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(12) **United States Patent**
Campanella

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(54) **DIGITAL BROADCAST SYSTEM USING SATELLITE DIRECT BROADCAST AND TERRESTRIAL REPEATER**

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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 0 days.

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(51) **Int. Cl.**[7] **H04B 7/155**
(52) **U.S. Cl.** **370/315**; 370/480; 455/3.02; 455/17
(58) **Field of Search** 370/315, 316, 370/480, 481, 485; 455/3.01, 3.02, 3.06, 455/11.1, 12.1, 7, 16, 17, 427, 430, 118

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,385,381	A	5/1983	Alexis	370/69.1
4,506,383	A *	3/1985	McGann	455/17
4,881,241	A	11/1989	Pommier et al.	375/38
4,901,307	A	2/1990	Gilhousen et al.	370/18
5,081,703	A *	1/1992	Lee	455/11.1
5,191,576	A	3/1993	Pommier et al.	370/18
5,228,025	A	7/1993	Le Floch et al.	370/20
5,283,780	A	2/1994	Schuchman et al.	370/50
5,291,289	A *	3/1994	Hulyalkar et al.	348/723
5,303,393	A	4/1994	Noreen et al.	455/3.2
5,319,673	A	6/1994	Briskman	375/1
5,450,448	A	9/1995	Sheynblat	375/346
5,450,456	A	9/1995	Mueller	375/224

(Continued)

FOREIGN PATENT DOCUMENTS

CA	2209165	1/1998	H04B 1/69

OTHER PUBLICATIONS

Layer, David H., "Digital Radio Takes to the Road", *IEEE Spectrum*, Jul. 2001, pp. 40-46.

(Continued)

Primary Examiner—Min Jung
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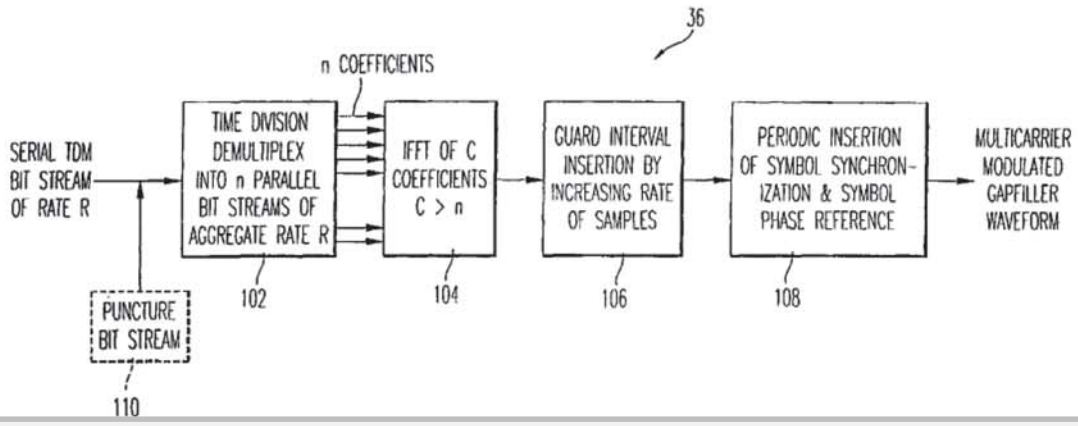
(57) **ABSTRACT**

A digital broadcast system is provided which uses a satellite direct radio broadcast system having different downlink modulation options in combination with a terrestrial repeater network employing different re-broadcasting modulation options to achieve high availability reception by mobile radios **(14)**, static radios and portable radios **(14)** in urban areas, suburban metropolitan areas, and rural areas, including geographically open areas and geographic areas characterized by high terrain elevations. Two-arm and three-arm receivers are provided which each comprise a combined architecture for receiving both satellite and terrestrial signals, and for maximum likelihood combining of received signals for diversity purposes. A terrestrial repeater is provided for reformatting a TDM satellite signal as a multicarrier modulated terrestrial signal. Configurations for indoor and outdoor terrestrial repeaters are also provided.

26 Claims, 10 Drawing Sheets



U.S. PATENT DOCUMENTS

5,454,009	A		9/1995	Fruit et al. 375/202
5,485,485	A	*	1/1996	Briskman et al. 375/130
5,550,812	A		8/1996	Philips 370/19
5,574,970	A		11/1996	Linquist et al. 455/13.1
5,592,471	A		1/1997	Briskman 455/52.3
5,613,194	A		3/1997	Olds et al. 455/12.1
5,636,246	A		6/1997	Tzannes et al. 375/260
5,640,386	A	*	6/1997	Wiedeman 370/320
5,659,353	A		8/1997	Kostreski et al. 348/21
5,726,980	A		3/1998	Rickard 370/293
5,784,418	A	*	7/1998	Sykes et al. 375/347
5,794,138	A		8/1998	Briskman 455/344
5,848,060	A	*	12/1998	Dent 370/281
5,864,579	A		1/1999	Briskman 375/200
5,930,708	A	*	7/1999	Stewart et al. 455/428
5,953,311	A		9/1999	Davies et al. 370/210
5,970,085	A	*	10/1999	Yi 370/342
6,061,387	A	*	5/2000	Yi 375/142
6,233,463	B1	*	5/2001	Wiedeman et al. 455/552.1
6,249,514	B1	*	6/2001	Campanella 370/316
6,404,775	B1	*	6/2002	Leslie et al. 370/466

OTHER PUBLICATIONS

Hoeher, P. et al., "Helicopter Emulation of Archimedes/Mediastar Satellite DAB Transmission to Mobile Receivers", International Journal of Satellite Communications, vol. 15, pp. 35-43 (1997).

Tuisel, U. et al., "Carrier-Recovery for Multicarrier-Transmissin Over Mobile Radio Channels", International Conference on Acoustics, Speech and Signal Processing, ICASSPGE, San Francisco, 1992, pp. 677-680.

F.C.C. Application of Satellite CD Radio, Inc. for Private CD Quality Satellite Sound Broadcasting System, May 18, 1990.

Terrestrial and Satellite Digital Sound Broadcasting to Vehicular Portable and Fixed Receivers in the VHF/UHF Bands, International Telecommunication Union, Radio Communication Bureau, Geneva, 1995, pp. 18-34, 48-49, 87-93, 118, 162, 168-172, 183, Annex C, Table of Contents and Description of Digital System B.

Principles for the Guidance of EBU Members for WARC-92 Broadcasting-Satellite Service, European Broadcasting Union, Feb. 1991 Draft SPB 483-E, pp. 1-75.

Le Floch et al., "Digital Sound Broadcasting to Mobile Receivers", IEEE, Transactions on Consumer Electronics, Aug. 1989, vol. 35, No. 3, pp. 493-503.

"Proceedings from Second International Symposium on Digital Audio Broadcasting: The Sound of 2000", Toronto, Canada, Mar. 14-17, 1994, vol. I, pp. 158-181 and vol. II, pp. 63-108 and pp. 240-248.

Annex C to ITU-R Special Publication on Terrestrial and Satellite Digital Sound Broadcasting to Vehicular Portable and Fixed Receivers in the VHF/UHF Bands on "Digital System B", Nov. 1, 1994.

Introduction of Satellite in Complimentary Terrestrial Digital Sound Broadcasting in the WARC-92 Frequency Allocations, International Telecommunication Union, Document 10/30-E, Feb. 22, 1995, pp. 1-17.

Advanced Digital Techniques for UHF Satellite Sound Broadcasting: Collected Papers on Concepts for Sound Broadcasting Into the 21st Century, European Broadcasting Union, Extracted from EBU Document SPB 442, Jan. 1998, pp. 11-69.

"Mixed Satellite/Terrestrial Sound Broadcasting Service: Effect of a Co-Channel Satellite Service on a Terrestrial DSB Coverage", International Telecommunications Unit, Radio Communications Study Group, Document 10B-CAN-6, Oct. 8, 1993, pp. 1-8.

The Eurcka 147 Project, Digital Audio Broadcasting System, DAB Project Office, Germany, pp. 1-11.

De Gaudenzi, R., "Analysis of an Advanced Satellite Digital Audio Broadcasting System and Complementary Terrestrial Gap-Filler Single Frequency Network", IEEE Transactions on Vehicular Technology, vol. 43, No. 2, May 1994, pp. 194-210.

Linnartz, Jean-Paul M.G. et al., "Wireless Communication", copyrighted 1995.

Zheng, H. et al., "Subband Coded Image Transmitting Over Noisy Channels Using Multicarrier Modulation", Technical Research Report T.R. 98-20, Institute for Systems Research.

Miller, John E., "Application of Coding and Diversity Coding to UHF Satellite Sound Broadcasting Systems", IEEE, pp. 465-475, copyright 1988.

* cited by examiner

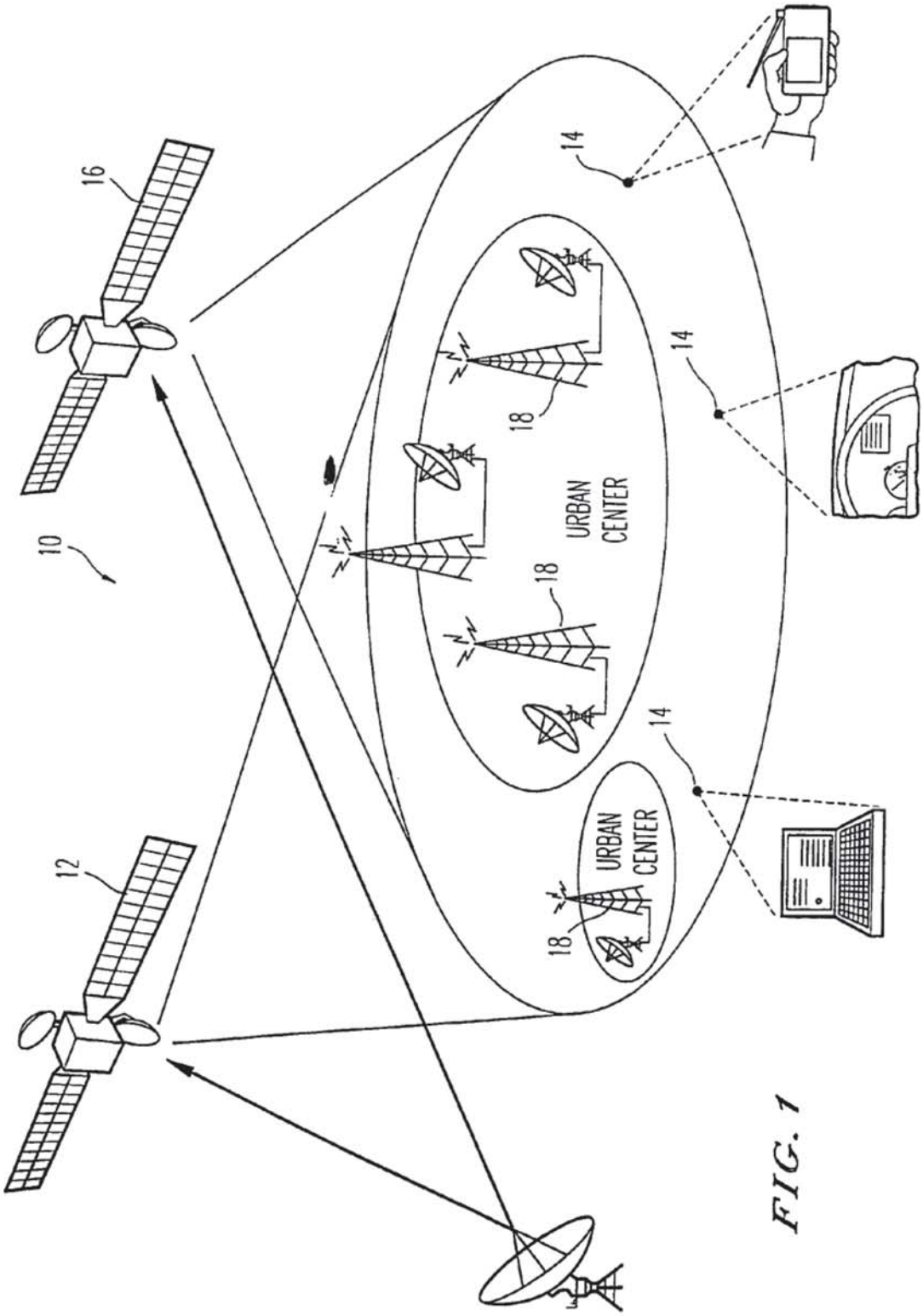
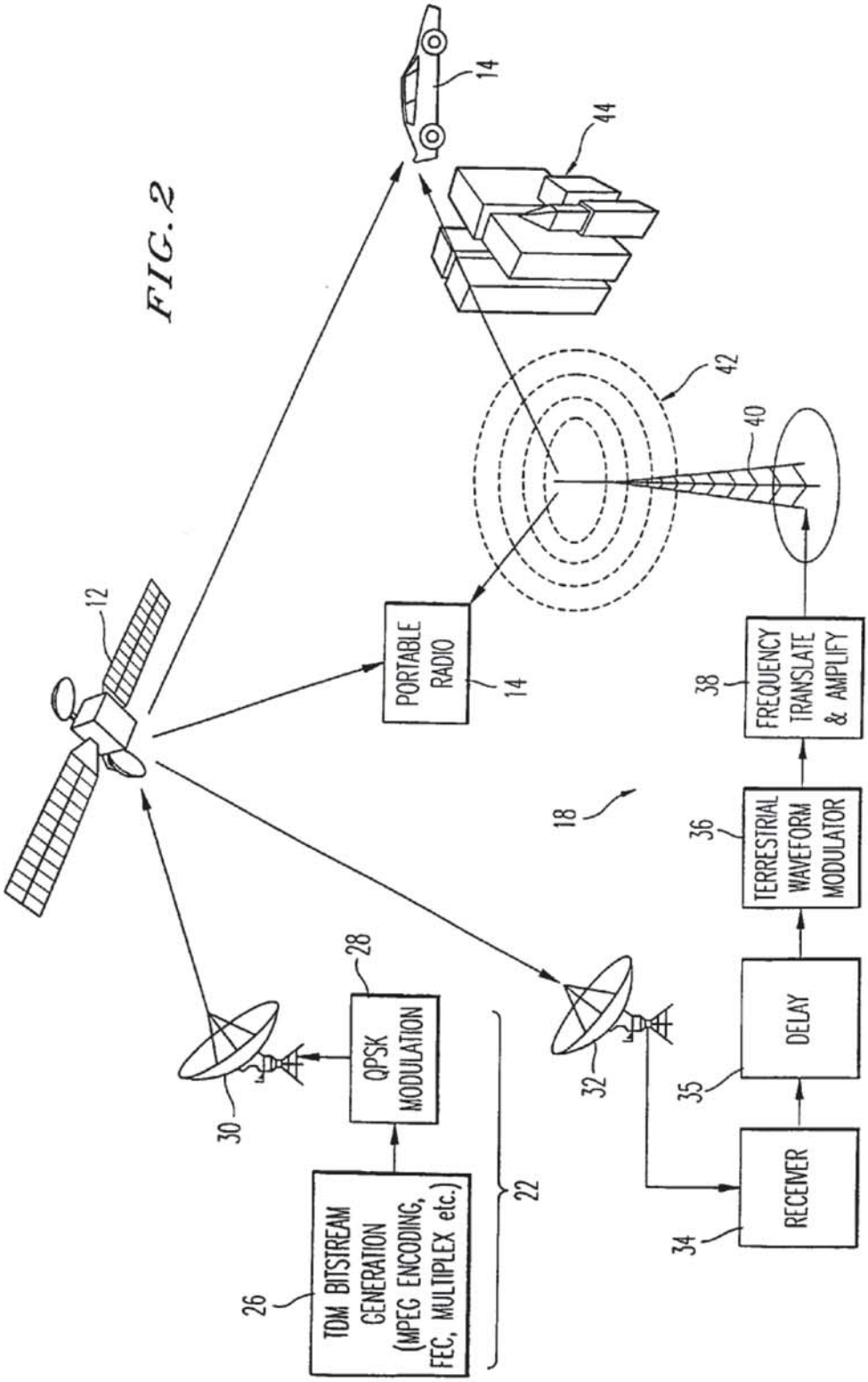


FIG. 1

FIG. 2



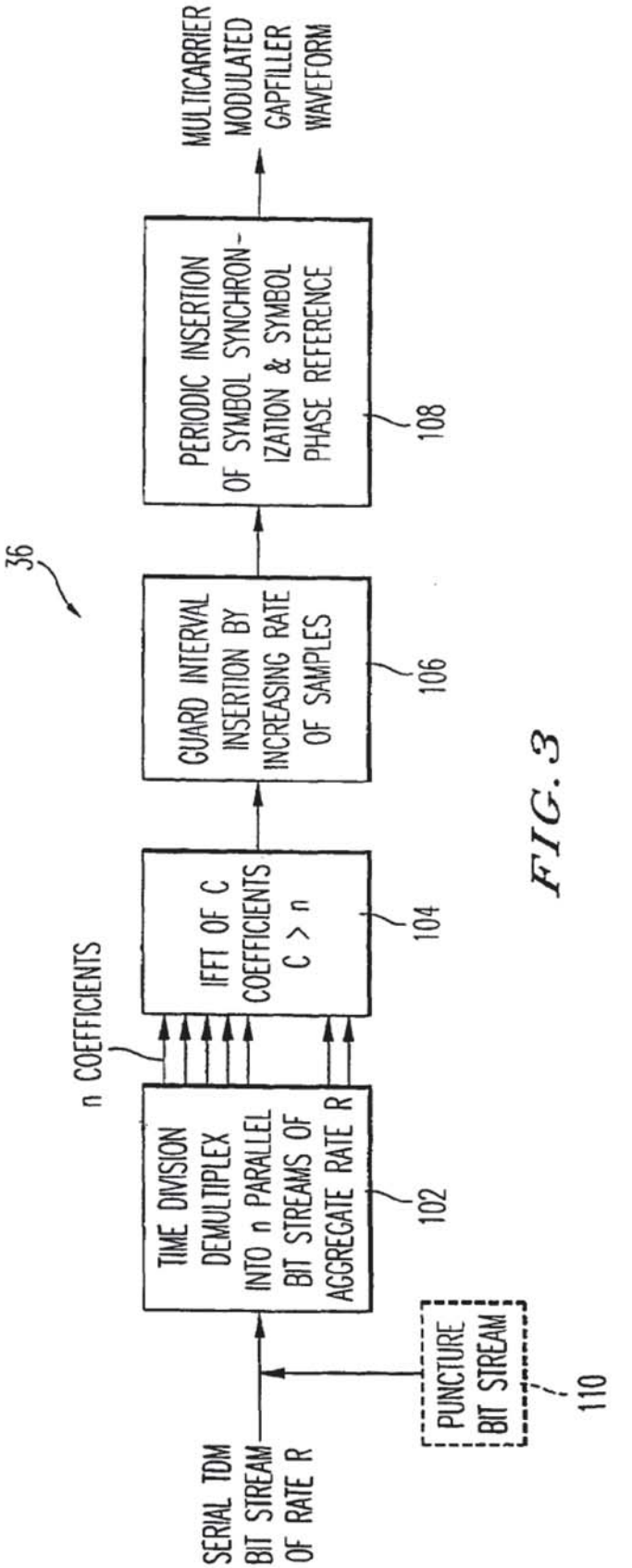


FIG. 3

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