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**Bachmann et al.**

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(54) **METHOD AND APPARATUS FOR MOTION TRACKING OF AN ARTICULATED RIGID BODY**

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(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 33 days.

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**Related U.S. Application Data**

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(51) **Int. Cl.**  
**G01C 17/00** (2006.01)  
**A61B 5/103** (2006.01)

(52) **U.S. Cl.** ..... **702/151; 600/595**

(58) **Field of Classification Search** ..... 702/151, 702/150, 141, 142, 94, 53; 600/595; 345/473  
See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

5,645,077 A \* 7/1997 Foxlin ..... 600/587

5,807,284 A \* 9/1998 Foxlin ..... 600/595  
5,819,206 A \* 10/1998 Horton et al. .... 702/150  
6,636,826 B1 \* 10/2003 Abe et al. .... 702/151  
6,691,074 B1 \* 2/2004 Moriya et al. .... 702/190  
6,820,025 B1 \* 11/2004 Bachmann et al. .... 702/94

**OTHER PUBLICATIONS**

Henault, G., A Computer Simulation Study and Component Evaluation for a Quaternion Filter for Sourceless Tracking of Human Limb Segment Motion, Mar. 1977, Naval PostGraduate School.\*

\* cited by examiner

*Primary Examiner*—John Barlow

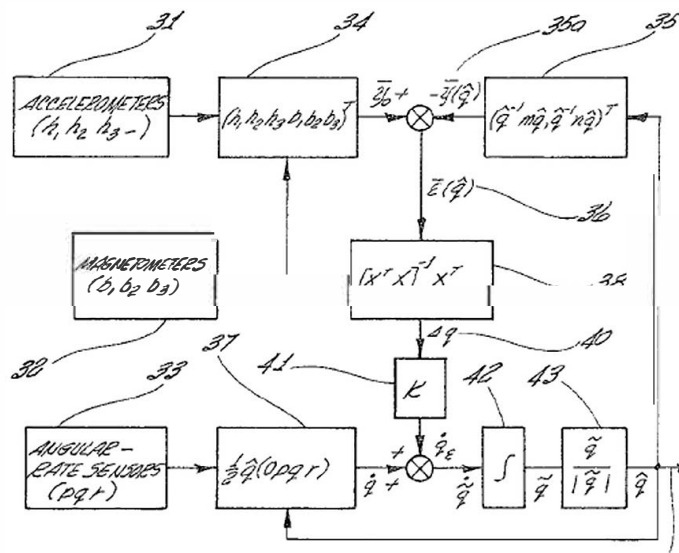
*Assistant Examiner*—Toan M. Le

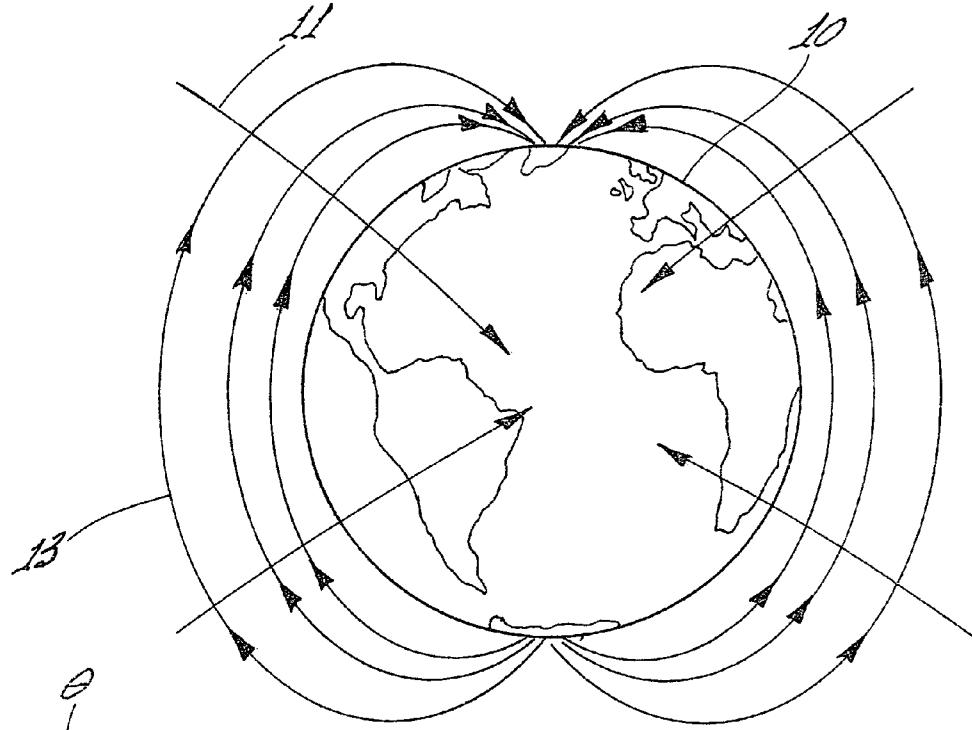
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(57) **ABSTRACT**

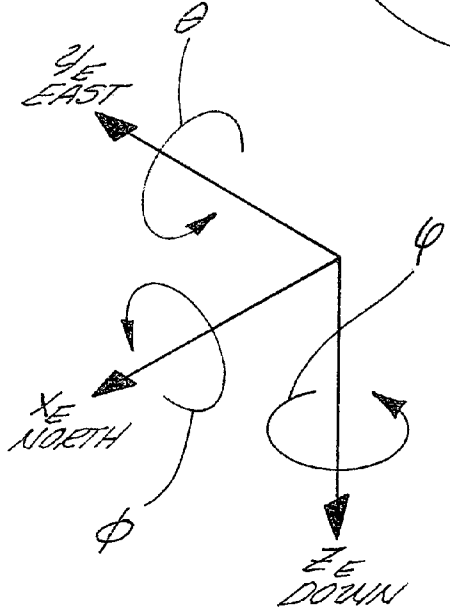
One embodiment the invention includes a method of determining an orientation of a sensor. The method includes measuring a local magnetic field vector and a local gravity vector and using those measurements to determine the orientation of the sensor. Embodiments can include measuring the magnetic field vector and the local gravity vector using quaternion coordinates. Another embodiment includes measuring a local magnetic field vector, a local gravity vector, and the angular velocity of the sensor. These three vectors are processed to determine the orientation of the sensor. In one embodiment the three vectors can all be measured in quaternion coordinates. Another method embodiment includes determining a local gravity vector by providing an acceleration detector, moving the detector from a start point to an end point over a time period, and summing acceleration measurements over the time period. The local gravity vector is calculated using the summed acceleration measurements.

**14 Claims, 6 Drawing Sheets**

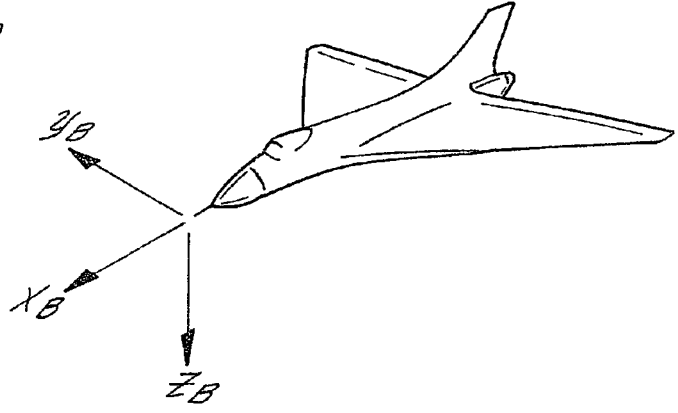




*Fig 1*



*Fig 2(a)*



*Fig 2(b)*

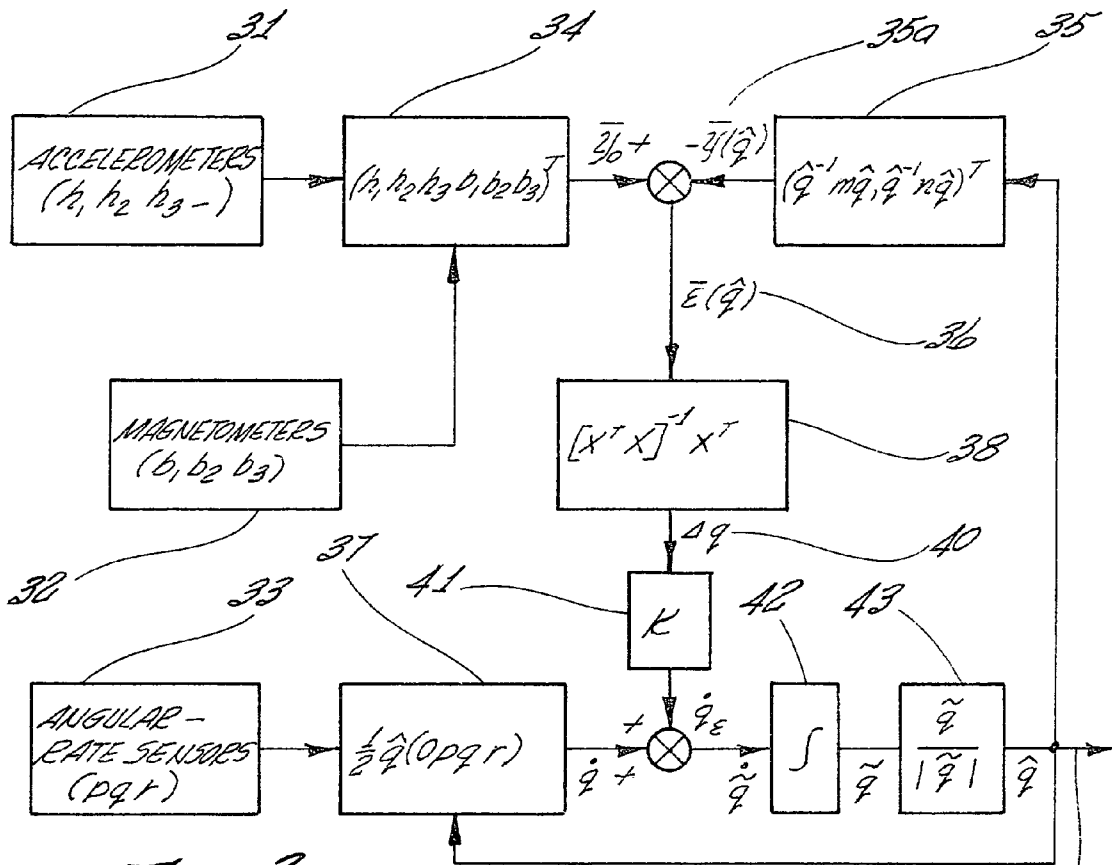


Fig 3

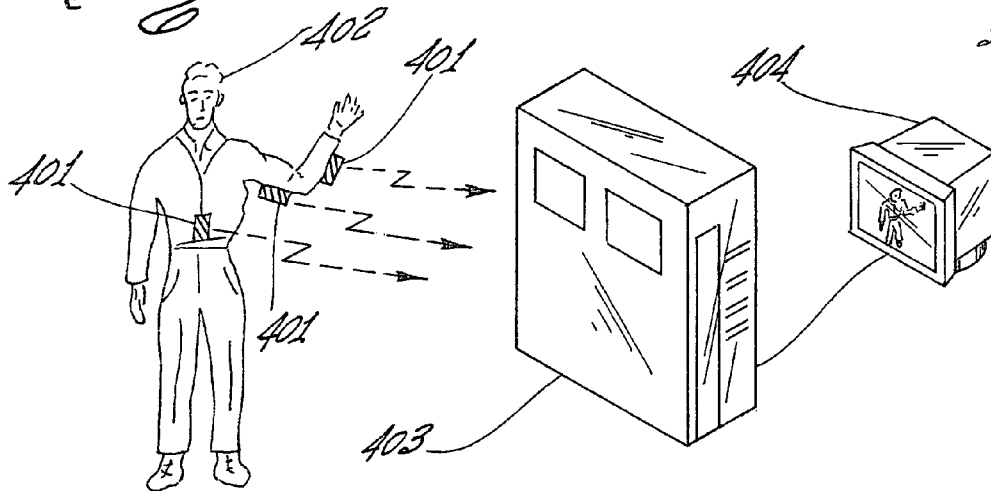


Fig 4

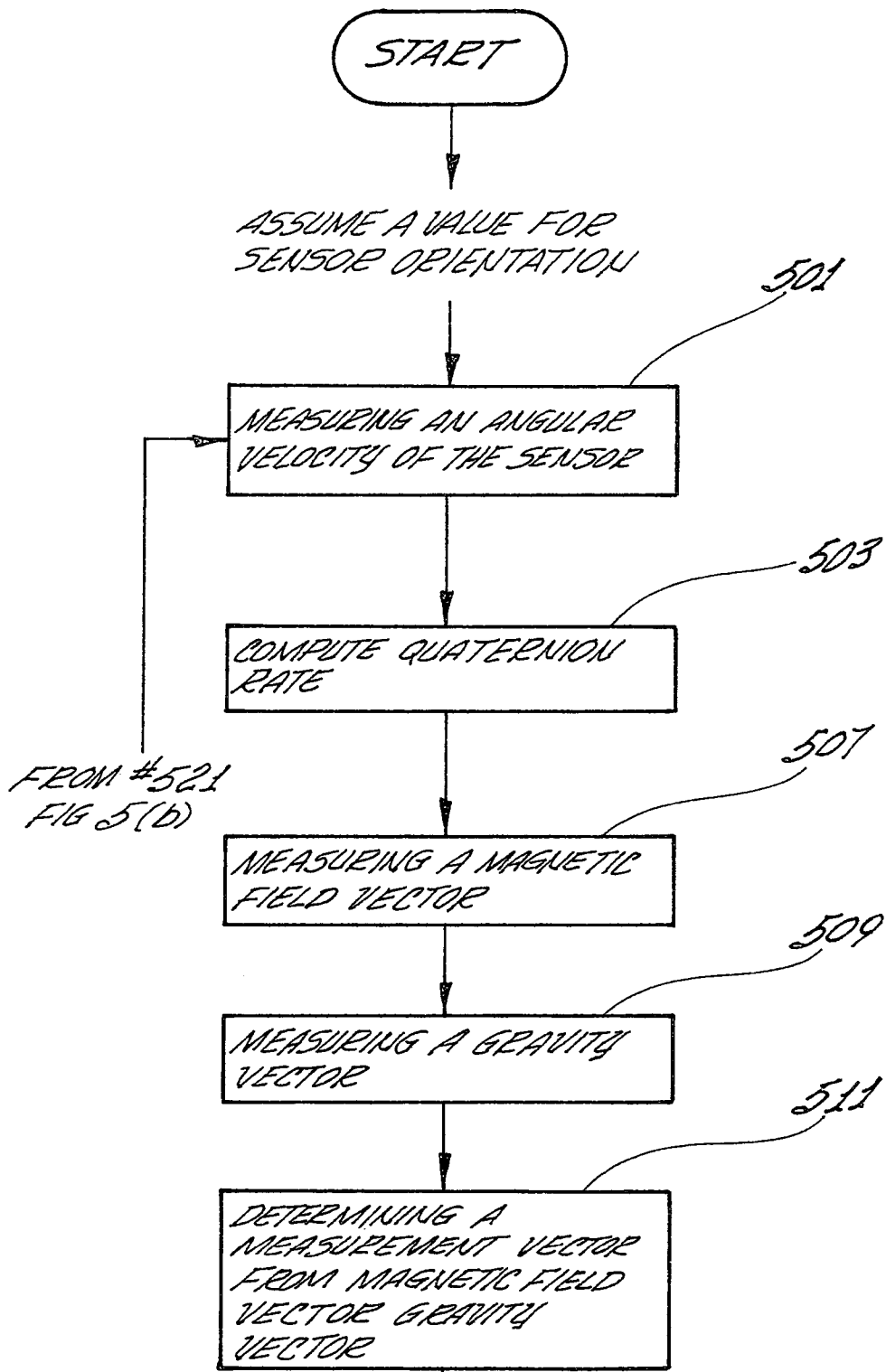


Fig 5(a)

TO #513, FIG 5(b)

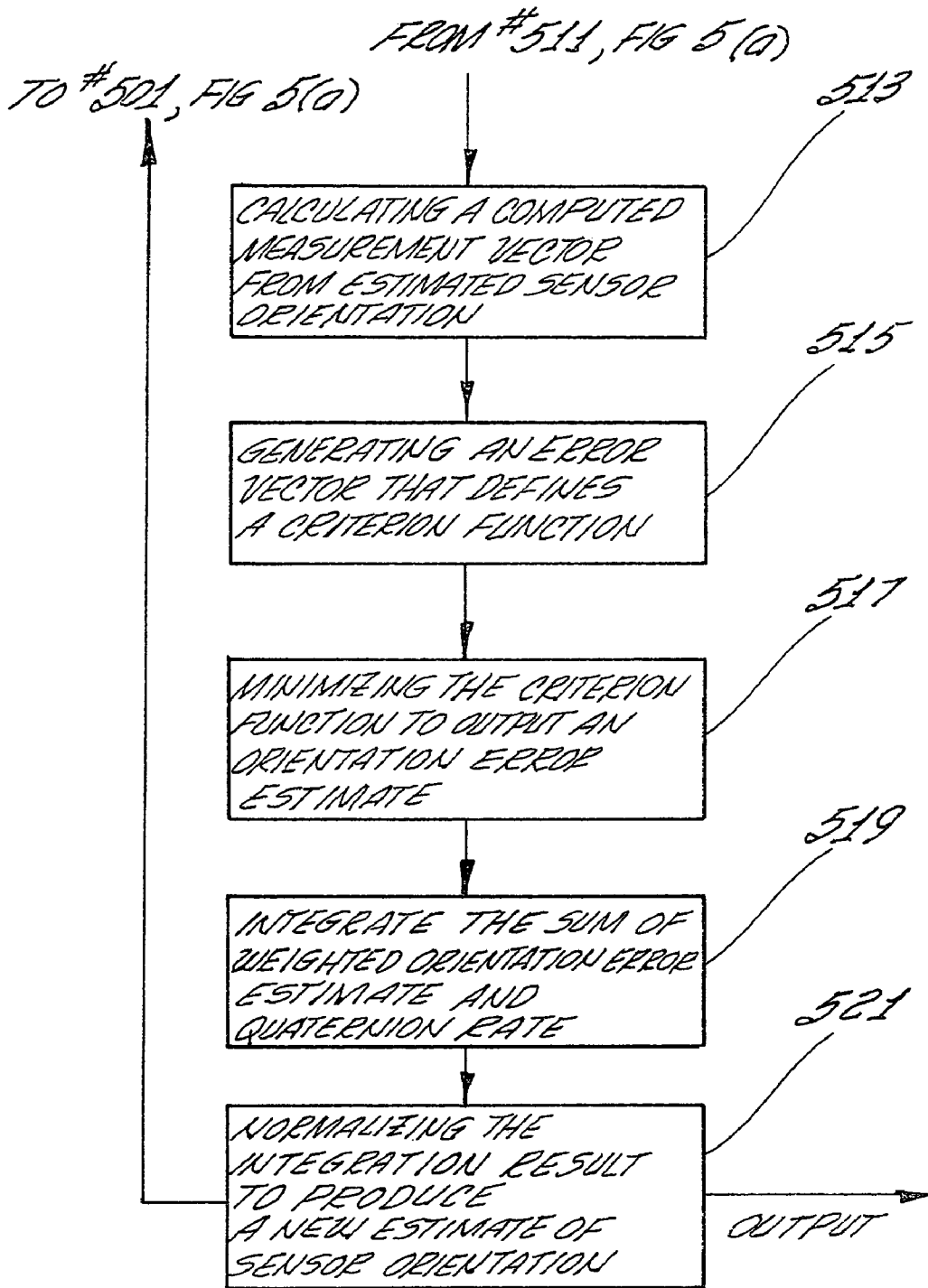


Fig 5(b)

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