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Rabinowitz et al.

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(54) **POSITION LOCATION USING TERRESTRIAL DIGITAL VIDEO BROADCAST TELEVISION SIGNALS**

(75) Inventors: **Matthew Rabinowitz**, Palo Alto, CA (US); **James J Spilker, Jr.**, Woodside, CA (US)

(73) Assignee: **Rosum Corporation**, Mountain View, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1280 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **09/932,010**

(22) Filed: **Aug. 17, 2001**

(65) **Prior Publication Data**

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Related U.S. Application Data

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(51) **Int. Cl.**
G01S 3/02 (2006.01)

(52) **U.S. Cl.** **342/464**

(58) **Field of Classification Search** 342/357.01, 342/357.06, 453, 463, 464

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,555,707 A 11/1985 Connelly

(Continued)

FOREIGN PATENT DOCUMENTS

GB 2 222 922 A 3/1990

(Continued)

OTHER PUBLICATIONS

Li, X., et al., "Indoor Geolocation Using OFDM Signals In HIPERLAN/2 Wireless LANS," 11th IEEE International Symposium on Personal Indoor and Mobile Radio Communications, PIMRC 2000, Proceedings (Cat. No. 00TH8525), Proceedings of 11th International Symposium on Personal Indoor and Mobile Radio Communication, London, UK, Sep. 18-21, pp. 1449-1453, vol. 2, XPO10520871, 2000, Piscatawat, NJ, USA, IEEE, USA, ISBN; 9-7803-6463-5, Chapter I and III.

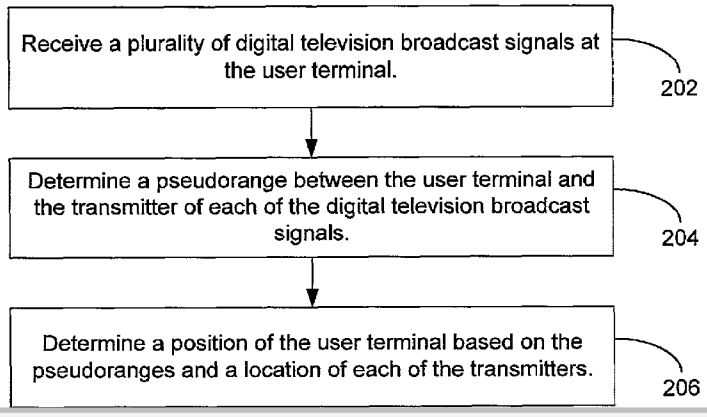
(Continued)

Primary Examiner—Dao L. Phan
(74) *Attorney, Agent, or Firm*—Richard A. Dunning, Jr.

(57) **ABSTRACT**

A method and computer program product for determining the position of a user terminal includes receiving at the user terminal a plurality of digital television (DTV) broadcast signals from a plurality of DTV transmitters, wherein each of the DTV signals is a European Telecommunications Standards Institute (ETSI) Digital Video Broadcasting-Terrestrial (DVB-T) signal; determining a pseudo-range between the user terminal and each DTV transmitter based on the DTV broadcast signals based on a known component in the DTV signals; and determining a position of the user terminal based on the pseudo-ranges and a location of each of the DTV transmitters.

87 Claims, 17 Drawing Sheets



U.S. PATENT DOCUMENTS

4,652,884	A	3/1987	Starker	
4,894,662	A	1/1990	Counselman	
5,045,861	A	9/1991	Duffett-Smith	342/457
5,157,686	A	10/1992	Omura et al.	
5,166,952	A	11/1992	Omura et al.	
5,271,034	A	12/1993	Abaunza	
5,323,322	A	6/1994	Mueller et al.	
5,398,034	A	3/1995	Spilker, Jr.	
5,481,316	A	1/1996	Patel	
5,504,492	A	4/1996	Class et al.	
5,510,801	A	4/1996	Engelbrecht et al.	342/457
5,604,765	A	2/1997	Bruno et al.	
5,648,982	A	7/1997	Durrant et al.	
5,774,829	A	6/1998	Cisneros et al.	
5,920,284	A	7/1999	Victor	342/357.01
5,952,958	A	9/1999	Speasl et al.	
5,953,311	A	9/1999	Davies et al.	
6,016,119	A	1/2000	Krasner	
6,078,284	A	6/2000	Levanon	342/357.16
6,094,168	A	7/2000	Duffett-Smith et al.	342/463
6,107,959	A	8/2000	Levanon	342/357
6,137,441	A	10/2000	Dai et al.	342/357.16
6,215,778	B1	4/2001	Lomp et al.	
6,317,452	B1	11/2001	Durrant et al.	
6,317,500	B1	11/2001	Murphy	
6,373,432	B1	4/2002	Rabinowitz et al.	
6,374,177	B1	4/2002	Lee et al.	
6,433,740	B1	8/2002	Gilhousen	
6,590,529	B1	7/2003	Schwoegler	
6,806,830	B1 *	10/2004	Panasik et al.	342/464
6,952,182	B1 *	10/2005	Spilker et al.	342/464
2003/0122711	A1	7/2003	Panasik et al.	
2003/0156063	A1	8/2003	Spilker et al.	

FOREIGN PATENT DOCUMENTS

GB	2 254 508	A	10/1992

OTHER PUBLICATIONS

Rabinowitz, M., et al., "Positioning Using the ATSC Digital Television Signal," Rosum whitepaper, Online! 2001, XP002235053, Retrieved from the Internet on Mar. 13, 2003 at URL www.rosum.com/whitepaper 8-7-01.pdf.

EP Abstract/Zusammenfassung/Abrege, 02102666.1.

JP Abstract/vol. 007, No. 241 (P-232), Oct. 26, 1983 & JP58 129277 A (Nihon Musen KK) Aug. 2, 1983.

Parkinson, B.W., et al., "Autonomous GPS Integrity Monitoring Using the Pseudorange Residual," *Journal of the Institute of Navigation* (1988), vol. 35, No. 2, pp. 255-274.

Rabinowitz, M., "A Differential Carrier Phase Navigation System Combining GPS with Low Earth Orbit Satellites for Rapid Resolution of Integer Cycle Ambiguities," *PhD Thesis for Department of Electrical Engineering, Stanford University* (Dec. 2000), pp. 59-73.

Spilker, Jr., J.J., Jr., "Fundamentals of Signal Tracking Theory," *Global Positioning System: Theory and Applications* (1994), vol. 1, Chapter 7, pp. 245-327.

Van Dierendonck, A.J., "GPS Receivers," *Global Positioning System: Theory and Applications* (1995), vol. 1, Chapter 8, pp. 329-407.

* cited by examiner

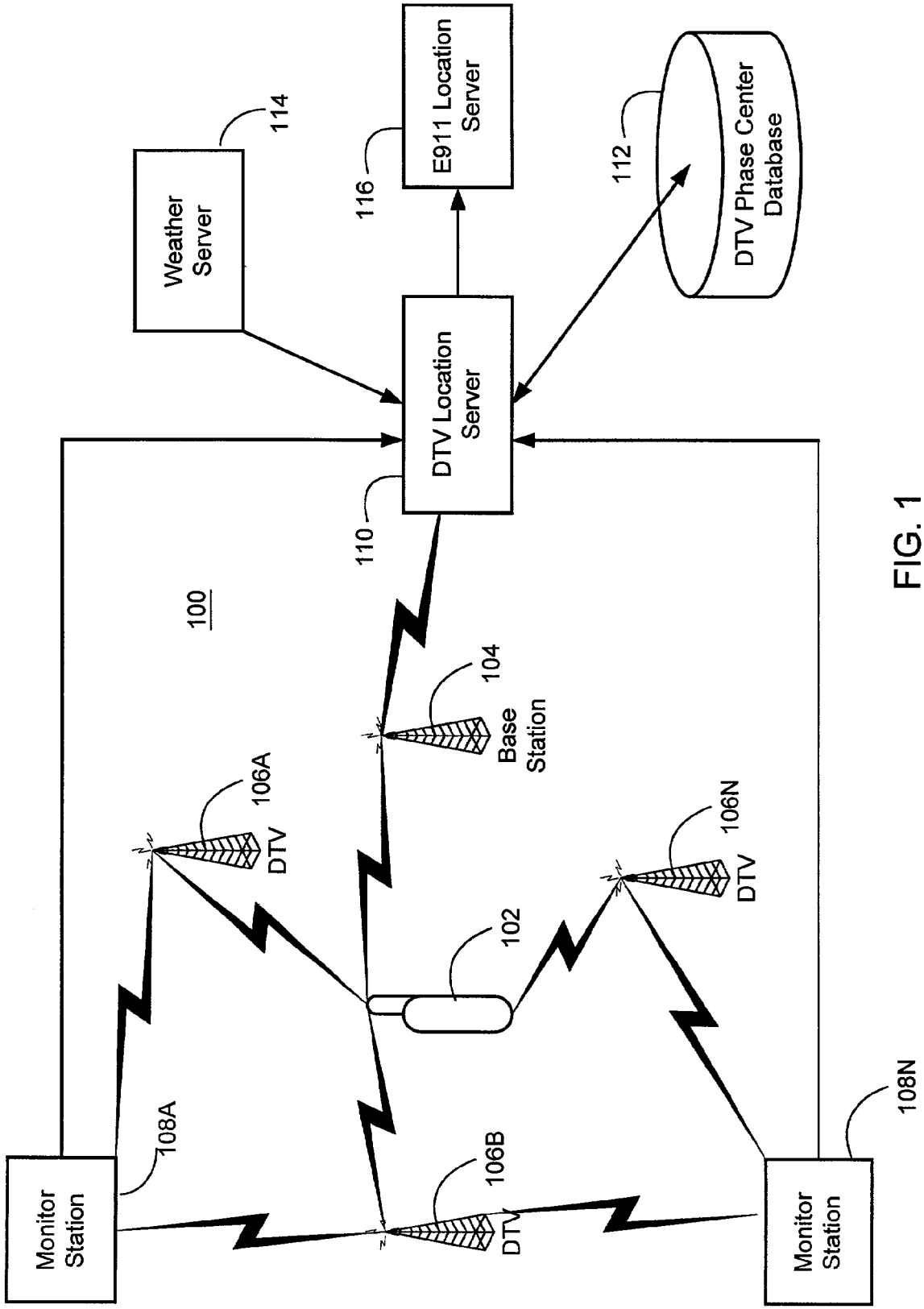


FIG. 1

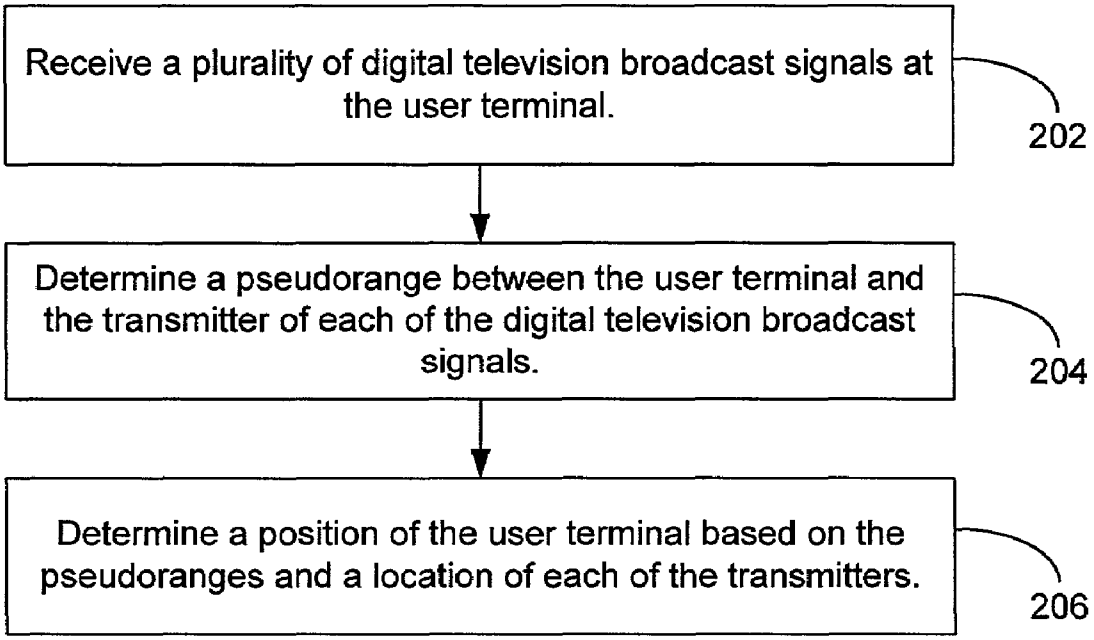


FIG. 2

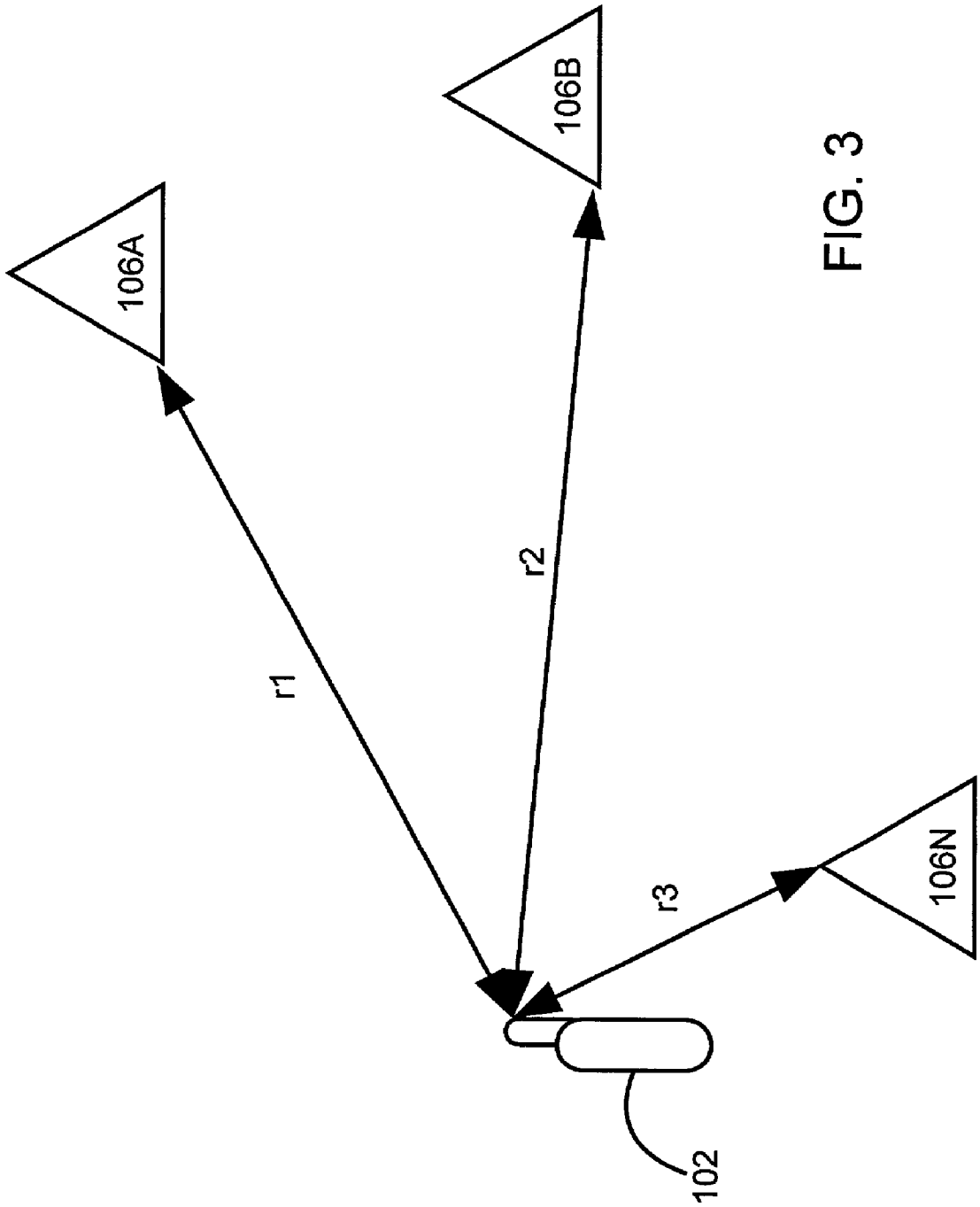


FIG. 3

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