first and second LFEs are activated, a wider effective total dynamic range determined by combining of the first dynamic range and the second dynamic range is achieved while maintaining a percent of reading accuracies over the combined ranges (which is not present in Group I).

The common technical features of Groups I and II include an enclosure attached to a base with a length; a conduit channeling through the base of the MFC to receive the process gas and to exhaust the process gas at a desired mass flow rate; a proportional inlet valve physically coupled to the base and having an input and an output to utilize conductance to control a PI pressure of a PI volume of the process gas, wherein a first pressure transducer is coupled to the proportional inlet valve without being physically coupled to the conduit in the base, and wherein a pressure of the process gas, after passing through a valve seat of proportional inlet valve, is communicated to the first pressure transducer via a hole in the proportional inlet valve; a restrictor coupled to the conduit of the base downstream from the proportional inlet valve; a second pressure transducer physically coupled to the conduit of the base downstream from the restrictor; an embedded temperature sensor; and a printed circuit board (PCB) containing support electronics and software to detect and control the gas flow.

These common technical features are disclosed by Applicant Admitted Prior Art PCT/US2013/58828 (AAPA) in view of US 6,116,269 A (MAXSON). AAPA discloses an enclosure attached to a base with a length (mass flow controller (MFC) 100 with a conventionally-located P1 pressure transducer 104 coupled to a base 220; figure 1; paragraph [031]); a conduit channeling through the base of the MFC to receive the process gas and to exhaust the process gas at a desired mass flow rate (process gas flows through proportional flow control valve 105 from an inlet 101 to the outlet (i.e., defining a conduit) to achieve the needed flow (desired mass flow rate); figure 1; paragraph [031]); a proportional inlet valve physically coupled to the base and having an input and an output to utilize conductance to control a PI pressure of a PI volume of the process gas (proportional flow control valve 105 is shown to be physically coupled to the base 220, and uses the P1 pressure transducer to monitor the P1 volume and adjust the proportional flow control valve 105 to maintain sufficient pressure in the volume between the poppet and the restrictor (i.e., conductance); figure 1; paragraph [031]), wherein a first pressure transducer is coupled to the proportional inlet valve and coupled to the conduit in the base, and wherein a pressure of the process gas, after passing through a valve seat of proportional inlet valve, is communicated to the first pressure transducer (P1 pressure transducer 104 (first pressure transducer) is coupled to proportional flow control valve 105 by the internal passage (i.e., conduit); figure 1; paragraph [031]); a restrictor coupled to the conduit of the base downstream from the proportional inlet valve; a second pressure transducer physically coupled to the conduit of the base downstream from the restrictor (laminar flow element (LFE) 105 acting as a flow restrictor is downstream of proportional flow control valve 105, followed by P2 pressure transducer 106 (second pressure transducer); figure 1; paragraph [031]); an embedded temperature sensor; and a printed circuit board (PCB) containing support electronics and software to detect and control the gas flow (printed control board (PCB) (not shown) containing supporting electronics, software and calibration coefficient for receiving, pressure signals, a temperature signal from a temperature sensor 107 embedded in the device and an external set point indicating the target flow; figure 1; paragraph [031]). AAPA does not disclose wherein a first pressure transducer is coupled to the proportional inlet valve without being physically coupled to the conduit in the base, and wherein a pressure of the process gas is communicated to the first pressure transducer via a hole in the proportional inlet valve. Maxson discloses wherein a first pressure transducer is coupled to the inlet valve without being physically coupled to the conduit in the base, and wherein a pressure of the process gas is communicated to the first pressure transducer via a hole in the inlet valve (the closed end of the solenoid valve (inlet valve) has an orifice 810 (hole) where piezoresistive micro-machined silicon die (first pressure transducer) measures pressure within the solenoid valve (inlet valve) without being coupled to the conduit being controlled by the solenoid valve (inlet valve); figure 5; column 6, lines 35-45). In order to measure the system pressure across the proportional inlet valve (AAPA, paragraph [031]), it would have been obvious to one of ordinary skill in the art at the time of the invention to replace the first pressure transducer on AAPA's conduit with the first pressure transducer on Maxson's inlet valve because, as Maxson discloses, combining a pressure transducer with an inlet valve adds value to a system by improving efficiencies, reducing costs, and miniaturizing package size (Maxson, column 1, lines 30-50).

Because the common technical features are disclosed by AAPA in view of Maxson, the inventions are not so linked as to form a single general inventive concept. Therefore, Groups I and II lack unity.