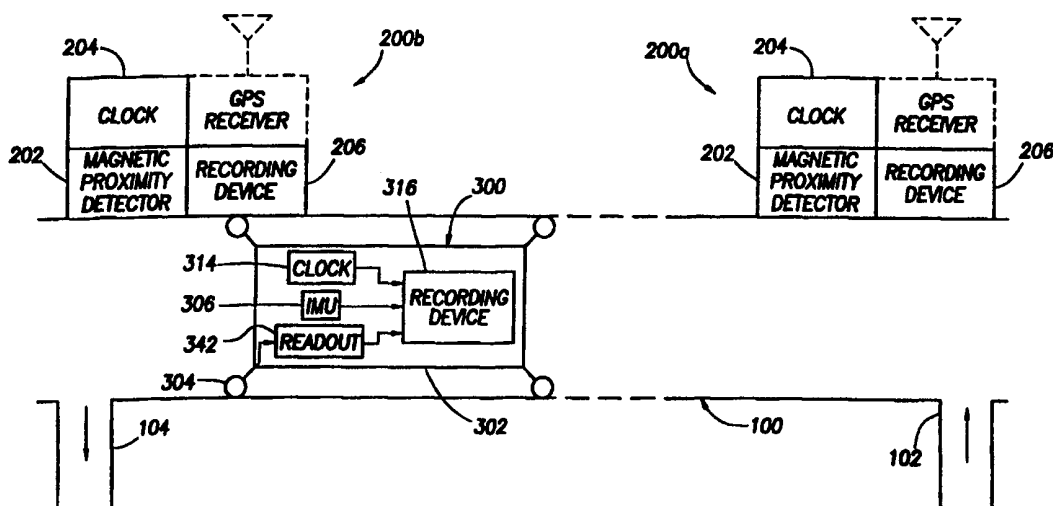




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : G01M 19/00, G01N 27/82, G01C 19/00, 22/00, G01B 7/14	A3	(11) International Publication Number: WO 99/32902 (43) International Publication Date: 1 July 1999 (01.07.99)
(21) International Application Number: PCT/US98/27506 (22) International Filing Date: 22 December 1998 (22.12.98) (30) Priority Data: 08/996,504 23 December 1997 (23.12.97) US (71) Applicants: PIPELINE INTEGRITY INTERNATIONAL, INC. [US/US]; 7105 Business Park Drive, Houston, TX 77041 (US). HONEYWELL, INC. [US/US]; Honeywell Plaza MN 12-8251, P.O. Box 524, Minneapolis, MN 55440-0524 (US). (72) Inventors: TUCK, Alan; 33 Torcross Way, Parkside Grange, Cramlington, Northumberland NE23 9PX (GB). BRAYSON, Gary; 51 The Drive, Tynemouth, North Shields, Tyne and Wear NE30 4JW (GB). IGNAGNI, Mario, B.; 1599 Chatham Avenue, Arden Hills, MN 55112 (US). TOUCHBERRY, Alan, B.; 6308 West 35th Street, St. Louis Park, MN 55416 (US). ANDERSON, Donald, William; Whitegates, 11 Darras Hall, Ponteland, Newcastle upon Tyne NE20 9PD (GB). GLEN, Stephen, James; 43 Leander Drive, Boldon, Tyne and Wear NE35 9LX (GB). GILMAN, James, Michael, Alexander; 49 Carrington Terrace, Heaton, Newcastle upon Tyne NE6 5SE (GB).		(74) Agents: HEWITT, Lester, L. et al.; Akin, Gump, Strass, Hauer & Feld, LLP, 10th floor, 1177 West Loop South, Houston, TX 77027 (US). (81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> (88) Date of publication of the international search report: 10 September 1999 (10.09.99)

(54) Title: METHOD AND APPARATUS FOR DETERMINING LOCATION OF CHARACTERISTICS OF A PIPELINE

**(57) Abstract**

A pipeline inspection and defect mapping system includes a pig (300) having an inertial measurement unit (306) and a pipeline inspection unit (312) for recording pig location and defect detection events, each record time-stamped by a highly precise onboard clock (314). The system also includes several magloggers (200) at precisely known locations along the pipeline, each containing a fluxgate magnetometer (202) for detecting the passage of the pig (300) along the pipeline and further containing a highly precise clock (204) synchronized with the clock (314) in the pig. The locations of the various magloggers (200) are known in a north/east/down coordinate system through a differential global positioning satellite process. Finally, a postprocessing off-line computer system (400) receives downloaded maglogger (804), inertial measurement (806 and 808), and odometer data (802) and through the use of several Kalman filters (830), derives the location of the detected defects in the north/east/down coordinate frame.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/27506

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : G01M 19/00; G01N 27/82; G01C 19/00, 22/00; G01B 7/14

US CL : 73/865.8, 49.1, 49.5; 33/302, 303, 320; 324/207.11

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)

U.S. : 73/865.8, 49.1, 49.5; 33/302, 303, 320; 324/207.11

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 3,769,711 A (FLOURNOY et al) 06 November 1973, (06/11/73) Abstract, column 2 lines 56-68.	19-22
A,E	US 5,752,513 A (ACKER et al) 19 May 1998, (19/05/98) Abstract.	1-18, 23-32
A	US 4,609,869 A (METCALF) 02 September 1986, (02/09/86) Abstract.	1-18, 23-26
Y	US 3,238,448 A (WOOD et al) 01 March 1966, (01/03/66) col. 2, lines 19-39, col. 3 lines 66 et seq.	1-18, 23-26, 30-32
Y	US 4,945,775 A (ADAMS et al) 30 December 1988, (20/12/88) Abstract.	1-18, 23-32

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:	*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
A document defining the general state of the art which is not considered to be of particular relevance	*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
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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	

Date of the actual completion of the international search

09 JUNE 1999

Date of mailing of the international search report

17 JUN 1999

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/27506

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,825,711 A (JENSEN et al) 05 September 1986, (05/09/86) Abstract, col. 2 lines 56-68, col. 5 lines 12-20.	19-22
A	US 4,491,018 A (STRINGER et al) 01 January 1985, (01/01/85) Abstract.	1-32
A	US 4,524,526 A (LEVINE) 25 June 1985, (25/06/85) Abstract, col. 3.	1-32
Y	US 5,331,578 A (Stieler) 14 September 1990, (14/09/90) Abstract, col. 2.	1-18, 23-32
A	US 5,565,633 A (Wernicke) 15 October 1996, (15/10/96) col. 3, lines 30-43 and 53-67, col. 5.	1-32
Y	US 5,659,142 A (LIMA et al) 04 December 1994, (04/12/94) Abstract.	28-29
Y	US 4,799,391 A (Lara), 18 December 1986, (18/12/86) Abstract.	1-32

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/27506

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international 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 II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

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 an additional fee, this Authority did not invite payment of any additional fee.
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.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/27506

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING

This ISA found multiple inventions as follows:

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

Group I, claim(s) 1-17 and 23-32, drawn to a system and method for inspecting a pipeline and mapping a defect within the pipeline.

Group II, claim(s) 19-22, drawn to a pig for insertion into a fluid-carrying pipeline.

This application contains claims directed to more than one species of the generic invention. These species are deemed to lack Unity of Invention because they are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for more than one species to be searched, the appropriate additional search fees must be paid. The species are as follows:

Embodiment 1 - A system for inspecting a pipeline having a pig with a real-time sensor generating real-time sensor data and a computer system configured to execute a post-traversal process for computing the position of the pig.

Embodiment 2 - A system for inspecting a pipeline having a pig with a real-time sensor(s) generating real-time sensor data and off-board sensor(s) external from the pig, including a maglogger, to provide a reference location relative to the pig or to detect the passage of the pig along the pipeline.

The claims are deemed to correspond to the species listed above in the following manner:

Embodiment 1 - claims 28 and 29.

Embodiment 2 - claims 1-17, 23-27 and 30-32.

The following claims are generic: None.

The inventions listed as Groups I and II do not relate to a single 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: Group I does not have one or more of the same or corresponding special technical features that, when considered as a whole, define a contribution over the prior art. More particularly, the claims in Group II recite particulars of an odometer apparatus as related to a pig for a pipeline (see claim 19).

The species listed above do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, the species lack the same or corresponding special technical features for the following reasons: Embodiment 1 discloses a system for pipeline inspecting through the insertion of a pig with a real-time sensor into the pipeline and a computer system to receive the real-time sensor data and to execute a post-traversal process after pig traversal for positioning the pig without the reference to a reference location and/or reference frame determined by an off-board sensor or maglogger. Such a system would not share the same or corresponding special technical features with embodiment 2 that, when considered as a whole, define a contribution over the prior art.