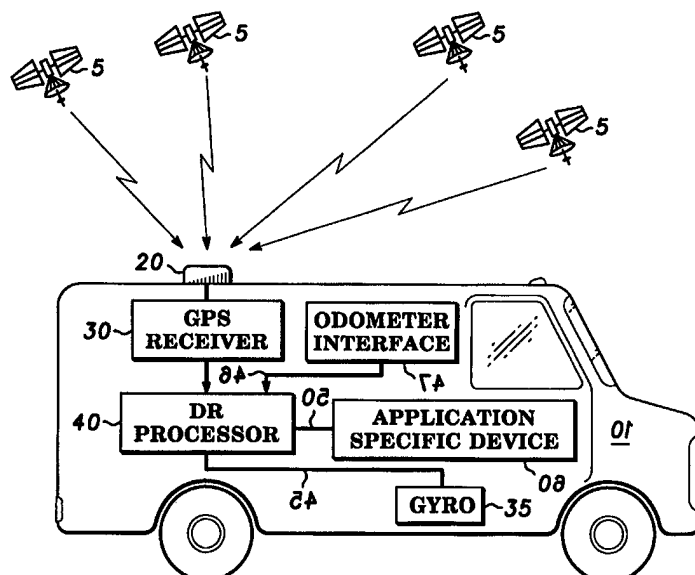




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(54) Title: METHODS FOR GYRO BIAS ESTIMATION USING GPS



(57) Abstract

Augmenting the GPS receiver (30) with some form of Dead Reckoning (DR), such as a gyros (35), fills in the gaps occurring as a result of loss of GPS coverage. The present invention permits reliable and automatic estimation and calibration of the gyro zero rate bias. In particular, three specific methods (FIGs. 2-4) are disclosed whereby one method (FIG. 2) makes use of a "GPS gyro" for detecting vehicle heading change, another (FIG. 3) makes use of a "GPS accelerometer" for detecting stationary periods, and another (FIG. 4) makes use of a Kalman filter model for open loop heading error and is used to extract the contribution of and so estimate the gyro bias.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/06568

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : G01S 5/02; G01C 21/00

US CL : 342/357; 701/216

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. : 342/357; 701/216, 220

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,416,712 A (GEIER et al.) 16 May 1995 (16/05/95), see entire document.	1-3
Y	US 5,512,904 A (BENNETT) 30 April 1996 (30/04/96), see Figures 1 and 6.	1-3
Y	US 4,903,212 A (YOKOUCHI et al.) 20 February 1990 (20/02/90) see Figures 6 and 8.	1-3
Y	US 5,367,463 A (TSUJI) 22 November 1994 (22/11/94), see Figures 1 and 5.	4-6
Y, P	US 5,644,317 A (WESTON et al.) 01 July 1997 (01/07/97) see entire document, specifically Figure 5.	4-8
A	US 5,574,650 A (DIESEL) 12 November 1996 (12/11/96).	1-8

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

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Date of the actual completion of the international search

14 DECEMBER 1998

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PCT/US98/06568

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,345,382 A (KAO) 06 September 1994 (06/09/94), see entire document.	1-8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/06568

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:

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.