UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,944,139 B1
APPLICATION NO. : 09/647007
DATED : September 13, 2005
INVENTOR(S) : S. Joseph Campanella

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Item (73) Assignee:
Please change the Assignee's Name on the Title Page of the Letters Patent as follows:

--WorldSpace Corporation, Silver Spring, MD. --.

Signed and Sealed this

Twelfth Day of December, 2006

JON W. DUDAS
Director of the United States Patent and Trademark Office

OIPE
MAY 1 1 2006
PATENT & TRADEMARK OFFICE

ZZW
DHC

40264

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	
S. Joseph Campanella	U.S. Patent No. 6,944,139 Issued on September 13, 2005
Serial No.: 09/647,007	
Filed: September 26, 2000	
For: Digital Broadcast System Using Satellite Direct Broadcast System and Terrestrial Repeater	

PETITION UNDER 37 C.F.R. § 1.183 FOR CORRECTION OF ASSIGNEE NAME ON ISSUED PATENT

Commissioner for Patents
Office of Petitions
Box DAC
Alexandria, VA 22313-1450

Sir:

Applicant respectfully petitions to change the Assignee name indicated on the above-referenced issued patent from "WorldSpace Management Corporation" to --WorldSpace Corporation--. The incorrect Assignee name was inadvertently provided on the issue fee transmittal. A copy of the recorded change of name to WorldSpace Corporation is attached. Also attached is a check to cover the $400.00 petition fee under C.F.R. § 1.17(f).

The Commissioner is hereby authorized to charge any additional fees associated with this communication or credit any overpayment to Deposit Account No. 18-2220.

Adjustment date: 08/02/2006 CKHLOK
05/12/2006 JADDO1 00000022 6944139
01 FC:1462 -400.00 OP

08/02/2006 CKHLOK 00000037 09647007
01 FC:1808 130.00 OP

Respectfully submitted,

Stacey J. Longanecker
Attorney of Record
Reg. No. 33,952

05/12/2006 JADDO1 00000022 6944139
01 FC:1462 400.00 OP

Roylance, Abrams, Berdo & Goodman, L.L.P.
1300 19th Street, N.W.
Washington, D.C. 20036
(202) 659-9076

Dated: May 11, 2006

Repln. Ref: 08/02/2006 CKHLOK 0013301900
DA#:182220 Name/Number:09647007
FC: 9204 $270.00 CR

UNITED STATES PATENT & TRADEMARK OFFICE
Washington, D.C. 20231

REQUEST FOR PATENT FEE REFUND 6,944,139

1 Date of Request: 08/01/06

2 Serial/Patent # 09647007

3 Please refund the following fee(s):		4 PAPER NUMBER	5 DATE FILED	6 AMOUNT
	Filing			$
	Amendment			$
	Extension of Time			$
	Notice of Appeal/Appeal			$
X	Petition (1462)			$ 270.00
	Issue			$
	Cert of Correction/Terminal Disc.			$
	Maintenance			$
	Assignment			$
	Other			$

7 TOTAL AMOUNT OF REFUND $ 270.00

8 TO BE REFUNDED BY:

	Treasury Check
X	Credit Deposit A/C #:

9 18--2220

10 REASON:

X	Overpayment
	Duplicate Payment
	No Fee Due (Explanation):

11 REFUND REQUESTED BY:

TYPED/PRINTED NAME: Charlema Grant TITLE: Atty

SIGNATURE: /Charlema Grant/ PHONE: X-3205

OFFICE: OP

****

THIS SPACE RESERVED FOR FINANCE USE ONLY:

APPROVED: CKhik DATE: 8/2/06

Instructions for completion of this form appear on the back. After completion, attach white and yellow copies to the official file and mail or hand-carry to:

Office of Finance
Refund Branch
Crystal Park One, Room 802B

FORM PTO 1577
(01/90)

UNITED STATES PATENT AND TRADEMARK OFFICE

Commissioner for Patents
United States Patent and Trademark Office
P.O. Box 1450
Alexandria, VA 22313-1450
www.uspto.gov

John E Holmes
Roylance Abrams Berdo & Goodman
Suite 600
1300 19th Street NW
Washington DC 20036

COPY MAILED

AUG 01 2006

OFFICE OF PETITIONS

In re Application of :
Campanella :
Application Number: 09/647,007 :
Patent: 6,944,139
Attorney Docket Number: 40264 :
Filing Date: September 26, 2000 :
Issue Date: September 13, 2005 : DECISION ON PETITION
:

This is a decision on the petition filed May 11, 2006 under 37 CFR 3.81 (b)[1] to correct the assignee on the front page of the above-identified patent by way of a Certificate of Correction.

The petition is **Granted**.

Petitioner has submitted a $400.00 petition fee. Pursuant to petitioner's request deposit account 18-2220 is being refunded $270.00. The certificate of correction pursuant 37 CFR 1.20 (a) fee is $100.00 and the processing fee pursuant to 37 CFR 1.17(i) is $130.00. A petition fee is no longer required.

The certificate of correction should reflect an address of Washington, DC and not Silver Spring, MD. as that was not the recorded address of the assignee at the time of issuance.

This application is being forwarded to the Certificate of Correction Branch for issuance of the requested Certificate of Correction.

Telephone inquiries concerning this matter should be directed to the undersigned at (571) 272-3215. Any questions concerning the issuance of the Certificate of Correction should be directed to the Certificate of Correction Branch at (703) 305-8309.

Charlema R. Grant
Charlema R. Grant
Petitions Attorney
Office of Petitions

---

[1]See 69 Fed. Reg. 29865 (May 26, 2004).

40264 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

S. Joseph Campanella

Serial No.: 09/647,007

Filed: September 26, 2000

For: Digital Broadcast System Using Satellite Direct Broadcast System and Terrestrial Repeater

U.S. Patent No. 6,944,139
Issued on September 13, 2005

OIPE IAP56 MAY 11 2006 PATENT & TRADEMARK OFFICE

REQUEST FOR CERTIFICATE OF CORRECTION
UNDER 35 U.S.C. § 255 AND 37 C.F.R. § 1.323

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Applicant respectfully requests that a Certificate of Correction be granted under 35 U.S.C. § 254 and 37 C.F.R. § 1.322 for the above-identified patent, to correct the Assignee's Name. The correct name of the Assignee is WorldSpace Corporation. A Certificate of Correction is attached reflecting this correction.

Respectfully submitted,

[signature]

Stacey J. Longanecker
Attorney of Record
Reg. No. 33,952

05/12/2006 JADDO1 00000022 6944139
02 FC:1811 100.00 OP

ROYLANCE, ABRAMS, BERDO & GOODMAN, L.L.P.
1300 19th Street, N.W.
Washington, D.C. 20036
(202) 659-9076

Dated: May 11, 2006

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO : 6,944,139

DATED : September 13, 2005

INVENTOR(S) : S. Joseph Campanella

It is certified that an error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Please change the Assignee's Name on the Title Page of the Letters Patent as follows:

--WorldSpace Corporation, Silver Spring, MD. --.

MAILING ADDRESS OF SENDER:

PATENT NO. 6,944,139

No. of additional copies

⇨

OIPE
MAY 11 2006
PATENT & TRADEMARK OFFICE

ZZW

DHC

40264 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	
S. Joseph Campanella	U.S. Patent No. 6,944,139 Issued on September 13, 2005
Serial No.: 09/647,007	
Filed: September 26, 2000	
For: Digital Broadcast System Using Satellite Direct Broadcast System and Terrestrial Repeater	

PETITION UNDER 37 C.F.R. § 1.183 FOR CORRECTION OF ASSIGNEE NAME ON ISSUED PATENT

Commissioner for Patents
Office of Petitions
Box DAC
Alexandria, VA 22313-1450

Sir:

Applicant respectfully petitions to change the Assignee name indicated on the above-referenced issued patent from "WorldSpace Management Corporation" to --WorldSpace Corporation--. The incorrect Assignee name was inadvertently provided on the issue fee transmittal. A copy of the recorded change of name to WorldSpace Corporation is attached. Also attached is a check to cover the $400.00 petition fee under C.F.R. § 1.17(f).

The Commissioner is hereby authorized to charge any additional fees associated with this communication or credit any overpayment to Deposit Account No. 18-2220.

Respectfully submitted,

Stacey J. Longanecker

Stacey J. Longanecker
Attorney of Record
Reg. No. 33,952

05/12/2006 JADDO1 00000022 6944139
01 FC:1462 400.00 OP

Roylance, Abrams, Berdo & Goodman, L.L.P.
1300 19th Street, N.W.
Washington, D.C. 20036
(202) 659-9076

Dated: May 11, 2006

UNITED STATES PATENT AND TRADEMARK OFFICE

OIPE MAY 11 2006 IAP56 PATENT & TRADEMARK OFFICE

Doc'd ____ File ____
Rec'd
NOV 29 2001
ROYLANCE, ABRAMS BERDO & GOODMAN, L.L.P.
BY ____

Under Secretary of Commerce For Intellectual Property and Director of the United States Patent and Trademark Office
Washington, DC 20231
www.uspto.gov

NOVEMBER 26, 2001

ROYLANCE, ABRAMS, BERDO, ET AL
JOHN E. HOLMES
1300 19TH STREET, N.W., SUITE 600
WASHINGTON, D.C. 20036

101852933A

UNITED STATES PATENT AND TRADEMARK OFFICE
NOTICE OF RECORDATION OF ASSIGNMENT DOCUMENT

THE ENCLOSED DOCUMENT HAS BEEN RECORDED BY THE ASSIGNMENT DIVISION OF THE U.S. PATENT AND TRADEMARK OFFICE. A COMPLETE MICROFILM COPY IS AVAILABLE AT THE ASSIGNMENT SEARCH ROOM ON THE REEL AND FRAME NUMBER REFERENCED BELOW.

PLEASE REVIEW ALL INFORMATION CONTAINED ON THIS NOTICE. THE INFORMATION CONTAINED ON THIS RECORDATION NOTICE REFLECTS THE DATA PRESENT IN THE PATENT AND TRADEMARK ASSIGNMENT SYSTEM. IF YOU SHOULD FIND ANY ERRORS OR HAVE QUESTIONS CONCERNING THIS NOTICE, YOU MAY CONTACT THE EMPLOYEE WHOSE NAME APPEARS ON THIS NOTICE AT 703-308-9723. PLEASE SEND REQUEST FOR CORRECTION TO: U.S. PATENT AND TRADEMARK OFFICE, ASSIGNMENT DIVISION, BOX ASSIGNMENTS, CG-4, 1213 JEFFERSON DAVIS HWY, SUITE 320, WASHINGTON, D.C. 20231.

RECORDATION DATE: 09/18/2001 REEL/FRAME: 012166/0950
NUMBER OF PAGES: 12

BRIEF: NUNC PRO TUNC ASSIGNMENT (SEE DOCUMENT FOR DETAILS).

ASSIGNOR:
WORLDSPACE MANAGEMENT CORPORATION DOC DATE: 01/27/1999

ASSIGNEE:
WORLDSPACE CORPORATION
2400 N STREET, N.W.
WASHINGTON, D.C. 20037-1153

SERIAL NUMBER: 60079591 FILING DATE: 03/27/1998
PATENT NUMBER: ISSUE DATE:

SERIAL NUMBER: 09058663 FILING DATE: 04/10/1998
PATENT NUMBER: ISSUE DATE:

SERIAL NUMBER: 09605396 FILING DATE: 06/29/2000
PATENT NUMBER: ISSUE DATE:

SERIAL NUMBER: 08924264 FILING DATE: 09/05/1997
PATENT NUMBER: ISSUE DATE:

SERIAL NUMBER: 09165385 PATENT NUMBER:	FILING DATE: 10/02/1998 ISSUE DATE:
SERIAL NUMBER: 09640686 PATENT NUMBER:	FILING DATE: 08/18/2000 ISSUE DATE:
SERIAL NUMBER: 09971049 PATENT NUMBER:	FILING DATE: 10/03/2001 ISSUE DATE:
SERIAL NUMBER: 09514387 PATENT NUMBER:	FILING DATE: 02/28/2000 ISSUE DATE:
SERIAL NUMBER: 09647007 PATENT NUMBER:	FILING DATE: 09/26/2000 ISSUE DATE:
SERIAL NUMBER: 09801674 PATENT NUMBER:	FILING DATE: 03/09/2001 ISSUE DATE:
SERIAL NUMBER: 09803988 PATENT NUMBER:	FILING DATE: 03/13/2001 ISSUE DATE:
SERIAL NUMBER: 09055935 PATENT NUMBER: 6185265	FILING DATE: 04/07/1998 ISSUE DATE: 02/06/2001
SERIAL NUMBER: 09112349 PATENT NUMBER: 6201798	FILING DATE: 07/09/1998 ISSUE DATE: 03/13/2001

SHARON LATIMER, EXAMINER
ASSIGNMENT DIVISION
OFFICE OF PUBLIC RECORDS

09-24-2001

101852933

FORM PTO-1619A
Expires 06/30/99
OMB 0651-0027

SEP 18 2001
Mail Date Canceled
PATENT & TRADEMARK OFFICE

OIPE
MAY 11 2006
PATENT & TRADEMARK OFFICE

U.S. Department of Commerce
Patent and Trademark Office
PATENT

RECORDATION FORM COVER SHEET
PATENTS ONLY

TO: The Commissioner of Patents and Trademarks: Please record the attached original document(s) or copy(ies).

Submission Type

09/18/01

- [x] New
- [ ] Resubmission (Non-Recordation) Document ID#
- [ ] Correction of PTO Error Reel # Frame #
- [ ] Corrective Document Reel # Frame #

Conveyance Type

- [ ] Assignment
- [ ] Security Agreement
- [ ] License
- [x] Change of Name
- [ ] Merger
- [ ] Other

U.S. Government
(For Use ONLY by U.S. Government Agencies)

- [ ] Departmental File
- [ ] Secret File

Conveying Party(ies)

- [ ] Mark if additional names of conveying parties attached

Name (line 1): WorldSpace Management Corporation

Execution Date (Month Day Year): 01/27/99

Name (line 2):

Second Party

Name (line 1):

Execution Date (Month Day Year):

Name (line 2):

Receiving Party

- [ ] Mark if additional names of receiving parties attached

Name (line 1): WorldSpace Corporation

Name (line 2):

Address (line 1): 2400 N Street, N.W.

Address (line 2):

Address (line 3): Washington (City) DC (State/Country) 20037-1153 (Zip Code)

- [ ] If document to be recorded is an assignment and the receiving party is not domiciled in the United States, an appointment of a domestic representative is attached. *(Designation must be a separate document from Assignment.)*

Domestic Representative Name and Address

Enter for the first Receiving Party only.

Name:

Address (line 1):

Address (line 2):

Address (line 3):

Address (line 4):

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09/21/2001 TDIAZ1 00000120 60079591

01 FC:581 520.00 OP

Public burden reporting for this collection of information is estimated to average approximately 30 minutes per Cover Sheet to be recorded, including time for reviewing the document and gathering the data needed to complete the Cover Sheet. Send comments regarding this burden estimate to the U.S. Patent and Trademark Office, Chief Information Officer, Washington, D.C. 20231 and to the Office of Information and Regulatory Affairs, Office of Management and Budget, Paperwork Reduction Project (0651-0027), Washington, D.C. 20503. See OMB Information Collection Budget Package 0651-0027, Patent and Trademark Assignment Practice. DO NOT SEND REQUESTS TO RECORD ASSIGNMENT DOCUMENTS TO THIS ADDRESS.

Mail documents to be recorded with required cover sheet(s) information to:
Commissioner of Patents and Trademarks, Box Assignments , Washington, D.C. 20231

Correspondent Name and Address

Area Code and Telephone Number: (202) 530-7374

Name: John E. Holmes

Address (line 1): Roylance, Abrams, Berdo & Goodman, L.L.P.

Address (line 2): 1300 19th Street, N.W., Suite 600

Address (line 3): Washington, D.C. 20036

Address (line 4):

Pages

Enter the total number of pages of the attached conveyance document including any attachments. # 9

Application Number(s) or Patent Number(s)

☑ Mark if additional numbers attached

Enter either the Patent Application Number or the Patent Number (DO NOT ENTER BOTH numbers for the same property).

Patent Application Number(s)			Patent Number(s)		
60/079,591	08/924,264	08/971,049	6,185,265	6,201,798	
09/058,663	09/165,385	09/514,387			
09/605,396	09/640,686	09/647,007			

If this document is being filed together with a new Patent Application, enter the date the patent application was signed by the first named executing inventor. Month Day Year

Patent Cooperation Treaty (PCT)

Enter PCT application number only if a U.S. Application Number has not been assigned.

PCT ___ PCT ___ PCT ___
PCT ___ PCT ___ PCT ___

Number of Properties

Enter the total number of properties involved. # 13

Fee Amount

Fee Amount for Properties Listed (37 CFR 3.41): $ 520.00

Method of Payment: Enclosed ☑ Deposit Account ☐

Deposit Account
(Enter for payment by deposit account or if additional fees can be charged to the account.)
Deposit Account Number: # 18-2220

Authorization to charge additional fees: Yes ☑ No ☐

Statement and Signature

To the best of my knowledge and belief, the foregoing information is true and correct and any attached copy is a true copy of the original document. Charges to deposit account are authorized, as indicated herein.

Name of Person Signing	Signature	Date
John E. Holmes	John E. Holmes [signature]	September 18, 2001

FORM PTO-1619C
Expires 06/30/99
OMB 0651-0027

RECORDATION FORM COVER SHEET CONTINUATION
PATENTS ONLY

U.S. Department of Commerce
Patent and Trademark Office
PATENT

Conveying Party(ies)

☐ Mark if additional names of conveying parties attached

Enter additional Conveying Parties

Name (line 1) ______ Execution Date Month Day Year ______

Name (line 2) ______

Name (line 1) ______ Execution Date Month Day Year ______

Name (line 2) ______

Name (line 1) ______ Execution Date Month Day Year ______

Name (line 2) ______

Receiving Party(ies)

☐ Mark if additional names of receiving parties attached

Enter additional Receiving Party(ies)

Name (line 1) ______

Name (line 2) ______

Address (line 1) ______

Address (line 2) ______

Address (line 3) ______ City ______ State/Country ______ Zip Code

☐ If document to be recorded is an assignment and the receiving party is not domiciled in the United States, an appointment of a domestic representative is attached. *(Designation must be a separate document from Assignment.)*

Name (line 1) ______

Name (line 2) ______

Address (line 1) ______

Address (line 2) ______

Address (line 3) ______ City ______ State/Country ______ Zip Code

☐ If document to be recorded is an assignment and the receiving party is not domiciled in the United States, an appointment of a domestic representative is attached. *(Designation must be a separate document from Assignment.)*

Application Number(s) or Patent Number(s)

☐ Mark if additional numbers attached

Enter either the Patent Application Number or the Patent Number (DO NOT ENTER BOTH numbers for the same property).

Patent Application Number(s)			Patent Number(s)		
09/801.674	09/803,988				

ATTESTATION OF TRUE COPIES

September 5, 2001

Washington, District of Columbia

I, Donald J. Frickel, Assistant Secretary, WorldSpace Corporation, being duly sworn, depose and say:

That the attached document from the State of Delaware, Office of the Secretary of State. is a true and complete copy of the document currently approved by the State of Delaware, to the best of my knowledge, ability, and belief.

Donald J. Frickel
Assistant Secretary

Subscribed and sworn to before me this 5th day of September, 2001 in Washington, DC.

Pamela S. King
Notary Public, D.C.

My commission expires: 10/31/02

State of Delaware

Office of the Secretary of State

I, EDWARD J. FREEL, SECRETARY OF STATE OF THE STATE OF DELAWARE, DO HEREBY CERTIFY THE ATTACHED ARE TRUE AND CORRECT COPIES OF ALL DOCUMENTS FILED FROM AND INCLUDING THE RESTATED CERTIFICATE OF "WORLDSPACE CORPORATION" AS RECEIVED AND FILED IN THIS OFFICE.

THE FOLLOWING DOCUMENTS HAVE BEEN CERTIFIED:

RESTATED CERTIFICATE, FILED THE EIGHTEENTH DAY OF DECEMBER, A.D. 1996, AT 4:30 O'CLOCK P.M.

CERTIFICATE OF AMENDMENT, CHANGING ITS NAME FROM "WORLDSPACE MANAGEMENT CORPORATION" TO "WORLDSPACE CORPORATION", FILED THE TWENTY-EIGHTH DAY OF JANUARY, A.D. 1999, AT 11:30 O'CLOCK A.M.

Edward J. Freel, Secretary of State

2690635 8100X

001074917

AUTHENTICATION: 0257568

DATE: 02-15-00

AMENDED AND RESTATED CERTIFICATE OF INCORPORATION

OF

WORLDSPACE MANAGEMENT CORPORATION

The undersigned being the sole incorporator of WorldSpace Management Corporation, a corporation organized and existing under and by virtue of the General Corporation Law of the state of Delaware (the "Corporation") does hereby certify that:

1. The name of the Corporation is WorldSpace Management Corporation.

2. The Corporation's original Certificate of Incorporation was filed with the Secretary of State on December 10, 1996.

3. The text of the Certificate of Incorporation is hereby restated and amended to read as hereinafter set forth in full:

FIRST: The name of the Corporation is WorldSpace Management Corporation.

SECOND: The registered office of the Corporation is to be located at 1209 Orange Street, in the City of Wilmington, in the County of New Castle, in the State of Delaware. The name of its registered agent at that address is The Corporation Trust Company.

THIRD: The purpose of the Corporation is to engage in any lawful act or activity for which a corporation may be organized under the General Corporation Law of Delaware.

FOURTH: The total number of shares of stock which the Corporation is authorized to issue is 500 shares of class A common stock and 500 shares of class B common stock and the par value of each of such share is $.01.

FIFTH: Except as set forth below, all shares of common stock shall have one vote on all matters to be voted on by holders of shares of common stock and shall be entitled to participate equally in all dividends payable with respect to the common stock and to share ratably in all assets of the Corporation in the event of any dissolution of, or upon any distribution of the assets of, the Corporation. The rights of the shares of class A common stock and the shares of class B common stock are as follows:

(i) Holders of shares of class A common stock shall be entitled, voting separately as a class, to elect 50% of the directors of the Corporation, to remove any director elected by the holders of the shares of class A common stock (and any successor to such director) and, in the manner provided in the by-laws, to replace any director so removed.

(ii) Holders of shares of class B common stock shall be entitled, voting separately as a class, to elect 50% of the directors of the Corporation, to remove any director elected by the holders of the shares of class B common stock (and any successor to such director) and, in the manner provided in the by-laws, to replace any director so removed.

(iii) Upon the conversion of all issued and outstanding Class A Ordinary Shares issued by WorldSpace International Network, Inc., a company incorporated under the International Business Companies Act of the British Virgin Islands ("WIN") into Class B Ordinary Shares issued by WIN, then, without further action by the Corporation, the Corporation's issued and outstanding shares of class A common stock shall be deemed to convert into shares of class B common stock.

SIXTH: The following provisions are inserted for the management of the business and for the conduct of the affairs of the Corporation, and for further definition, limitation and regulation of the powers of the Corporation and of its directors and stockholders:

(1) The number of directors of the Corporation shall be such as from time to time shall be fixed by, or in the manner provided in, the by-laws. Election of directors need not be by ballot unless the by-laws so provide.

(2) The Board of Directors shall have powers without the assent or vote of the stockholders to make, alter, amend, change, add to or repeal the by-laws of the Corporation; to fix and vary the amount to be reserved for any proper purpose; to authorize and cause to be executed mortgages and liens upon all or any part of the property of the Corporation; to determine the use and disposition of any surplus or net profits; and to fix the times for the declaration and payment of dividends.

(3) The directors in their discretion may submit any contract or act for approval or ratification at any annual meeting of the stockholders or at any meeting of the

stockholders called for the purpose of considering any such act or contract, and any contract or act that shall be approved or be ratified by the vote of the holders of a majority of the stock of the Corporation which is represented in person or by proxy at such meeting and entitled to vote thereat (provided that a lawful quorum of stockholders be there represented in person or by proxy) shall be as valid and as binding upon the Corporation and upon all the stockholders as though it had been approved or ratified by every stockholder of the Corporation, whether or not the contract or act would otherwise be open to legal attack because of directors' interest, or for any other reason.

(4) In addition to the powers and authorities hereinbefore or by statute expressly conferred upon them, the directors are hereby empowered to exercise all such powers and do all such acts and things as may be exercised or done by the Corporation; subject, nevertheless, to the provisions of the statutes of Delaware, of this certificate, and to any by-law from time to time made by the stockholders; provided, however, that no by-law so made shall invalidate any prior act of the directors which would have been valid if such by-law had not been made.

SEVENTH: The Corporation shall, to the full extent permitted by Section 145 of the Delaware General Corporation Law, as amended from time to time, indemnify all persons whom it may indemnify pursuant thereto.

EIGHTH: Whenever a compromise or arrangement is proposed between the Corporation and its creditors or any class of them and/or between the Corporation and its stockholders or any class of them, any court of equitable jurisdiction within the State of

Delaware, may, on the application in a summary way of the Corporation or of any creditor or stockholder thereof or on the application of any receiver or receivers appointed for the Corporation under the provisions of section 291 of Title 8 of the Delaware Code or on the application of trustees in dissolution or of any receiver or receivers appointed for the Corporation under the provisions of section 279 of Title 8 of the Delaware Code order a meeting of the creditors or class of creditors, and/or of the stockholders or class of stockholders of the Corporation, as the case may be, to be summoned in such manner as the said court directs. If a majority in number representing three-fourths in value of the creditors or class of creditors, and/or of the stockholders or class of stockholders of the Corporation, as the case may be, agree to any compromise or arrangement and to any reorganization of the Corporation as consequence of such compromise or arrangement, the said compromise or arrangement and the said reorganization shall, if sanctioned by the court to which the said application has been made, be binding on all the creditors or class of creditors, and/or on all the stockholders or class of stockholders, of the Corporation, as the case may be, and also on the Corporation.

NINTH: The Corporation reserves the right to amend, alter, change or repeal any provision contained in this Amended and Restated Certificate of Incorporation in the manner now or hereafter prescribed by law, and all rights and powers conferred herein on stockholders, directors and officers are subject to this reserved power.

4. The Corporation has not any received any payment for any of its stock.

1-28-99

CERTIFICATE OF AMENDMENT
OF
CERTIFICATE OF INCORPORATION
OF
WORLDSPACE MANAGEMENT CORPORATION

WorldSpace Management Corporation, a Delaware corporation (the "Corporation"), DOES HEREBY CERTIFY:

FIRST: That the Directors of the Corporation, by unanimous written consent, adopted a resolution proposing and declaring advisable the following amendment to the Certificate of Incorporation of the Corporation:

> RESOLVED, that the Certificate of Incorporation of the Corporation be amended by changing the First Article thereof so that, as amended, said Article shall be and read as follows:
>
> FIRST: The name of the corporation is WorldSpace Corporation (hereinafter referred to as the "Corporation").

SECOND: That in lieu of a meeting and vote of stockholders, the sole stockholder has given its unanimous written consent in accordance with the provisions of Section 228 of the General Corporation Law of the State of Delaware.

THIRD: That the aforesaid amendment was duly adopted in accordance with the applicable provisions of Section 242 of the General Corporation Law of the State of Delaware.

IN WITNESS WHEREOF, WorldSpace Management Corporation has caused this certificate to be signed this 27th day of January, 1999.

WORLDSPACE MANAGEMENT CORPORATION

By: James R. Laramie
Name: JAMES R. LARAMIE
Title: SECRETARY

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

or Fax (703) 746-4000

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed wh appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

7590 03/30/2005

John E Holmes
Roylance Abrams Berdo & Goodman
Suite 600
1300 19th Street NW
Washington, DC 20036

06/29/2005 MBIZUNE2 00000042 09647007

01 FC:1501 1400.00 OP

OIPE
JUN 2 8 2005
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Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the Un States Postal Service with sufficient postage for first class mail in an envel addressed to the Mail Stop ISSUE FEE address above, or being facsim transmitted to the USPTO (703) 746-4000, on the date indicated below.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/647,007	09/26/2000	S. Joseph Campanella	40264	3843

TITLE OF INVENTION: DIGITAL BROADCAST SYSTEM USING SATELLITE DIRECT BROADCAST AND TERRESTRIAL REPEATER

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1400	$0	$1400	06/30/2005

EXAMINER	ART UNIT	CLASS-SUBCLASS
JUNG, MIN	2663	370-315000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Roylance, Abrams, Berdo & Goodman, L.L.P.
2 ____
3 ____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: WorldSpace Management Corporation

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Washington, District of Columbia

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Governm

4a. The following fee(s) are enclosed:

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☐ Advance Order - # of Copies ____

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☐ Payment by credit card. Form PTO-2038 is attached.
☒ The Director is hereby authorized by charge the required fee(s), or credit any overpayment Deposit Account Number 18-2220 (enclose an extra copy of this form).

5. Change in Entity Status (from status indicated above)

☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.
NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other part interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature: Stacey Longanecker (signature)   Date: June 28, 2005

Typed or printed name: Stacey Longanecker   Registration No. 33,952

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to proc an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to comp this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 14 Alexandria, Virginia 22313-1450.

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NOTICE OF ALLOWANCE AND FEE(S) DUE

7590 03/30/2005

John E Holmes
Roylance Abrams Berdo & Goodman
Suite 600
1300 19th Street NW
Washington, DC 20036

EXAMINER	
JUNG, MIN	
ART UNIT	PAPER NUMBER
2663	

DATE MAILED: 03/30/2005

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/647,007	09/26/2000	S. Joseph Campanella	40264	3843

TITLE OF INVENTION: DIGITAL BROADCAST SYSTEM USING SATELLITE DIRECT BROADCAST AND TERRESTRIAL REPEATER

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1400	$0	$1400	06/30/2005

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATEN PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHT THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPO PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM TH MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. TH STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOV REFLECTS A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE APPLIED IN THIS APPLICATION. THE PTOL-85B (O AN EQUIVALENT) MUST BE RETURNED WITHIN THIS PERIOD EVEN IF NO FEE IS DUE OR THE APPLICATION WIL BE REGARDED AS ABANDONED.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is n claiming SMALL ENTITY status, check box 5a on Part B - Fee Transmittal and pay the PUBLICATION FEE (if required) and 1 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL should be completed and returned to the United States Patent and Trademark Office (USPTO) w your ISSUE FEE and PUBLICATION FEE (if required). Even if the fee(s) have already been paid, Part B - Fee(s) Transmittal should completed and returned. If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should completed and an extra copy of the form should be submitted.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

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INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed wh appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

7590 03/30/2005

John E Holmes
Roylance Abrams Berdo & Goodman
Suite 600
1300 19th Street NW
Washington, DC 20036

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JUNG, MIN	2663	370-315000

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☐ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies __________

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5. **Change in Entity Status** (from status indicated above)

☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

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NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other part interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature __________ Date __________

Typed or printed name __________ Registration No. __________

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/647,007	09/26/2000	S. Joseph Campanella	40264	3843

7590 03/30/2005

John E Holmes
Roylance Abrams Berdo & Goodman
Suite 600
1300 19th Street NW
Washington, DC 20036

EXAMINER	
JUNG, MIN	
ART UNIT	**PAPER NUMBER**
2663	

DATE MAILED: 03/30/2005

Determination of Patent Term Extension under 35 U.S.C. 154 (b)
(application filed after June 7, 1995 but prior to May 29, 2000)

The Patent Term Extension is 0 day(s). Any patent to issue from the above-identified application will include indication of the 0 day extension on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date th determines Patent Term Extension is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retriev (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office Patent Legal Administration at (571) 272-7702. Questions relating to issue and publication fee payments should directed to the Customer Service Center of the Office of Patent Publication at (703) 305-8283.

Notice of Allowability	Application No.	Applicant(s)
	09/647,007	CAMPANELLA, S. JOSEPH
	Examiner	Art Unit
	Min Jung	2663

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *Amendment filed November 23, 2004*.
2. ☒ The allowed claim(s) is/are *10-17, 25-34, 42-45, 21-24 (renumbered as 1-26, respectively)*.
3. ☒ The drawings filed on *26 September 2000* are accepted by the Examiner.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
6. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
   1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☒ Interview Summary (PTO-413), Paper No./Mail Date *herewith* .
7. ☒ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

MIN JUNG
PRIMARY EXAMINER

EXAMINER'S AMENDMENT

1. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with Ms. Stacey Longanecker on March 18, 2005.

The application has been amended as follows:

IN THE CLAIMS:

Claims 35-38 have been cancelled.

2. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Min Jung whose telephone number is 571-272-3127. The examiner can normally be reached on Monday, Thursday, Friday 7:30 - 6:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Ricky Ngo can be reached on 571-272-3139. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Min Jung
Primary Examiner

MJ
March 18, 2005

Examiner-Initiated Interview Summary	Application No.	Applicant(s)
	09/647,007	CAMPANELLA, S. JOSEPH
	Examiner	Art Unit
	Min Jung	2663

All Participants:

(1) Min Jung.

(2) Stacey Longanecker.

(3) _____.

(4) _____.

Status of Application: pending

Date of Interview: 18 March 2005

Time: 1PM

Type of Interview:

☒ Telephonic
☐ Video Conference
☐ Personal (Copy given to: ☐ Applicant ☐ Applicant's representative)

Exhibit Shown or Demonstrated: ☐ Yes ☒ No
If Yes, provide a brief description: .

Part I.

Rejection(s) discussed:

Claims discussed:
35-38

Prior art documents discussed:

Part II.

SUBSTANCE OF INTERVIEW DESCRIBING THE GENERAL NATURE OF WHAT WAS DISCUSSED:
It was agreed to cancel claims 35-38 which were withdrawn from consideration due to Restriction Requirement.

Part III.

☒ It is not necessary for applicant to provide a separate record of the substance of the interview, since the interview directly resulted in the allowance of the application. The examiner will provide a written summary of the substance of the interview in the Notice of Allowability.

☐ It is not necessary for applicant to provide a separate record of the substance of the interview, since the interview did not result in resolution of all issues. A brief summary by the examiner appears in Part II above.

(Examiner/SPE Signature)

(Applicant/Applicant's Representative Signature – if appropriate)

Notice of References Cited	Application/Control No. 09/647,007	Applicant(s)/Patent Under Reexamination CAMPANELLA, S. JOSEPH	
	Examiner Min Jung	Art Unit 2663	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-5,081,703	01-1992	Lee, William C. Y.	455/13.1
	B	US-5,291,289	03-1994	Hulyalkar et al.	348/723
	C	US-4,506,383	03-1985	McGann, William E.	455/17
	D	US-5,784,418	07-1998	Sykes et al.	375/347
	E	US-6,249,514	06-2001	Campanella, S. Joseph	370/316
	F	US-6,404,775	06-2002	Leslie et al.	370/466
	G	US-5,970,085	10-1999	Yi, Byung Kwan	370/342
	H	US-6,061,387	05-2000	Yi, Byung Kwan	375/142
	I	US-5,485,485	01-1996	Briskman et al.	375/130
	J	US-5,640,386	06-1997	Wiedeman, Robert A.	370/320
	K	US-6,233,463	05-2001	Wiedeman et al.	455/552.1
	L	US-5,848,060	12-1998	Dent, Paul W.	370/281
	M	US-5,930,708	07-1999	Stewart et al.	455/428

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Form PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE INFORMATION DISCLOSURE CITATION (Use several sheets if necessary)	ATTY. DOCKET NO. 40264	SERIAL NO. 09/647,007
	APPLICANT S. Joseph Campanella	
	FILING DATE September 26, 2000	GROUP 2663

U.S. PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
		5613194	03/1997	Olds et al.	455	12.1	

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (including Author, Title, Date, Pertinent Pages, Etc.)

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

EXAMINER [signature] | DATE CONSIDERED 4/30/04

*EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw Line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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	APPLICANT S. Joseph Campanella	
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mj	5 2 2 8 0 2 5	07/1993	Le Floch et al.	370	20	
	5 4 5 0 4 4 8	09/1995	Sheynblat	375	346	
	5 7 2 6 9 8 0	03/1998	Rickard	370	293	
	5 4 8 5 4 8 5	01/1996	Briskman et al.	375	200	
	5 3 0 3 3 9 3	04/1994	Noreen et al.	455	3.2	
	5 3 1 9 6 7 3	06/1994	Briskman	375	1	
	5 6 5 9 3 5 3	08/1997	Kostreski et al.	348	21	
	5 5 9 2 4 7 1	01/1997	Briskman	455	52.3	
mj	5 7 9 4 1 3 8	08/1998	Briskman	455	344	

FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (including Author, Title, Date, Pertinent Pages, Etc.)

mj	Le Floch et al., "Digital Sound Broadcasting to Mobile Receivers", IEEE, Transactions on Consumer Electronics, August 1989, Vol. 35, No. 3, pp. 493-503.
mj	"Proceedings from Second International Symposium on Digital Audio Broadcasting: The Sound of 2000", Toronto, Canada, March 14-17, 1994, Vol. I, pp. 158-181 and Vol. II, pp. 63-108 and pp. 240-248.
mj	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", November 1, 1994.
mj	Introduction of Satellite in Complimentary Terrestrial Digital Sound Broadcasting in the WARC-92 Frequency Allocations, International Telecommunication Union, Document 10/30-E, February 22, 1995, pp. 1-17.
mj	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, January 1998, pp. 11-69.

EXAMINER [signature] DATE CONSIDERED 4/30/04

*EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw Line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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MJ		5 6 3 6 2 4 6	6/1997	Tzannes et al.	375	260	
MJ		5 9 5 3 3 1 1	9/1999	Davies et al.	370	210	
MJ		5 8 6 4 5 7 9	1/1999	Briskman	375	200	

OIPE MAR 0 7 2001 PATENT & TRADEMARK OFFICE

FOREIGN PATENT DOCUMENTS

		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	NO

OTHER DOCUMENTS (including Author, Title, Date, Pertinent Pages, Etc.)

MJ		"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, October 8, 1993, pp. 1-8.
MJ		The Eureka 147 Project, Digital Audio Broadcasting System, DAB Project Office, Germany, pp. 1-11.
MJ		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.
MJ		Linnartz, Jean-Paul M.G. et al., "Wireless Communication", copyrighted 1995.
MJ		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.
MJ		Miller, John E., "Application of Coding and Diversity Coding to UHF Satellite Sound Broadcasting Systems", IEEE, pp. 465-475, copyright 1988.

EXAMINER [signature]	DATE CONSIDERED 4/30/04

*EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw Line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Issue Classification

Application No.	Applicant(s)
09/647,007	CAMPANELLA, S. JOSEPH
Examiner	**Art Unit**
Min Jung	2663

ISSUE CLASSIFICATION

ORIGINAL		CROSS REFERENCE(S)						
CLASS	SUBCLASS	CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)					
370	315	370	480					
INTERNATIONAL CLASSIFICATION		455	3.02	17				
H04B	7/155							
	/							
	/							
	/							
	/							

(Assistant Examiner) (Date)

Jay Dobbs 3/28/05
(Legal Instruments Examiner) (Date)

Min Jung
[illegible]
(Primary Examiner) (Date)

Total Claims Allowed: 26

O.G. Print Claim(s)	O.G. Print Fig.
1	3

☐ **Claims renumbered in the same order as presented by applicant** ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
	1	15	31		61		91		121		151		181
	2	16	32		62		92		122		152		182
	3	17	33		63		93		123		153		183
	4	18	34		64		94		124		154		184
	5		35		65		95		125		155		185
	6		36		66		96		126		156		186
	7		37		67		97		127		157		187
	8		38		68		98		128		158		188
	9		39		69		99		129		159		189
1	10		40		70		100		130		160		190
2	11		41		71		101		131		161		191
3	12	19	42		72		102		132		162		192
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	18		48		78		108		138		168		198
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23	21		51		81		111		141		171		201
24	22		52		82		112		142		172		202
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26	24		54		84		114		144		174		204
9	25		55		85		115		145		175		205
10	26		56		86		116		146		176		206
11	27		57		87		117		147		177		207
12	28		58		88		118		148		178		208
13	29		59		89		119		149		179		209
14	30		60		90		120		150		180		210

SEARCHED

Class	Sub.	Date	Exmr.
370	315		
	316	4/22/04	
	480		
	481	4/22/04	
	485	4/30/04	
455	3.01	5/17/04	
	3.02	5/18/04	
	3.06	5/19/04	
	11.1		
	12.1		
	7		
	16		
	17		
	427		
	430		
	118		
updated		3/18/05	mJ

INTERFERENCE SEARCHED

Class	Sub.	Date	Exmr.
370	315	3/18/05	mJ
	480		
455	3.02		
	17		

SEARCH NOTES
(INCLUDING SEARCH STRATEGY)

	Date	Exmr.
EAST	4/21-5/19/04	mJ
EAST	3/18/05	mJ

(RIGHT OUTSIDE)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	610	multicarrier adj modulation	US-PGPUB; USPAT	OR	ON	2005/03/18 09:18
L2	8124	mcm	US-PGPUB; USPAT	OR	ON	2005/03/18 09:18
L3	8685	1 or 2	US-PGPUB; USPAT	OR	ON	2005/03/18 09:18
L4	495	3.ab.	US-PGPUB; USPAT	OR	ON	2005/03/18 09:18
L5	893	terrestrial adj repeater	US-PGPUB; USPAT	OR	ON	2005/03/18 09:19
L6	13	5.ab.	US-PGPUB; USPAT	OR	ON	2005/03/18 09:19
L7	0	4 and 6	US-PGPUB; USPAT	OR	ON	2005/03/18 09:19
L8	0	4 and 5	US-PGPUB; USPAT	OR	ON	2005/03/18 09:19
L9	8727	satellite.ab.	US-PGPUB; USPAT	OR	ON	2005/03/18 09:19
L10	1	4 and 9	US-PGPUB; USPAT	OR	ON	2005/03/18 09:22
L11	12809	tdm	US-PGPUB; USPAT	OR	ON	2005/03/18 09:23
L12	46024	time adj division	US-PGPUB; USPAT	OR	ON	2005/03/18 09:23
L13	50973	11 or 12	US-PGPUB; USPAT	OR	ON	2005/03/18 09:23
L14	4604	13.ab.	US-PGPUB; USPAT	OR	ON	2005/03/18 09:23
L15	1	4 and 14	US-PGPUB; USPAT	OR	ON	2005/03/18 09:26
L16	27297	fourier adj transform	USPAT	OR	ON	2005/03/18 09:27
L17	31	4 and 16	USPAT	OR	ON	2005/03/18 09:27
L18	12	13 and 17	USPAT	OR	ON	2005/03/18 09:44
L19	538	370/315,480.ccls.	USPAT	OR	ON	2005/03/18 09:45
L20	1	4 and 19	USPAT	OR	ON	2005/03/18 09:46
L21	18	3 and 19	USPAT	OR	ON	2005/03/18 09:47
L22	0	9 and 21	USPAT	OR	ON	2005/03/18 09:46
L23	289	455/3.02,17.ccls.	USPAT	OR	ON	2005/03/18 09:47
L24	0	4 and 23	USPAT	OR	ON	2005/03/18 09:47
L25	5	3 and 23	USPAT	OR	ON	2005/03/18 09:47

PTO/SB/06 (08-03)
Approved for use through 7/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 91647007

CLAIMS AS FILED – PART I

FOR	NUMBER FILED (Column 1)	NUMBER EXTRA (Column 2)	SMALL ENTITY RATE	SMALL ENTITY FEE	OR	OTHER THAN SMALL ENTITY RATE	OTHER THAN SMALL ENTITY FEE
BASIC FEE (37 CFR 1.16(a))				$____	OR		$____
TOTAL CLAIMS (37 CFR 1.16(c))	minus 20 =	*	X $____ =		OR	X $____ =	
INDEPENDENT CLAIMS (37 CFR 1.16(b))	minus 3 =	*	X $____ =		OR	X $____ =	
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(d))			+ $____ =		OR	+ $____ =	
			TOTAL		OR	TOTAL	

* If the difference in column 1 is less than zero, enter "0" in column 2.

CLAIMS AS AMENDED – PART II

11·23·04

AMENDMENT A

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE	SMALL ENTITY ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	OTHER THAN SMALL ENTITY ADDITIONAL FEE
Total (37 CFR 1.16(c))	* 30	Minus	** 41	=	X $9 =		OR	X $18 =	
Independent (37 CFR 1.16(b))	* 7	Minus	*** 9	=	X $44 =		OR	X $88 =	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(d))					+ $150 =		OR	+ $300 =	
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE	SMALL ENTITY ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	OTHER THAN SMALL ENTITY ADDITIONAL FEE
Total (37 CFR 1.16(c))	*	Minus	**	=	X $____ =		OR	X $____ =	
Independent (37 CFR 1.16(b))	*	Minus	***	=	X $____ =		OR	X $____ =	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(d))					+ $____ =		OR	+ $____ =	
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT C

	CLAIMS REMAINING AFTER AMENDMENT (Column 1)		HIGHEST NUMBER PREVIOUSLY PAID FOR (Column 2)	PRESENT EXTRA (Column 3)	SMALL ENTITY RATE	SMALL ENTITY ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	OTHER THAN SMALL ENTITY ADDITIONAL FEE
Total (37 CFR 1.16(c))	*	Minus	**	=	X $____ =		OR	X $____ =	
Independent (37 CFR 1.16(b))	*	Minus	***	=	X $____ =		OR	X $____ =	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(d))					+ $____ =		OR	+ $____ =	
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Index of Claims	Application No. 9/647007	Applicant(s)	
	Examiner	Art Unit	

√	Rejected	–	(Through numeral) Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

Claim Final	Claim Original	Date	Claim Final	Claim Original	Date	Claim Final	Claim Original	Date
	1			51			101	
	2			52			102	
	3			53			103	
	4			54			104	
	5			55			105	
	6			56			106	
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	46			96			146	
	47			97			147	
	48			98			148	
	49			99			149	
	50			100			150	

U.S. Patent and Trademark Office

Part of Paper No.

Appl. No. 09/647,007
Amdt. Dated November 23, 2004, 2004
Reply to Office Action of May 25, 2004

40264

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	
S. Joseph Campanella	Group Art Unit: 2663
Serial No.: 09/647,007	Examiner: Min Jung
Filed: September 26, 2000	
For: Digital Broadcast System Using Satellite Direct Broadcast System and Terrestrial Repeater	

AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Office Action dated May 25, 2004, please amend the above-identified application as follows:

Claim amendments commence on page 2 herein; and

A remarks section commences on page 12 herein.

2663 41

PATENT

Case Docket No.: 40264

In re Application of: S. Joseph Campanella

Serial No.: 09/647,007

Filed: September 26, 2000

Patent Art Unit: 2663

Examiner: Jung, Min

For: DIGITAL BROADCAST SYSTEM USING SATELLITE DIRECT BROADCAST SYSTEM AND TERRESTRIAL REPEATER

OIPE JC177 NOV 2 3 2004 PATENT & TRADEMARK OFFICE

RECEIVED
NOV 2 6 2004
Technology Center 2600

COMMISSIONER FOR PATENTS
P.O. BOX 1450
ALEXANDRIA, VA 22313-1450

Transmitted herewith is an Amendment in the above-identified application:

☐ Small entity status of this application under 37 C.F.R. § 1.9 and 1.27 has been established by a verified statement previously submitted.

☐ A verified statement to establish small entity status under 37 C.F.R. § 1.9 and 1.27 is enclosed.

☐ No additional fee is required.

The fee has been calculated as shown below:

	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NO. PREVIOUSLY PAID FOR	PRESENT EXTRA	SMALL ENTITY RATE	SMALL ENTITY ADDIT. FEE $395.00	OTHER THAN A SMALL ENTITY RATE	OTHER THAN A SMALL ENTITY ADDIT. FEE $790.00
TOTAL	26	- 41 =	0	x 9 =	$	x 18 =	$
INDEP	7	- 9 =	0	x 44 =	$	x 88 =	$
☐FIRST PRESENTATION OF MULT. DEP. CLAIM				+ 150 =	$	+ 300 =	$
If the difference in Col. 1 is less than zero, enter "0" in Col. 2				TOTAL	$	TOTAL	$

☒ Applicant(s) petition(s) for an extension of 3 month(s) to respond and submits herewith the fee of $980.00.

☐ Please charge my Deposit Account No. 18-2220 in the amount of $_____. A duplicate copy of this sheet is attached.

☒ Two checks in the amount of **$870.00 and $110.00** are attached.

☒ The Commissioner is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to Deposit Account No. 18-2220. A duplicate copy of this sheet is attached.

- ☒ Any additional excess claim fees under 37 C.F.R. § 1.16.
- ☒ Any additional patent application processing fees under 37 C.F.R. § 1.17.

Dated: 23 November, 2004

Stacey J. Longanecker
Stacey J. Longanecker
Attorney of Record
Reg. No. 33,952

Roylance, Abrams, Berdo & Goodman, L.L.P.
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(202) 659-9076

11/24/2004 HTECKLU1 00000048 09647007
01 FC:1253 960.00 OP

Appl. No. 09/647,007
Amdt. Dated November 23, 2004, 2004
Reply to Office Action of May 25, 2004

40264

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	:	
S. Joseph Campanella	:	Group Art Unit: 2663
Serial No.: 09/647,007	:	Examiner: Min Jung
Filed: September 26, 2000	:	
For: Digital Broadcast System Using Satellite Direct Broadcast System and Terrestrial Repeater	:	

AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

In response to the Office Action dated May 25, 2004, please amend the above-identified application as follows:

Claim amendments commence on page 2 herein; and

A remarks section commences on page 12 herein.

2663
4
41

PATENT

Case Docket No.: **40264**

In re Application of: **S. Joseph Campanella**

Serial No.: **09/647,007**

Filed: **September 26, 2000**

For: **DIGITAL BROADCAST SYSTEM USING SATELLITE DIRECT BROADCAST SYSTEM AND TERRESTRIAL REPEATER**

Patent Art Unit: **2663**

Examiner: **Jung, Min**

OIPE JC177 NOV 2 3 2004 PATENT & TRADEMARK OFFICE

RECEIVED
NOV 2 6 2004
Technology Center 2600

COMMISSIONER FOR PATENTS
P.O. BOX 1450
ALEXANDRIA, VA 22313-1450

Transmitted herewith is an Amendment in the above-identified application:

☐ Small entity status of this application under 37 C.F.R. § 1.9 and 1.27 has been established by a verified statement previously submitted.

☐ A verified statement to establish small entity status under 37 C.F.R. § 1.9 and 1.27 is enclosed.

☐ No additional fee is required.

The fee has been calculated as shown below:

	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NO. PREVIOUSLY PAID FOR	PRESENT EXTRA	SMALL ENTITY RATE	SMALL ENTITY ADDIT. FEE $395.00	OTHER THAN A SMALL ENTITY RATE	OTHER THAN A SMALL ENTITY ADDIT. FEE $790.00
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INDEP	7	- 9 =	0	x 44 =	$	x 88 =	$
☐ FIRST PRESENTATION OF MULT. DEP. CLAIM				+ 150 =	$	+ 300 =	$
If the difference in Col. 1 is less than zero, enter "0" in Col. 2				TOTAL	$	TOTAL	$

☒ Applicant(s) petition(s) for an extension of 3 month(s) to respond and submits herewith the fee of $980.00.

☐ Please charge my Deposit Account No. 18-2220 in the amount of $_____. A duplicate copy of this sheet is attached.

☒ Two checks in the amount of **$870.00 and $110.00** are attached.

☒ The Commissioner is hereby authorized to charge payment of the following fees associated with this communication or credit any overpayment to Deposit Account No. 18-2220. A duplicate copy of this sheet is attached.

☒ Any additional excess claim fees under 37 C.F.R. § 1.16.

☒ Any additional patent application processing fees under 37 C.F.R. § 1.17.

Dated: 23 November, 2004

Stacey J. Longanecker
Stacey J. Longanecker
Attorney of Record
Reg. No. 33,952

Roylance, Abrams, Berdo & Goodman, L.L.P.
1225 Connecticut Avenue, N.W.
Washington, D.C. 20036-2680
(202) 659-9076

11/24/2004 HTECKLU1 00000048 09647007
01 FC:1253 980.00 OP

AMENDMENTS TO THE CLAIMS:

This listing of the claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

1. (Canceled)

2. (Canceled)

3. (Canceled)

4. (Canceled)

5. (Canceled)

6. (Canceled)

7. (Canceled)

8. (Canceled)

9. (Canceled)

10. (Original) A method for converting a time division multiplexed bit stream into a plurality of multicarrier modulated signals at a terrestrial repeater, comprising the steps of:

receiving said time division multiplexed bit stream from a satellite;

dividing said time division multiplexed bit stream into a plurality of parallel bit paths;

representing each of a predetermined number of bits in each of said plurality of bit paths as a symbol comprising an imaginary component and a real component;

providing said symbols to parallel inputs of an inverse Fourier transform converter as complex number frequency coefficient inputs to generate outputs which comprise modulated, narrow-band, orthogonal carriers; and

transmitting said modulated, narrow-band, orthogonal carriers from said terrestrial repeater.

11. (Original) A method as claimed in claim 10, further comprising the step of generating a guard interval for said carriers.

12. (Original) A method as claimed in claim 11, wherein said generating step comprises the steps of:

allocating a fraction of the symbol period corresponding to the duration of each of said symbols to guard time; and

reducing the duration of each of said symbols.

13. (Original) A method as claimed in claim 12, wherein said reducing step comprises the steps of:

storing said outputs of said inverse Fourier transform converter in a memory device every said symbol period; and

reading from said memory device after each said fraction of said symbol period has elapsed.

14. (Original) A method as claimed in claim 11, wherein said generating step further comprises the step of filling said guard interval with a subset of said outputs of said inverse Fourier transform.

15. (Original) A method as claimed in claim 10, further comprising the step of inserting a synchronization symbol every predetermined number of said symbol periods

to synchronize a sampling window corresponding to said fraction of said symbol period with respect to said carriers every said symbol period at a receiver for said plurality of multicarrier modulated signals.

16. (Original) A method as claimed in claim 10, further comprising the step of puncturing said time division multiplexed bit stream to reduce the total bandwidth associated with said carriers.

17. (Original) A method as claimed in claim 16, wherein said puncturing step comprises the step of selectively eliminating bits from said time division multiplexed bit stream prior to providing said symbols to parallel inputs of an inverse Fourier transform converter.

18. (Canceled)

19. (Canceled)

20. (Canceled)

21. (Currently Amended) A digital broadcasting system as claimed in claim [[18]]45, further comprising a second satellite configured to receive said broadcast signal from said earth station and to transmit a second time division multiplexed satellite signal comprising said broadcast signal, said second satellite signal being delayed with respect to said first satellite signal by a selected time delay.

22. (Original) A digital broadcasting system as claimed in claim 21, further comprising at least one radio receiver configured to receive said first satellite signal, said second satellite signal and said terrestrial signal, to delay at least one of said first satellite signal and said terrestrial signal in accordance with said selected time delay, and to

generate an output signal from at least one of said first satellite signal, said second satellite signal and said terrestrial signal.

23. (Original) A digital broadcasting system as claimed in claim 22, wherein said radio receiver comprises a diversity combiner and a switched combiner, said radio receiver using said diversity combiner to perform maximum likelihood decision combining of said first satellite signal and said second satellite signal and said switch combiner to select between the output of said diversity combiner and said terrestrial signal depending on which of said output of said diversity combiner and said terrestrial signal has the least number of bit errors.

24. (Original) A digital broadcasting system as claimed in claim 22, wherein said radio receiver comprises a diversity combiner to perform maximum likelihood decision combining of said first satellite signal, said second satellite signal and said terrestrial signal.

25. (Currently Amended) A receiver for receiving a broadcast signal in a combined satellite and terrestrial digital broadcasting system, comprising:

a first receiver arm for receiving a first satellite signal transmitted from a first satellite on a first carrier frequency, said first satellite signal comprising said broadcast signal and being modulated in accordance with at least one of time division multiplexing and code division multiplexing, said first receiver arm comprising a demodulator for recovering said broadcast signal;

a second receiver arm for receiving a terrestrial signal transmitted from a terrestrial station on a second carrier frequency, said terrestrial signal comprising said broadcast signal and being modulated in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing and multicarrier modulation, said second receiver arm comprising a demodulator for recovering said broadcast signal; and a combiner for generating an output signal from at least one of said [third]first satellite signal and said terrestrial signal.

26. (Original) A receiver as claimed in claim 25, further comprising:

a third receiver arm for receiving a second satellite signal from a second satellite that is delayed with respect to said first satellite signal in accordance with a selected time delay, said second satellite signal comprising said broadcast signal and being modulated in accordance with the corresponding at least one of time division multiplexing and code division multiplexing employed by said first satellite signal, said third receiver arm comprising a demodulator for recovering said broadcast signal; and

a delay device for delaying said first satellite signal in accordance with said selected time delay, said combiner generating an output signal from at least one of said first satellite signal, said second satellite signal and said terrestrial signal.

27. (Original) A method of transmitting a broadcast signal to a radio receiver, comprising the steps of:

modulating said broadcast signal for transmission to said radio receiver as a first signal in accordance with at least one of time division multiplexing and code division multiplexing;

transmitting said first signal to said radio receiver from a first satellite on a first carrier frequency;

modulating said broadcast signal at a terrestrial station for transmission to said radio receiver as a second signal in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing, and multicarrier modulation; and

transmitting said second signal to said radio receiver from said terrestrial station on a second carrier frequency that is different from said first carrier frequency.

28. (Original) A method as claimed in claim 27, wherein said step of modulating said broadcast signal as said second signal comprises the steps of:

receiving said first signal at said terrestrial station; and

performing baseband processing of said first signal prior to modulating in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing, and multicarrier modulation.

29. (Original) A method as claimed in claim 28, further comprising the step of receiving said first signal and said second signal using at said radio receiver.

30. (Original) A method as claimed in claim 29, further comprising the step of demodulating each of said first signal and said received second signal to remove said respective modulations and to recover a first recovered broadcast signal and a second recovered broadcast signal, respectively.

31. (Original) A method as claimed in claim 30, further comprising the steps of generating an output broadcast signal from said first recovered broadcast signal and said second recovered broadcast signal.

32. (Original) A method as claimed in claim 31, wherein said generating step comprises the step of performing maximum likelihood combining of said first recovered broadcast signal and said second recovered broadcast signal.

33. (Original) A method as claimed in claim 27, further comprising the steps of:

modulating a broadcast signal for transmission to said radio receiver as a third signal in accordance with at least one of time division multiplexing and code division multiplexing;

transmitting said third signal to said radio receiver from a second satellite, said transmission being delayed with respect to the transmission of said first signal by a predetermined period of time.

34. (Original) A method as claimed in claim 33, further comprising the steps of:

receiving said first signal, said second signal and said third signal at said radio receiver;

demodulating each of said first signal, said second signal and said third signal to remove said respective modulations and to recover a first recovered broadcast signal, a second recovered broadcast signal and a third recovered broadcast signal, respectively; and

generating an output broadcast signal from at least one of said first recovered broadcast signal, said second recovered broadcast signal and said third recovered broadcast signal.

35. (Withdrawn) An indoor reinforcement system for receiving satellite signals transmitted by a digital broadcasting system using a radio receiver located indoors, comprising:

a line of site antenna for receiving line of site satellite signals;

a radio frequency front-end unit connected to said line of site antenna for passing frequency spectrum comprising said satellite signals with low noise;

an indoor amplifier;

a cable for connecting said radio frequency front-end unit to said indoor amplifier; and

an indoor re-radiating antenna connected to said indoor amplifier, said indoor re-radiating antenna having a power level selected to be sufficiently high to achieve satisfactory indoor reception of said satellite signals at radio receivers at indoor locations where line of site reception of said satellite signals is not possible and sufficiently low to prevent interference by said satellite signals transmitted between said indoor re-radiating antenna and said line of site antenna.

36. (Withdrawn) An indoor reinforcement system as claimed in claim 35, wherein said satellite signals are characterized by a selected symbol period, and the duration of the transmission of said satellite signals between said line of site antenna and said indoor

re-radiating antenna is maintained to be less than a selected amount of said symbol duration by limiting the length of said cable.

37. (Withdrawn) An indoor reinforcement system as claimed in claim 36, wherein said duration of the transmission of said satellite signals between said line of site antenna and said indoor re-radiating antenna is no more than between 20 percent and 25 percent of said selected symbol period.

38. (Withdrawn) A reinforcement system for receiving satellite signals transmitted by a digital broadcasting system using a radio receiver located outdoors, wherein said satellite signals are characterized by a selected symbol period, said reinforcement system comprising at least two terrestrial repeaters, said terrestrial repeaters being characterized by a height h and being spaced apart by a distance d, the slant distance $(d^2 + h^2)^{1/2}$ from one of said terrestrial repeaters to said radio receiver being selected to limit a delay in reception of said satellite signals at said radio receiver from one of said terrestrial repeaters to between 20 percent and 25 percent of said symbol period.

39. (Canceled)

40. (Canceled)

41. (Canceled)

42. (New) A digital broadcasting system for transmitting a broadcast signal, said broadcast signal being transmitted from an earth station, comprising:

a satellite for receiving said broadcast signal from said earth station and for transmitting a satellite signal comprising said broadcast signal on a first carrier frequency; and

a terrestrial repeater for receiving said satellite signal and for generating and transmitting a terrestrial signal from said satellite signal comprising said broadcast signal on a second carrier frequency that is different from said first carrier frequency, said terrestrial signal being modulated by said terrestrial repeater in accordance with a multipath-tolerant modulation technique;

wherein said terrestrial repeater is operable to modulate said terrestrial signal using multicarrier modulation, and

said terrestrial repeater to operable to receive said satellite signal and to demodulate said satellite signal into a baseband signal prior to modulating said baseband signal using multicarrier modulation.

43. (New) A digital broadcasting system for transmitting a broadcast signal, said broadcast signal being transmitted from an earth station, comprising:

a satellite for receiving said broadcast signal from said earth station and for transmitting a satellite signal comprising said broadcast signal on a first carrier frequency;

a terrestrial repeater for receiving said satellite signal and for generating and transmitting a terrestrial signal from said satellite signal comprising said broadcast signal on a second carrier frequency that is different from said first carrier frequency, said terrestrial signal being modulated by said terrestrial repeater in accordance with a multipath-tolerant modulation technique; and

a second satellite operable to receive said broadcast program from said earth station and to transmit a second satellite signal comprising said broadcast signal on said first carrier frequency and delayed a predetermined period of time with respect to the transmission of the first satellite signal.

44. (New) A terrestrial repeater for retransmitting satellite signals to radio receivers, comprising:

a terrestrial receiver for receiving said satellite signals; and

a terrestrial waveform modulator for generating terrestrial signals from said satellite signals, said terrestrial signals being modulated by said terrestrial waveform modulator in accordance with multicarrier modulation;

wherein said satellite signals are transmitted from a satellite using a first carrier frequency, and said terrestrial waveform modulator is operable to transmit said terrestrial signals to said radio receivers using a second carrier frequency that is different from said first carrier frequency; and

wherein said terrestrial waveform modulator comprises

a time division demultiplexer for demultiplexing said satellite signals from a serial time division multiplexed bit stream into a plurality of parallel bit streams, and

an inverse fast Fourier transform device for generating a digital analog signal comprising a plurality of discrete Fourier transform coefficients.

45. (New) A digital broadcasting system for transmitting a broadcast signal, said broadcast signal being transmitted from an earth station, comprising:

a first satellite configured to receive said broadcast program from said earth station and to transmit a time division multiplexed satellite signal comprising said broadcast signal;

a terrestrial repeater configured to receive said satellite signal and to generate and transmit a terrestrial signal from said satellite signal comprising said broadcast signal, said terrestrial signal being modulated by said terrestrial repeater in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing and multicarrier modulation; and

at least one radio receiver configured to receive said satellite signal and said terrestrial signal, said radio receiver comprising a diversity combiner for generating an output signal from at least one of said satellite signal and said terrestrial signal.

REMARKS

Applicants note with appreciation the allowance of claims 10-17 and 27-24, the allowance of claims 5, 7, 9 and 20-24 if rewritten in independent form, and the allowance of claims 25 and 26 if claim 25 is amended to overcome the rejection under 35 U.S.C. § 112, second paragraph. By the present Amendment, claims 1-9, 18-20 and 39-41 have been canceled. Claim 25 has been amended to correct a typographical error and therefore to the rejection under 35 U.S.C. § 112, second paragraph. Claims 1, 4 and 5 have been rewritten and combined as new claim 42. Claims 1 and 7 have been rewritten and combined as new claim 43. Claims 8 and 9 have been rewritten and combined as new claim 44. Claims 18 and 20 have been rewritten and combined as new claim 45. Finally, claims 21 has been amended to change its dependency to another base claim.

In view of the above, it is believed that the application is in condition for allowance and notice to this effect is respectfully requested. Should the Examiner have any questions, the Examiner is invited to contact the undersigned at the telephone number indicated below.

Respectfully submitted,

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Dated: 23 November, 2004

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/647,007	09/26/2000	S. Joseph Campanella	40264	3843

7590 05/25/2004

John E Holmes
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EXAMINER	
JUNG, MIN	
ART UNIT	**PAPER NUMBER**
2663	7

DATE MAILED: 05/25/2004

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 10/03)

Office Action Summary	Application No. 09/647,007	Applicant(s) CAMPANELLA, S. JOSEPH	
	Examiner Min Jung	Art Unit 2663	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 26 September 2000.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-41 is/are pending in the application.

4a) Of the above claim(s) 35-38 is/are withdrawn from consideration.

5)☒ Claim(s) 10-17 and 27-34 is/are allowed.

6)☒ Claim(s) 1-4,6,8,18,19,25,26 and 39-41 is/are rejected.

7)☒ Claim(s) 5,7,9 and 20-24 is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☒ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date 4,6.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

1. Restriction is required under 35 U.S.C. 121 and 372.

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1.

In accordance with 37 CFR 1.499, applicant is required, in reply to this action, to elect a single invention to which the claims must be restricted.

Group I, claim(s) 1-34 and 39-41, drawn to broadcasting system including satellite and a terrestrial repeater, and covering functions performed at the repeater or at a radio receiver.

Group II, claim(s) 35-37, drawn to an indoor reinforcement system for receiving satellite signals with selective power level.

Group III, claim(s) 38, drawn to a reinforcement system for receiving satellite signals including at least two terrestrial repeaters characterized by certain height, distance, and the slant distance.

2. The inventions listed as Groups I, II, and III do not relate to a single general 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 II covers one area of satellite communication technology, which specifically covers the concept of power level selection for optimum performance, while Group III covers the specific distance relationship between two repeaters to control the delay in reception of satellite signals. Each of these distinct ideas is further distinct from the concept of invention in Group I, which covers the technique of frequency translation functions, signal conversion functions, and receiver functions.

3. During a telephone conversation with Mr. John Holms on April 23 and 29, 2004 a provisional election was made without traverse to prosecute the invention of I, claims 1-34 and 39-41. Affirmation of this election must be made by applicant in replying to this

Office action. Claims 35-38 are withdrawn from further consideration by the examiner, 37 CFR 1.142(b), as being drawn to a non-elected invention.

Claim Rejections - 35 USC § 112

4. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

5. Claims 25-26 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

In claim 25, line 14, "said third satellite signal" lacks antecedent basis.

Claim Rejections - 35 USC § 103

6. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

7. Claims 1-4, 6, 39, and 40 are rejected under 35 U.S.C. 103(a) as being unpatentable over Lee, US 5,081,703.

Lee discloses a Satellite mobile communication system for rural service areas. Lee teaches that the satellite (130) receives communication signals transmitted from earth stations (cell sites and remote converter sites) and transmits the communication signals on a first carrier frequency (SHF); and a terrestrial repeater for receiving the satellite signal and for generating and transmitting a terrestrial signal from the satellite signal on a second carrier frequency that is different from the first carrier frequency. The terrestrial signal is modulated by the terrestrial repeater in accordance with a modulation technique (the signal is fed to the mixer 402 and the filter 433 before being transmitted, the process of which read on the signal modulation). See col. 5, line 36 – col. 6, line 8. The signal modulated to be transmitted on UHF band would inherently be a multipath-tolerant modulation technique because any kind of radio transmission has to fight the multipath effect. What Lee fails to specifically teach is the broadcast signal. Lee's system is generally for a mobile communication using communication satellite, and therefore does not include specific detail of broadcasting using the disclosed system. However, broadcasting is just one form of communication, and can be applied using the mobile communication system taught by Lee. That is, it would have been obvious for one of ordinary skill in the art at the time of the invention to implement the system of Lee by making the signals transmitted by the cell site 140 a broadcast signal to be broadcast to the remote cell sites.

Further, Lee fails to teach specific modulation technique. However, it would have been obvious for one of ordinary skill in the art at the time of the invention to employ any of the available modulation techniques to properly modulate the signals for radio transmission since the recited modulation technique are well known and widely used in radio communication environment including satellite and terrestrial communication systems.

8. Claims 8, 18, 19, and 41 is rejected under 35 U.S.C. 103(a) as being unpatentable over Lee in view of Hulyalkar et al., US 5,291,289 (Hulyalkar).

Lee, as summarized above, fails to specifically teach multicarrier modulation for generating the terrestrial signal. However, multicarrier modulation is a common form of modulation adopted in terrestrial broadcasting, as evidenced by the patent to Hulyalkar. Hulyalkar teaches a technique for modulating and demodulating an MCM television signal in HDTV terrestrial broadcasting environment. Therefore, it would have been obvious for one of ordinary skill in the art at the time of the invention to implement Lee's system so as to modulate the signals according to multicarrier modulation as taught by Hulyalkar in order to generate a modulated signal for transmission on radio link.

Allowable Subject Matter

9. Claims 10-17, 27-34 are allowed.

10. Claims 5, 7, 9, and 20-24 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

11. Claims 25-26 would be allowable if rewritten or amended to overcome the rejection(s) under 35 U.S.C. 112, second paragraph, set forth in this Office action.

Conclusion

12. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. The McGann patent, the Sykes et al. patent, the Campanella

patent, the Leslie et al. patent, the Yi patents, the Briskman et al. patent, the Wiedeman patents, the Dent patent, and the Stewart et al. patent, are cited for further references.

13. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Min Jung whose telephone number is 703-305-4363. The examiner can normally be reached on Monday-Friday, 7AM-3PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Chau Nguyen can be reached on 703-308-5340. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Min Jung
Primary Examiner

MJ
May 19, 2004

Notice of References Cited	Application/Control No. 09/647,007	Applicant(s)/Patent Under Reexamination CAMPANELLA, S. JOSEPH	
	Examiner Min Jung	Art Unit 2663	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
	A	US-5,081,703	01-1992	Lee, William C. Y.	455/13.1
	B	US-5,291,289	03-1994	Hulyalkar et al.	348/723
	C	US-4,506,383	03-1985	McGann, William E.	455/17
	D	US-5,784,418	07-1998	Sykes et al.	375/347
	E	US-6,249,514	06-2001	Campanella, S. Joseph	370/316
	F	US-6,404,775	06-2002	Leslie et al.	370/466
	G	US-5,970,085	10-1999	Yi, Byung Kwan	370/342
	H	US-6,061,387	05-2000	Yi, Byung Kwan	375/142
	I	US-5,485,485	01-1996	Briskman et al.	375/130
	J	US-5,640,386	06-1997	Wiedeman, Robert A.	370/320
	K	US-6,233,463	05-2001	Wiedeman et al.	455/552.1
	L	US-5,848,060	12-1998	Dent, Paul W.	370/281
	M	US-5,930,708	07-1999	Stewart et al.	455/428

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	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
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	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Form PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE INFORMATION DISCLOSURE CITATION (Use several sheets if necessary)	ATTY. DOCKET NO. 40264	SERIAL NO. 09/647,007
	APPLICANT S. Joseph Campanella	
	FILING DATE September 26, 2000	GROUP 2663

U.S. PATENT DOCUMENTS

EXAMINER INITIAL		DOCUMENT NUMBER	DATE	NAME	CLASS	SUBCLASS	FILING DATE IF APPROPRIATE
		5 6 1 3 1 9 4	03/1997	Olds et al.	455	12.1	

OIPE JC152 SEP 18 2001 PATENT & TRADEMARK OFFICE

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		DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUBCLASS	TRANSLATION YES	TRANSLATION NO

OTHER DOCUMENTS (including Author, Title, Date, Pertinent Pages, Etc.)

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

EXAMINER [signature] DATE CONSIDERED 4/30/04

*EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw Line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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APPLICANT S. Joseph Campanella

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GROUP

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		4 3 8 5 3 8 1	05/1983	Alexis	370	69.1	
		5 5 5 0 8 1 2	08/1996	Philips	370	19	
		5 4 5 0 4 5 6	09/1995	Mueller	375	224	
		5 4 5 4 0 0 9	09/1995	Fruit et al.	375	202	
		5 2 8 3 7 8 0	02/1994	Schuchman et al.	370	50	
		4 9 0 1 3 0 7	02/1990	Gilhousen et al.	370	18	
		5 5 7 4 9 7 0	11/1996	Linquist et al.	455	13.1	
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MJ		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).
MJ		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.
MJ		F.C.C. Application of Satellite CD Radio, Inc. for Private CD Quality Satellite Sound Broadcasting System, May 18, 1990.
MJ		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.
MJ		Principles for the Guidance of EBU Members for WARC-92 Broadcasting-Satellite Service, European Broadcasting Union, February 1991 Draft SPB 483-E, pp. 1-75.

EXAMINER [signature] DATE CONSIDERED 4/30/04

*EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw Line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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mj		Le Floch et al., "Digital Sound Broadcasting to Mobile Receivers", IEEE, Transactions on Consumer Electronics, August 1989, Vol. 35, No. 3, pp. 493-503.
mj		"Proceedings from Second International Symposium on Digital Audio Broadcasting: The Sound of 2000", Toronto, Canada, March 14-17, 1994, Vol. I, pp. 158-181 and Vol. II, pp. 63-108 and pp. 240-248.
mj		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", November 1, 1994.
mj		Introduction of Satellite in Complimentary Terrestrial Digital Sound Broadcasting in the WARC-92 Frequency Allocations, International Telecommunication Union, Document 10/30-E, February 22, 1995, pp. 1-17.
mj		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, January 1998, pp. 11-69.

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Form PTO-1449 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 40264	SERIAL NO. 09/647,007
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MJ		The Eureka 147 Project, Digital Audio Broadcasting System, DAB Project Office, Germany, pp. 1-11.
MJ		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.
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MJ		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.
MJ		Miller, John E., "Application of Coding and Diversity Coding to UHF Satellite Sound Broadcasting Systems", IEEE, pp. 465-475, copyright 1988.

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*EXAMINER: Initial if citation considered, whether or not citation is in conformance with MPEP 609; Draw Line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

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1	1	4506383.pn.	USPAT	2004/05/19 08:33
2	20	4506383.URPN.	USPAT	2004/05/19 08:33
3	88	5081703.URPN.	USPAT	2004/05/19 08:49
4	6138	satellite.ab.	USPAT	2004/05/19 08:49
6	6585	broadcast$.ab.	USPAT	2004/05/19 08:50
7	3	(5081703.URPN. and satellite.ab.) and broadcast$.ab.	USPAT	2004/05/19 08:50
5	68	5081703.URPN. and satellite.ab.	USPAT	2004/05/19 09:00
8	12310	digital adj audio	USPAT	2004/05/19 09:00
9	1123	8.ab.	USPAT	2004/05/19 09:00
10	1208	dar	USPAT	2004/05/19 09:00
11	12	10.ab.	USPAT	2004/05/19 09:00
12	1134	8.ab. or 10.ab.	USPAT	2004/05/19 09:00
13	31	satellite.ab. and (8.ab. or 10.ab.)	USPAT	2004/05/19 09:00

L Number	Hits	Search Text	DB	Time stamp
1	805	370/466.ccls.	USPAT	2004/05/18 08:37
2	6138	satellite.ab.	USPAT	2004/05/18 08:37
3	15	370/466.ccls. and satellite.ab.	USPAT	2004/05/18 08:43
4	115	370/481.ccls.	USPAT	2004/05/18 08:44
5	1	satellite.ab. and 370/481.ccls.	USPAT	2004/05/18 08:44
6	386	370/485,486.ccls.	USPAT	2004/05/18 08:44
7	14	satellite.ab. and 370/485,486.ccls.	USPAT	2004/05/18 08:44

L Number	Hits	Search Text	DB	Time stamp
1	314	455/3.01,3.02,3.06.ccls.	USPAT	2004/05/17 09:57
2	16200	baseband	USPAT	2004/05/17 09:58
3	1057	remodulat$	USPAT	2004/05/17 09:58
4	222	baseband same remodulat$	USPAT	2004/05/17 09:58
5	1	455/3.01,3.02,3.06.ccls. and (baseband same remodulat$)	USPAT	2004/05/17 10:01
6	254443	modulat$	USPAT	2004/05/17 10:01
7	7878	baseband same modulat$	USPAT	2004/05/17 10:01
8	15	455/3.01,3.02,3.06.ccls. and (baseband same modulat$)	USPAT	2004/05/17 11:21
9	702	7.ab.	USPAT	2004/05/17 10:01
10	2	455/3.01,3.02,3.06.ccls. and 7.ab.	USPAT	2004/05/17 10:03
11	695	terrestrial.ab.	USPAT	2004/05/17 10:03
12	10	455/3.01,3.02,3.06.ccls. and terrestrial.ab.	USPAT	2004/05/17 10:10
13	30694	second adj2 frequency	USPAT	2004/05/17 10:11
14	3014	13.ab.	USPAT	2004/05/17 10:11
15	5	455/3.01,3.02,3.06.ccls. and 13.ab.	USPAT	2004/05/17 10:14
16	301	multicarrier adj modulation	USPAT	2004/05/17 10:15
17	2	455/3.01,3.02,3.06.ccls. and (multicarrier adj modulation)	USPAT	2004/05/17 10:15
18	804	455/12.1.ccls.	USPAT	2004/05/17 10:16
19	14	(baseband same remodulat$) and 455/12.1.ccls.	USPAT	2004/05/17 10:16
20	78	(baseband same modulat$) and 455/12.1.ccls.	USPAT	2004/05/17 11:22
21	4	7.ab. and ((baseband same modulat$) and 455/12.1.ccls.)	USPAT	2004/05/17 11:36
22	19	("3789142" | "3917998" | "4105973" | "4145573" | "4425639" | "4450582" | "4831619" | "4901310" | "4931802" | "5073930" | "5111534" | "5119504" | "5161248" | "5191594" | "5249181" | "5303393" | "5343512" | "5363428" | "5473601").PN.	USPAT	2004/05/17 11:30
23	70	terrestrial.ab. and 455/12.1.ccls.	USPAT	2004/05/17 11:36
24	1752	transponder.ab.	USPAT	2004/05/17 11:36
25	0	(terrestrial.ab. and 455/12.1.ccls.) and transponder.ab.	USPAT	2004/05/17 11:36
26	1	13.ab. and (terrestrial.ab. and 455/12.1.ccls.)	USPAT	2004/05/17 11:38
27	0	(multicarrier adj modulation) and 455/12.1.ccls.	USPAT	2004/05/17 11:38
28	492	455/427,430.ccls.	USPAT	2004/05/17 11:39
29	0	7.ab. and 455/427,430.ccls.	USPAT	2004/05/17 11:39
30	70	terrestrial.ab. and 455/427,430.ccls.	USPAT	2004/05/17 11:40
31	1920	repeater.ab.	USPAT	2004/05/17 11:40
32	1	(terrestrial.ab. and 455/427,430.ccls.) and repeater.ab.	USPAT	2004/05/17 11:47
33	2	("6108364" | "6275475").PN.	USPAT	2004/05/17 11:41
34	0	(multicarrier adj modulation) and 455/427,430.ccls.	USPAT	2004/05/17 11:48
35	361	455/7,16,17.ccls.	USPAT	2004/05/17 11:49
36	6126	satellite.ab.	USPAT	2004/05/17 11:52
37	30	455/7,16,17.ccls. and satellite.ab.	USPAT	2004/05/17 11:49
38	4	7.ab. and 455/7,16,17.ccls.	USPAT	2004/05/17 11:53
39	1671	455/3.01,3.02,3.06.ccls. or 455/12.1.ccls. or 455/427,430.ccls. or 455/7,16,17.ccls.	USPAT	2004/05/17 12:05
40	446	terrestrial adj repeater	USPAT	2004/05/17 11:55
41	9	40.ab.	USPAT	2004/05/17 12:03
42	10	("5278863" | "5319673" | "5485485" | "5592471" | "5748686" | "5757767" | "5794138" | "6038263" | "6175587" | "6272168").PN.	USPAT	2004/05/17 11:59
43	651	ground adj relay	USPAT	2004/05/17 12:03
44	15	43.ab.	USPAT	2004/05/17 12:04
45	3753	ground adj station	USPAT	2004/05/17 12:04
46	477	45.ab.	USPAT	2004/05/17 12:04
47	65	(455/3.01,3.02,3.06.ccls. or 455/12.1.ccls. or 455/427,430.ccls. or 455/7,16,17.ccls.) and 45.ab.	USPAT	2004/05/17 12:05

48	61	satellite.ab. and ((455/3.01,3.02,3.06.ccls. or 455/12.1.ccls. or 455/427,430.ccls. or 455/7,16,17.ccls.) and 45.ab.)	USPAT	2004/05/17 12:19
49	1752	transponder.ab.	USPAT	2004/05/17 12:19
50	37	(455/3.01,3.02,3.06.ccls. or 455/12.1.ccls. or 455/427,430.ccls. or 455/7,16,17.ccls.) and transponder.ab.	USPAT	2004/05/17 12:20

	Type	Hits	Search Text	DBs
1	BRS	129	multicarrier.ab.	USPAT
2	BRS	1003	multi adj carrier	USPAT
3	BRS	132	2.ab.	USPAT
4	BRS	4896	mcm	USPAT
5	BRS	346	4.ab.	USPAT
6	BRS	606	multicarrier.ab. or 2.ab. or 4.ab.	USPAT
7	BRS	34857	fourier	USPAT
8	BRS	149	(multicarrier.ab. or 2.ab. or 4.ab.) and fourier	USPAT
9	BRS	45121	satellite	USPAT
10	BRS	24	((multicarrier.ab. or 2.ab. or 4.ab.) and fourier) and satellite	USPAT
11	BRS	6103	9.ab.	USPAT
12	BRS	692	terrestrial.ab.	USPAT
13	BRS	6475	9.ab. or terrestrial.ab.	USPAT
14	BRS	8	(multicarrier.ab. or 2.ab. or 4.ab.) and (9.ab. or terrestrial.ab.)	USPAT
15	BRS	0	terretrial adj repeater	USPAT
16	BRS	441	terrestrial adj repeater	USPAT
17	BRS	9	16.ab.	USPAT
18	BRS	10	("5278863" | "5319673" | "5485485" | "5592471" | "5748686" | "5757767" | "5794138" | "6038263" | "6175587" | "6272168").PN.	USPAT

	Time Stamp	Comments	Error Definition	Errors
1	2004/04/30 09:26			0
2	2004/04/30 09:26			0
3	2004/04/30 09:27			0
4	2004/04/30 09:27			0
5	2004/04/30 09:27			0
6	2004/04/30 09:27			0
7	2004/04/30 09:27			0
8	2004/04/30 09:27			0
9	2004/04/30 09:27			0
10	2004/04/30 09:47			0
11	2004/04/30 09:52			0
12	2004/04/30 09:52			0
13	2004/04/30 09:52			0
14	2004/04/30 10:38			0
15	2004/04/30 12:35			0
16	2004/04/30 12:35			0
17	2004/04/30 12:35			0
18	2004/04/30 12:37			0

L Number	Hits	Search Text	DB	Time stamp
1	3160	digital adj2 broadcast$	USPAT	2004/04/22 09:53
2	344	1.ab.	USPAT	2004/04/22 09:53
3	6091	satellite.ab.	USPAT	2004/04/22 09:53
4	61	1.ab. and satellite.ab.	USPAT	2004/04/22 09:54
5	142799	modulation	USPAT	2004/04/22 14:43
6	31	(1.ab. and satellite.ab.) and modulation	USPAT	2004/04/22 09:55
7	253264	modulat$	USPAT	2004/04/22 09:55
8	39	(1.ab. and satellite.ab.) and modulat$	USPAT	2004/04/22 10:50
9	3738	ground adj station	USPAT	2004/04/22 10:51
10	474	9.ab.	USPAT	2004/04/22 10:51
11	253	satellite.ab. and 9.ab.	USPAT	2004/04/22 10:51
12	152	modulat$ and (satellite.ab. and 9.ab.)	USPAT	2004/04/22 10:52
13	43262	7.ab.	USPAT	2004/04/22 10:52
14	18	(modulat$ and (satellite.ab. and 9.ab.)) and 7.ab.	USPAT	2004/04/22 14:20
15	688	370/480,481,485.ccls.	USPAT	2004/04/22 12:57
16	3	1.ab. and 370/480,481,485.ccls.	USPAT	2004/04/22 13:19
17	344	370/315,316.ccls.	USPAT	2004/04/22 14:22
18	21	7.ab. and 370/315,316.ccls.	USPAT	2004/04/22 13:20
19	13	("5272525" | "5299264" | "5319716" | "5349386" | "5410735" | "5477539" | "5491839" | "5581617" | "5619582" | "5666658" | "5768696" | "6067039" | "6137995").PN.	USPAT	2004/04/22 13:25
20	0	6256303.URPN.	USPAT	2004/04/22 13:26
21	0	6256303.URPN.	USPAT	2004/04/22 13:26
22	7	("5745839" | "5915210" | "5963587" | "6049561" | "6115366" | "6154452" | "6247158").PN.	USPAT	2004/04/22 13:36
23	298	multicarrier adj modulation	USPAT	2004/04/22 14:21
24	181	multi adj carrier adj modulation	USPAT	2004/04/22 14:21
25	420	(multicarrier adj modulation) or (multi adj carrier adj modulation)	USPAT	2004/04/22 14:21
26	4881	mcm	USPAT	2004/04/22 14:21
27	5259	((multicarrier adj modulation) or (multi adj carrier adj modulation)) or mcm	USPAT	2004/04/22 14:21
28	2	370/315,316.ccls. and (((multicarrier adj modulation) or (multi adj carrier adj modulation)) or mcm)	USPAT	2004/04/22 14:27
29	1371	retransmi$.ab.	USPAT	2004/04/22 14:28
30	7	370/480,481,485.ccls. and retransmi$.ab.	USPAT	2004/04/22 14:33
31	30	370/480,481,485.ccls. and (((multicarrier adj modulation) or (multi adj carrier adj modulation)) or mcm)	USPAT	2004/04/22 14:33
32	30	(370/480,481,485.ccls. and (((multicarrier adj modulation) or (multi adj carrier adj modulation)) or mcm)) not (370/315,316.ccls. and (((multicarrier adj modulation) or (multi adj carrier adj modulation)) or mcm))	USPAT	2004/04/22 14:39
33	0	455/3.2.ccls.	USPAT	2004/04/22 14:42
34	87	455/3.02.ccls.	USPAT	2004/04/22 14:42
35	7	7.ab. and 455/3.02.ccls.	USPAT	2004/04/22 14:45
36	111	remodulat$.ab.	USPAT	2004/04/22 14:45
37	0	455/3.02.ccls. and remodulat$.ab.	USPAT	2004/04/22 14:45
38	396	455/427.ccls.	USPAT	2004/04/22 14:45
39	0	remodulat$.ab. and 455/427.ccls.	USPAT	2004/04/22 14:46
40	315	455/11.1,11.2.ccls.	USPAT	2004/04/22 14:46
41	0	remodulat$.ab. and 455/11.1,11.2.ccls.	USPAT	2004/04/22 14:46
42	392	455/118,190.1.ccls.	USPAT	2004/04/22 14:47
43	0	remodulat$.ab. and 455/118,190.1.ccls.	USPAT	2004/04/22 14:47
44	770	455/3.02.ccls. or 455/427.ccls. or 455/11.1,11.2.ccls.	USPAT	2004/04/22 14:48
45	0	remodulat$.ab. and (455/3.02.ccls. or 455/427.ccls. or 455/11.1,11.2.ccls.)	USPAT	2004/04/22 14:49
46	1913	repeater.ab.	USPAT	2004/04/22 14:49
47	2368	9.ab. or repeater.ab.	USPAT	2004/04/22 14:49
48	112	(455/3.02.ccls. or 455/427.ccls. or 455/11.1,11.2.ccls.) and (9.ab. or repeater.ab.)	USPAT	2004/04/22 14:50
49	6523	broadcast$.ab.	USPAT	2004/04/22 14:50

50	12	((455/3.02.ccls. or 455/427.ccls. or 455/11.1,11.2.ccls.) and (9.ab. or repeater.ab.)) and broadcast$.ab.	USPAT	2004/04/22 15:14
51	13	("4276653" | "4906989" | "5056152" | "5278990" | "5301354" | "5363426" | "5404569" | "5446924" | "5475863" | "5506886" | "5519761" | "5543785" | "5574970").PN.	USPAT	2004/04/22 15:12
52	107014	frequency.ab.	USPAT	2004/04/22 15:16
53	80	370/315,316.ccls. and frequency.ab.	USPAT	2004/04/22 15:17
54	158527	different.ab.	USPAT	2004/04/22 15:17
55	21	(370/315,316.ccls. and frequency.ab.) and different.ab.	USPAT	2004/04/22 15:18
56	3	("5640386" | "5732076" | "5878343").PN.	USPAT	2004/04/22 15:41

L Number	Hits	Search Text	DB	Time stamp
1	437	terrestrial adj repeater	USPAT	2004/04/21 10:53
2	8	1.ab.	USPAT	2004/04/21 11:55
3	7	("5745839" | "5915210" | "5963587" | "6049561" | "6115366" | "6154452" | "6247158").PN.	USPAT	2004/04/21 11:48
4	346	mcm.ab.	USPAT	2004/04/21 11:58
5	298	multicarrier adj modulation	USPAT	2004/04/21 11:58
6	30	5.ab.	USPAT	2004/04/21 11:59
7	375	mcm.ab. or 5.ab.	USPAT	2004/04/21 11:59
8	44991	satellite	USPAT	2004/04/21 12:00
9	6091	8.ab.	USPAT	2004/04/21 12:00
10	0	(mcm.ab. or 5.ab.) and 8.ab.	USPAT	2004/04/21 12:00
11	15	(mcm.ab. or 5.ab.) and satellite	USPAT	2004/04/21 12:02
12	999	multi adj carrier	USPAT	2004/04/21 12:02
13	131	12.ab.	USPAT	2004/04/21 12:03
14	3	8.ab. and 12.ab.	USPAT	2004/04/21 12:46
15	145	370/315.ccls.	USPAT	2004/04/21 12:46
16	2	(terrestrial adj repeater) and 370/315.ccls.	USPAT	2004/04/21 12:48
17	0	(multicarrier adj modulation) and 370/315.ccls.	USPAT	2004/04/21 12:50
18	2	multipath adj tolerant	USPAT	2004/04/21 13:26
19	142799	tolerant adj 1.ab. modulation	USPAT	2004/04/21 13:27
20	7	tolerant adj2 modulation	USPAT	2004/04/21 13:30
21	53217	ground.ab.	USPAT	2004/04/21 13:31
22	668	8.ab. and ground.ab.	USPAT	2004/04/21 13:32
23	15169	modulation.ab.	USPAT	2004/04/21 13:32
24	13	(8.ab. and ground.ab.) and modulation.ab.	USPAT	2004/04/21 14:51
25	43	reradiation.ab.	USPAT	2004/04/21 14:52
26	592	retransmission.ab.	USPAT	2004/04/21 14:51
27	97	re-transmission.ab.	USPAT	2004/04/21 14:51
28	34	re-radiation.ab.	USPAT	2004/04/21 14:52
29	765	reradiation.ab. or retransmission.ab. or re-transmission.ab. or re-radiation.ab.	USPAT	2004/04/21 14:53
30	47	8.ab. and (reradiation.ab. or retransmission.ab. or re-transmission.ab. or re-radiation.ab.)	USPAT	2004/04/21 15:11
31	43262	modulat$.ab.	USPAT	2004/04/21 15:11
32	9	(8.ab. and (reradiation.ab. or retransmission.ab. or re-transmission.ab. or re-radiation.ab.)) and modulat$.ab.	USPAT	2004/04/21 15:11

#6
BA 9/22/01

57

40264 PATENT

OIPE JC152 SEP 1 8 2001 PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	:	
	:	
S. Joseph Campanella	:	Group Art Unit: 2663
	:	
Serial No.: 09/647,007	:	Examiner:
	:	
Filed: September 26, 2000	:	
	:	
For: Digital Broadcast System Using Satellite Direct Broadcast System and Terrestrial Repeater	:	

RECEIVED SEP 2 0 2001 Technology Center 2600

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Submitted herewith for consideration by the Examiner pursuant to 37 C.F.R. §§1.56, 1.97 and 1.98 are copies of the items listed in the attached Form PTO-1449. The Examiner's consideration and acknowledgement of these items is respectfully requested.

Respectfully submitted,

John E. Holmes

John E. Holmes
Reg. No. 29,392

Roylance, Abrams, Berdo & Goodman, L.L.P.
1300 19th Street N.W., Suite 600
Washington, D.C. 20036
(202) 659-9076

Dated: September 18, 2001

2663

40264 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of :

Joseph S. Campanella : Group Art Unit: 2663

Serial No.: 09/647,007 :

Filed: September 26, 2000 :

For: Digital Broadcast System Using Satellite Direct Broadcast and Terrestrial Repeater :

REQUEST FOR RETENTION OF DISCLOSURE DOCUMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Reference is made to the following Disclosure Document which contains subject matter related to that disclosed and claimed in the present application:

Number:	456952
Title:	Satellite Mobile Time Diversity On-Board
Date of Deposit:	May 24, 1999

In view of the filing of the present application, it is requested that the Disclosure Document identified above be designated for permanent retention. A copy of the Disclosure Document is attached for reference purposes.

Respectfully submitted,

Stacey J. Longanecker
Reg. No. 33,952

Roylance, Abrams, Berdo & Goodman, L.L.P.
1225 Connecticut Avenue, N.W.
Washington, D.C. 20036
(202) 659-9076

Dated: 24 May 2001

WORLDSPACE
CORPORATION

DISCLOSURE DOCUMENT NO.

456952

FILING FEE: $10.00
RETAINED FOR 2 YEARS
THIS IS NOT A PATENT APPLICATION
PTO-1652 (4/96)

OIPE JC181
MAY 24 2001
PATENT & TRADEMARK OFFICE

May 24, 1999

RECEIVED
MAY 29 2001
Technology Center 2600

Commissioner of Patents and Trademarks
Washington, D.C. 20231

Re: Submission of Disclosure Document
for "Satellite Mobile Time Diversity On Board"

Dear Sir:

The undersigned, S. Joseph Campanella and D.K. Sachdev, assignors to WorldSpace Corporation, request that the attached papers be accepted under the Disclosure Document Program and that they be preserved for a period of two (2) years.

A check in the amount of $10.00 is attached to cover the required fee. Also attached is a stamped, pre-addressed envelope for use by the U.S. Patent and Trademark Office in acknowledging receipt of this document.

Please send the acknowledgement of filing and any other correspondence relating to this Disclosure Document, to counsel for WorldSpace at the following address: John E. Holmes, Roylance, Abrams, Berdo & Goodman, L.L.P., 1225 Connecticut Avenue, N.W., Washington, D.C. 20036-2680.

Respectfully submitted,

S. Joseph Campanella

D.K. Sachdev

Enclosures

2400 N Street, NW Washington, D.C. 20037 USA Tel: 202 969 6000 Fax: 202 969 6001 www.worldspace.com

2663

#4

40264 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of :

S. Joseph Campanella : Group Art Unit: 2663

Serial No.: 09/647,007

Filed: September 26, 2000

For: Digital Broadcast System Using Satellite Direct Broadcast System and Terrestrial Repeater

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Submitted herewith for consideration by the Examiner pursuant to 37 C.F.R. §§1.56, 1.97 and 1.98 are copies of the items listed in the attached Form PTO-1449. The Examiner's consideration and acknowledgement of these items is respectfully requested.

Respectfully submitted,

Stacey J. Longanecker
Reg. No. 33,952

Roylance, Abrams, Berdo & Goodman, L.L.P.
1300 19th Street N.W., Suite 600
Washington, D.C. 20036
(202) 659-9076

Dated: 7 March 2001

GP2661

40264 PATENT

#3

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:	
	:	
Joseph S. Campanella	:	Group Art Unit:
	:	
Serial No.: 09/647,007	:	
	:	
Filed: September 26, 2000	:	
	:	
For: Digital Broadcast System Using Satellite Direct Broadcast and Terrestrial Repeater	:	

REQUEST FOR RETENTION OF DISCLOSURE DOCUMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Reference is made to the following Disclosure Document which contains subject matter related to that disclosed and claimed in the present application:

Number:	447705
Title:	Eureka + Worldspace Mobile
Date of Deposit:	November 24, 1998

In view of the filing of the present application, it is requested that the Disclosure Document identified above be designated for permanent retention. A copy of the Disclosure Document is attached for reference purposes.

Respectfully submitted,

Stacey J. Longanecker

Stacey J. Longanecker
Reg. No. 33,952

Roylance, Abrams, Berdo & Goodman, L.L.P.
1225 Connecticut Avenue, N.W.
Washington, D.C. 20036
(202) 659-9076

Dated: 22 November 2000

WorldSpace Corporation

DISCLOSURE DOCUMENT NO.

447705

FILING FEE: $10.00
RETAINED FOR 2 YEARS
THIS IS NOT A PATENT APPLICATION

PTO-1652 (4/96)

Doc'd ___ File ___
Rec'd
DEC 4 1998
ROYLANCE, ABRAMS
BERDO & GOODMAN, L.L.P.
BY ___

November 24, 1998

Commissioner of Patents and Trademarks
Washington, D.C. 20231

Re: Submission of Disclosure Document for "Eureka + WorldSpace Mobile"

Dear Sir:

The undersigned, S. Joseph Campanella, assignor to WorldSpace Corporation, requests that the attached paper be accepted under the Disclosure Document program and that it be preserved for a period of (2) years.

A check in the amount of $10.00 is attached to cover the required fee. Also attached is a stamped, pre-addressed envelope for use by the U.S. Patent and Trademark Office in acknowledging receipt of this document.

Please send the acknowledgment of filing, and any other correspondence relating to this Disclosure Document, to counsel for Worldspace at the following address: John E. Holmes, Roylance, Abrams, Berdo & Goodman, L.L.P., 1225 Connecticut Avenue, N.W., Suite 315, Washington, DC 20036.

Respectfully submitted,

S. Joseph Campanella

2400 N Street, NW Washington, D.C. 20037 USA Tel: 202 969 6000 Fax: 202 969 6001 www.worldspace.com

09/647007

FE

UNITED STATES DEPARTMENT OF COMMERCE
Patent and Trademark Office
Address: ASSISTANT COMMISSIONER FOR PATENTS
Washington, D.C. 20231

U.S. APPLICATION NO.	FIRST NAMED APPLICANT	ATTY. DOCKET NO.
09/647,007	CAMPANELLA	J 40264

5071
ROYLANCE ABRAMS BERDO GOODMAN
1300 19TH STREET N W SUITE 600
WASHINGTON DC 20036

INTERNATIONAL APPLICATION NO	
PCT/US98/14280	
I.A. FILING DATE	PRIORITY DATE
07/10/98	03/27/98

DATE MAILED: 10/25/00

NOTIFICATION OF ACCEPTANCE OF APPLICATION UNDER 35 U.S.C. 371 AND 37 CFR 1.494 OR 1.495

1. The applicant is hereby advised that the United States Patent and Trademark Office in its capacity as ☐ a Designated Office (37 CFR 1.494), ☒ an Elected Office (37 CFR 1.495), has determined that the above identified international application has met the requirements of 35 U.S.C. 371, and is **ACCEPTED** for national patentability examination in the United States Patent and Trademark Office.

2. The United States Application Number assigned to the application is shown above and the relevant dates are:

26 SEP 2000	26 SEP 2000
35 U.S.C. 102(e) DATE	DATE OF RECEIPT OF 35 U.S.C. 371 REQUIREMENTS

A Filing Receipt (PTO-103X) will be issued for the present application in due course. **THE DATE APPEARING ON THE FILING RECEIPT AS THE "FILING DATE" IS THE DATE ON WHICH THE LAST OF THE 35 U.S.C. 371(C) REQUIREMENTS HAS BEEN RECEIVED IN THE OFFICE. THIS DATE IS SHOWN ABOVE.** *The filing date of the above identified application is the international filing date of the international application (Article 11(3) and 35 U.S.C. 363).* Once the Filing Receipt has been received, send all correspondence to the Group Art Unit designated thereon.

3. ☐ A request for immediate examination under 35 U.S.C. 371(f) was received on ______________ and the application will be examined in turn.

4. The following items have been received:
- ☒ U.S. Basic National Fee.
- ☒ Copy of the international application in:
  - ☒ a non-English language.
  - ☒ English.
- ☐ Translation of the international application into English.
- ☒ Oath or Declaration of inventors(s) for DO/EO/US.
- ☒ Copy of Article 19 amendments. ☐ Translation of Article 19 amendments into English.
  The Article 19 amendments ☐ have ☐ have not been entered.
- ☒ The International Preliminary Examination Report in English and its Annexes, if any.
- ☐ Copy of the Annexes to the International Preliminary Examination Report (IPER).
  - ☐ Translation of Annexes to the IPER into English.

  The Annexes ☒ have ☐ have not been entered.
- ☐ Preliminary amendment(s) filed ______________ and ______________.
- ☐ Information Disclosure Statement(s) filed ______________ and ______________.
- ☐ Assignment document.
- ☐ Power of Attorney and/or Change of Address.
- ☐ Substitute specification filed ______________.
- ☐ Statement Claiming Small Entity Status.
- ☐ Priority Document.
- ☒ Copy of the International Search Report ☐ and copies of the references cited therein.
- ☐ Other:

Applicant is reminded that any communication to the United States Patent and Trademark Office must be mailed to the address given in the heading and include the U.S. application no. shown above. (37 CFR 1.5)

Vonda M. Wallace
Paralegal Specialist
V.W.
Telephone: (703) 305-3736

FORM PCT/DO/EO/903 (December 1997)

09/647007

BEST AVAILABLE COPY

Class	Subclass

ISSUE CLASSIFICATION

FILED UNDER 35 U.S.C. 371

PATENT NUMBER

U.S. UTILITY Patent Application

O.I.P.E.

SCANNED MH SBG Q.A. LA

PATENT DATE

APPLICATION NO.	CONT/PRIOR	CLASS	SUBCLASS	ART UNIT	EXAMINER
09/647007	D	370	319	~~2665~~ 2661	JUNG

APPLICANTS: S. Campanella

TITLE: Digital broadcast system using satellite direct broadcast and terrestrial repeater

PTO-2040
12/99

ISSUING CLASSIFICATION

ORIGINAL		CROSS REFERENCE(S)					
CLASS	SUBCLASS	CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
INTERNATIONAL CLASSIFICATION							

☐ Continued on Issue Slip Inside File Jacket

☐ TERMINAL DISCLAIMER	DRAWINGS			CLAIMS ALLOWED	
	Sheets Drwg.	Figs. Drwg.	Print Fig.	Total Claims	Print Claim for O.G.
☐ The term of this patent subsequent to ________ (date) has been disclaimed.	________ (Assistant Examiner) ________ (Date)			NOTICE OF ALLOWANCE MAILED	
☐ The term of this patent shall not extend beyond the expiration date of U.S Patent. No. ________	________ (Primary Examiner) ________ (Date)			ISSUE FEE	
				Amount Due	Date Paid
☐ The terminal ____ months of this patent have been disclaimed.	________ (Legal Instruments Examiner) ________ (Date)			ISSUE BATCH NUMBER	

WARNING:
The information disclosed herein may be restricted. Unauthorized disclosure may be prohibited by the United States Code Title 35, Sections 122, 181 and 368. Possession outside the U.S. Patent & Trademark Office is restricted to authorized employees and contractors only.

Form PTO-436A
(Rev. 6/99)

FILED WITH: ☐ DISK (CRF) ☐ FICHE ☐ CD-ROM
(Attached in pocket on right inside flap)

(FACE)

SEARCHED

Class	Sub.	Date	Exmr.
370	315		
	316	4/22/04	
	480		
	481	4/22/04	
	485	4/30/04	
455	3.01	5/17/04	
	3.02	5/18/04	
	3.06	5/19/04	
	11.1		
	12.1		
	7		
	16		
	17		
	427		
	430		
	118		

SEARCH NOTES
(INCLUDING SEARCH STRATEGY)

	Date	Exmr.
EAST	4/21-5/19/04	MJ

INTERFERENCE SEARCHED

Class	Sub.	Date	Exmr.

(RIGHT OUTSIDE)

ISSUE SLIP STAPLE AREA (for additional cross references) 10-30-06

Vonda M. Wallace
Paralegal Specialist

POSITION	INITIALS	ID NO.	DATE
FEE DETERMINATION			
O.I.P.E. CLASSIFIER			
FORMALITY REVIEW			
RESPONSE FORMALITY REVIEW			

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INDEX OF CLAIMS

✓ .... Rejected		N .... Non-elected	
= .... Allowed		I .... Interference	
— (Through numeral)... Canceled		A .... Appeal	
÷ .... Restricted		O .... Objected	

Claim		Date									
Final	Original	5/19/06									
	1	✓									
	2	✓									
	3	✓									
	4	✓									
	5	O									
	6	✓									
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If more than 150 claims or 10 actions
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FORM PTO-1390
(REV 11-98)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER
40264

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)
09/647007

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/US98/14280	10 July 1998	27 March 1998

TITLE OF INVENTION
Digital Broadcast System Using Satellite Direct Broadcast and Terrestrial Repeater

APPLICANT(S) FOR DO/EO/US
S. Joseph Campanella

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☑ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☑ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☑ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ has been transmitted by the International Bureau.
   c. ☑ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☑ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☑ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☑ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☐ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☑ Other items or information:

(a) Copy of International Search Report (27 April 1999).

(b) Copy of Published International Application (30 September 1999).

(c) Copy of International Preliminary Examination Reports (4 May 2000 and 10 August 2000).

430 Rec'd PCT/PTO 26 SEP 2000

...N NO. (if known, see 37 CFR 1.5) 09/647027	INTERNATIONAL APPLICATION NO. PCT/US98/14...	ATTORNEY'S DOCKET NUMBER 40264

☑ The following fees are submitted: — CALCULATIONS — PTO USE ONLY

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO $970.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO $840.00

International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO $760.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) $670.00

International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) $96.00

ENTER APPROPRIATE BASIC FEE AMOUNT =				$ 96.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	41 - 20 =	21	X **$18.00**	$ 378.00	
Independent claims	9 - 3 =	6	X **$78.00**	$ 468.00	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$260.00**	$ 0.00	
TOTAL OF ABOVE CALCULATIONS =				$ 942.00	
Reduction of 1/2 for filing by small entity, if applicable. A Small Entity Statement must also by filed (Note 37 CFR 1.9, 1.27, 1.28).				$ 0.00	
SUBTOTAL =				$ 942.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$ 0.00	
TOTAL NATIONAL FEE =				$ 942.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$ 0.00	
TOTAL FEES ENCLOSED =				$ 942.00	
				Amount to be: refunded	$
				charged	$

a. ☑ A check in the amount of $ 942.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. ________ in the amount of $________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☑ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 18-2220. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Roylance, Abrams, Berdo & Goodman, L.L.P.
1300 19th Street, N.W.
Suite 600
Washington, D.C. 20036

John E. Holmes
SIGNATURE:

John E. Holmes
NAME

29,392
REGISTRATION NUMBER

Fraunhofer Ex 2044-p 85
Sirius v Fraunhofer
IPR2018-00690

09/647007

532 Rec'd PCT/PTC 26 SEP 2000

The PTO did not receive the following listed item(s) NO POST CARD

532 Rec'd PCT/PTC 26 SEP 2000

FORM PTO-1390
(REV 11-98)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER
40264

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)
09/647007

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/US98/14280	10 July 1998	27 March 1998

TITLE OF INVENTION
Digital Broadcast System Using Satellite Direct Broadcast and Terrestrial Repeater

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S. Joseph Campanella

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   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
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   c. ☑ is not required, as the application was filed in the United States Receiving Office (RO/US).
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   b. ☐ have been transmitted by the International Bureau.
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   d. ☑ have not been made and will not be made.
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Items 11. to 16. below concern document(s) or information included:

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    ☐ A SECOND or SUBSEQUENT preliminary amendment.
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15. ☐ A change of power of attorney and/or address letter.
16. ☑ Other items or information:

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(b) Copy of Published International Application (30 September 1999).

(c) Copy of International Preliminary Examination Reports (4 May 2000 and 10 August 2000).

430 Rec'd PCT/PTO 26 SEP 2000

U.S. APPLICATION NO. (if known, see 37 CFR 1.5) 09/6470	INTERNATIONAL APPLICATION NO. PCT/US98/14	ATTORNEY'S DOCKET NUMBER 40264

☑ The following fees are submitted:	CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO $970.00		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$840.00**		
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International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$670.00**		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) **$96.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 96.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

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TOTAL OF ABOVE CALCULATIONS =					$ 942.00	
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					Amount to be: refunded	$
					charged	$

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SEND ALL CORRESPONDENCE TO:

Roylance, Abrams, Berdo & Goodman, L.L.P.
1300 19th Street, N.W.
Suite 600
Washington, D.C. 20036

John E. Holmes
SIGNATURE

John E. Holmes
NAME

29,392
REGISTRATION NUMBER

09/647007

532 Rec'd PCT/PTC 26 SEP 2000

The PTO did not receive the following listed item(s) NO POST CARD

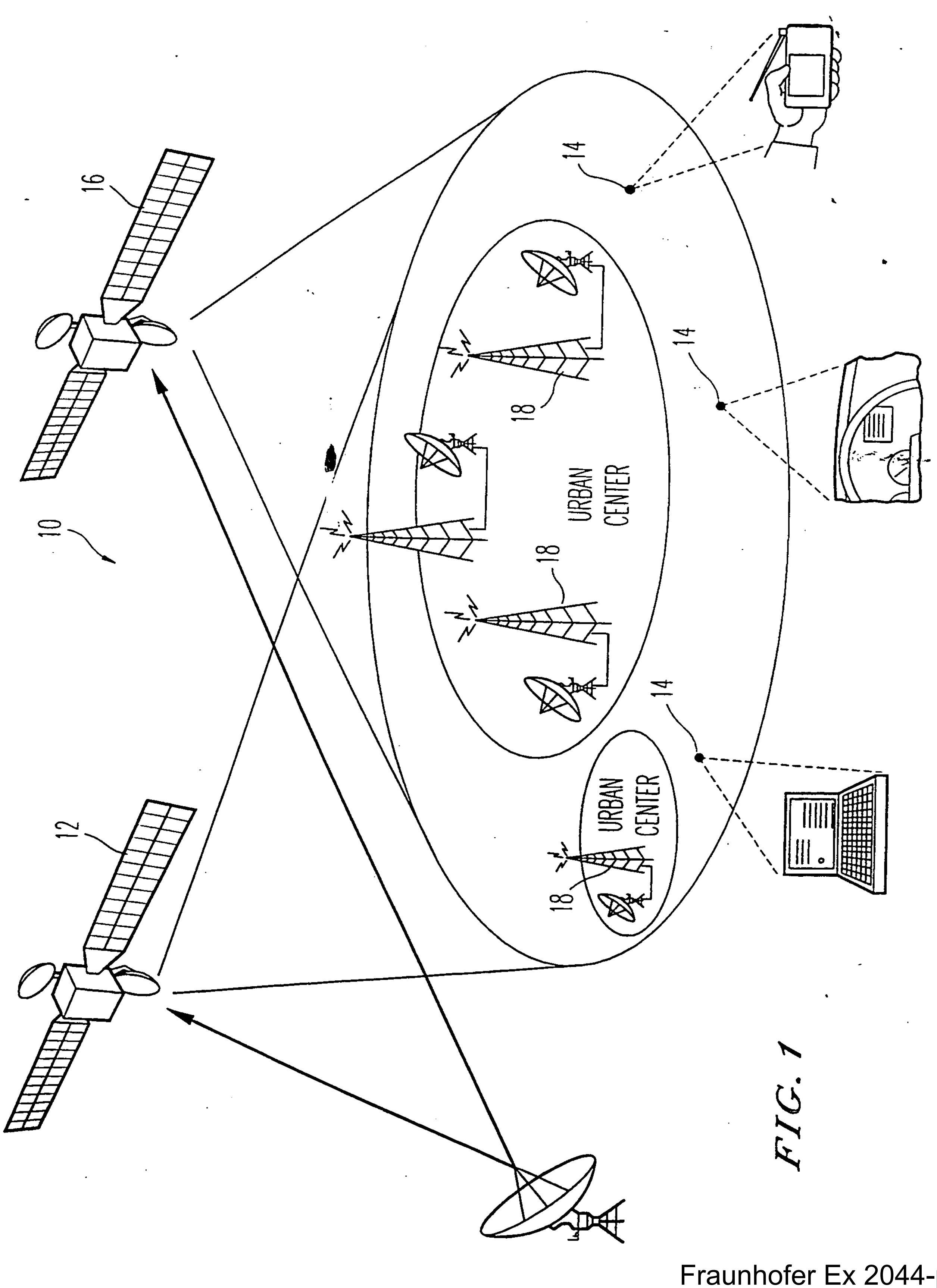
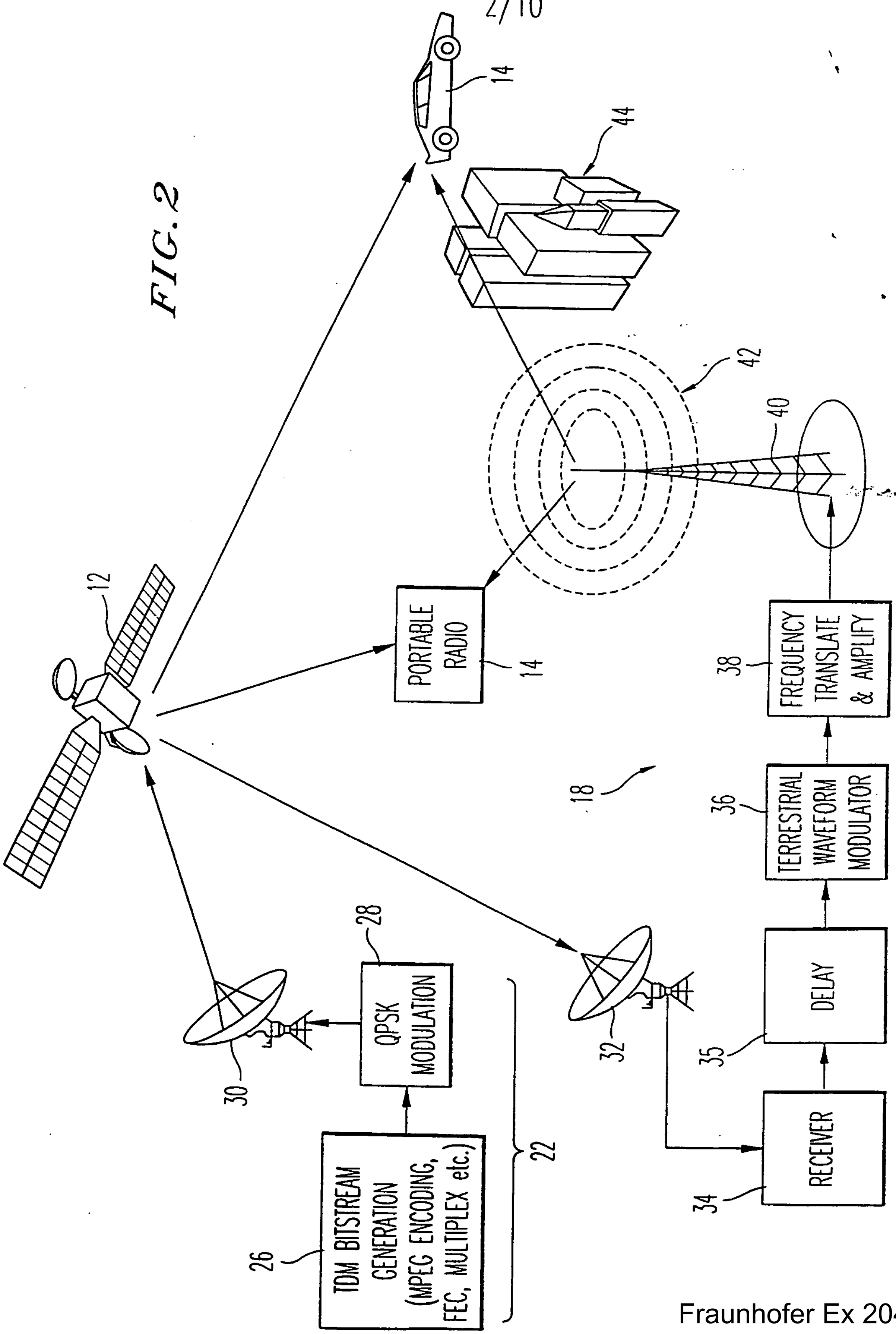


FIG. 1



14
44
42
40
PORTABLE RADIO
14
12
FREQUENCY TRANSLATE & AMPLIFY
38
TERRESTRIAL WAVEFORM MODULATOR
36
18
QPSK MODULATION
28
DELAY
35
30
32
TDM BITSTREAM GENERATION (MPEG ENCODING, FEC, MULTIPLEX etc.)
26
22
RECEIVER
34

FIG. 2

09/647007

3/10

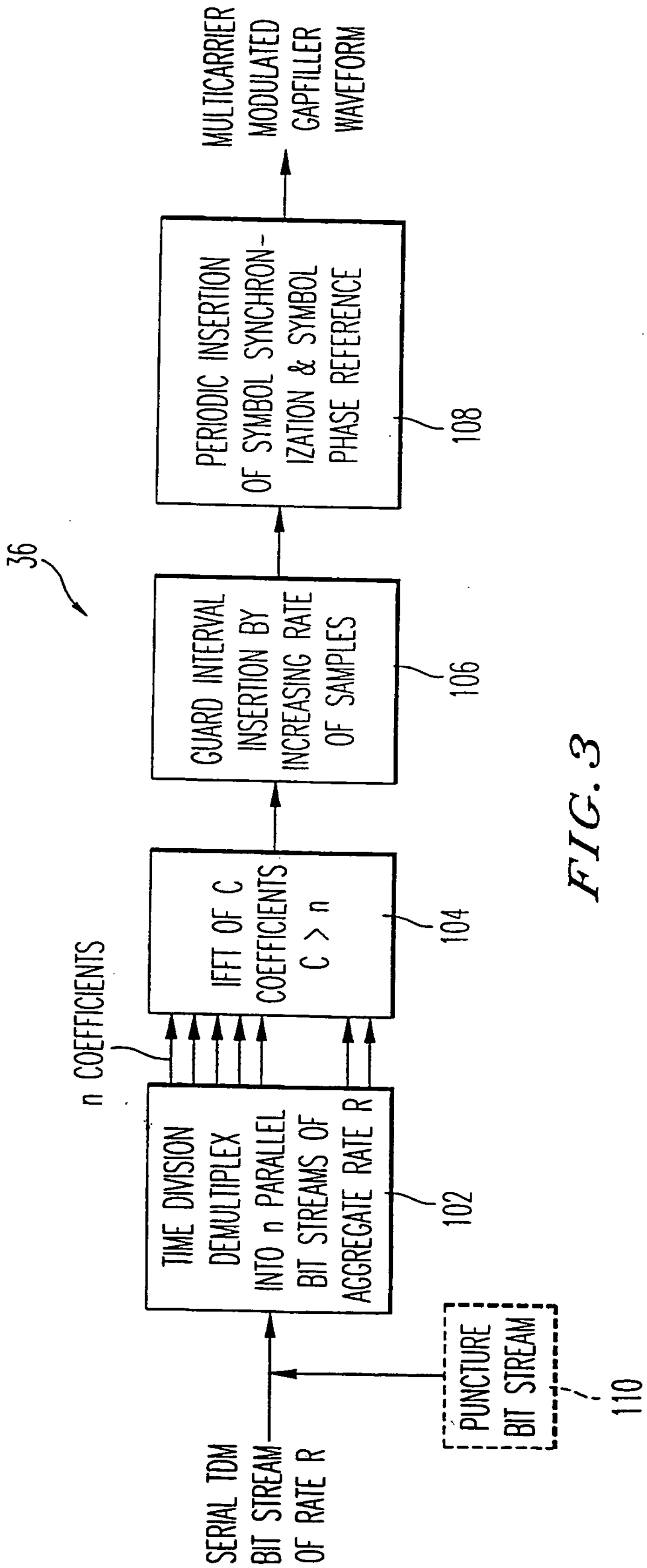
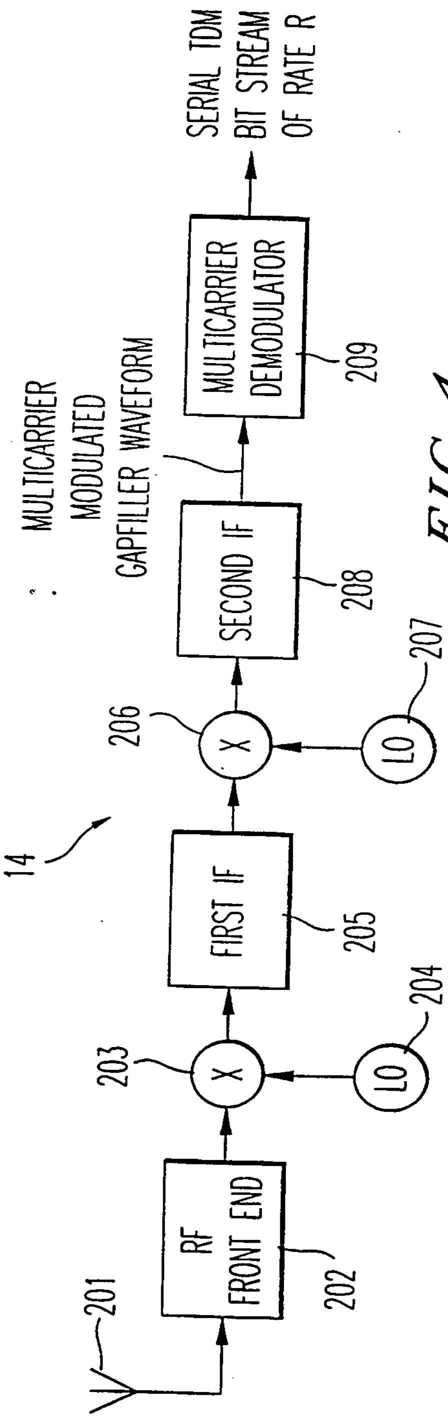


FIG. 3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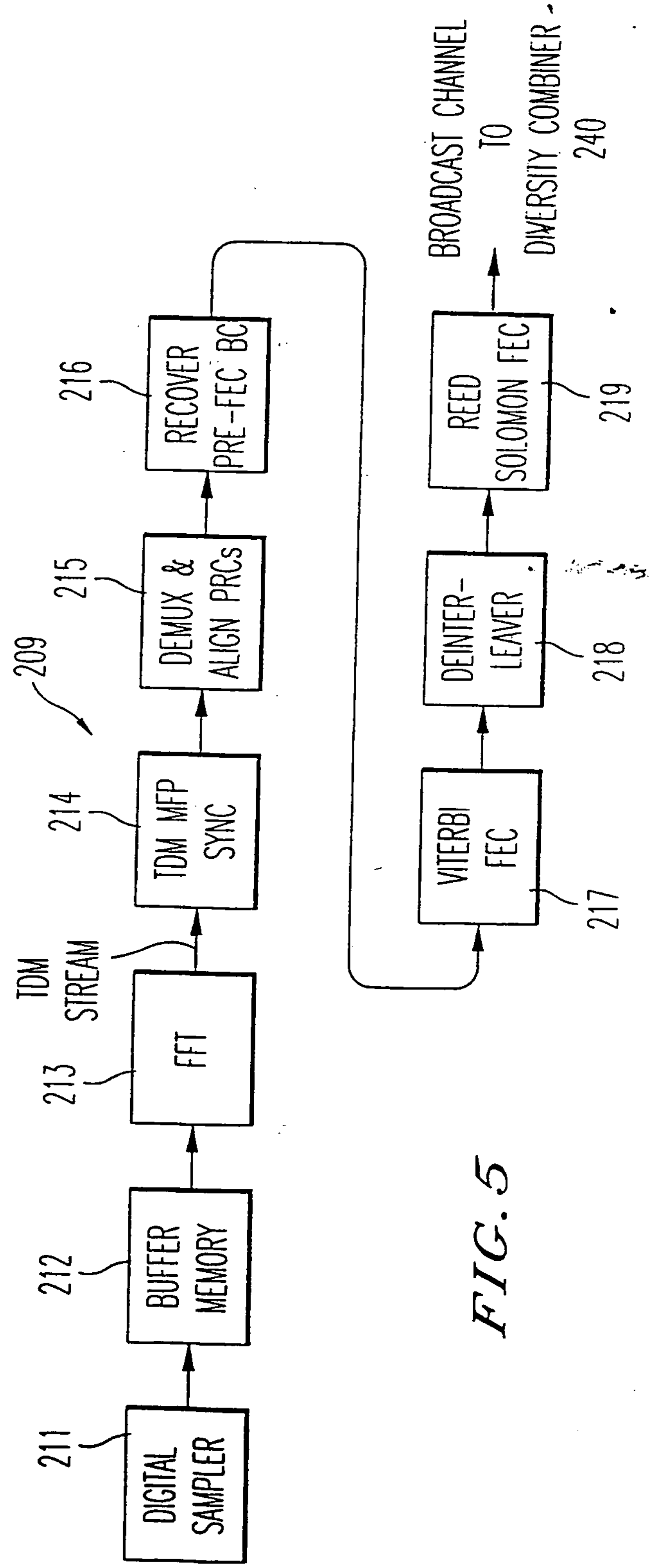
201
RF FRONT END
202
203
X
LO
204
FIRST IF
205
206
X
LO
207
SECOND IF
208
MULTICARRIER MODULATED GAPFILLER WAVEFORM
MULTICARRIER DEMODULATOR
209
SERIAL TDM BIT STREAM OF RATE R

FIG. 4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BUFFER MEMORY
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FFT
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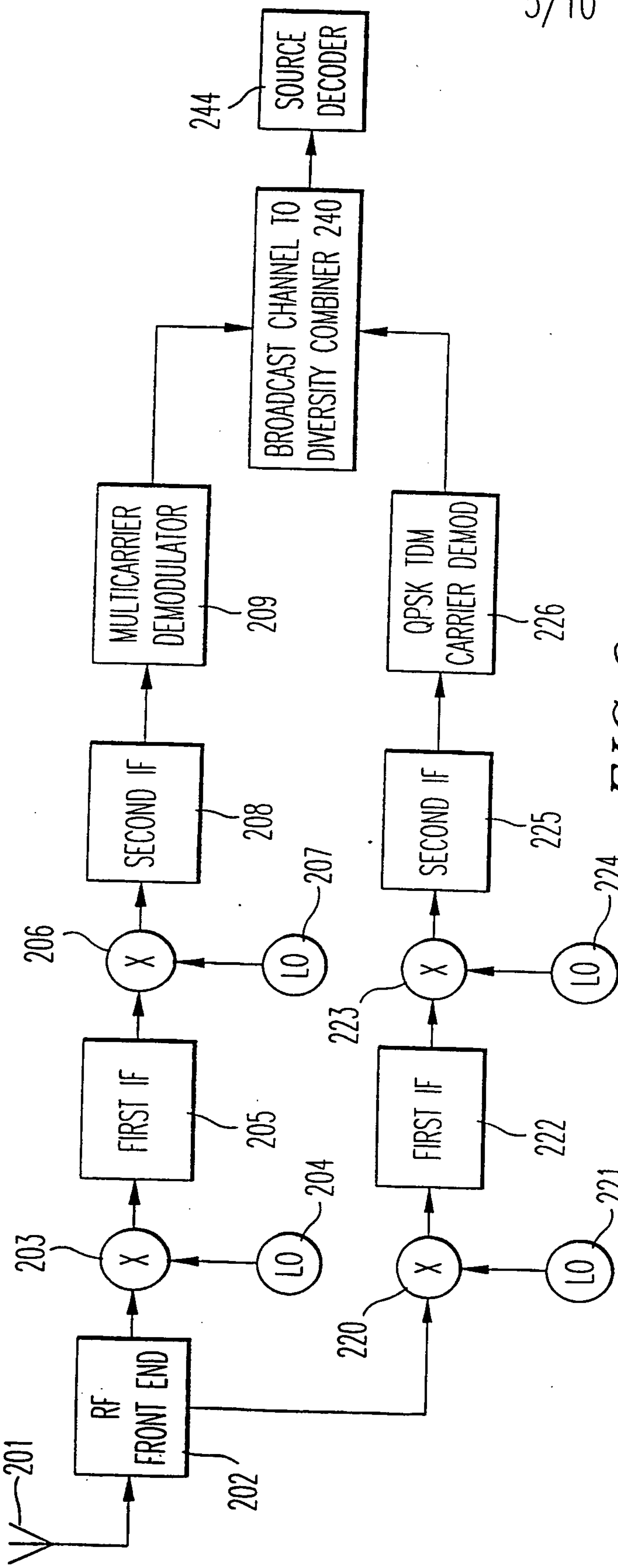
TDM MFP SYNC
215
DEMUX & ALIGN PRCs
216
RECOVER PRE-FEC BC
VITERBI FEC
217
DEINTER-LEAVER
218
REED SOLOMON FEC
219
BROADCAST CHANNEL TO DIVERSITY COMBINER 240

FIG. 5


201
RF FRONT END
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203
X
LO
204
FIRST IF
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206
X
LO
207
SECOND IF
208
MULTICARRIER DEMODULATOR
209
220
X
LO
221
FIRST IF
222
223
X
LO
224
SECOND IF
225
QPSK TDM CARRIER DEMOD
226
BROADCAST CHANNEL TO DIVERSITY COMBINER 240
244
SOURCE DECODER

FIG. 6

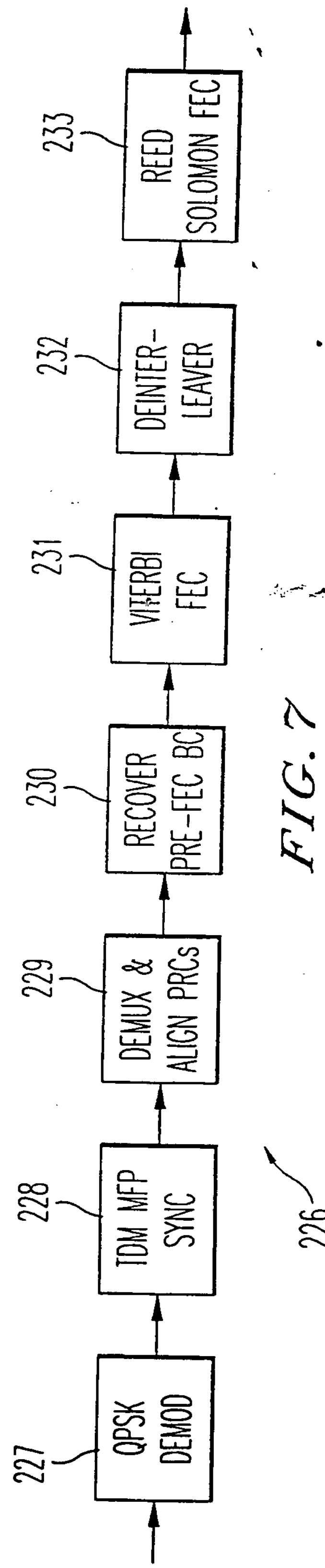

227
QPSK DEMOD
228
TDM MFP SYNC
229
DEMUX & ALIGN PRCs
230
RECOVER PRE-FEC BC
231
VITERBI FEC
232
DEINTER-LEAVER
233
REED SOLOMON FEC
226

FIG. 7

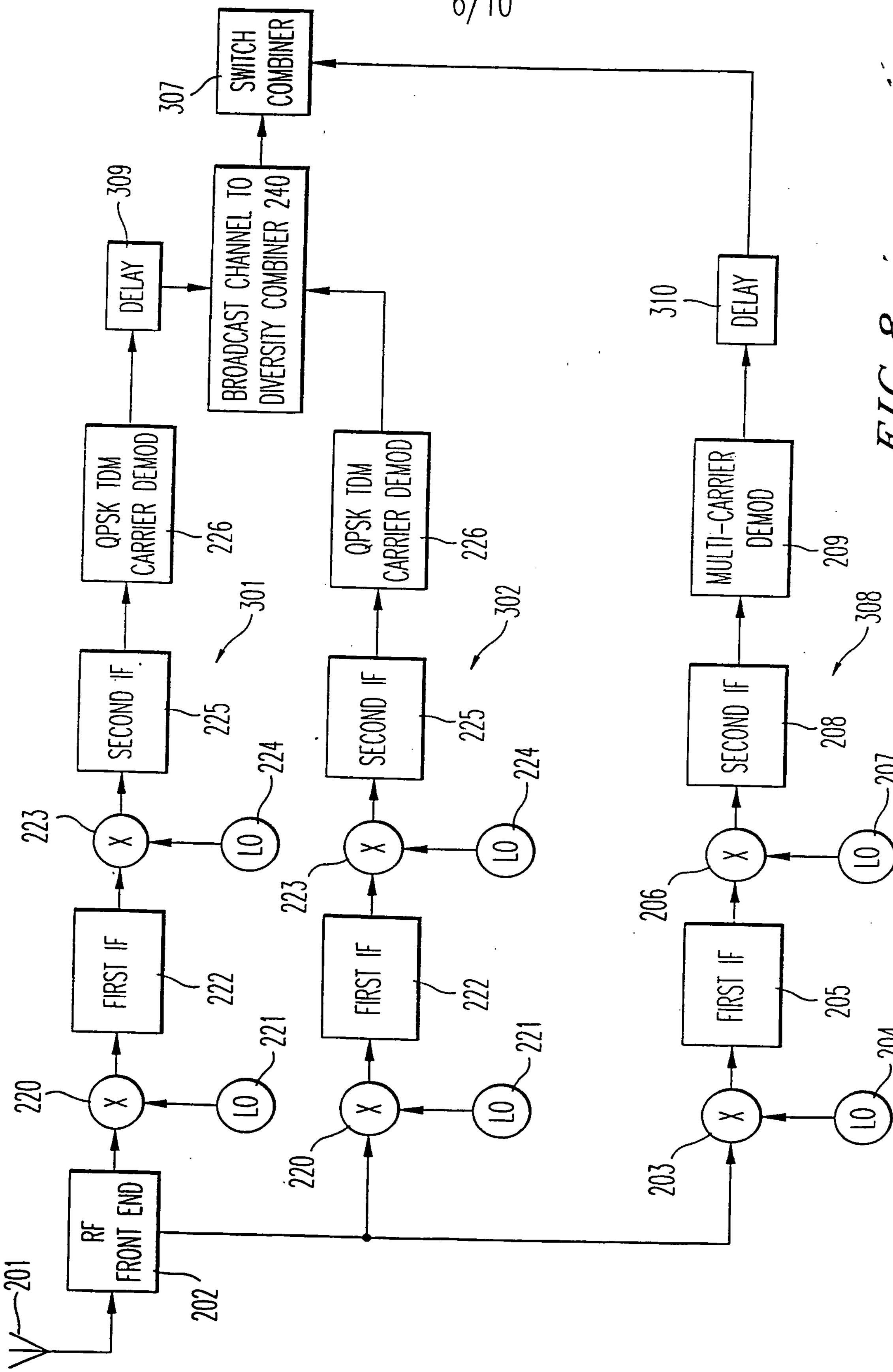

SWITCH COMBINER
307
BROADCAST CHANNEL TO DIVERSITY COMBINER 240
DELAY
309
DELAY
310
QPSK TDM CARRIER DEMOD
226
QPSK TDM CARRIER DEMOD
226
MULTI-CARRIER DEMOD
209
SECOND IF
225
SECOND IF
225
SECOND IF
208
301
302
308
X
223
LO
224
X
223
LO
224
X
206
LO
207
FIRST IF
222
FIRST IF
222
FIRST IF
205
X
220
LO
221
X
220
LO
221
X
203
LO
204
RF FRONT END
202
201

FIG. 8

7/10

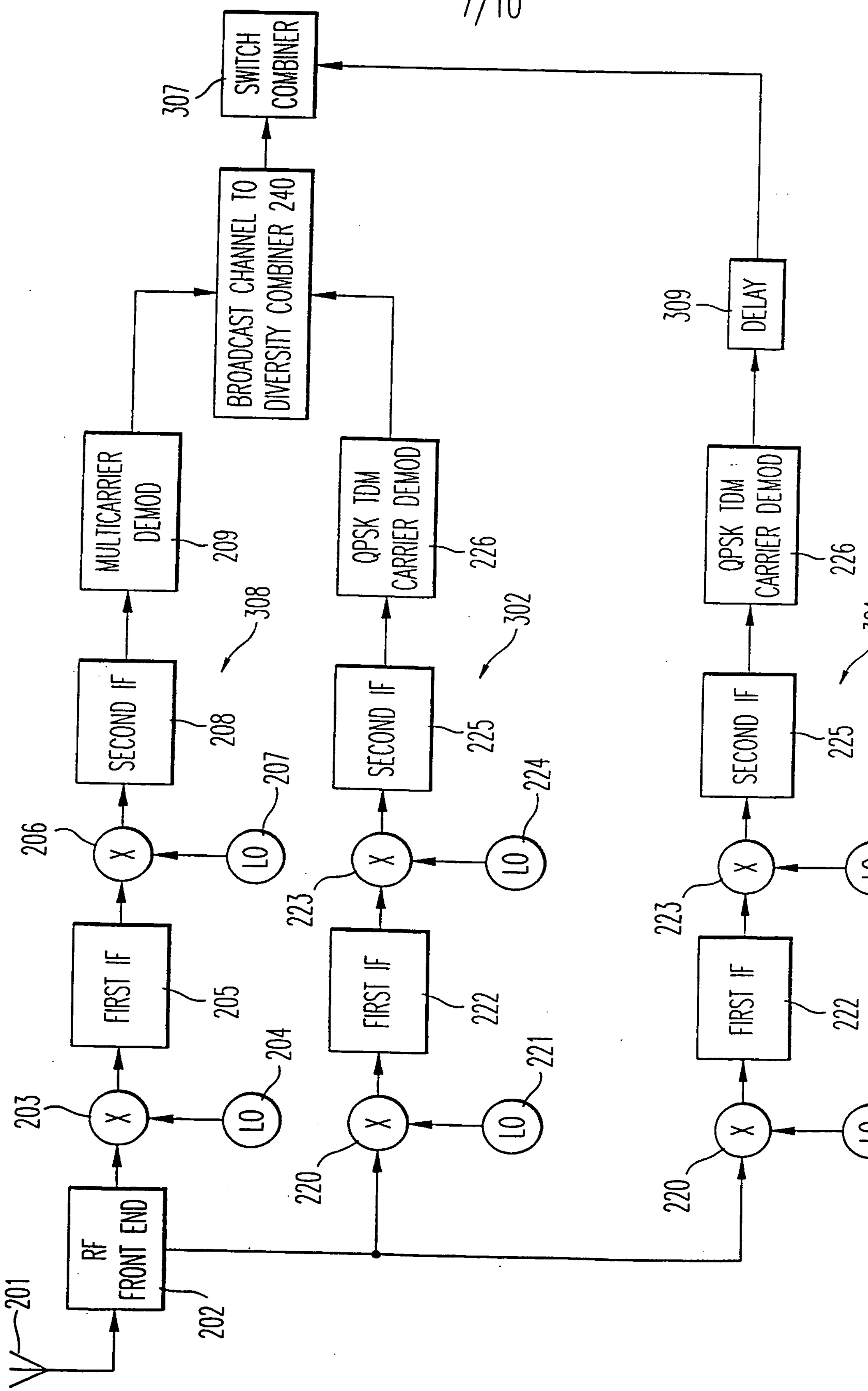

SWITCH COMBINER
307
BROADCAST CHANNEL TO DIVERSITY COMBINER 240
DELAY
309
MULTICARRIER DEMOD
209
QPSK TDM CARRIER DEMOD
226
308
302
301
SECOND IF
208
225
207
224
LO
X
206
223
FIRST IF
205
222
204
221
203
220
RF FRONT END
201
202

FIG. 9

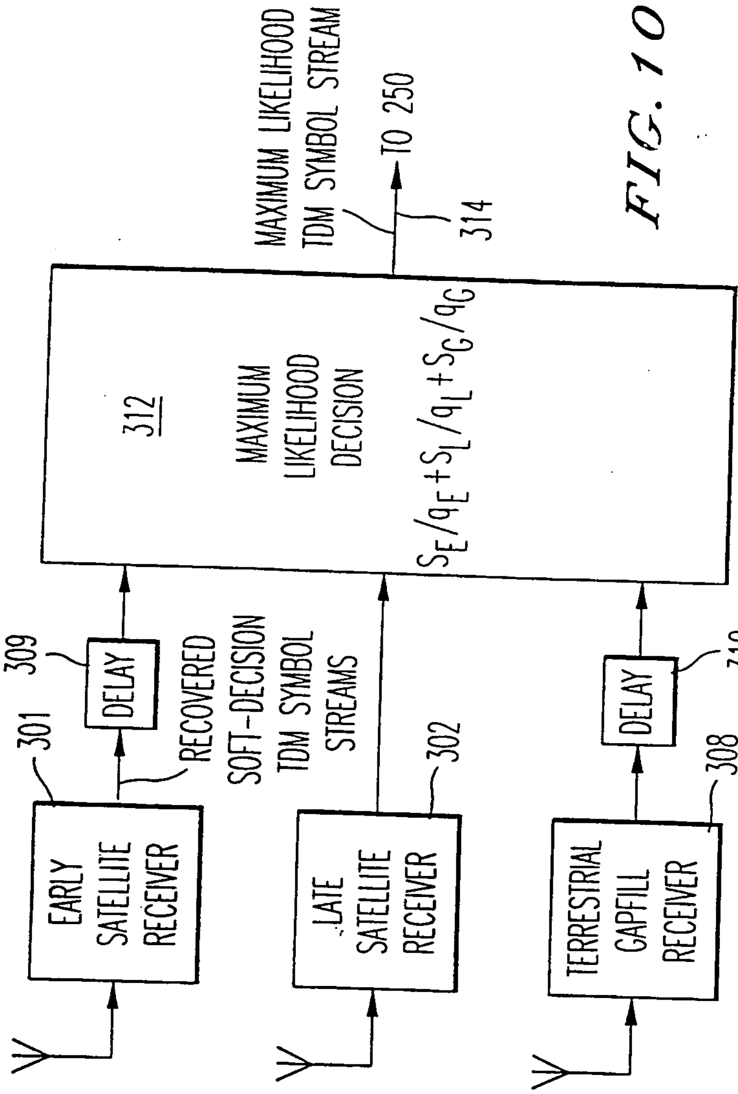

EARLY SATELLITE RECEIVER
LATE SATELLITE RECEIVER
TERRESTRIAL GAPFILL RECEIVER
301
302
308
DELAY
DELAY
309
310
RECOVERED SOFT-DECISION TDM SYMBOL STREAMS
312
MAXIMUM LIKELIHOOD DECISION
$S_E/q_E+S_L/q_L+S_G/q_G$
MAXIMUM LIKELIHOOD TDM SYMBOL STREAM
TO 250
314

FIG. 10

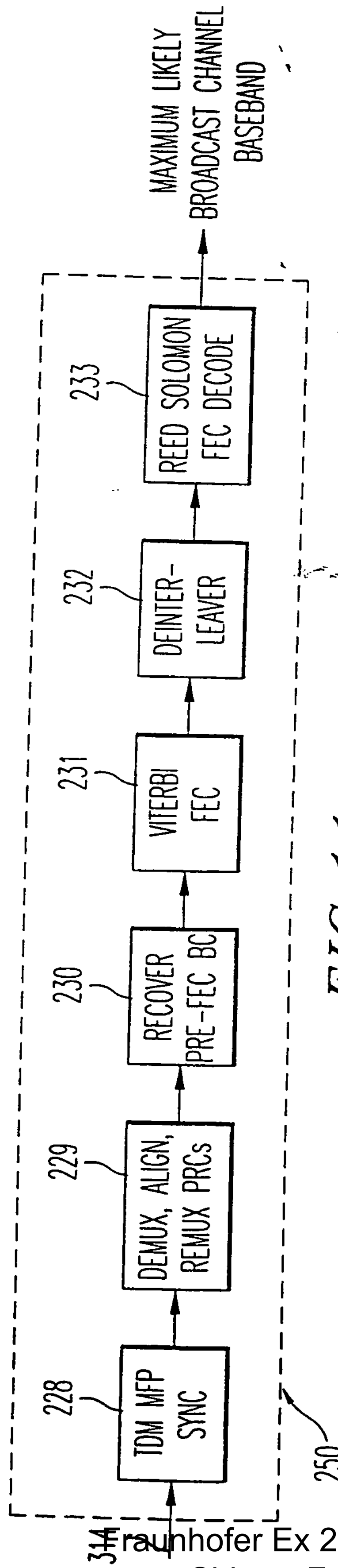

314
TDM MFP SYNC
228
DEMUX, ALIGN, REMUX PRCs
229
RECOVER PRE-FEC BC
230
VITERBI FEC
231
DEINTER-LEAVER
232
REED SOLOMON FEC DECODE
233
MAXIMUM LIKELY BROADCAST CHANNEL BASEBAND
250

FIG. 11

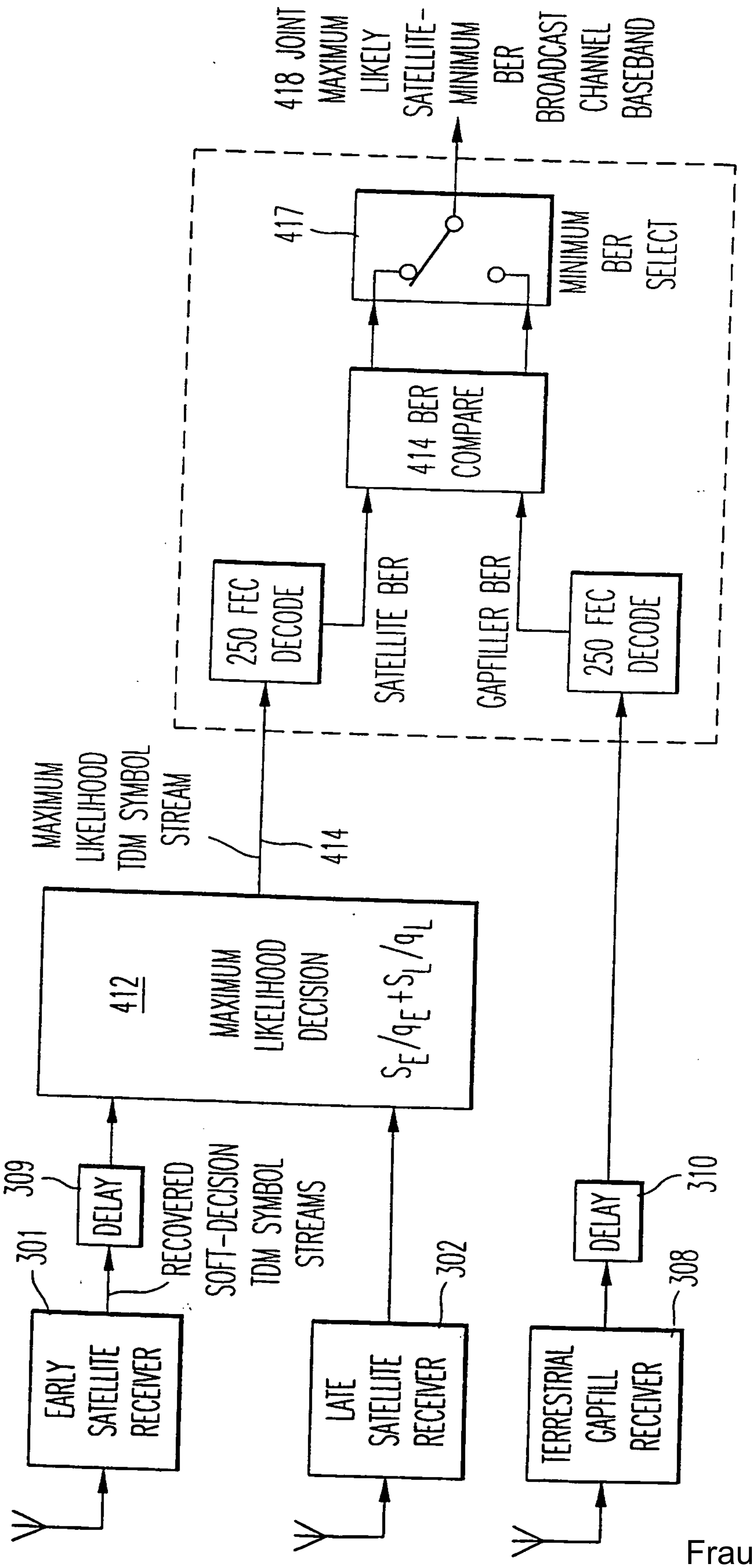

418 JOINT MAXIMUM LIKELY SATELLITE-MINIMUM BER BROADCAST CHANNEL BASEBAND
417
MINIMUM BER SELECT
414 BER COMPARE
SATELLITE BER
GAPFILLER BER
250 FEC DECODE
250 FEC DECODE
MAXIMUM LIKELIHOOD TDM SYMBOL STREAM
414
412
MAXIMUM LIKELIHOOD DECISION
$S_E/q_E+S_L/q_L$
309
DELAY
301
RECOVERED SOFT-DECISION TDM SYMBOL STREAMS
EARLY SATELLITE RECEIVER
302
LATE SATELLITE RECEIVER
310
DELAY
308
TERRESTRIAL GAPFILL RECEIVER

FIG. 12

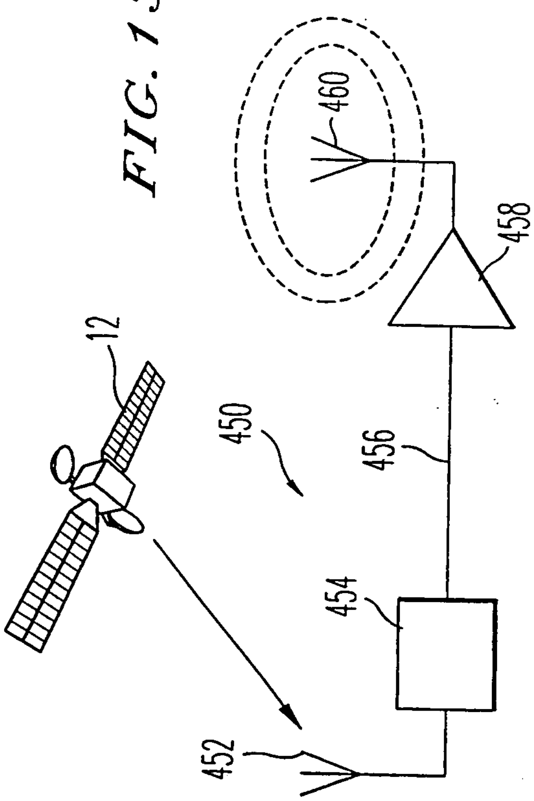

12
450
452
454
456
458
460

FIG. 13

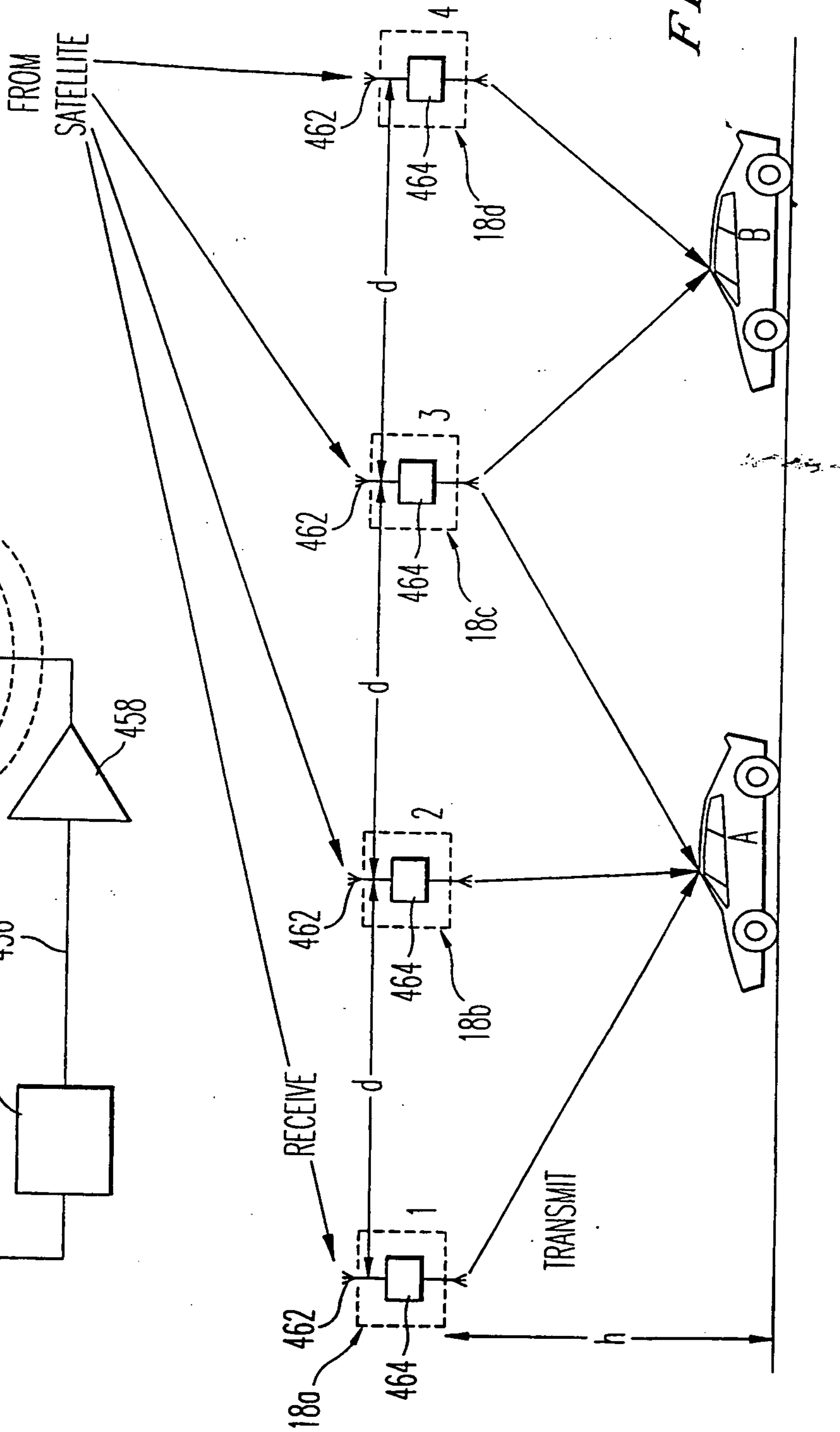

FROM SATELLITE
RECEIVE
TRANSMIT
1
2
3
4
462
464
18a
18b
18c
18d
d
h
A
B

FIG. 14

WO 99/49602

10/prts

09/647007

PCT/US98/14280

430 Rec'd PCT/PTO 26 SEP 2000

DIGITAL BROADCAST SYSTEM USING SATELLITE DIRECT BROADCAST AND TERRESTRIAL REPEATER

Field of Invention

A digital broadcast system is provided which uses a satellite direct radio broadcast system having different downlink options in combination with a terrestrial repeater network employing different re-broadcasting options to achieve high availability reception by mobile radios, static radios and portable radios in urban areas, suburban metropolitan areas, rural areas, including geographically open areas and geographic areas characterized by terrain having high elevations.

Background of the Invention

Receivers in existing systems which provide digital audio radio service (DARS) have been radically affected by multipath effects which create severe degradations in signal quality, such as signal fading and inter-symbol interference (ISI). Fading effects on broadcast channels to receivers can be sensitive to frequency, particularly in an urban environment or geographic areas with high elevations where blockage of line of sight (LOS) signals from satellites is most prevalent. Locations directly beneath a satellite (hereinafter referred to as the sub-satellite point) inherently have the highest elevation angles, while locations that depart from the sub-satellite point inherently have decreasing elevation angles and, accordingly, an increase of the earth center angle subtended between the sub-satellite point and the reception location. Locations that are near the sub-satellite point typically enjoy virtually unblocked LOS reception. Thus, the need for terrestrial reinforcement of potentially blocked LOS signals is minimal. When the LOS elevation angle to the satellite becomes less than about 85 degrees, however, blockage by tall buildings or geological elevations (i.e., on the order of 30 meters) becomes significant. Terrestrial re-radiation for gap filling is needed to achieve satisfactory coverage for mobile radios, static radios, as well as portable radios. In areas where the heights of buildings or geological sites are relatively low (i.e., on the order of less than 10 meters), the blockage is not significant until the LOS elevation angle is lower than 75 degrees. Thus, at the mid-latitude and high latitude locations within the coverages of one or more broadcast satellites, terrestrial re-radiation is needed to achieve suitable radio reception. A need exists for fully satisfactory radio reception that combines satellite LOS transmission and terrestrial re-radiation of a satellite downlink signal waveform.

Summary of the Invention

In accordance with one aspect of the present invention, a digital broadcast system (DBS) is provided which overcomes a number of disadvantages associated with existing broadcast systems and realizes a number of advantages. The DBS of the present invention comprises a TDM carrier satellite delivery system for digital audio broadcasts (DAB) and other digital information which is combined with a network of terrestrial repeaters for the re-radiation of satellite downlink signals toward radio receivers. The terrestrial repeaters are configured to employ multipath-tolerant modulation techniques.

In accordance with another aspect of the present invention, a satellite delivery system and a terrestrial repeater operate using different carrier frequencies. The terrestrial repeater employs multipath-tolerant modulation techniques.

In accordance with yet another aspect of the present invention, a satellite delivery system and a terrestrial repeater both employ multipath-tolerant modulation techniques and can be configured to use the same or different carrier frequencies, depending on the type of waveform used. The satellite delivery system preferably employs a TDM or code division multiple access (CDMA)-type waveform. The terrestrial repeater preferably employs a multipath-tolerant waveform such as CDMA, Adaptive Equalized TDM (AETDM), Coherent Frequency Hopping Adaptively Equalized TDM (CFHATDM) or Multiple Carrier Modulation (MCM).

In accordance with still another aspect of the present invention, a single geostationary satellite transmits downlink signals which can be received by radio receivers in the LOS of the satellite signal, as well as by terrestrial repeaters. Each terrestrial repeater is configured to recover the digital baseband signal from the satellite signal and modulate the signal using multicarrier modulation (MCM) for retransmission toward radio receivers. Radio receivers are configured to receive both a quadrature phase shift keyed (QPSK) modulated TDM bit stream, as well as an MCM stream. Radio receivers are programmed to select a broadcast channel demodulated from the TDM bit stream and the MCM bit stream, and to select the broadcast channel recovered with the least errors using a diversity combiner.

In accordance with still yet another aspect of the present invention, a DBS is provided which comprises two geostationary satellites in combination with a network of terrestrial repeaters. The terrestrial repeaters are configured to process satellite downlink signals to achieve the baseband satellite signal and to modulate the signal using MCM. Radio receivers are configured to implement a diversity decision logic to select from among three diversity signals, including the two satellite signals and the MCM signal. Each radio receiver employs maximum likelihood combining of two LOS satellite signals with switch combining between the terrestrial re-radiated signal, or MCM signal, and the output of the maximum likelihood combiner.

In accordance with another aspect of the present invention, a broadcast channel may be selected from the three diversity signals by using maximum likelihood combining of all three signals, that is, early and late LOS satellite signals and the MCM signal from the terrestrial repeater.

Brief Description of the Drawings

These and other features and advantages of the present invention will be more readily comprehended from the following detailed description when read in connection with the appended drawings, which form a part of this original disclosure, and wherein:

Fig. 1 depicts a digital broadcast system for transmitting satellite signals and terrestrial signals in accordance with an embodiment of the present invention;

Fig. 2 is a diagram of a digital broadcast system comprising a satellite and a terrestrial repeater in accordance with an embodiment of the present invention;

Fig. 3 is a schematic block diagram illustrating a generation of a multicarrier modulated (MCM) signal in accordance with an embodiment of the present invention;

Fig. 4 is a schematic block diagram depicting a radio receiver arm configured to demodulate MCM signals in accordance with an embodiment of the present invention;

Fig. 5 is a block diagram illustrating MCM signal demodulation in accordance with an embodiment of the present invention;

Fig. 6 is a schematic block diagram depicting a radio receiver arm configured to demodulate time division multiplexed (TDM) signals in accordance with an embodiment of the present invention;

Fig. 7 is a block diagram illustrating QPSK TDM signal demodulation in accordance with an embodiment of the present invention;

Figs. 8 and 9 are schematic block diagrams illustrating respective embodiments of the present invention for diversity combining in a radio receiver;

Fig. 10 illustrates a system of combining three diversity signals using a maximum likelihood decision unit in accordance with an embodiment of the present invention;

Fig. 11 is a schematic block diagram illustrating TDM signal demultiplexing in accordance with an embodiment of the present invention;

Fig. 12 illustrates a system of combining bit streams recovered at a radio receiver using a maximum likelihood decision unit on a first satellite signal and a delayed second satellite signal and then a diversity combiner for terrestrial repeater signal and the output of the maximum likelihood decision unit in accordance with an embodiment of the present invention;

Fig. 13 illustrates an arrangement for indoor reception of a broadcast signal in accordance with an embodiment of the present invention; and

Fig. 14 illustrates an arrangement for terrestrial repeaters along a path in accordance with an embodiment of the present invention.

Detailed Description of the Preferred Embodiments

Fig. 1 depicts a digital broadcast system (DBS) 10 comprising at least one geostationary satellite 12 for line of sight (LOS) satellite signal reception at radio receivers indicated generally at 14. Another geostationary satellite 16 at a different orbital position can be provided for time and/or spatial diversity purposes as discussed below in connection with Figs. 6 and 7. The system 10 further comprises at least one terrestrial repeater 18 for retransmission of satellite signals in geographic areas 20 where LOS reception is obscured by tall buildings, hills and other obstructions. The radio receiver 14 is preferably configured for dual-mode operation to receive both satellite signals and terrestrial signals and to select one of the signals as the receiver output.

As stated previously, the present invention relates to a DBS 10 for optimized static, portable and mobile radio reception. In accordance with the present invention, the DBS 10 combines line-of-sight (LOS) reception of satellite waveforms that are optimized for satellite delivery with re-radiation of the LOS signal from the satellite 12 or 16 via one or more terrestrial repeaters 18. The terrestrial repeaters 18 use other waveforms which are optimized for terrestrial delivery where blockage of the satellite LOS signal occurs. LOS signal blockage caused by buildings, bridges, trees and other obstructions typically occurs in urban centers and suburban areas. Waveforms particularly suitable for LOS satellite transmission are Time Division Multiplex (TDM) and Code Division Multiple Access (CDMA). Multipath-tolerant waveforms particularly suitable for overcoming terrestrial multipath interference encountered in blocked urban areas are CDMA, Adaptive Equalized TDM (AETDM), Coherent Frequency Hopping Adaptively Equalized TDM (CFHATDM) and Multiple Carrier Modulation (MCM).

Frequency hopping is described in U.S. Patent No. 5,283,780, to Schuchman et al, which is hereby incorporated herein by reference. When a terrestrial repeater 18 employs AETDM, radio receivers 14 are provided with an equalizer (not shown). For AETDM, a TDM bit stream is received from the satellite 12 or 16. The bit stream is converted into a new TDM bit stream into which training sequences are inserted by a process called puncturing. Puncturing replaces a small fraction of the TDM data bits with the training sequences. The number of bits punctured is so small that the errors thereby produced are correctable at the receiver by forward error correction. The new TDM bit stream is QPSK-modulated by the repeater onto a radio frequency (RF) carrier that is transmitted at high power into the multipath environment of a central city business district, for example. This transmitted signal is received by a receiver 14 equipped with an adaptive time domain equalizer. By using the training sequences, it can adjust the taps of an inverse multipath processor to cause the various multipath arrival components to add constructively. The signal thus reconstructed is next processed to recover the bits of the TDM stream with high accuracy. The forward error correction available in the receiver 14 corrects both the errors introduced by the puncturing and those caused by thermal noise and receiver impairments.

In accordance with another aspect of the present invention, the combination of a satellite-efficient LOS waveform and terrestrial multipath interference-tolerant waveform in a DBS system is the optimum means for achieving high availability reception by mobile radios, static radios and portable radios in urban areas, suburban areas and in rural areas. For example, in accordance with an embodiment of the present invention illustrated in Figs. 2-9, an MCM signal is sent from a network of terrestrial repeaters 18 deployed to cover a blocked area with high reception availability. The signaling techniques described in connection with the present invention are applicable over the electromagnetic wave frequency range from 200 to 3000 MHz to facilitate the combination of LOS satellite radiation with terrestrial re-radiation of the signal received from the satellite 12 or 16.

Optimal satellite waveforms permit very efficient transformation of solar power, which is collected by the solar arrays of the satellites 12 and 16 into radiated radio frequency power. These waveforms are characterized by a low peak-to-average power ratio (i.e., crest factor), thereby permitting operation of high power amplifiers that feed the satellite earth-pointing antennas at or near the maximum power output and therefore the most efficient power output. A TDM waveform is particularly useful for permitting operation within a few tenths of a dB of maximum power output. A CDMA waveform that uses properly selected codes allows operation at approximately 2 to 4 dB below maximum power output. Because the MCM waveform is composed of the sum of hundreds of phase modulated sinusoids, as described below with reference to Fig. 3, the MCM waveform inherently possesses a high peak-to-average ratio. Consequently, a MCM waveform encounters significantly greater amplitude and phase intermodulation distortion in the satellite's high power amplifier. To achieve acceptable reception by an LOS satellite receiver, a MCM waveform is backed in the high power amplifier and allocated a receiver implementation impairment of at least 6 dB on the down-link budget, as compared with a quadrature phase shift keying (QPSK) TDM waveform. This translates to a 4-to-1 reduction in satellite power conversion, rendering the MCM waveform an unsuitable choice for satellite LOS delivery on a DBS 10. Regarding the AETDM and CFHATDM waveforms, these waveforms are specifically designated to combat terrestrial multipath and are not intended for, nor are they efficient, for satellite LOS delivery.

Regarding terrestrial reinforcement by re-radiation of the satellite LOS signal from a terrestrial repeater, for example, a TDM waveform is not suitable because its reception is severely impaired by multipath effects. Furthermore, some proposed systems which use CDMA waveforms for reinforcement repeat the same program signal using one CDMA channel code for LOS satellite delivery and another CDMA channel code for terrestrial re-radiated delivery on carriers that occupy the same frequency bandwidth. Reception is achieved by means of adaptive rake receivers. These proposed CDMA systems are disadvantageous because an annulus zone occurs in which reception is not possible between the region where the reinforcement signal can be received and the region where the satellite LOS signal can be received. Receivers 14 in the annulus are not able to receive the terrestrial re-radiated signal because the signal power level falls below a receiver threshold for that signal. These receivers 14 are also not able to receive the satellite LOS signal because there remains sufficient re-radiated signal to jam LOS satellite reception. Thus, these receivers 14 in the annulus must move far enough away from the zone of re-radiation to decrease the re-radiated signal power to below the threshold of jamming; otherwise, LOS satellite reception is not possible.

In accordance with one embodiment of the present invention, the CDMA waveform is adapted to make possible its use for simultaneous delivery via satellite LOS and via terrestrial re-radiation. The CDMA channel codes are assigned for each delivery to different RF carriers. The orthogonality thereby created permits the two signals (i.e., the satellite LOS signal and the terrestrial repeater signal) to be separated by RF/IF filtering in the radio receiver.

The identification of workable and unworkable waveform combinations for accomplishing terrestrial reinforcement of satellite LOS reception in accordance with the present invention are listed in the TABLE 1. More than one type of modulation or signal formatting method can be used with the satellite signal, as well as with the terrestrial repeater signal.

TABLE 1

Satellite Waveform	Reinforcement Waveform	Recommended	Not Recommended	RF Carrier Spectra Are:
TDM	TDM		X	Same or Different
TDM	AETDM	X		Same or Different
TDM	MCM	X		Different
TDM	CFHATDM	X		Different
TDM	CDMA	X		Different
CDMA	CDMA	X		Different
CDMA	AETDM	X		Different
CDMA	CHFATDM	X		Different
CDMA	MCM	X		Different
CDMA	ANY		X	Same
AETDM	ANY		X	Same or Different
CFHATDM	ANY		X	Same of Different
MCM	ANY		X	Same or Different

AETDM waveforms can be satisfactorily implemented and operated in multipath environments characterized by signal propagation delays as long as 20 microseconds (μs). Care must be exercised to ensure that signal arrivals from distant repeaters 18 do not exceed this bound. The adaptively equalized re-radiated waveform can be received by radio receivers 14 designed to use the parent non-equalized TDM waveform when the former does not exhibit severe multipath. This compatibility prevents obsolescence of direct LOS non-equalized TDM radios when the AETDM re-radiation is turned on.

The CFHATDM waveform can be satisfactorily implemented and operated in multipath environments characterized by delays as long as 65 μs. Care must be exercised to ensure that signal arrivals from distant repeaters 18 do not exceed this bound. The waveform cannot be received by radio receivers 14 designed to use the parent non-equalized TDM waveform.

The MCM waveform can be satisfactorily implemented and operated in multipath environments characterized by delays as long as 65 μs. The maximum delay is affected by the guard time assignment given to the waveform's periodic symbol period assignment. Care must be exercised to ensure that signal arrivals from distant repeaters 18 do not exceed this bound. The waveform cannot be received by radio receivers 14 designed to use the parent non-equalized TDM waveform.

The CDMA waveform can be satisfactorily implemented and operated in multipath environments characterized by delays determined by the span of the time delays implemented in the rake paths at the receivers 14. Care must be exercised to ensure that all signal arrivals from distant repeaters 18, multipath reflections and different satellites do not exceed this bound. The waveform cannot be received by radio receivers 14 designed to use the parent non-equalized TDM waveform.

The satellite signals can be transmitted from one satellite 12 or 16 or from two satellites 12 and 16. Use of two geostationary satellites 12 and 16 sufficiently separated in their orbits creates diversity in the LOS elevation and azimuth angles to enhance signal reception availability. Also, time diversity achieved by repeating a satellite signal from a single satellite 12 or 16, or by transmitting a signal from two satellites 12 and 16 with the properly selected time difference, further enhances the reception availability.

In accordance with a preferred embodiment of the present invention, a waveform comprising multiple channel TDM with QPSK, Offset QPSK, Differential QPSK, Differentially Coded QPSK, or Minimum Shift Keyed (MSK) modulation is used for the transmission of signals from a satellite for LOS reception by a radio receiver 14. Terrestrial re-radiation is preferably implemented using an MCM waveform designed to carry a TDM bit stream of a capacity of up to 3.68 Mbit/s. MCM is preferably implemented which creates between 400 and 1200 multiple carriers by means of an Inverse Fast Fourier Transform as described below in connection with Fig. 3, resulting in a symbol period between 200 and 300 μs. A guard interval of between 55 to 65 microseconds is included in each symbol period. The MCM waveform is designed to accommodate Doppler carrier frequency shifts among multipath components occurring simultaneously. Puncturing is preferably used to eliminate bits or pairs of bits from the TDM bit stream to reduce the rate to a value of between 70% to 80% of the 3.68 Mbit/s rate. A special symbol is inserted between each of a selected number of FFT-generated symbols periods to provide a means to recover symbol period timing and carrier frequency synchronization . In the receiver 14, a Viterbi soft decision trellis decoder is preferably implemented to re-establish the bits or bit pairs punctured at the repeater 18, as well as all other bits transmitted, by use of an erasure technique. In this technique, the decoder simply ignores the bits in locations known to have been punctured at the repeater 18.

TDM carrier satellite delivery of the DBS 10 is discussed in U.S. patent application Serial No. 08/971,049, filed November 14, 1997, the entire subject matter of which is hereby incorporated herein by reference for all purposes. Briefly, with reference to Fig. 2, the broadcast segment 22 preferably includes encoding of a broadcast channel into a 3.68 Megabits per second (Mbps) time division multiplex (TDM) bit stream, as indicated in block 26. The TDM bit stream comprises 96 16 kilobits per second (kbps) prime rate channels and additional information for synchronization, demultiplexing, broadcast channel control and services. Broadcast channel encoding preferably involves MPEG audio coding, forward error correction (FEC) and multiplexing. The resulting TDM bit stream is modulated using quadrature phase shift keying (QPSK) modulation, as shown in block 28, prior to transmission via a satellite uplink 30.

TDM satellite delivery achieves the greatest satellite on-board payload efficiency possible in terms of the conversion of solar power to electromagnetic wave power. This is because single TDM carrier per tube operation permits each satellite traveling wave tube to operate at its saturated power output, which is its most efficient operating point. The TDM carrier in a typical application is designed to deliver 96 prime bit rate increments, each bearing 16 kbit/s, to small, economical radio receivers 14 located in the beams of the satellite 12 or 16. From one to eight prime rate increments are grouped to constitute a broadcast channel. A broadcast channel can be divided into a number of service channels for delivery of audio, video, data and multimedia.

The power density delivered to the earth by TDM carriers from satellites 12 and 16 can made very high and hence provide excellent LOS reception by radio receivers 14 in automobiles and trucks when traveling on open highways in the country side and in suburban areas. However, in urban areas where tall buildings abound, or in forests where tall towering damp foliage trees abound, LOS reception is blocked, thus inhibiting suitable operation of the receiver 14 for LOS reception. Attempting to overcome these conditions by raising the satellite power is both excessively expensive and technically impractical. Accordingly, a more practical alternative is to augment the direct LOS satellite reception by adding a network of terrestrial repeaters 18.

Concerning the nature of the blockage of LOS reception consider the following. Locations directly beneath the satellite 12 or 16 (i.e., the sub-satellite point) inherently have the highest elevation angles, while locations that depart from the sub-satellite point inherently have decreasing elevation angles and an increase of the earth center angle subtended between the sub-satellite location and the reception location. Receivers 14 at locations that are near the sub-satellite point are permitted virtually unblocked LOS reception and the need for terrestrial reinforcement is minimal. However, when the LOS elevation angle to the satellite becomes less than about 85 degrees, blockage by tall buildings (i.e., >30 m) becomes significant. Accordingly, terrestrial re-radiation for gap-filling is needed to achieve satisfactory coverage for mobile radio receivers. In areas where building heights are low (e.g., <10 m), blockages are not significant until the LOS elevation angle is lower than 75 degrees. At the mid-latitude and high latitude locations within the 6 degree beam width coverages of the satellites 12 and 16, terrestrial re-radiation of the TDM waveform is needed to achieve suitable mobile reception. Thus, fully satisfactory mobile reception requires a system that combines satellite LOS and terrestrial re-radiation of the satellite waveform.

The DBS 10 of the present invention re-radiates the LOS satellite signal from a multiplicity of terrestrial repeaters 18 which are judiciously spaced and deployed within the central part of a city, as well as in metropolitan areas and suburban areas, to achieve maximum coverage. This type of deployment is a recognized art for terrestrial digital audio broadcast (DAB) and cell telephone systems, and can be extended in accordance with the present invention to terrestrial re-radiation of the TDM satellite LOS signal. The deployment utilizes a mix of radiated power levels (EIRP) ranging from as little as 1 to 10 watts for short range fill-in repeaters 18 (out to 1 km radius) to as great as 100 to 10,000 watts for re-radiators or repeaters having wide area coverage (from 1 km to 10 km radius).

Two preferred embodiments for a DBS 10 having a satellite-LOS/terrestrial-re-radiation configuration are described below. The first embodiment involves one geostationary orbit (GSO) satellite 12 or 16 having a judiciously selected longitude along the GSO arc which operates in coordination with a network of the terrestrial repeaters 18. The second embodiment involves two satellites 12 and 16 having different judiciously spaced GSO longitudes to achieve space and time diversity.

The embodiment for a DBS 10 using one GSO satellite 12 with at least one terrestrial repeater 18 is shown in Fig. 2 for illustrative purposes. For each terrestrial repeater 18, the LOS satellite signal is received by an antenna 32 operating in conjunction with a radio receiver 34 to demodulate and recover the digital baseband signal from the signal radiated from the satellite 12. A delay block 35 delays the entire digital baseband signal by the amount of time diversity delay (if any) between transmissions from the satellites 12 and 16. The digital baseband signal is supplied to a terrestrial waveform modulator 36 that generates a waveform which is judiciously designed to make possible the recovery of the digital baseband signal after the waveform has been transmitted from the terrestrial repeater 18 and received by a radio receiver 14. The modulated waveform is then frequency translated to a carrier frequency and amplified, as indicated by block 38. The terrestrial re-radiated waveform is specifically chosen to withstand the dynamic multipath encountered over the terrestrial path between the transmitter antenna 40 and the receiver 14. This multipath is caused by reflections and diffractions from and around obstacles such as buildings 44 and terrain and from troposphere wavebending and reflections.

The antenna 32 is designed to have high gain (> 10 dBi) toward the satellite 12, while achieving low gain in other directions such that the LOS signal is received with low interference and consequently very high quality (i.e. error rate < 10^{-9}). The demodulator and other reception elements in the receiver 34 are those designed for the LOS radio receivers 14 used in the DBS 10 and described in the aforementioned application Serial No. 08/971,049, filed November 14, 1997. The radio receivers 18 are designed to receive the 3.68 Mbit/s QPSK modulated TDM bit stream. As stated previously, the digital baseband is preferably a 3.68 Mbit/s digital waveform TDM bit stream that carries 96 16 kbit/s prime bit rate digital channels organized into broadcast channels, and side information needed to synchronize, demultiplex and control the broadcast channels and the services they bare. The terrestrial waveform modulator 36 and the waveform that it generates is designed to allow reception unimpeded by the multipath vagaries indicated at 42 of the terrestrial path as described previously. Possible multipath-tolerant waveforms are adaptive equalized TDM, adaptive equalized multiple carrier frequency hoppers with adaptive equalization, Fast Fourier Transform multiple carrier modulation and CDMA with rake receivers. The repeater 18 is equipped to assemble the multipath-tolerant waveform, to frequency convert the waveform to the desired re-radiator transmitter RF frequency at the selected power level via the RF translator 38, and to radiate the waveform from antenna 40. The antenna 40 is preferably configured to provide omni-directional or sector directional propagation in the horizontal plane and high directive toward the horizon. The net antenna gain is expected to range from 10 to 16 dBi. The antenna 40 can be located on top of a building and/or on a tower at a desired height. As previously mentioned, the radiated power level can range from 1 to 10,000 watts of EIRP depending on the application.

A particularly desirable multipath-tolerant re-radiated waveform uses multicarrier modulation (MCM). The manner in which the waveform is generated is shown in Fig. 3. A digital stream such as the 3.68 Mbit/s TDM stream is time-domain-divided into a number of parallel paths (block 102), for example, 460 parallel paths with each parallel path carrying 8000 bits per second. The bits on each of these paths are paired into 2 bit symbols with one bit identified as the I (imaginary) component and the other as the Q (Real) component of a complex number. This creates a complex symbol rate of 4000 per second. These bits are fed as 460 parallel complex number frequency coefficient inputs to a Discrete Inverse Fourier Transform converter implemented using a 512 coefficient Inverse Fast Fourier Transform (IFFT) 104. It is well known in the current state of the art that the Fast Fourier Transform algorithm must operate with 2^n input and output coefficients where n is any integer. Thus, for n = 9, $2^9 = 512$. Since the number of coefficients is 460, the remaining 52 missing input coefficients are set equal to zero. This is done by assigning 23 zero-valued coefficients at each the uppermost and lower most IFFT inputs, thus leaving the 460 center coefficients assigned to non-zero values. The output 104 of the IFFT is a set of 460 QPSK-modulated, orthogonal sine coefficients which constitute 460 narrow band orthogonal carriers, each supporting a symbol rate of 4000 per second and consequently having a symbol period of 250 μs. No carriers appear at the output of the IFFT 104 for the coefficients that are set equal to zero.

The IFFT multicarrier output 104 is further processed to create a guard interval 105 for the set of 460 complex symbol narrow band orthogonal carriers (block 106). It is assumed that a fraction f of a symbol period Ts is to be allocated to guard time. To do this the symbol duration must be reduced to a value Ts = (1-f) Ts. For the example considered above Ts = 250 μs. If 25 % of the symbol time is to be allocated guard time, then f =0.25 and Ts = 187.5 μs. To do this, the symbol period output of the IFFT is stored in a memory every 250 μs and then played back in 187.5 μs. To fill the 250 μs symbol interval, the first samples of the IFFT output are again played back during the 62.5 μs guard interval. This procedure causes an increase in the bandwidth of the multicarrier output by a multiplication of (1-f)-1. Thus, the bandwidth needed for the multicarrier modulator output is multiplied by 1.33 to a value of 4000 x 460 x 1.33 = 2.453 MHz.

Finally, to complete the multicarrier modulator processing, a symbol 106 containing a synchronization symbol is introduced periodically, as indicated by block 108. This is done to provide the means for synchronizing a sampling window of 187.5 μs duration at the receiver 14 to the center of the group of multipath arrivals every 250 μs. Also, a phase reference symbol for differential reference coding of the symbol information is also added periodically. The synchronization and phase reference symbols are preferably introduced every 20 to 100 symbol periods depending on the design requirements.

An additional feature of the modulation design is to puncture the TDM digital bit stream, as indicated by phantom block 110, at the input to the modulator 36 to reduce the final bandwidth of the multicarrier waveform. Puncturing means selective, sparse elimination of real data bits from the data stream applied at the input to the IFFT 104. This can be done for a fraction of the bits of the stream in anticipation that the forward error correction scheme applied at the receiver 14 will simply treat the punctured bits as errors and correct them. This has the consequence of increasing the signal to noise ratio (E_b/N_o) for a desired reception BER objective by 1 to 3 dB, depending on the fraction of bits removed by the puncturing. The design for the punctured waveform proportionately reduces the bandwidth of the multicarrier modulation. For example, if the bit rate of the TDM stream is reduced by 75% , the bandwidth will also be reduced by 75%. For the example previously given, the bit rate is reduced to 2.76 Mbit/s and the multicarrier bandwidth to 1.84 MHz. Such bandwidth compression can be necessary in applications where the available frequency spectrum would otherwise be insufficient to carry the desired capacity.

Further details concerning the preferred multicarrier modulation techniques used herein can be found in International Application Nos. PCT/EP98/02167, PCT/EP98/02168, PCT/EP98/02169, PCT/EP98/02170 and PCT/EP98/02184, all filed on April 14, 1998 by Fraunhofer-Gesellschaft zur Förderung.

It is to be understood that the terrestrial repeater described with reference to Figs. 2 and 3 is used to recover a TDM satellite downlink signal, and to demodulate and reformat the TDM signal via baseband processing into a different waveform using, for example, CDMA, AETDM, MCM or CHFATDM. It is to be understood, however, that the DBS 10 can comprise terrestrial repeaters 18 which are co-channel or non-co-channel repeaters. For example, terrestrial repeaters 18 can be provided which are co-channel gap-fillers which merely amplify and repeat a received satellite signal on the same carrier as the satellite signal. Alternatively, terrestrial repeaters can be provided which are non-co-channel gap-fillers which amplify and repeat a satellite signal on a different carrier frequency via frequency translation. In either case, baseband processing of the satellite signal is not performed at the repeater. These types of gap-fillers can be used, for example, indoors (Fig. 10) or along a roadway (Fig. 11).

At a radio receiver 14 shown in Fig. 4, the multicarrier modulated RF waveform is received by the antenna 201 operating in conjunction with a low noise RF front end 202, mixer 203, local oscillator 204, first intermediate frequency (IF) 205, second mixer 206, second local oscillator 207, second IF 208 to recover the multicarrier modulated carrier. A multicarrier demodulator 209 recovers the TDM digital baseband signal. To demodulate the multicarrier waveform, the received modulated signal is digitally sampled by a sampler 211, as shown in Fig. 5, at a rate equal to two of four times the bandwidth of the modulation. These samples are taken during a window of 187.5 μs duration which is optimally centered on the cluster of time dispersed multipath arrivals during each symbol period once every 250 μs. The samples are rate down converted by a buffer memory 212 to expand them to the 460 complex time domain samples in the original 250 μs duration window. These samples are then processed by an 512 coefficient FFT 213 to recover the bits of the TDM bit stream. The receiver 14 next synchronizes to the TDM masterframe frame preamble via unit 214, demultiplexes and aligns the prime rate bits via unit 215 and then recovers the bits of a selected broadcast channel via unit 216. These bits are then forward error corrected using concatenation of a soft decision Viterbi decoder 217, a de-interleaver 218, followed by a Reed Solomon decoder 219, to recover the broadcast channel (BC). This recovered BC is supplied as one input to a decision/combiner unit 240, as described below in connection with Fig. 6.

For a two-arm receiver 14, as depicted in Fig. 6, the MCM signal is received as described with reference to Fig. 4. The QPSK modulated satellite TDM RF waveform is also received by the antenna 201 operating in conjunction with the low noise RF front end 202, a mixer 220, a local oscillator 221, a first IF 222, a second mixer 223, a second local oscillator 224, and a second IF 225, to recover the QPSK-modulated TDM carrier. As shown in Fig. 7, a QPSK TDM carrier demodulator 226 comprises a QPSK demodulator 227 which recovers the TDM digital baseband. The receiver 14 next synchronizes to the TDM masterframe frame preamble 228, demultiplexes and aligns the prime rate bits 229 and then recovers the bits of a selected broadcast channel. These bits are then forward error corrected 230 using the concatenation of a soft decision Viterbi decoder 231, a de-interleaver 232, and a Reed Solomon decoder 232, to recover the broadcast channel. This recovered BC is supplied as a second input to the decision/combiner unit 240.

The diversity combiner 240 selects which of the two input BCs is to be submitted for further processing. It does this based on selecting that BC which is recovered with the least errors. Estimates of the error counts are available from the soft decision data supplied by the Viterbi decoders 217 and 231 or the Reed Solomon decoders 219 and 233. The decision is preferably made with a hysterisis logic which requires that several errors of difference exist before the decision is reversed. This process is needed to prevent chattering between the two BCs when the decisions are nearly equally likely. The broadcast channel selected by the diversity combiner 240 is next supplied to the appropriate source decoder 244 to recover the service(s).

The embodiment of the DBS 10 which uses two GSO satellites 12 and 16 with terrestrial repeater 18 is shown in Fig. 8. In this configuration, two satellites 12 and 16 are separated by between 30 degrees to 40 degrees longitude along the GSO circle. One satellite repeats a signal sent from a ground station, and the other satellite repeats the same signal sent from the same ground station but delays the signal as much as 5 to 10 seconds. The use of two satellites 12 and 16 separated in space results in elevation angle diversity in the LOS paths between a radio receiver 14 on the earth and each satellite 12 and 16. The time delay between the two satellite signal arrivals results in time diversity. Each of these types of diversity taken alone can significantly improve the availability of the LOS signal for a moving mobile receiver 14, and the improvement in availability is further significantly enhanced by both space and time diversity. Space and time diversity are particularly important when a mobile receiver 14 is traveling in a suburban area or in a rural area where the LOS signal blockage is due to bridges, trees and low buildings. However, for central city and metropolitan areas, where tall buildings abound, terrestrial re-radiation of the signal is also supplied in accordance with the present invention to achieve acceptable total area coverage for mobile reception. Thus, this two-satellite diversity configuration operates essentially the same way as the single satellite configuration with regard to the diversity between direct LOS satellite reception and terrestrial re-radiated reception, but adds the time and space diversity provided by the two satellites. The signal from the early satellite is the one re-radiated by the terrestrial repeater 18. Choice of the early signal allows any delay encountered in the signal processing at the repeater 18 or the receiver 14 to be absorbed. The terrestrial re-radiation network is otherwise implemented in the same way as previously described for the single satellite configuration.

Another difference between the two-satellite system and the one-satellite system resides in the three-arm radio receiver 14. The receiver 14 introduces appropriate compensating delays via delay units 309 and 310 to achieve simultaneous signal reception among the three received signals and implement a diversity decision logic which selects among the three diversity signals. The delay unit 309 provides a time diversity delay to the early signal to compensate for the signal propagation differential between the early and late satellites 12 and 16. The delay unit 310 is preferably a vernier delay to allow fine compensation for signal alignment. The radio receiver diversity logic design is shown in Fig. 8. It incorporates a maximum likelihood combiner 240 for the Early and Late LOS satellite signals with a switched combiner 307 between the terrestrial re-radiated signal and the output of the maximum likelihood combiner 240. When both signals are degraded, maximum-likelihood combining can improve the quality of reception. The improvement can be as much as 3 dB in terms of threshold E_b/N_o when both signals are equally degraded.

The radio receiver 14 is equipped with two receiver chains 301 and 302 that individually receive and recover the TDM signals from the early and late satellites, respectively, and selects a desired broadcast channel from each. This is done for each received signal in the same manner as previously described for LOS satellite reception in Fig. 6. Next, the broadcast channel signal derived from the early satellite is delayed by a delay unit 309 comprising a memory device to align it precisely, that is, symbol by symbol, with the symbols of the broadcast channel derived from the late satellite signal. This can be done by aligning the two broadcast channels relative to one another so as to cause coincidence of their service control header preamble correlation spikes. This coincidence is detected in a correlation comparitor unit in the delay unit 309. The next step is to use the maximum likelihood combiner 240 to combine the bits of the two broadcast channels, bit-by-bit, each bit expressed in soft decision form. The maximum likelihood combining coefficients are determined over 1 ms blocks of bits. Next, the output of the maximum likelihood combiner 240 is applied as one input to the switched combiner 307, with the other input coming from the terrestrial re-radiated signal receiver arm 308. The choice of which input is to be passed to the output is based on selecting that BC which is recovered with the least errors. In accordance with another embodiment of the present invention, one of the TDM signal receiver chains (e.g., receiver chain 302 for the late satellite TDM signal) can be maximum likelihood combined with the signal from the terrestrial re-radiated signal receiver arm 308, as shown in Fig. 9. Thus, the switched combiner 307 selects from between the output of the maximum likelihood combiner 240 and the other satellite signal receiver arm (e.g., arm 301), as shown in Fig. 9. The delay units 309 and 310 can be configured to store the entire recovered bit stream for delay purposes, which requires more buffering but simplifies combining. Alternatively, the delay units 309 and 310 can be configured to store only a portion of the recovered TDM bit stream; however, synchronization requirements for combining become more complicated.

With regard to switched combiner 307, estimates of the error counts are available from the soft decision data supplied by the Viterbi decoders 217 and 231 or the Reed Solomon decoders 219 and 233. The decision is made with a hysterisis logic which requires that several errors of difference exist before the decision is reversed. This process is prevents chattering between the two BCs when the decisions are nearly equally likely. Alternatively, a simple switching logic may be used in which the switch always favors the choice of the BC having the least errors. Hysterisis is used to prevent chattering. The latter implementation avoids the more complex maximum likelihood combining. Yet another alternative could be maximum likelihood combining of the three input BCs (e.g., from receiver arms 301, 302 and 308), as shown in Fig. 10.

The diversity combiner shown in Fig. 10 combines three signals. Two are received from two spatially separated satellites 12 and 16, one broadcasting an early signal and the other broadcasting a late signal. The third signal is received from a terrestrial repeater 18 which rebroadcasts the early satellite signal. These signals are received by receiver arm 301 for the early satellite 12, receiver arm 302 for the late satellite 16 and receiver arm 308 for the early signal retransmitted by the repeater 18. The diversity combiner 312 combines the symbols in the three signals by maximum likelihood ratio combining. By this method, the samples of the symbol appearing at the output have the highest probability of representing the original transmitted symbol. To do this, the early satellite 12 and repeater 18 signals are delayed relative to the late satellite signal by delay units 309 and 310 to realign the individual symbols of the three signals causing them to be in time coincidence. Simple *a priori* adjustment of the delay units 309 and 310 suffices to coarsely align the output of the delay units 309 and 310 to within a TDM frame of 138 μs. Thus, fine alignment of the symbols to the master frame preamble (MFP) of a TDM frame is nonambiguous. To align the symbols of the three signals precisely, the MFPs for each signal stream are aligned by fine tuning the delay units 309 and 310 to within a small fraction of a symbol.

With continued reference to symbol combining in unit 312, the normalized variance σ_x^2 for the signal symbols, as contained in the background of noise, and uncorrelated multipath interference, is calculated from the observed samples. These variances are calculated for the early (E), late (L) and repeater 18 or gap-filler (G) signal symbols. The respective signal samples of the symbols for the early, late and gap-filler signals are then multiplexed by their variance ratios $(q_E)^{-1}$, $(q_L)^{-1}$ and $(q_G)^{-1}$, which are defined as follows:

$(q_E)^{-1}$ is the weighting factor associated with early symbol S_E
$(q_L)^{-1}$ is the weighting factor associated with early symbol S_L
$(q_G)^{-1}$ is the weighting factor associated with early symbol S_G

The weighting factors are inversely proportional to the estimated variance and are normalized such that

$$q_E + q_L + q_G = 1$$
$$q_E = \sigma_E^2/(\sigma_E^2 + \sigma_L^2 + \sigma_G^2)$$
$$q_L = \sigma_L^2/(\sigma_E^2 + \sigma_L^2 + \sigma_G^2)$$
$$q_G = \sigma_G^2/(\sigma_E^2 + \sigma_L^2 + \sigma_G^2)$$

Their sum constitutes the maximum likelihood ratio combined symbols. These are then passed on to the time demultiplexer/FEC decoder/BC remultiplexer unit 250 (Fig. 11), the components of which have previously been described above in connection with Fig. 5, to recover the maximum likelihood ratio combined symbols by decision processing.

The diversity combiner shown in Fig. 12 first combines signals received from two satellites 12 and 16, one broadcasting an early signal and the other broadcasting a late signal. The result of this is next combined by minimum bit error decision with reception of the early signal that has been retransmitted by a gap-filler repeater 18 located on the ground. The individual signals are received by the receiver arm 301 for the early satellite, the receiver arm 302 for the late satellite and the receiver arm 308 for the early signal retransmitted by the gap-filler repeater 18. The maximum likelihood ratio diversity combiner 412 combines the symbols of the early and late satellite signals in the same manner described above in connection with combiner 312 in Fig. 10 for three signals. By this method, the final symbol appearing at the output of unit 412 has the highest probability of representing the original transmitted symbol .

The result from unit 412 is next combined with that from the terrestrial repeater 18 by minimum BER select unit 417. Within the unit 417, there are preferably two units 250 that make FEC-decoded symbol decisions for an entire broadcast channel frame of the signals applied at their inputs. One unit 250 makes its decisions on the output from maximum likelihood decision unit 412, and the other unit 250 from the signal received from the terrestrial repeater 18. These decisions also provide the number of errors made with each decision observed over the duration of a broadcast frame. A BER compare unit 414 operates in conjunction with a minimum BER select unit 417 to select the symbols of that broadcast frame with the least error, as determined from inputs from Viterbi FEC units 217 and 231. To implement the necessary delay operations, the early and gap-filler signals are delayed by delay units 309 and 310 to realign their individual symbols to be in symbol time coincidence with the symbols received from the late satellite. The delay alignment method used here is the same as that described for the implementation of Fig. 10.

In accordance with another aspect of the present invention, an indoor re-radiation system 450 is provided which is illustrated in Fig. 13. Since LOS reception of a satellite signal at a radio receiver located inside a building or other structure is generally not available, unless the radio receiver 14 is located at a window in LOS of the satellite 12 or 16, indoor reinforcement of satellite signals for more complete coverage.

As shown in Fig. 13, an antenna 452 can be located externally with respect to a building so as to achieve LOS reception of satellite signals. A tuned RF front-end unit 454 is connected to the antenna 452 and is preferably configured to select the portion of the RF spectrum that contains the essential frequency content of the satellite signal and by doing so with very low added noise. An interconnecting cable 456 is provided to supply the signal at the output of the tuned RF front-end unit 454 to an amplifier 458. The amplifier 458 is connected to a re-radiating antenna 460 located within the building.

The amplifier 458 is configured to increase the power of the satellite signal to a level that, when re-radiated, by the antenna 460, is sufficient to permit satisfactory indoor reception for a radio receiver. The power level radiated from the antenna 460 is sufficiently high to achieve satisfactory indoor reception at locations which are not in the LOS of the satellite, but not so high as to cause instability by signals returned by the path between the indoor antenna 460 and one or more of the receiving antennas 452. Thus, high isolation (i.e., on the order of 70-80 dB) is preferred between the indoor antenna 466 and the outdoor antenna 452.

Reception areas will be present (e.g., through windows or other openings to the building or structure) where indoor re-radiated signals combine with an outdoor signal transmitted directly from the satellite. To assure that the combination of these signals does not occur in an manner which is destructive to signal content, the time delay between an outdoor signal and an indoor signal in the region of combination is preferably less than a fraction of the symbol width of the signal being transmitted. For example, for a symbol width of approximately 540 nanoseconds, a time delay between 50 and 100 nanoseconds can be tolerated. The time delay is generally due to the time required for a signal to travel the path comprising the outdoor antenna 452, the cable (where signals generally travel at two-thirds the speed of light), and onward to the indoor antenna 460. Another delay occurs as the signal travels from the indoor antenna 460 to the radio receiver 14 in an area covered by the indoor antenna. This time delay is preferably only 20% of the symbol width, that is, not more than 100 nanoseconds for a system in which the symbol width is 540 nanoseconds.

The purpose of a terrestrial repeater is to repeat a signal received from the satellite into areas where the signal is otherwise blocked. A multiplicity of these terrestrial repeaters 18 may be placed along a roadway or other path at a height h and separated by distances d, as shown in Fig. 14. The heights and separation distances between the terrestrial repeaters need not be equal. A terrestrial repeater 18 comprises a receive antenna 462 that is pointed at the satellite 12 or 16, a receiver (not shown) that recovers the signal and amplifies it with a gain that is sufficient to drive a transmit antenna 464 such as to a power flux density in the path below which is comparative to that normally expected from the satellite. The transmit antenna 464 is shielded so as to prevent the transmitted signal from reaching the terrestrial repeater receive antenna 462 at a level sufficient to create instability. The transmit antenna 464 radiates its power over an aperture of length L sufficient to cause path length diversity over several wavelengths between the transmitter 464 and the vehicle's receive antenna at the carrier frequency.

As a vehicle drives along the path, the radio receiver 14 therein receives signals coming from more than one terrestrial repeater 18. For example, in position A, a vehicle is nearest to terrestrial repeater 18b and that terrestrial repeater's signal dominates and be responsible for reception. Signals from terrestrial repeaters 18a and 18b are low because of distance and antenna pattern and cause little interference. If the vehicle is at position B, the radio receiver 14 therein receives signals from both terrestrial repeaters 18c and 18d. Since the distances are nearly equal, and assuming that the time difference between signals radiated from terrestrial repeaters 3 and 4 is adjusted to zero, the time difference of arrival between the signals received at the vehicle are sufficiently small so as to cause constructive reinforcement. By proper choice of the distances h and d in relationship with the symbol period of the digital signal being received, this condition can be achieved.

It is important to cause diversity in the signals that arrive at the vehicle from the different terrestrial repeaters. If this is not done, then the signals from two terrestrial repeaters, as would be received in the location B, would combine alternately in-phase and out-of-phase and phases in between. When they are in phase, the signals reinforce, and when out-of-phase the signals cancel. When signal cancellation occurs, the signal is completely lost. In addition, the resulting carrier phase of the signal created by addition of the terrestrial repeater carriers rotates at a rate equal to a nearly monochromatic Doppler difference, making it difficult to recover the QPSK modulation. The spread in arrival times caused by the diversity transmission resulting from distribution of the transmitted signal over the aperture L, or over an equivalent time difference of L/C where C = speed of light, eliminates the amplitude cancellation and provides the possibility of correcting the impact of the phase rotation by application of adaptive equalization techniques. This applied to all vehicle locations between locations A and B.

An example of the proper choice of distances in relationship to symbol period is seen by considering a signal having a symbol period on the order of 540 to 550 nanoseconds. The spacing d and height h is selected so as to cause the time delay in transversing the slant distance $(d^2 + h^2)^{1/2}$ to cause a delay of no greater than a quarter of a symbol period. In this example, the slant distance is 550/d = 137.5 ft. One nanosecond is equivalent to one foot at the speed of light. Thus, if the height is 20 feet, the distance d is 180 feet. The height h is preferably relatively small when compared to distance d so as to cause the difference in distance between the vehicle and each terrestrial repeater 18 to change by an amount sufficient to assure that the signal level from any one terrestrial repeater is attenuated by 10 dB or more compared to that from a terrestrial repeater immediately overhead. The length L is preferably between 5 to 10 feet to provide sufficient path length diversity at L-band frequencies. If an equalizer unit is incorporated in the vehicle's mobile receiver 14, the time difference in arrival can be extended to several symbols, thus increasing the distance between the terrestrial repeaters to over 1000 feet. An equivalent time difference would be to transmit the signal several times from the same source over a spread not exceeding 5-10 nanoseconds.

While various embodiments have been chosen to illustrate the invention, it will be understood by those skilled in the art that various changes and modifications can be made therein without departing from the scope of the invention as defined in the appended claims.

What is Claimed Is:

1. A digital broadcasting system for transmitting a broadcast signal, said broadcast signal being transmitted from an earth station, comprising:

a satellite for receiving said broadcast signal from said earth station and for transmitting a satellite signal comprising said broadcast signal on a first carrier frequency; and

a terrestrial repeater for receiving said satellite signal and for generating and transmitting a terrestrial signal from said satellite signal comprising said broadcast signal on a second carrier frequency that is different from said first carrier frequency, said terrestrial signal being modulated by said terrestrial repeater in accordance with a multipath-tolerant modulation technique.

2. A system as claimed in claim 1, wherein said terrestrial repeater is operable to modulate said terrestrial signal using at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptively equalized time division multiplexing, multicarrier modulation, and code division multiplexing.

3. A system as claimed in claim 1, wherein said satellite signal is modulated in accordance with at least one of time division multiplexing and code division multiplexing.

4. A system as claimed in claim 1, wherein said terrestrial repeater is operable to modulate said terrestrial signal using multicarrier modulation.

5. A system as claimed in claim 4, wherein said terrestrial repeater is operable to receive said satellite signal and to demodulate said satellite signal into a baseband signal prior to modulating said baseband signal using multicarrier modulation.

6. A system as claimed in claim 1, wherein said satellite signal is assigned a first code division multiple access channel code and said terrestrial signal is assigned a second code division multiple access channel code.

7. A system as claimed in claim 1, further comprising a second satellite, said second satellite being operable to receive said broadcast signal from said earth station and to

transmit a second satellite signal comprising said broadcast signal on said first carrier frequency and delayed by a predetermined period of time with respect to the transmission of the first satellite signal.

8. A terrestrial repeater for retransmitting satellite signals to radio receivers, comprising:

a terrestrial receiver for receiving said satellite signals; and

a terrestrial waveform modulator for generating terrestrial signals from said satellite signals, said terrestrial signals being modulated by said terrestrial waveform modulator in accordance with multicarrier modulation;

wherein said satellite signals are transmitted from a satellite using a first carrier frequency, and said terrestrial waveform modulator is operable to transmit said terrestrial signals to said radio receivers using a second carrier frequency that is different from said first carrier frequency.

9. A terrestrial repeater as claimed in claim 8, wherein said terrestrial waveform modulator comprises:

a time division demultiplexer for demultiplexing said satellite signals from a serial time division multiplexed bit stream into a plurality of parallel bit streams; and

an inverse fast Fourier transform device for generating a digital analog signal comprising a plurality of discrete Fourier transform coefficients.

10. A method for converting a time division multiplexed bit stream into a plurality of multicarrier modulated signals at a terrestrial repeater, comprising the steps of:

receiving said time division multiplexed bit stream from a satellite;

dividing said time division multiplexed bit stream into a plurality of parallel bit paths;

representing each of a predetermined number of bits in each of said plurality of bit paths as a symbol comprising an imaginary component and a real component;

providing said symbols to parallel inputs of an inverse Fourier transform converter as complex number frequency coefficient inputs to generate outputs which comprise modulated, narrow-band, orthogonal carriers; and

transmitting said modulated, narrow-band, orthogonal carriers from said terrestrial repeater.

11. A method as claimed in claim 10, further comprising the step of generating a guard interval for said carriers.

12. A method as claimed in claim 11, wherein said generating step comprises the steps of:

allocating a fraction of the symbol period corresponding to the duration of each of said symbols to guard time; and

reducing the duration of each of said symbols.

13. A method as claimed in claim 12, wherein said reducing step comprises the steps of:

storing said outputs of said inverse Fourier transform converter in a memory device every said symbol period; and

reading from said memory device after each said fraction of said symbol period has elapsed.

14. A method as claimed in claim 11, wherein said generating step further comprises the step of filling said guard interval with a subset of said outputs of said inverse Fourier transform.

15. A method as claimed in claim 10, further comprising the step of inserting a synchronization symbol every predetermined number of said symbol periods to synchronize a sampling window corresponding to said fraction of said symbol period with respect to said carriers every said symbol period at a receiver for said plurality of multicarrier modulated signals.

16. A method as claimed in claim 10, further comprising the step of puncturing said time division multiplexed bit stream to reduce the total bandwidth associated with said carriers.

17. A method as claimed in claim 16, wherein said puncturing step comprises the step of selectively eliminating bits from said time division multiplexed bit stream prior to providing said symbols to said parallel inputs of said inverse Fourier transform converter.

18. A digital broadcasting system for transmitting a broadcast signal, said broadcast signal being transmitted from an earth station, comprising:

a first satellite configured to receive said broadcast signal from said earth station and to transmit a time division multiplexed satellite signal comprising said broadcast signal;

a terrestrial repeater configured to receive said satellite signal and to generate and transmit a terrestrial signal from said satellite signal comprising said broadcast signal, said terrestrial signal being modulated by said terrestrial repeater in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing, and multicarrier modulation.

19. A digital broadcasting system as claimed in claim 18, wherein said satellite signal is transmitted using a first carrier frequency, and said terrestrial signal is transmitted using a second carrier frequency that is different from said first carrier frequency.

20. A digital broadcasting system as claimed in claim 18, further comprising at least one radio receiver configured to receive said satellite signal and said terrestrial signal, said radio receiver comprising a diversity combiner for generating an output signal from at least one of said satellite signal and said terrestrial signal.

21. A digital broadcasting system as claimed in claim 18, further comprising a second satellite configured to receive said broadcast signal from said earth station and to transmit a second time division multiplexed satellite signal comprising said broadcast signal, said second satellite signal being delayed with respect to said first satellite signal by a selected time delay.

22. A digital broadcasting system as claimed in claim 21, further comprising at least one radio receiver configured to receive said first satellite signal, said second satellite signal and said terrestrial signal, to delay at least one of said first satellite signal and said terrestrial signal in accordance with said selected time delay, and to generate an output signal from at least one of first satellite signal, said second satellite signal and said terrestrial signal.

23. A digital broadcasting system as claimed in claim 22, wherein said radio receiver comprises a diversity combiner and a switched combiner, said radio receiver using said diversity combiner to perform maximum likelihood decision combining of said first satellite

signal and said second satellite signal and said switched combiner to select between the output of said diversity combiner and said terrestrial signal depending on which of said output of said diversity combiner and said terrestrial signal has the least number of bit errors.

24. A digital broadcasting system as claimed in claim 22, wherein said radio receiver comprises a diversity combiner to perform maximum likelihood decision combining of said first satellite signal, said second satellite signals and said terrestrial signal.

25. A receiver for receiving a broadcast signal in a combined satellite and terrestrial digital broadcasting system, comprising:

a first receiver arm for receiving a first satellite signal transmitted from a first satellite on a first carrier frequency, said first satellite signal comprising said broadcast signal and being modulated in accordance with at least one of time division multiplexing and code division multiplexing, said first receiver arm comprising a demodulator for recovering said broadcast signal;

a second receiver arm for receiving a terrestrial signal transmitted from a terrestrial station on a second carrier frequency, said terrestrial signal comprising said broadcast signal and being modulated in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing, and multicarrier modulation, said second receiver arm comprising a demodulator for recovering said broadcast signal; and

a combiner for generating an output signal from at least one of said third satellite signal and said terrestrial signal. ? AG

26. A receiver as claimed in claim 25, further comprising:

a third receiver arm for receiving a second satellite signal from a second satellite that is delayed with respect to said first satellite signal in accordance with a selected time delay, said second satellite signal comprising said broadcast signal and being modulated in accordance with the corresponding at least one of time division multiplexing and code division multiplexing employed by said first satellite signal, said third receiver arm comprising a demodulator for recovering said broadcast signal; and a delay device for delaying said first satellite signal in accordance with said selected time delay, said combiner being operable to generate an output signal from at least one of said first satellite signal, said second satellite signal and said terrestrial signal.

27. A method for transmitting a broadcast signal to a radio receiver, comprising the steps of:

modulating said broadcast signal for transmission to said radio receiver as a first signal in accordance with at least one of time division multiplexing and code division multiplexing;

transmitting said first signal to said radio receiver from a first satellite on a first carrier frequency;

modulating said broadcast signal at a terrestrial station for transmission to said radio receiver as a second signal in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing, and multicarrier modulation; and

transmitting said second signal to said radio receiver from said terrestrial station on a second carrier frequency that is different from said first carrier frequency.

28. A method as claimed in claim 27, wherein the step of modulating said broadcast signal as said second signal comprises the steps of:

receiving said first signal at said terrestrial station; and

performing baseband processing of said first signal prior to modulating in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing, and multicarrier modulation.

29. A method as claimed in claim 28, further comprising the step of receiving said first signal and said second signal at said radio receiver.

30. A method as claimed in claim 29, further comprising the step of demodulating each of said received first signal and said received second signal to remove said respective modulations and to recover a first recovered broadcast signal and a second recovered broadcast signal, respectively.

AMENDED SHEET

31. A method as claimed in claim 30, further comprising the step of generating an output broadcast signal from said first recovered broadcast signal and said second recovered broadcast signal.

32. A method as claimed in claim 31, wherein said generating step comprises the step of performing maximum likelihood combining of said first recovered broadcast signal and said second recovered broadcast signal.

33. A method as claimed in claim 27, further comprising the steps of:

modulating a broadcast signal for transmission to said radio receiver as a third signal in accordance with at least one of time division multiplexing and code division multiplexing;

transmitting said third signal to said radio receiver from a second satellite, said transmission being delayed with respect to the transmission of said first signal by a predetermined period of time.

34. A method as claimed in claim 33, further comprising the steps of:

receiving said first signal, said second signal and said third signal at said radio receiver;

demodulating each of said first signal, said second signal and said third signal to remove said respective modulations and to recover a first recovered broadcast signal, a second recovered broadcast signal and a third recovered broadcast signal, respectively; and

generating an output broadcast signal from at least one of said first recovered broadcast signal, said second recovered broadcast signal and said third recovered broadcast signal.

35. An indoor reinforcement system for receiving satellite signals transmitted by a digital broadcasting system using a radio receiver located indoors, comprising:

a line of sight antenna for receiving line of sight satellite signals;

a radio frequency front-end unit connected to said line of sight antenna for passing frequency spectrum comprising said satellite signals with low noise;

an indoor amplifier;

a cable for connecting said radio frequency front-end unit to said indoor amplifier; and

an indoor re-radiating antenna connected to said indoor amplifier, said indoor re-radiating antenna having a power level selected to be sufficiently high to achieve satisfactory indoor reception of said satellite signals at radio receivers at indoor locations where line of sight reception of said satellite signals is not possible and sufficiently low to prevent interference by said satellite signals transmitted between said indoor re-radiating antenna and said line of sight antenna.

36. An indoor reinforcement system as claimed in claim 35, wherein said satellite signals are characterized by a selected symbol period, and the duration of the transmission of said satellite signals between said line of sight antenna and said indoor re-radiating antenna is maintained to be less than a selected amount of said symbol duration by limiting the length of said cable.

37. An indoor reinforcement system as claimed in claim 36, wherein said duration of the transmission of said satellite signals between said line of sight antenna and said indoor re-radiating antenna is no more than between 20 percent and 25 percent of said selected symbol period.

38. A reinforcement system for receiving satellite signals transmitted by a digital broadcasting system using a radio receiver located outdoors, wherein said satellite signals are characterized by a selected period, said reinforcement system comprising at least two terrestrial repeaters, said terrestrial repeaters being characterized by a height *h* and being spaced apart by a distance *d*, the slant distance $(d^2 + h^2)^{1/2}$ from one of said terrestrial repeaters to said radio receiver being selected to limit a delay in reception of said satellite signals at said radio receiver from one of said terrestrial repeaters to between 20 percent and 25 percent of said symbol period.

39. A digital broadcasting system for transmitting a broadcast signal to a radio receiver, said broadcast signal being transmitted by an earth station, comprising:

a satellite configured to receive said broadcast signal from said earth station and to transmit a satellite signal comprising said broadcast signal to said radio receiver on a first carrier frequency; and

at least one terrestrial repeater configured to receive said satellite signal and to generate and transmit a terrestrial signal from said satellite signal comprising said broadcast signal to said radio receiver on a second carrier frequency that is different from said first carrier frequency, wherein said satellite signal and said terrestrial signal are each modulated using a multipath-tolerant modulation technique.

40. A system as claimed in claim 39, wherein said satellite signal is modulated in accordance with code division multiplexing.

41. A system as claimed in claim 39, wherein said terrestrial signal is modulated in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing, and multicarrier modulation.

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04H 1/00, H04B 7/155 — A1

(11) International Publication Number: WO 99/49602

(43) International Publication Date: 30 September 1999 (30.09.99)

(21) International Application Number: PCT/US98/14280

(22) International Filing Date: 10 July 1998 (10.07.98)

(30) Priority Data:
60/079,591 27 March 1998 (27.03.98) US
09/058,663 10 April 1998 (10.04.98) US

(63) Related by Continuation (CON) or Continuation-in-Part (CIP) to Earlier Application
US 09/058,663 (CIP)
Filed on 10 April 1998 (10.04.98)

(71) Applicant (*for all designated States except US*): WORLDSPACE MANAGEMENT CORPORATION [US/US]; 2400 N Street, N.W., Washington, DC 20037 (US).

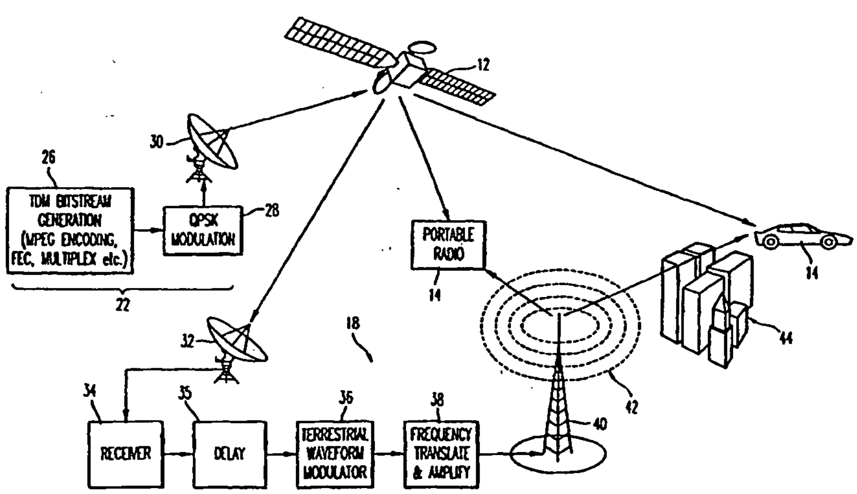
(72) Inventor; and
(75) Inventor/Applicant (*for US only*): CAMPANELLA, S., Joseph [US/US]; 18917 Whetstone Circle, Gaithersburg, MD 20879 (US).

(74) Agents: HOLMES, John, .E. et al.; Roylance, Abrams, Berdo & Goodman, LLP, 1225 Connecticut Avenue, N.W., Washington, DC 20036 (US).

(81) Designated States: AL, AM, AT, AT (Utility model), AU (Petty patent), AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), 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, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, 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
With international search report.

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



(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.

Please type a plus sign (+) inside this box → [+]

PTO/SB/01 (12-97)
Approved for use through 9/30/00. OMB 0651-0032
Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

DECLARATION FOR UTILITY OR DESIGN PATENT APPLICATION (37 CFR 1.63)

☑ Declaration Submitted with Initial Filing OR ☐ Declaration Submitted after Initial Filing (surcharge (37 CFR 1.16 (e)) required)

Attorney Docket Number	40264
First Named Inventor	S. Joseph Campanella
COMPLETE IF KNOWN	
Application Number	/
Filing Date	
Group Art Unit	
Examiner Name	

As a below named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Digital Broadcast System Using Satellite Direct Broadcast and Terrestrial Repeater

(Title of the Invention)

the specification of which

☐ is attached hereto

OR

☑ was filed on (MM/DD/YYYY) 07/10/1998 as United States Application Number or PCT International Application Number PCT/US98/14280 and was amended on (MM/DD/YYYY) ______ (if applicable).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment specifically referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or of any PCT international application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached? YES	NO
			☐	☐	☑
			☐	☐	☑
			☐	☐	☐
			☐	☐	☐

☐ Additional foreign application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto:

I hereby claim the benefit under 35 U.S.C. 119(e) of any United States provisional application(s) listed below.

Application Number(s)	Filing Date (MM/DD/YYYY)
60/079,591	03/27/1998

☐ Additional provisional application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

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PTO/SB/01 (12-97)
Approved for use through 9/30/00. OMB 0651-0032
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Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

DECLARATION — Utility or Design Patent Application

I hereby claim the benefit under 35 U.S.C. 120 of any United States application(s), or 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

U.S. Parent Application or PCT Parent Number	Parent Filing Date (MM/DD/YYYY)	Parent Patent Number *(if applicable)*
09/058,663	04/10/1998	

☐ Additional U.S. or PCT international application numbers are listed on a supplemental priority data sheet PTO/SB/02B attached hereto.

As a named inventor, I hereby appoint the following registered practitioner(s) to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: ☐ Customer Number ______ → *Place Customer Number Bar Code Label here*
OR
☑ Registered practitioner(s) name/registration number listed below

Name	Registration Number	Name	Registration Number
David S. Abrams	22,576	Stacey J. Longanecker	33,952
Robert H. Berdo	19,415	Joseph J. Buczynski	35,084
Alfred N. Goodman	26,458	Wayne C. Jaeschke, Jr.	38,503
Mark S. Bicks	28,770	Tara Laster Hoffman	P-46,510
John E. Holmes	29,392	Jeffrey J. Howell	46,402
Garrett V. Davis	32,023	Marcus R. Mickney	44,941
Lance G. Johnson	32,531	Christian C. Michel	46,300

☐ Additional registered practitioner(s) named on supplemental Registered Practitioner Information sheet PTO/SB/02C attached hereto.

Direct all correspondence to: ☐ Customer Number or Bar Code Label ______ *OR* ☑ Correspondence address below

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City	Washington	State	D.C.	ZIP	20036
Country	USA	Telephone	(202)659-9076	Fax	(202)659-9344

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Name of Sole or First Inventor: ☐ A petition has been filed for this unsigned inventor

1-0

Given Name (first and middle [if any])				Family Name or Surname			
S. Joseph				Campanella			
Inventor's Signature	S. Joseph Campanella					Date	Sept 26, 2000
Residence: City	Gaithersburg MD	State	MD	Country	USA	Citizenship	USA
Post Office Address							
Post Office Address	18917 Whetstone Circle						
City	Gaithersburg	State	MD	ZIP	20879	Country	USA

☐ Additional inventors are being named on the ____ supplemental Additional Inventor(s) sheet(s) PTO/SB/02A attached hereto

UNITED STATES PATENT AND TRADEMARK OFFICE

COMMISSIONER FOR PATENTS
UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. 20231
www.uspto.gov

Bib Data Sheet

SERIAL NUMBER	FILING DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
09/647,007	09/26/2000 RULE –	370	2663	40264

APPLICANTS

S. Joseph Campanella, Gaithersburg, MD ;

** CONTINUING DATA **************************

THIS APPLICATION IS A 371 OF PCT/US98/14280 07/10/1998
WHICH CLAIMS BENEFIT OF 60/079,591 03/27/1998

** FOREIGN APPLICATIONS **********************

None

IF REQUIRED, FOREIGN FILING LICENSE GRANTED ** 10/26/2000

	STATE OR COUNTRY	SHEETS DRAWING	TOTAL CLAIMS	INDEPENDENT CLAIMS
Foreign Priority claimed ☑ yes ☐ no 35 USC 119 (a-d) conditions met ☑ yes ☐ no ☐ Met after Allowance Verified and Acknowledged [signature] Examiner's Signature Initials	MD	10	41	9

ADDRESS

John E Holmes
Roylance Abrams Berdo & Goodman
Suite 600
1300 19th Street NW
Washington ,DC 20036

TITLE

Digital broadcast system using satellite direct broadcast and terrestrial repeater

FILING FEE RECEIVED		
942	FEES: Authority has been given in Paper No. _________ to charge/credit DEPOSIT ACCOUNT No. _________ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other ____________ ☐ Credit

DO/EO BIBLIOGRAPHIC DATA ENTRY

SERIAL NUMBER: 09 / 647007	RECEIPT DATE: 09 / 26 / 00
IA NUMBER: PCT/ US98 / 14280	IA FILING DATE: 07 / 10 / 98
FAMILY NAME: CAMPANELLA	DELAY WAIVED (Y/N): N
GIVEN NAME: JOSEPH S	DEMAND RECEIVED (Y/N): Y
PRIORITY CLAIMED (Y/N): Y	PRIORITY DATE: 03 / 27 / 98
NO BASIC FEE (Y/N): N	US DESIGNATED ONLY (Y/N): N
ATTORNEY DOCKET NUMBER: 40264	COUNTRY:

CORRESPONDENCE NAME/ADDRESS: CUSTOMER NUMBER: 000000 TELEPHONE 0000000000
FAX

NAME: ROYLANCE ABRAMS BERDO GOODMAN

STREET: 1300 19TH STREET N W SUITE 600

CITY: WASHINGTON
STATE/COUNTRY: DC ZIP: 20036
EMAIL:
APPLICATION TITLES:
DIGITAL BROADCAST SYSTEM USING SATELLITE DIRECT BROADCAST AND TERRESTR
IAL REPEATER

TAB TO LAST POSITION,PUSH SEND

09/647007

patent application serial no.

Department of Commerce
Patent and Trademark Office
fee record

09/28/2000 MBIZUNES 00000059 09647007

01 FC:966	378.00 OP
02 FC:964	468.00 OP
03 FC:962	96.00 OP

PATENT APPLICATION FEE DETERMINATION RECORD Effective December 29, 1999	Application or Docket Number 09/647007

CLAIMS AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY TYPE ☐ RATE	FEE	OR	OTHER THAN SMALL ENTITY RATE	FEE
BASIC FEE					OR		96.0
TOTAL CLAIMS	41 minus 20=	* 21	X$ 9=		OR	X$18=	378
INDEPENDENT CLAIMS	9 minus 3 =	* 6	X39=		OR	X78=	468
MULTIPLE DEPENDENT CLAIM PRESENT			+130=		OR	+260=	
			TOTAL		OR	TOTAL	942

* If the difference in column 1 is less than zero, enter "0" in column 2

CLAIMS AS AMENDED - PART II

AMENDMENT A	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE	ADDITIONAL FEE	OR	OTHER THAN SMALL ENTITY RATE	ADDITIONAL FEE
Total	*	Minus	**	=	X$ 9=		OR	X$18=	
Independent	*	Minus	***	=	X39=		OR	X78=	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM					+130=		OR	+260=	
					TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT B	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE	ADDITIONAL FEE	OR	RATE	ADDITIONAL FEE
Total	*	Minus	**	=	X$ 9=		OR	X$18=	
Independent	*	Minus	***	=	X39=		OR	X78=	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM					+130=		OR	+260=	
					TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE	ADDITIONAL FEE	OR	RATE	ADDITIONAL FEE
Total	*	Minus	**	=	X$ 9=		OR	X$18=	
Independent	*	Minus	***	=	X39=		OR	X78=	
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM					+130=		OR	+260=	
					TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20."
***If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3."
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

MULTIPLE DEPENDENT CLAIM
FEE CALCULATION SHEET
(FOR USE WITH FORM PTO-875)

SERIAL NO.	FILING DATE
APPLICANT(S) 09/647007	

CLAIMS

	AS FILED IND.	AS FILED DEP.	AFTER 1st AMENDMENT IND.	AFTER 1st AMENDMENT DEP.	AFTER 2nd AMENDMENT IND.	AFTER 2nd AMENDMENT DEP.
1	/					
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TOTAL IND.	9					
TOTAL DEP.	32					
TOTAL CLAIMS	41					

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TOTAL IND.						
TOTAL DEP.						
TOTAL CLAIMS						

PTO-1360 (3-78)

*MAY BE USED FOR ADDITIONAL CLAIMS OR AMENDMENTS

U.S. DEPARTMENT OF COMMERCE
Patent and Trademark Office

U.S NATIONAL STAGE WORKSHEET (PCT/EO)

U.S. APPL. NO. 09/647007 INTERNATIONAL APPL. US98/14280

APPLICATION FILED BY: 20 MOS., ____ OR 30 MOS., X SCREENED BY [redacted]

Vonda M. Wallace
Paralegal Specialist

INTERNATIONAL APPLICATION PAPERS IN THE APPLICATION FILE:

X International application
_ Article 19 amendments
_ Priority Document(s) No.___
_ Request Form PCT/RO/101
_ PCT/IB/302
_ PCT/IB/304
_ PCT/IB/306
_ PCT/IB/308
X PCT/IB/331
X OTHER PCT/IB/________
X PCT/IPEA/409 also 416

_ 409 annexes to IPER
X PCT/ISA/210 (Search report)
____ Search report References
____ Other Papers filed

WIPO PUBLICATION
PUBLICATION NO. *WO* 99 49602
PUBLICATION DATE 30-SEP-99
PUBLICATION LANG., English
NOT PUBLISHED
______ U.S. only ______ Requested

RECEIVED FROM THE APPLICANT: (other than checked above)

X National application basic fee paid
_ Express Processing Requested
_ Translation of the International Application
Used the IB copy of the IA
X Description
X Claims____
X Drawings___
Foreign Language in drawing
Article 19 Amendments
Amendment used in application
Article 34 Amendment
Amendment used in application
DNA
1194 transaction done

____ Preliminary Amendment(s) filed________
____ second submission________
____ Information Disclosure Statement________
____ second submission________
____ Assignment
____ Forward to Assignment Branch
____ Substitute Specification________
____ Small Entity Statement ________
____ type ________
X Oath/Declaration (date submitted 26 SEP 2000)
____ Not executed
X Executed
____ Power of Attorney
____ Change of Address

USC Receipt of Request (PTO – 1399 Transmittal Letter)	26 SEP 2000
Acceptable oath/declaration received	26 SEP 2000
(e) Date	26 SEP 2000
complete 35 USC 371 requirements met	26 SEP 2000

DATE NOTICE COMPLETED

EO 903	Notice of Acceptance	10-20-00
EO 905	Notice of Missing Requirements	
EO 917	Notice of A defective oath or declaration	
EO 916	Notice of defective response	
EO 913	Notice of defective translation	
EO 909	Notifiication of Abandonment	

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04H 1/00, H04B 7/155

A1

(11) International Publication Number: WO 99/49602

(43) International Publication Date: 30 September 1999 (30.09.99)

(21) International Application Number: PCT/US98/14280

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(30) Priority Data:
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Filed on 10 April 1998 (10.04.98)

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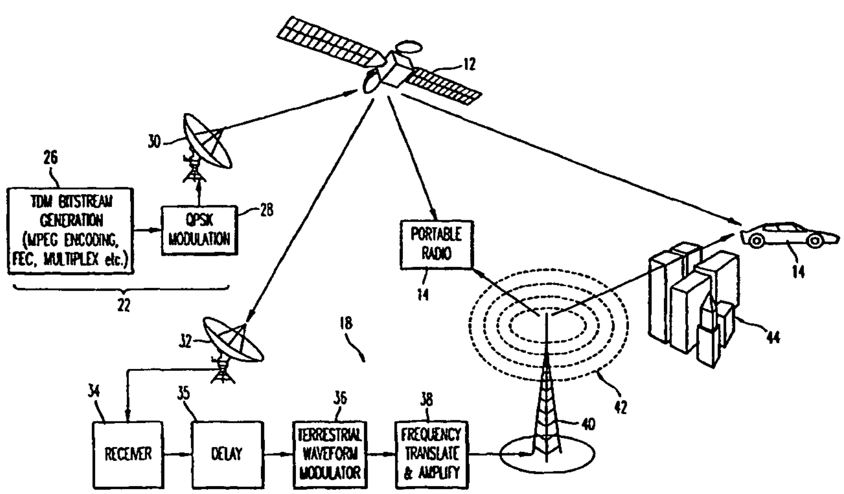
(72) Inventor; and
(75) Inventor/Applicant (*for US only*): CAMPANELLA, S., Joseph [US/US]; 18917 Whetstone Circle, Gaithersburg, MD 20879 (US).

(74) Agents: HOLMES, John, E. et al.; Roylance, Abrams, Berdo & Goodman, LLP, 1225 Connecticut Avenue, N.W., Washington, DC 20036 (US).

(81) Designated States: AL, AM, AT, AT (Utility model), AU (Petty patent), AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), 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, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, 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
With international search report.

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



(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.

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DIGITAL BROADCAST SYSTEM USING SATELLITE DIRECT BROADCAST AND TERRESTRIAL REPEATER

Field of Invention

A digital broadcast system is provided which uses a satellite direct radio broadcast system having different downlink options in combination with a terrestrial repeater network employing different re-broadcasting options to achieve high availability reception by mobile radios, static radios and portable radios in urban areas, suburban metropolitan areas, rural areas, including geographically open areas and geographic areas characterized by terrain having high elevations.

Background of the Invention

Receivers in existing systems which provide digital audio radio service (DARS) have been radically affected by multipath effects which create severe degradations in signal quality, such as signal fading and inter-symbol interference (ISI). Fading effects on broadcast channels to receivers can be sensitive to frequency, particularly in an urban environment or geographic areas with high elevations where blockage of line of sight (LOS) signals from satellites is most prevalent. Locations directly beneath a satellite (hereinafter referred to as the sub-satellite point) inherently have the highest elevation angles, while locations that depart from the sub-satellite point inherently have decreasing elevation angles and, accordingly, an increase of the earth center angle subtended between the sub-satellite point and the reception location. Locations that are near the sub-satellite point typically enjoy virtually unblocked LOS reception. Thus, the need for terrestrial reinforcement of potentially blocked LOS signals is minimal. When the LOS elevation angle to the satellite becomes less than about 85 degrees, however, blockage by tall buildings or geological elevations (i.e., on the order of 30 meters) becomes significant. Terrestrial re-radiation for gap filling is needed to achieve satisfactory coverage for mobile radios, static radios, as well as portable radios. In areas where the heights of buildings or geological sites are relatively low (i.e., on the order of less than 10 meters), the blockage is not significant until the LOS elevation angle is lower than 75 degrees. Thus, at the mid-latitude and high latitude locations within the coverages of one or more broadcast satellites, terrestrial re-radiation is needed to achieve suitable radio reception. A need exists for fully satisfactory radio reception that combines satellite LOS transmission and terrestrial re-radiation of a satellite downlink signal waveform.

Summary of the Invention

In accordance with one aspect of the present invention, a digital broadcast system (DBS) is provided which overcomes a number of disadvantages associated with existing broadcast systems and realizes a number of advantages. The DBS of the present invention comprises a TDM carrier satellite delivery system for digital audio broadcasts (DAB) and other digital information which is combined with a network of terrestrial repeaters for the re-radiation of satellite downlink signals toward radio receivers. The terrestrial repeaters are configured to employ multipath-tolerant modulation techniques.

In accordance with another aspect of the present invention, a satellite delivery system and a terrestrial repeater operate using different carrier frequencies. The terrestrial repeater employs multipath-tolerant modulation techniques.

In accordance with yet another aspect of the present invention, a satellite delivery system and a terrestrial repeater both employ multipath-tolerant modulation techniques and can be configured to use the same or different carrier frequencies, depending on the type of waveform used. The satellite delivery system preferably employs a TDM or code division multiple access (CDMA)-type waveform. The terrestrial repeater preferably employs a multipath-tolerant waveform such as CDMA, Adaptive Equalized TDM (AETDM), Coherent Frequency Hopping Adaptively Equalized TDM (CFHATDM) or Multiple Carrier Modulation (MCM).

In accordance with still another aspect of the present invention, a single geostationary satellite transmits downlink signals which can be received by radio receivers in the LOS of the satellite signal, as well as by terrestrial repeaters. Each terrestrial repeater is configured to recover the digital baseband signal from the satellite signal and modulate the signal using multicarrier modulation (MCM) for retransmission toward radio receivers. Radio receivers are configured to receive both a quadrature phase shift keyed (QPSK) modulated TDM bit stream, as well as an MCM stream. Radio receivers are programmed to select a broadcast channel demodulated from the TDM bit stream and the MCM bit stream, and to select the broadcast channel recovered with the least errors using a diversity combiner.

In accordance with still yet another aspect of the present invention, a DBS is provided which comprises two geostationary satellites in combination with a network of terrestrial repeaters. The terrestrial repeaters are configured to process satellite downlink signals to achieve the baseband satellite signal and to modulate the signal using MCM. Radio receivers are configured to implement a diversity decision logic to select from among three diversity signals, including the two satellite signals and the MCM signal. Each radio receiver employs maximum likelihood combining of two LOS satellite signals with switch combining between the terrestrial re-radiated signal, or MCM signal, and the output of the maximum likelihood combiner.

In accordance with another aspect of the present invention, a broadcast channel may be selected from the three diversity signals by using maximum likelihood combining of all three signals, that is, early and late LOS satellite signals and the MCM signal from the terrestrial repeater.

Brief Description of the Drawings

These and other features and advantages of the present invention will be more readily comprehended from the following detailed description when read in connection with the appended drawings, which form a part of this original disclosure, and wherein:

Fig. 1 depicts a digital broadcast system for transmitting satellite signals and terrestrial signals in accordance with an embodiment of the present invention;

Fig. 2 is a diagram of a digital broadcast system comprising a satellite and a terrestrial repeater in accordance with an embodiment of the present invention;

Fig. 3 is a schematic block diagram illustrating a generation of a multicarrier modulated (MCM) signal in accordance with an embodiment of the present invention;

Fig. 4 is a schematic block diagram depicting a radio receiver arm configured to demodulate MCM signals in accordance with an embodiment of the present invention;

Fig. 5 is a block diagram illustrating MCM signal demodulation in accordance with an embodiment of the present invention;

Fig. 6 is a schematic block diagram depicting a radio receiver arm configured to demodulate time division multiplexed (TDM) signals in accordance with an embodiment of the present invention;

Fig. 7 is a block diagram illustrating QPSK TDM signal demodulation in accordance with an embodiment of the present invention;

Figs. 8 and 9 are schematic block diagrams illustrating respective embodiments of the present invention for diversity combining in a radio receiver;

Fig. 10 illustrates a system of combining three diversity signals using a maximum likelihood decision unit in accordance with an embodiment of the present invention;

Fig. 11 is a schematic block diagram illustrating TDM signal demultiplexing in accordance with an embodiment of the present invention;

Fig. 12 illustrates a system of combining bit streams recovered at a radio receiver using a maximum likelihood decision unit on a first satellite signal and a delayed second satellite signal and then a diversity combiner for terrestrial repeater signal and the output of the maximum likelihood decision unit in accordance with an embodiment of the present invention;

Fig. 13 illustrates an arrangement for indoor reception of a broadcast signal in accordance with an embodiment of the present invention; and

Fig. 14 illustrates an arrangement for terrestrial repeaters along a path in accordance with an embodiment of the present invention.

Detailed Description of the Preferred Embodiments

Fig. 1 depicts a digital broadcast system (DBS) 10 comprising at least one geostationary satellite 12 for line of sight (LOS) satellite signal reception at radio receivers indicated generally at 14. Another geostationary satellite 16 at a different orbital position can be provided for time and/or spatial diversity purposes as discussed below in connection with Figs. 6 and 7. The system 10 further comprises at least one terrestrial repeater 18 for retransmission of satellite signals in geographic areas 20 where LOS reception is obscured by tall buildings, hills and other obstructions. The radio receiver 14 is preferably configured for dual-mode operation to receive both satellite signals and terrestrial signals and to select one of the signals as the receiver output.

As stated previously, the present invention relates to a DBS 10 for optimized static, portable and mobile radio reception. In accordance with the present invention, the DBS 10 combines line-of-sight (LOS) reception of satellite waveforms that are optimized for satellite delivery with re-radiation of the LOS signal from the satellite 12 or 16 via one or more terrestrial repeaters 18. The terrestrial repeaters 18 use other waveforms which are optimized for terrestrial delivery where blockage of the satellite LOS signal occurs. LOS signal blockage caused by buildings, bridges, trees and other obstructions typically occurs in urban centers and suburban areas. Waveforms particularly suitable for LOS satellite transmission are Time Division Multiplex (TDM) and Code Division Multiple Access (CDMA). Multipath-tolerant waveforms particularly suitable for overcoming terrestrial multipath interference encountered in blocked urban areas are CDMA, Adaptive Equalized TDM (AETDM), Coherent Frequency Hopping Adaptively Equalized TDM (CFHATDM) and Multiple Carrier Modulation (MCM).

Frequency hopping is described in U.S. Patent No. 5,283,780, to Schuchman et al, which is hereby incorporated herein by reference. When a terrestrial repeater 18 employs AETDM, radio receivers 14 are provided with an equalizer (not shown). For AETDM, a TDM bit stream is received from the satellite 12 or 16. The bit stream is converted into a new TDM bit stream into which training sequences are inserted by a process called puncturing. Puncturing replaces a small fraction of the TDM data bits with the training sequences. The number of bits punctured is so small that the errors thereby produced are correctable at the receiver by forward error correction. The new TDM bit stream is QPSK-modulated by the repeater onto a radio frequency (RF) carrier that is transmitted at high power into the multipath environment of a central city business district, for example. This transmitted signal is received by a receiver 14 equipped with an adaptive time domain equalizer. By using the training sequences, it can adjust the taps of an inverse multipath processor to cause the various multipath arrival components to add constructively. The signal thus reconstructed is next processed to recover the bits of the TDM stream with high accuracy. The forward error correction available in the receiver 14 corrects both the errors introduced by the puncturing and those caused by thermal noise and receiver impairments.

In accordance with another aspect of the present invention, the combination of a satellite-efficient LOS waveform and terrestrial multipath interference-tolerant waveform in a DBS system is the optimum means for achieving high availability reception by mobile radios, static radios and portable radios in urban areas, suburban areas and in rural areas. For example, in accordance with an embodiment of the present invention illustrated in Figs. 2-9, an MCM signal is sent from a network of terrestrial repeaters 18 deployed to cover a blocked area with high reception availability. The signaling techniques described in connection with the present invention are applicable over the electromagnetic wave frequency range from 200 to 3000 MHz to facilitate the combination of LOS satellite radiation with terrestrial re-radiation of the signal received from the satellite 12 or 16.

Optimal satellite waveforms permit very efficient transformation of solar power, which is collected by the solar arrays of the satellites 12 and 16 into radiated radio frequency power. These waveforms are characterized by a low peak-to-average power ratio (i.e., crest factor), thereby permitting operation of high power amplifiers that feed the satellite earth-pointing antennas at or near the maximum power output and therefore the most efficient power output. A TDM waveform is particularly useful for permitting operation within a few tenths of a dB of maximum power output. A CDMA waveform that uses properly selected codes allows operation at approximately 2 to 4 dB below maximum power output. Because the MCM waveform is composed of the sum of hundreds of phase modulated sinusoids, as described below with reference to Fig. 3, the MCM waveform inherently possesses a high peak-to-average ratio. Consequently, a MCM waveform encounters significantly greater amplitude and phase intermodulation distortion in the satellite's high power amplifier. To achieve acceptable reception by an LOS satellite receiver, a MCM waveform is backed in the high power amplifier and allocated a receiver implementation impairment of at least 6 dB on the down-link budget, as compared with a quadrature phase shift keying (QPSK) TDM waveform. This translates to a 4-to-1 reduction in satellite power conversion, rendering the MCM waveform an unsuitable choice for satellite LOS delivery on a DBS 10. Regarding the AETDM and CFHATDM waveforms, these waveforms are specifically designated to combat terrestrial multipath and are not intended for, nor are they efficient, for satellite LOS delivery.

Regarding terrestrial reinforcement by re-radiation of the satellite LOS signal from a terrestrial repeater, for example, a TDM waveform is not suitable because its reception is severely impaired by multipath effects. Furthermore, some proposed systems which use CDMA waveforms for reinforcement repeat the same program signal using one CDMA channel code for LOS satellite delivery and another CDMA channel code for terrestrial re-radiated delivery on carriers that occupy the same frequency bandwidth. Reception is achieved by means of adaptive rake receivers. These proposed CDMA systems are disadvantageous because an annulus zone occurs in which reception is not possible between the region where the reinforcement signal can be received and the region where the satellite LOS signal can be received. Receivers 14 in the annulus are not able to receive the terrestrial re-radiated signal because the signal power level falls below a receiver threshold for that signal. These receivers 14 are also not able to receive the satellite LOS signal because there remains sufficient re-radiated signal to jam LOS satellite reception. Thus, these receivers 14 in the annulus must move far enough away from the zone of re-radiation to decrease the re-radiated signal power to below the threshold of jamming; otherwise, LOS satellite reception is not possible.

In accordance with one embodiment of the present invention, the CDMA waveform is adapted to make possible its use for simultaneous delivery via satellite LOS and via terrestrial re-radiation. The CDMA channel codes are assigned for each delivery to different RF carriers. The orthogonality thereby created permits the two signals (i.e., the satellite LOS signal and the terrestrial repeater signal) to be separated by RF/IF filtering in the radio receiver.

The identification of workable and unworkable waveform combinations for accomplishing terrestrial reinforcement of satellite LOS reception in accordance with the present invention are listed in the TABLE 1. More than one type of modulation or signal formatting method can be used with the satellite signal, as well as with the terrestrial repeater signal.

TABLE 1

Satellite Waveform	Reinforcement Waveform	Recommended	Not Recommended	RF Carrier Spectra Are:
TDM	TDM		X	Same or Different
TDM	AETDM	X		Same or Different
TDM	MCM	X		Different
TDM	CFHATDM	X		Different
TDM	CDMA	X		Different
CDMA	CDMA	X		Different
CDMA	AETDM	X		Different
CDMA	CHFATDM	X		Different
CDMA	MCM	X		Different
CDMA	ANY		X	Same
AETDM	ANY		X	Same or Different
CFHATDM	ANY		X	Same of Different
MCM	ANY		X	Same or Different

AETDM waveforms can be satisfactorily implemented and operated in multipath environments characterized by signal propagation delays as long as 20 microseconds (μs). Care must be exercised to ensure that signal arrivals from distant repeaters 18 do not exceed this bound. The adaptively equalized re-radiated waveform can be received by radio receivers 14 designed to use the parent non-equalized TDM waveform when the former does not exhibit severe multipath. This compatibility prevents obsolescence of direct LOS non-equalized TDM radios when the AETDM re-radiation is turned on.

The CFHATDM waveform can be satisfactorily implemented and operated in multipath environments characterized by delays as long as 65 μs. Care must be exercised to ensure that signal arrivals from distant repeaters 18 do not exceed this bound. The waveform cannot be received by radio receivers 14 designed to use the parent non-equalized TDM waveform.

The MCM waveform can be satisfactorily implemented and operated in multipath environments characterized by delays as long as 65 μs. The maximum delay is affected by the guard time assignment given to the waveform's periodic symbol period assignment. Care must be exercised to ensure that signal arrivals from distant repeaters 18 do not exceed this bound. The waveform cannot be received by radio receivers 14 designed to use the parent non-equalized TDM waveform.

The CDMA waveform can be satisfactorily implemented and operated in multipath environments characterized by delays determined by the span of the time delays implemented in the rake paths at the receivers 14. Care must be exercised to ensure that all signal arrivals from distant repeaters 18, multipath reflections and different satellites do not exceed this bound. The waveform cannot be received by radio receivers 14 designed to use the parent non-equalized TDM waveform.

The satellite signals can be transmitted from one satellite 12 or 16 or from two satellites 12 and 16. Use of two geostationary satellites 12 and 16 sufficiently separated in their orbits creates diversity in the LOS elevation and azimuth angles to enhance signal reception availability. Also, time diversity achieved by repeating a satellite signal from a single satellite 12 or 16, or by transmitting a signal from two satellites 12 and 16 with the properly selected time difference, further enhances the reception availability.

In accordance with a preferred embodiment of the present invention, a waveform comprising multiple channel TDM with QPSK, Offset QPSK, Differential QPSK, Differentially Coded QPSK, or Minimum Shift Keyed (MSK) modulation is used for the transmission of signals from a satellite for LOS reception by a radio receiver 14. Terrestrial re-radiation is preferably implemented using an MCM waveform designed to carry a TDM bit stream of a capacity of up to 3.68 Mbit/s. MCM is preferably implemented which creates between 400 and 1200 multiple carriers by means of an Inverse Fast Fourier Transform as described below in connection with Fig. 3, resulting in a symbol period between 200 and 300 μs. A guard interval of between 55 to 65 microseconds is included in each symbol period. The MCM waveform is designed to accommodate Doppler carrier frequency shifts among multipath components occurring simultaneously. Puncturing is preferably used to eliminate bits or pairs of bits from the TDM bit stream to reduce the rate to a value of between 70% to 80% of the 3.68 Mbit/s rate. A special symbol is inserted between each of a selected number of FFT-generated symbols periods to provide a means to recover symbol period timing and carrier frequency synchronization . In the receiver 14, a Viterbi soft decision trellis decoder is preferably implemented to re-establish the bits or bit pairs punctured at the repeater 18, as well as all other bits transmitted, by use of an erasure technique. In this technique, the decoder simply ignores the bits in locations known to have been punctured at the repeater 18.

TDM carrier satellite delivery of the DBS 10 is discussed in U.S. patent application Serial No. 08/971,049, filed November 14, 1997, the entire subject matter of which is hereby incorporated herein by reference for all purposes. Briefly, with reference to Fig. 2, the broadcast segment 22 preferably includes encoding of a broadcast channel into a 3.68 Megabits per second (Mbps) time division multiplex (TDM) bit stream, as indicated in block 26. The TDM bit stream comprises 96 16 kilobits per second (kbps) prime rate channels and additional information for synchronization, demultiplexing, broadcast channel control and services. Broadcast channel encoding preferably involves MPEG audio coding, forward error correction (FEC) and multiplexing. The resulting TDM bit stream is modulated using quadrature phase shift keying (QPSK) modulation, as shown in block 28, prior to transmission via a satellite uplink 30.

TDM satellite delivery achieves the greatest satellite on-board payload efficiency possible in terms of the conversion of solar power to electromagnetic wave power. This is because single TDM carrier per tube operation permits each satellite traveling wave tube to operate at its saturated power output, which is its most efficient operating point. The TDM carrier in a typical application is designed to deliver 96 prime bit rate increments, each bearing 16 kbit/s, to small, economical radio receivers 14 located in the beams of the satellite 12 or 16. From one to eight prime rate increments are grouped to constitute a broadcast channel. A broadcast channel can be divided into a number of service channels for delivery of audio, video, data and multimedia.

The power density delivered to the earth by TDM carriers from satellites 12 and 16 can made very high and hence provide excellent LOS reception by radio receivers 14 in automobiles and trucks when traveling on open highways in the country side and in suburban areas. However, in urban areas where tall buildings abound, or in forests where tall towering damp foliage trees abound, LOS reception is blocked, thus inhibiting suitable operation of the receiver 14 for LOS reception. Attempting to overcome these conditions by raising the satellite power is both excessively expensive and technically impractical. Accordingly, a more practical alternative is to augment the direct LOS satellite reception by adding a network of terrestrial repeaters 18.

Concerning the nature of the blockage of LOS reception consider the following. Locations directly beneath the satellite 12 or 16 (i.e., the sub-satellite point) inherently have the highest elevation angles, while locations that depart from the sub-satellite point inherently have decreasing elevation angles and an increase of the earth center angle subtended between the sub-satellite location and the reception location. Receivers 14 at locations that are near the sub-satellite point are permitted virtually unblocked LOS reception and the need for terrestrial reinforcement is minimal. However, when the LOS elevation angle to the satellite becomes less than about 85 degrees, blockage by tall buildings (i.e., >30 m) becomes significant. Accordingly, terrestrial re-radiation for gap-filling is needed to achieve satisfactory coverage for mobile radio receivers. In areas where building heights are low (e.g., < 10 m), blockages are not significant until the LOS elevation angle is lower than 75 degrees. At the mid-latitude and high latitude locations within the 6 degree beam width coverages of the satellites 12 and 16, terrestrial re-radiation of the TDM waveform is needed to achieve suitable mobile reception. Thus, fully satisfactory mobile reception requires a system that combines satellite LOS and terrestrial re-radiation of the satellite waveform.

The DBS 10 of the present invention re-radiates the LOS satellite signal from a multiplicity of terrestrial repeaters 18 which are judiciously spaced and deployed within the central part of a city, as well as in metropolitan areas and suburban areas, to achieve maximum coverage. This type of deployment is a recognized art for terrestrial digital audio broadcast (DAB) and cell telephone systems, and can be extended in accordance with the present invention to terrestrial re-radiation of the TDM satellite LOS signal. The deployment utilizes a mix of radiated power levels (EIRP) ranging from as little as 1 to 10 watts for short range fill-in repeaters 18 (out to 1 km radius) to as great as 100 to 10,000 watts for re-radiators or repeaters having wide area coverage (from 1 km to 10 km radius).

Two preferred embodiments for a DBS 10 having a satellite-LOS/terrestrial-re-radiation configuration are described below. The first embodiment involves one geostationary orbit (GSO) satellite 12 or 16 having a judiciously selected longitude along the GSO arc which operates in coordination with a network of the terrestrial repeaters 18. The second embodiment involves two satellites 12 and 16 having different judiciously spaced GSO longitudes to achieve space and time diversity.

The embodiment for a DBS 10 using one GSO satellite 12 with at least one terrestrial repeater 18 is shown in Fig. 2 for illustrative purposes. For each terrestrial repeater 18, the LOS satellite signal is received by an antenna 32 operating in conjunction with a radio receiver 34 to demodulate and recover the digital baseband signal from the signal radiated from the satellite 12. A delay block 35 delays the entire digital baseband signal by the amount of time diversity delay (if any) between transmissions from the satellites 12 and 16. The digital baseband signal is supplied to a terrestrial waveform modulator 36 that generates a waveform which is judiciously designed to make possible the recovery of the digital baseband signal after the waveform has been transmitted from the terrestrial repeater 18 and received by a radio receiver 14. The modulated waveform is then frequency translated to a carrier frequency and amplified, as indicated by block 38. The terrestrial re-radiated waveform is specifically chosen to withstand the dynamic multipath encountered over the terrestrial path between the transmitter antenna 40 and the receiver 14. This multipath is caused by reflections and diffractions from and around obstacles such as buildings 44 and terrain and from troposphere wavebending and reflections.

The antenna 32 is designed to have high gain (> 10 dBi) toward the satellite 12, while achieving low gain in other directions such that the LOS signal is received with low interference and consequently very high quality (i.e. error rate < 10^{-9}). The demodulator and other reception elements in the receiver 34 are those designed for the LOS radio receivers 14 used in the DBS 10 and described in the aforementioned application Serial No. 08/971,049, filed November 14, 1997. The radio receivers 18 are designed to receive the 3.68 Mbit/s QPSK modulated TDM bit stream. As stated previously, the digital baseband is preferably a 3.68 Mbit/s digital waveform TDM bit stream that carries 96 16 kbit/s prime bit rate digital channels organized into broadcast channels, and side information needed to synchronize, demultiplex and control the broadcast channels and the services they bare. The terrestrial waveform modulator 36 and the waveform that it generates is designed to allow reception unimpeded by the multipath vagaries indicated at 42 of the terrestrial path as described previously. Possible multipath-tolerant waveforms are adaptive equalized TDM, adaptive equalized multiple carrier frequency hoppers with adaptive equalization, Fast Fourier Transform multiple carrier modulation and CDMA with rake receivers. The repeater 18 is equipped to assemble the multipath-tolerant waveform, to frequency convert the waveform to the desired re-radiator transmitter RF frequency at the selected power level via the RF translator 38, and to radiate the waveform from antenna 40. The antenna 40 is preferably configured to provide omni-directional or sector directional propagation in the horizontal plane and high directive toward the horizon. The net antenna gain is expected to range from 10 to 16 dBi. The antenna 40 can be located on top of a building and/or on a tower at a desired height. As previously mentioned, the radiated power level can range from 1 to 10,000 watts of EIRP depending on the application.

A particularly desirable multipath-tolerant re-radiated waveform uses multicarrier modulation (MCM). The manner in which the waveform is generated is shown in Fig. 3. A digital stream such as the 3.68 Mbit/s TDM stream is time-domain-divided into a number of parallel paths (block 102), for example, 460 parallel paths with each parallel path carrying 8000 bits per second. The bits on each of these paths are paired into 2 bit symbols with one bit identified as the I (imaginary) component and the other as the Q (Real) component of a complex number. This creates a complex symbol rate of 4000 per second. These bits are fed as 460 parallel complex number frequency coefficient inputs to a Discrete Inverse Fourier Transform converter implemented using a 512 coefficient Inverse Fast Fourier Transform (IFFT) 104. It is well known in the current state of the art that the Fast Fourier Transform algorithm must operate with 2^n input and output coefficients where n is any integer. Thus, for n = 9, $2^9 = 512$. Since the number of coefficients is 460, the remaining 52 missing input coefficients are set equal to zero. This is done by assigning 23 zero-valued coefficients at each the uppermost and lower most IFFT inputs, thus leaving the 460 center coefficients assigned to non-zero values. The output 104 of the IFFT is a set of 460 QPSK-modulated, orthogonal sine coefficients which constitute 460 narrow band orthogonal carriers, each supporting a symbol rate of 4000 per second and consequently having a symbol period of 250 μs. No carriers appear at the output of the IFFT 104 for the coefficients that are set equal to zero.

The IFFT multicarrier output 104 is further processed to create a guard interval 105 for the set of 460 complex symbol narrow band orthogonal carriers (block 106). It is assumed that a fraction f of a symbol period Ts is to be allocated to guard time. To do this the symbol duration must be reduced to a value Ts = (1-f) Ts. For the example considered above Ts = 250 μs. If 25 % of the symbol time is to be allocated guard time, then f =0.25 and Ts = 187.5 μs. To do this, the symbol period output of the IFFT is stored in a memory every 250 μs and then played back in 187.5 μs. To fill the 250 μs symbol interval, the first samples of the IFFT output are again played back during the 62.5 μs guard interval. This procedure causes an increase in the bandwidth of the multicarrier output by a multiplication of (1-f)-1. Thus, the bandwidth needed for the multicarrier modulator output is multiplied by 1.33 to a value of 4000 x 460 x 1.33 = 2.453 MHz.

Finally, to complete the multicarrier modulator processing, a symbol 106 containing a synchronization symbol is introduced periodically, as indicated by block 108. This is done to provide the means for synchronizing a sampling window of 187.5 μs duration at the receiver 14 to the center of the group of multipath arrivals every 250 μs. Also, a phase reference symbol for differential reference coding of the symbol information is also added periodically. The synchronization and phase reference symbols are preferably introduced every 20 to 100 symbol periods depending on the design requirements.

An additional feature of the modulation design is to puncture the TDM digital bit stream, as indicated by phantom block 110, at the input to the modulator 36 to reduce the final bandwidth of the multicarrier waveform. Puncturing means selective, sparse elimination of real data bits from the data stream applied at the input to the IFFT 104. This can be done for a fraction of the bits of the stream in anticipation that the forward error correction scheme applied at the receiver 14 will simply treat the punctured bits as errors and correct them. This has the consequence of increasing the signal to noise ratio (E_b/N_o) for a desired reception BER objective by 1 to 3 dB, depending on the fraction of bits removed by the puncturing. The design for the punctured waveform proportionately reduces the bandwidth of the multicarrier modulation. For example, if the bit rate of the TDM stream is reduced by 75% , the bandwidth will also be reduced by 75%. For the example previously given, the bit rate is reduced to 2.76 Mbit/s and the multicarrier bandwidth to 1.84 MHz. Such bandwidth compression can be necessary in applications where the available frequency spectrum would otherwise be insufficient to carry the desired capacity.

Further details concerning the preferred multicarrier modulation techniques used herein can be found in International Application Nos. PCT/EP98/02167, PCT/EP98/02168, PCT/EP98/02169, PCT/EP98/02170 and PCT/EP98/02184, all filed on April 14, 1998 by Fraunhofer-Gesellschaft zur Förderung.

It is to be understood that the terrestrial repeater described with reference to Figs. 2 and 3 is used to recover a TDM satellite downlink signal, and to demodulate and reformat the TDM signal via baseband processing into a different waveform using, for example, CDMA, AETDM, MCM or CHFATDM. It is to be understood, however, that the DBS 10 can comprise terrestrial repeaters 18 which are co-channel or non-co-channel repeaters. For example, terrestrial repeaters 18 can be provided which are co-channel gap-fillers which merely amplify and repeat a received satellite signal on the same carrier as the satellite signal. Alternatively, terrestrial repeaters can be provided which are non-co-channel gap-fillers which amplify and repeat a satellite signal on a different carrier frequency via frequency translation. In either case, baseband processing of the satellite signal is not performed at the repeater. These types of gap-fillers can be used, for example, indoors (Fig. 10) or along a roadway (Fig. 11).

At a radio receiver 14 shown in Fig. 4, the multicarrier modulated RF waveform is received by the antenna 201 operating in conjunction with a low noise RF front end 202, mixer 203, local oscillator 204, first intermediate frequency (IF) 205, second mixer 206, second local oscillator 207, second IF 208 to recover the multicarrier modulated carrier. A multicarrier demodulator 209 recovers the TDM digital baseband signal. To demodulate the multicarrier waveform, the received modulated signal is digitally sampled by a sampler 211, as shown in Fig. 5, at a rate equal to two of four times the bandwidth of the modulation. These samples are taken during a window of 187.5 μs duration which is optimally centered on the cluster of time dispersed multipath arrivals during each symbol period once every 250 μs. The samples are rate down converted by a buffer memory 212 to expand them to the 460 complex time domain samples in the original 250 μs duration window. These samples are then processed by an 512 coefficient FFT 213 to recover the bits of the TDM bit stream. The receiver 14 next synchronizes to the TDM masterframe frame preamble via unit 214, demultiplexes and aligns the prime rate bits via unit 215 and then recovers the bits of a selected broadcast channel via unit 216. These bits are then forward error corrected using concatenation of a soft decision Viterbi decoder 217, a de-interleaver 218, followed by a Reed Solomon decoder 219, to recover the broadcast channel (BC). This recovered BC is supplied as one input to a decision/combiner unit 240, as described below in connection with Fig. 6.

For a two-arm receiver 14, as depicted in Fig. 6, the MCM signal is received as described with reference to Fig. 4. The QPSK modulated satellite TDM RF waveform is also received by the antenna 201 operating in conjunction with the low noise RF front end 202, a mixer 220, a local oscillator 221, a first IF 222, a second mixer 223, a second local oscillator 224, and a second IF 225, to recover the QPSK-modulated TDM carrier. As shown in Fig. 7, a QPSK TDM carrier demodulator 226 comprises a QPSK demodulator 227 which recovers the TDM digital baseband. The receiver 14 next synchronizes to the TDM masterframe frame preamble 228, demultiplexes and aligns the prime rate bits 229 and then recovers the bits of a selected broadcast channel. These bits are then forward error corrected 230 using the concatenation of a soft decision Viterbi decoder 231, a de-interleaver 232, and a Reed Solomon decoder 232, to recover the broadcast channel. This recovered BC is supplied as a second input to the decision/combiner unit 240.

The diversity combiner 240 selects which of the two input BCs is to be submitted for further processing. It does this based on selecting that BC which is recovered with the least errors. Estimates of the error counts are available from the soft decision data supplied by the Viterbi decoders 217 and 231 or the Reed Solomon decoders 219 and 233. The decision is preferably made with a hysterisis logic which requires that several errors of difference exist before the decision is reversed. This process is needed to prevent chattering between the two BCs when the decisions are nearly equally likely. The broadcast channel selected by the diversity combiner 240 is next supplied to the appropriate source decoder 244 to recover the service(s).

The embodiment of the DBS 10 which uses two GSO satellites 12 and 16 with terrestrial repeater 18 is shown in Fig. 8. In this configuration, two satellites 12 and 16 are separated by between 30 degrees to 40 degrees longitude along the GSO circle. One satellite repeats a signal sent from a ground station, and the other satellite repeats the same signal sent from the same ground station but delays the signal as much as 5 to 10 seconds. The use of two satellites 12 and 16 separated in space results in elevation angle diversity in the LOS paths between a radio receiver 14 on the earth and each satellite 12 and 16. The time delay between the two satellite signal arrivals results in time diversity. Each of these types of diversity taken alone can significantly improve the availability of the LOS signal for a moving mobile receiver 14, and the improvement in availability is further significantly enhanced by both space and time diversity. Space and time diversity are particularly important when a mobile receiver 14 is traveling in a suburban area or in a rural area where the LOS signal blockage is due to bridges, trees and low buildings. However, for central city and metropolitan areas, where tall buildings abound, terrestrial re-radiation of the signal is also supplied in accordance with the present invention to achieve acceptable total area coverage for mobile reception. Thus, this two-satellite diversity configuration operates essentially the same way as the single satellite configuration with regard to the diversity between direct LOS satellite reception and terrestrial re-radiated reception, but adds the time and space diversity provided by the two satellites. The signal from the early satellite is the one re-radiated by the terrestrial repeater 18. Choice of the early signal allows any delay encountered in the signal processing at the repeater 18 or the receiver 14 to be absorbed. The terrestrial re-radiation network is otherwise implemented in the same way as previously described for the single satellite configuration.

Another difference between the two-satellite system and the one-satellite system resides in the three-arm radio receiver 14. The receiver 14 introduces appropriate compensating delays via delay units 309 and 310 to achieve simultaneous signal reception among the three received signals and implement a diversity decision logic which selects among the three diversity signals. The delay unit 309 provides a time diversity delay to the early signal to compensate for the signal propagation differential between the early and late satellites 12 and 16. The delay unit 310 is preferably a vernier delay to allow fine compensation for signal alignment. The radio receiver diversity logic design is shown in Fig. 8. It incorporates a maximum likelihood combiner 240 for the Early and Late LOS satellite signals with a switched combiner 307 between the terrestrial re-radiated signal and the output of the maximum likelihood combiner 240. When both signals are degraded, maximum-likelihood combining can improve the quality of reception. The improvement can be as much as 3 dB in terms of threshold E_b/N_o when both signals are equally degraded.

The radio receiver 14 is equipped with two receiver chains 301 and 302 that individually receive and recover the TDM signals from the early and late satellites, respectively, and selects a desired broadcast channel from each. This is done for each received signal in the same manner as previously described for LOS satellite reception in Fig. 6. Next, the broadcast channel signal derived from the early satellite is delayed by a delay unit 309 comprising a memory device to align it precisely, that is, symbol by symbol, with the symbols of the broadcast channel derived from the late satellite signal. This can be done by aligning the two broadcast channels relative to one another so as to cause coincidence of their service control header preamble correlation spikes. This coincidence is detected in a correlation comparitor unit in the delay unit 309. The next step is to use the maximum likelihood combiner 240 to combine the bits of the two broadcast channels, bit-by-bit, each bit expressed in soft decision form. The maximum likelihood combining coefficients are determined over 1 ms blocks of bits. Next, the output of the maximum likelihood combiner 240 is applied as one input to the switched combiner 307, with the other input coming from the terrestrial re-radiated signal receiver arm 308. The choice of which input is to be passed to the output is based on selecting that BC which is recovered with the least errors. In accordance with another embodiment of the present invention, one of the TDM signal receiver chains (e.g., receiver chain 302 for the late satellite TDM signal) can be maximum likelihood combined with the signal from the terrestrial re-radiated signal receiver arm 308, as shown in Fig. 9. Thus, the switched combiner 307 selects from between the output of the maximum likelihood combiner 240 and the other satellite signal receiver arm (e.g., arm 301), as shown in Fig. 9. The delay units 309 and 310 can be configured to store the entire recovered bit stream for delay purposes, which requires more buffering but simplifies combining. Alternatively, the delay units 309 and 310 can be configured to store only a portion of the recovered TDM bit stream; however, synchronization requirements for combining become more complicated.

With regard to switched combiner 307, estimates of the error counts are available from the soft decision data supplied by the Viterbi decoders 217 and 231 or the Reed Solomon decoders 219 and 233. The decision is made with a hysterisis logic which requires that several errors of difference exist before the decision is reversed. This process is prevents chattering between the two BCs when the decisions are nearly equally likely. Alternatively, a simple switching logic may be used in which the switch always favors the choice of the BC having the least errors. Hysterisis is used to prevent chattering. The latter implementation avoids the more complex maximum likelihood combining. Yet another alternative could be maximum likelihood combining of the three input BCs (e.g., from receiver arms 301, 302 and 308), as shown in Fig. 10.

The diversity combiner shown in Fig. 10 combines three signals. Two are received from two spatially separated satellites 12 and 16, one broadcasting an early signal and the other broadcasting a late signal. The third signal is received from a terrestrial repeater 18 which rebroadcasts the early satellite signal. These signals are received by receiver arm 301 for the early satellite 12, receiver arm 302 for the late satellite 16 and receiver arm 308 for the early signal retransmitted by the repeater 18. The diversity combiner 312 combines the symbols in the three signals by maximum likelihood ratio combining. By this method, the samples of the symbol appearing at the output have the highest probability of representing the original transmitted symbol. To do this, the early satellite 12 and repeater 18 signals are delayed relative to the late satellite signal by delay units 309 and 310 to realign the individual symbols of the three signals causing them to be in time coincidence. Simple *a priori* adjustment of the delay units 309 and 310 suffices to coarsely align the output of the delay units 309 and 310 to within a TDM frame of 138 μs. Thus, fine alignment of the symbols to the master frame preamble (MFP) of a TDM frame is nonambiguous. To align the symbols of the three signals precisely, the MFPs for each signal stream are aligned by fine tuning the delay units 309 and 310 to within a small fraction of a symbol.

With continued reference to symbol combining in unit 312, the normalized variance σ_x^2 for the signal symbols, as contained in the background of noise, and uncorrelated multipath interference, is calculated from the observed samples. These variances are calculated for the early (E), late (L) and repeater 18 or gap-filler (G) signal symbols. The respective signal samples of the symbols for the early, late and gap-filler signals are then multiplexed by their variance ratios $(q_E)^{-1}$, $(q_L)^{-1}$ and $(q_G)^{-1}$, which are defined as follows:

$(q_E)^{-1}$ is the weighting factor associated with early symbol S_E

$(q_L)^{-1}$ is the weighting factor associated with early symbol S_L

$(q_G)^{-1}$ is the weighting factor associated with early symbol S_G

The weighting factors are inversely proportional to the estimated variance and are normalized such that

$$q_E + q_L + q_G = 1$$
$$q_E = \sigma_E^2/(\sigma_E^2 + \sigma_L^2 + \sigma_G^2)$$
$$q_L = \sigma_L^2/(\sigma_E^2 + \sigma_L^2 + \sigma_G^2)$$
$$q_G = \sigma_G^2/(\sigma_E^2 + \sigma_L^2 + \sigma_G^2)$$

Their sum constitutes the maximum likelihood ratio combined symbols. These are then passed on to the time demultiplexer/FEC decoder/BC remultiplexer unit 250 (Fig. 11), the components of which have previously been described above in connection with Fig. 5, to recover the maximum likelihood ratio combined symbols by decision processing.

The diversity combiner shown in Fig. 12 first combines signals received from two satellites 12 and 16, one broadcasting an early signal and the other broadcasting a late signal. The result of this is next combined by minimum bit error decision with reception of the early signal that has been retransmitted by a gap-filler repeater 18 located on the ground. The individual signals are received by the receiver arm 301 for the early satellite, the receiver arm 302 for the late satellite and the receiver arm 308 for the early signal retransmitted by the gap-filler repeater 18. The maximum likelihood ratio diversity combiner 412 combines the symbols of the early and late satellite signals in the same manner described above in connection with combiner 312 in Fig. 10 for three signals. By this method, the final symbol appearing at the output of unit 412 has the highest probability of representing the original transmitted symbol .

The result from unit 412 is next combined with that from the terrestrial repeater 18 by minimum BER select unit 417. Within the unit 417, there are preferably two units 250 that make FEC-decoded symbol decisions for an entire broadcast channel frame of the signals applied at their inputs. One unit 250 makes its decisions on the output from maximum likelihood decision unit 412, and the other unit 250 from the signal received from the terrestrial repeater 18. These decisions also provide the number of errors made with each decision observed over the duration of a broadcast frame. A BER compare unit 414 operates in conjunction with a minimum BER select unit 417 to select the symbols of that broadcast frame with the least error, as determined from inputs from Viterbi FEC units 217 and 231. To implement the necessary delay operations, the early and gap-filler signals are delayed by delay units 309 and 310 to realign their individual symbols to be in symbol time coincidence with the symbols received from the late satellite. The delay alignment method used here is the same as that described for the implementation of Fig. 10.

In accordance with another aspect of the present invention, an indoor re-radiation system 450 is provided which is illustrated in Fig. 13. Since LOS reception of a satellite signal at a radio receiver located inside a building or other structure is generally not available, unless the radio receiver 14 is located at a window in LOS of the satellite 12 or 16, indoor reinforcement of satellite signals for more complete coverage.

As shown in Fig. 13, an antenna 452 can be located externally with respect to a building so as to achieve LOS reception of satellite signals. A tuned RF front-end unit 454 is connected to the antenna 452 and is preferably configured to select the portion of the RF spectrum that contains the essential frequency content of the satellite signal and by doing so with very low added noise. An interconnecting cable 456 is provided to supply the signal at the output of the tuned RF front-end unit 454 to an amplifier 458. The amplifier 458 is connected to a re-radiating antenna 460 located within the building.

The amplifier 458 is configured to increase the power of the satellite signal to a level that, when re-radiated, by the antenna 460, is sufficient to permit satisfactory indoor reception for a radio receiver. The power level radiated from the antenna 460 is sufficiently high to achieve satisfactory indoor reception at locations which are not in the LOS of the satellite, but not so high as to cause instability by signals returned by the path between the indoor antenna 460 and one or more of the receiving antennas 452. Thus, high isolation (i.e., on the order of 70-80 dB) is preferred between the indoor antenna 466 and the outdoor antenna 452.

Reception areas will be present (e.g., through windows or other openings to the building or structure) where indoor re-radiated signals combine with an outdoor signal transmitted directly from the satellite. To assure that the combination of these signals does not occur in an manner which is destructive to signal content, the time delay between an outdoor signal and an indoor signal in the region of combination is preferably less than a fraction of the symbol width of the signal being transmitted. For example, for a symbol width of approximately 540 nanoseconds, a time delay between 50 and 100 nanoseconds can be tolerated. The time delay is generally due to the time required for a signal to travel the path comprising the outdoor antenna 452, the cable (where signals generally travel at two-thirds the speed of light), and onward to the indoor antenna 460. Another delay occurs as the signal travels from the indoor antenna 460 to the radio receiver 14 in an area covered by the indoor antenna. This time delay is preferably only 20% of the symbol width, that is, not more than 100 nanoseconds for a system in which the symbol width is 540 nanoseconds.

The purpose of a terrestrial repeater is to repeat a signal received from the satellite into areas where the signal is otherwise blocked. A multiplicity of these terrestrial repeaters 18 may be placed along a roadway or other path at a height h and separated by distances d, as shown in Fig. 14. The heights and separation distances between the terrestrial repeaters need not be equal. A terrestrial repeater 18 comprises a receive antenna 462 that is pointed at the satellite 12 or 16, a receiver (not shown) that recovers the signal and amplifies it with a gain that is sufficient to drive a transmit antenna 464 such as to a power flux density in the path below which is comparative to that normally expected from the satellite. The transmit antenna 464 is shielded so as to prevent the transmitted signal from reaching the terrestrial repeater receive antenna 462 at a level sufficient to create instability. The transmit antenna 464 radiates its power over an aperture of length L sufficient to cause path length diversity over several wavelengths between the transmitter 464 and the vehicle's receive antenna at the carrier frequency.

As a vehicle drives along the path, the radio receiver 14 therein receives signals coming from more than one terrestrial repeater 18. For example, in position A, a vehicle is nearest to terrestrial repeater 18b and that terrestrial repeater's signal dominates and be responsible for reception. Signals from terrestrial repeaters 18a and 18b are low because of distance and antenna pattern and cause little interference. If the vehicle is at position B, the radio receiver 14 therein receives signals from both terrestrial repeaters 18c and 18d. Since the distances are nearly equal, and assuming that the time difference between signals radiated from terrestrial repeaters 3 and 4 is adjusted to zero, the time difference of arrival between the signals received at the vehicle are sufficiently small so as to cause constructive reinforcement. By proper choice of the distances h and d in relationship with the symbol period of the digital signal being received, this condition can be achieved.

It is important to cause diversity in the signals that arrive at the vehicle from the different terrestrial repeaters. If this is not done, then the signals from two terrestrial repeaters, as would be received in the location B, would combine alternately in-phase and out-of-phase and phases in between. When they are in phase, the signals reinforce, and when out-of-phase the signals cancel. When signal cancellation occurs, the signal is completely lost. In addition, the resulting carrier phase of the signal created by addition of the terrestrial repeater carriers rotates at a rate equal to a nearly monochromatic Doppler difference, making it difficult to recover the QPSK modulation. The spread in arrival times caused by the diversity transmission resulting from distribution of the transmitted signal over the aperture L, or over an equivalent time difference of L/C where C = speed of light, eliminates the amplitude cancellation and provides the possibility of correcting the impact of the phase rotation by application of adaptive equalization techniques. This applied to all vehicle locations between locations A and B.

An example of the proper choice of distances in relationship to symbol period is seen by considering a signal having a symbol period on the order of 540 to 550 nanoseconds. The spacing d and height h is selected so as to cause the time delay in transversing the slant distance $(d^2 + h^2)^{1/2}$ to cause a delay of no greater than a quarter of a symbol period. In this example, the slant distance is 550/d = 137.5 ft. One nanosecond is equivalent to one foot at the speed of light. Thus, if the height is 20 feet, the distance d is 180 feet. The height h is preferably relatively small when compared to distance d so as to cause the difference in distance between the vehicle and each terrestrial repeater 18 to change by an amount sufficient to assure that the signal level from any one terrestrial repeater is attenuated by 10 dB or more compared to that from a terrestrial repeater immediately overhead. The length L is preferably between 5 to 10 feet to provide sufficient path length diversity at L-band frequencies. If an equalizer unit is incorporated in the vehicle's mobile receiver 14, the time difference in arrival can be extended to several symbols, thus increasing the distance between the terrestrial repeaters to over 1000 feet. An equivalent time difference would be to transmit the signal several times from the same source over a spread not exceeding 5-10 nanoseconds.

While various embodiments have been chosen to illustrate the invention, it will be understood by those skilled in the art that various changes and modifications can be made therein without departing from the scope of the invention as defined in the appended claims.

What is Claimed Is:

1. A digital broadcasting system for transmitting a broadcast program to radio receivers, the broadcast program being generated at an earth station, comprising:

a satellite for receiving said broadcast program from said earth station and transmitting at least one satellite signal comprising at least a portion of said broadcast program to said radio receivers on a first carrier frequency; and

at least one terrestrial repeater for receiving said satellite signal and generating and transmitting at least one terrestrial signal from said satellite signal comprising said at least a portion of said broadcast program on a second carrier frequency and modulated in accordance with a multipath-tolerant modulation technique.

2. A system as claimed in claim 1, wherein said satellite is operable to modulate said broadcast program in accordance with at least one of time division multiplexing and code division multiplexing, and said terrestrial repeater is operable to modulate said terrestrial signal using at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptively equalized time division multiplexing, multicarrier modulation and code division multiplexing.

3. A system as claimed in claim 1, wherein said terrestrial repeater is operable to modulate said terrestrial signal using multicarrier modulation.

4. A system as claimed in claim 3, wherein said terrestrial repeater is operable to receive said satellite signal and to demodulate said satellite signal into a baseband signal prior to modulating said baseband signal using multicarrier modulation.

5. A system as claimed in claim 1, wherein said satellite signal is assigned a first code division multiple access channel code and said terrestrial signal is assigned a second code division multiple access channel code.

6. A system as claimed in claim 1, further comprising a second satellite, said second satellite being operable to receive said broadcast program from said earth station and to

transmit at least one second satellite signal comprising said at least a portion of said broadcast program to said radio receivers on said first carrier frequency and delayed a predetermined period of time with respect to the transmission of the other said satellite signal.

7. A terrestrial repeater for re-radiating broadcast signals to radio receivers comprising:

a receiver for receiving said broadcast signals; and

a terrestrial waveform modulator for generating terrestrial signals comprising said broadcast signals, said terrestrial signals being modulated by said terrestrial waveform modulator in accordance with multicarrier modulation.

8. A terrestrial repeater as claimed in claim 7, wherein said broadcast signals are transmitted to said radio receivers from a satellite using a first carrier frequency, said terrestrial waveform modulator being operable to transmit said terrestrial signals to said radio receivers using a second carrier frequency.

9. A terrestrial repeater as claimed in claim 7, wherein said terrestrial waveform modulator comprises:

a time division demultiplexer for demultiplexing said broadcast signals from a serial time division multiplexed bit stream into a plurality of parallel bit streams; and

an inverse fast Fourier transform device for generating a digital analog signal comprising a plurality of discrete Fourier transform coefficients.

10. A method of converting a time division multiplexed bit stream into a plurality of multicarrier modulated signals at a terrestrial repeater comprising the steps of:

receiving said time division multiplexed bit stream from a satellite;

dividing said time division multiplexed bit stream into a plurality of parallel bit paths;

representing each of a predetermined number of bits in each of said plurality of bit paths as a symbol comprising an imaginary component and a real component;

providing said symbols to parallel inputs of an inverse Fourier transform converter as complex number frequency coefficient inputs to generate outputs which are narrow band, orthogonal carriers; and

re-radiating said narrow band, orthogonal carriers.

11. A method as claimed in claim 10, further comprising the step of generating a guard interval for said carriers.

12. A method as claimed in claim 11, wherein said generating step comprises the steps of:

allocating a fraction of the symbol period corresponding to the duration of each of said symbols to guard time; and

reducing the duration of each of said symbols.

13. A method as claimed in claim 12, wherein said reducing step comprises the steps of:

storing said outputs of said inverse Fourier transform converter in a memory device every said symbol period; and

reading from said memory device after each said fraction of said symbol period has elapsed.

14. A method as claimed in claim 11, wherein said generating step further comprises the step of filling said guard interval with a subset of said outputs of said inverse Fourier transform.

15. A method as claimed in claim 10, further comprising the step of inserting a synchronization symbol every predetermined number of said symbol periods to synchronize a sampling window corresponding to said fraction of said symbol period with respect to said carriers every said symbol period at a receiver for said plurality of multicarrier modulated signals.

16. A method as claimed in claim 10, further comprising the step of puncturing said time division multiplexed bit stream to reduce the total bandwidth associated with said carriers.

17. A method as claimed in claim 16, wherein said puncturing step comprises the step of selectively eliminating bits from said time division multiplexed bit stream prior to providing said symbols to parallel inputs of an inverse Fourier transform converter.

18. A digital broadcasting system for transmitting a broadcast program to radio receivers, the broadcast program being generated at an earth station, comprising:

a first satellite configured to receive said broadcast program from said earth station and to transmit at least one first satellite signal comprising at least a portion of said broadcast program to said radio receivers, said first satellite signal being formatted in accordance with at least one of time division multiplexing and code division multiplexing; and

at least one terrestrial repeater configured to receive said first satellite signal and to generate and transmit at least one terrestrial signal from said first satellite signal comprising at least a portion of said broadcast program, said terrestrial signal being formatted in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing and multicarrier modulation.

19. A digital broadcasting system as claimed in claim 18, wherein said first satellite signal is transmitted to said radio receivers using a first carrier frequency, and said at last one terrestrial signal is transmitted to said radio receivers using a second carrier frequency.

20. A digital broadcasting system as claimed in claim 18, wherein at least one of said radio receivers is configured to receive said first satellite signal and said terrestrial signal and comprises a diversity combiner to generate an output signal from said first satellite signal and said terrestrial signal.

21. A digital broadcasting system as claimed in claim 18, further comprising a second satellite configured to receive said broadcast program from said earth station and to transmit at least one second satellite signal comprising at least a portion of said broadcast program to said radio receivers, said second satellite signal being delayed with respect to said first satellite signal by a selected time delay, said second satellite signal being formatted in accordance with the corresponding at least one of time division multiplexing and code division multiplexing employed by said first satellite.

22. A digital broadcasting system as claimed in claim 21, wherein at least one of said radio receivers is configured to receive said first satellite signal, said second satellite signal and said terrestrial signal, to delay at least one of said first satellite signal and said terrestrial signal in accordance with said selected time delay, and to generate an output signal from first satellite signal, said second satellite signal and said terrestrial signal.

23. A digital broadcasting system as claimed in claim 22, wherein said radio receiver comprises a diversity combiner and a switched combiner, said radio receiver using said diversity combiner to perform maximum likelihood decision combining of said first satellite signal and said second satellite signals and said switch combiner to select between the output of said diversity combiner and said terrestrial signal depending on which of said output of said diversity combiner and said terrestrial signal comprises the least number of bit errors.

24. A digital broadcasting system as claimed in claim 22, wherein said radio receiver comprises a diversity combiner to perform maximum likelihood decision combining of said first satellite signal, said second satellite signals and said terrestrial signal.

25. A receiver for receiving a broadcast signal in a digital broadcasting system comprising:

a first receiver arm for receiving a first satellite signal transmitted from a first satellite on a first carrier frequency, said first satellite signal comprising at least a portion of said broadcast signal and being formatted in accordance with at least one of time division multiplexing and code division multiplexing, said first receiver arm comprising a demodulator for recovering said at least a portion of said broadcast signal;

a second receiver arm for receiving a terrestrial signal transmitted on a second carrier frequency, said terrestrial signal comprising said at least a portion of said broadcast signal and being formatted in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing and multicarrier modulation, said second receiver arm comprising a demodulator for recovering said at least a portion of said broadcast signal; and

a combiner for generating an output signal from said first satellite signal and said terrestrial signal.

26. A receiver as claimed in claim 25, further comprising:

a third receiver arm for receiving a second satellite signal from a second satellite and delayed with respect to said first satellite signal in accordance with a selected time delay, said second satellite signal comprising at least a portion of said broadcast signal and being formatted in accordance with the corresponding at least one of time division multiplexing and code division multiplexing employed by said first satellite, said first receiver arm comprising a demodulator for recovering said at least a portion of said broadcast signal; and

a delay device for delaying said first satellite signal in accordance with said selected time delay, said combiner being operable to generate an output signal from said first satellite signal, said second satellite signal and said terrestrial signal.

27. A method of transmitting a broadcast program to radio receivers comprising the steps of:

formatting a broadcast signal for transmission to said radio receivers as a first signal in accordance with one of time division multiplexing and code division multiplexing;

transmitting said first signal to said radio receivers from a first satellite on a first carrier frequency;

formatting said broadcast signal for transmission to said radio receivers as a second signal in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing and multicarrier modulation; and

transmitting said second signal to said radio receivers from a terrestrial repeater on a second carrier frequency.

28. A method as claimed in claim 27, wherein said formatting step for formatting said broadcast signal as said second signal comprises the steps of:

receiving said first signal at said terrestrial repeater; and

performing baseband processing of said first signal prior to formatting in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing and multicarrier modulation.

29. A method as claimed in claim 28, further comprising the step of receiving said first signal and said second signal at one of said radio receivers.

30. A method as claimed in claim 29, further comprising the step of demodulating each of said first signal and said second signal to remove said respective formatting and to recover a first recovered broadcast signal and a second recovered broadcast signal, respectively.

31. A method as claimed in claim 30, further comprising the steps of generating an output broadcast signal from said first recovered broadcast signal and said second recovered broadcast signal.

32. A method as claimed in claim 31, wherein said generating step comprises the step of performing maximum likelihood combining of said first recovered broadcast signal and said second recovered broadcast signal.

33. A method as claimed in claim 27, further comprising the steps of:

formatting a broadcast signal for transmission to said radio receivers as a third signal in accordance with at least one of time division multiplexing and code division multiplexing;

transmitting said third signal to said radio receivers from a second satellite, said transmission being delayed with respect to said first signal by a predetermined period of time.

34. A method as claimed in claim 33, further comprising the steps of:

receiving said first signal, said second signal and said third signal at one of said radio receivers;

demodulating each of said first signal, said second signal and said third signal to remove said respective formatting and to recover a first recovered broadcast signal, a second recovered broadcast signal and a third recovered broadcast signal, respectively; and

generating an output broadcast signal from said first recovered broadcast signal, said second recovered broadcast signal and said third recovered broadcast signal.

35. An indoor reinforcement system for receiving a satellite signals transmitted in a digital broadcasting system using a radio receiver located indoors, comprising:

a line of sight antenna for receiving line of sight satellite signals;

a radio frequency front-end unit connected to said line of sight antenna for passing frequency spectrum comprising said satellite signal with low noise;

at least one indoor amplifier;

at least one cable for connecting said radio frequency front-end unit to said indoor amplifier; and

at least one indoor re-radiating antenna connected to said indoor amplifier, said indoor re-radiating antenna having a power level selected to be sufficiently high to achieve satisfactory indoor reception of said satellite signals at radio receivers at indoor locations where line of sight reception of said satellite signals is not possible and sufficiently low to prevent interference by said satellite signals transmitted between said line of sight antenna and said indoor re-radiating antenna.

36. An indoor reinforcement system as claimed in claim 35, wherein said satellite signals are characterized by a selected symbol period, and the duration of the transmission of said satellite signals between said line of sight antenna and said indoor re-radiating antenna is maintained to be less than a selected amount of said symbol duration by limiting the length of said at least one cable.

37. An indoor reinforcement system as claimed in claim 36, wherein said duration of the transmission of said satellite signals between said line of sight antenna and said indoor re-radiating antenna is no more than between 20 percent and 25 percent of said selected symbol period.

38. A reinforcement system for receiving a satellite signals transmitted in a digital broadcasting system using a radio receiver located outdoors, wherein said satellite signals are characterized by a selected symbol period, comprising at least two terrestrial repeaters, said terrestrial repeaters being characterized by a height h and being spaced apart by a distance d, the slant distance $(d^2 + h^2)^{1/2}$ from one of said terrestrial repeaters to said radio receiver being selected to limit a delay in reception of said satellite signals at said radio receiver from one of said terrestrial repeaters to between 20 percent and 25 percent of said symbol period.

39. A digital broadcasting system for transmitting a broadcast program to radio receivers, the broadcast program being generated at an earth station, comprising:

a first satellite configured to receive said broadcast program from said earth station and to transmit at least one satellite signal comprising at least a portion of said broadcast program to said radio receivers; and

at least one terrestrial repeater configured to receive said first satellite signal and to generate and transmit at least one terrestrial signal from said first satellite signal comprising at least a portion of said broadcast program, wherein said satellite signal and said terrestrial signal are each modulated using a multipath-tolerant modulation technique.

40. A system as claimed in claim 39, wherein said first satellite signal is formatted in accordance with at least one of time division multiplexing and code division multiplexing.

41. A system as claimed in claim 39, wherein said terrestrial signal is formatted in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing and multicarrier modulation.

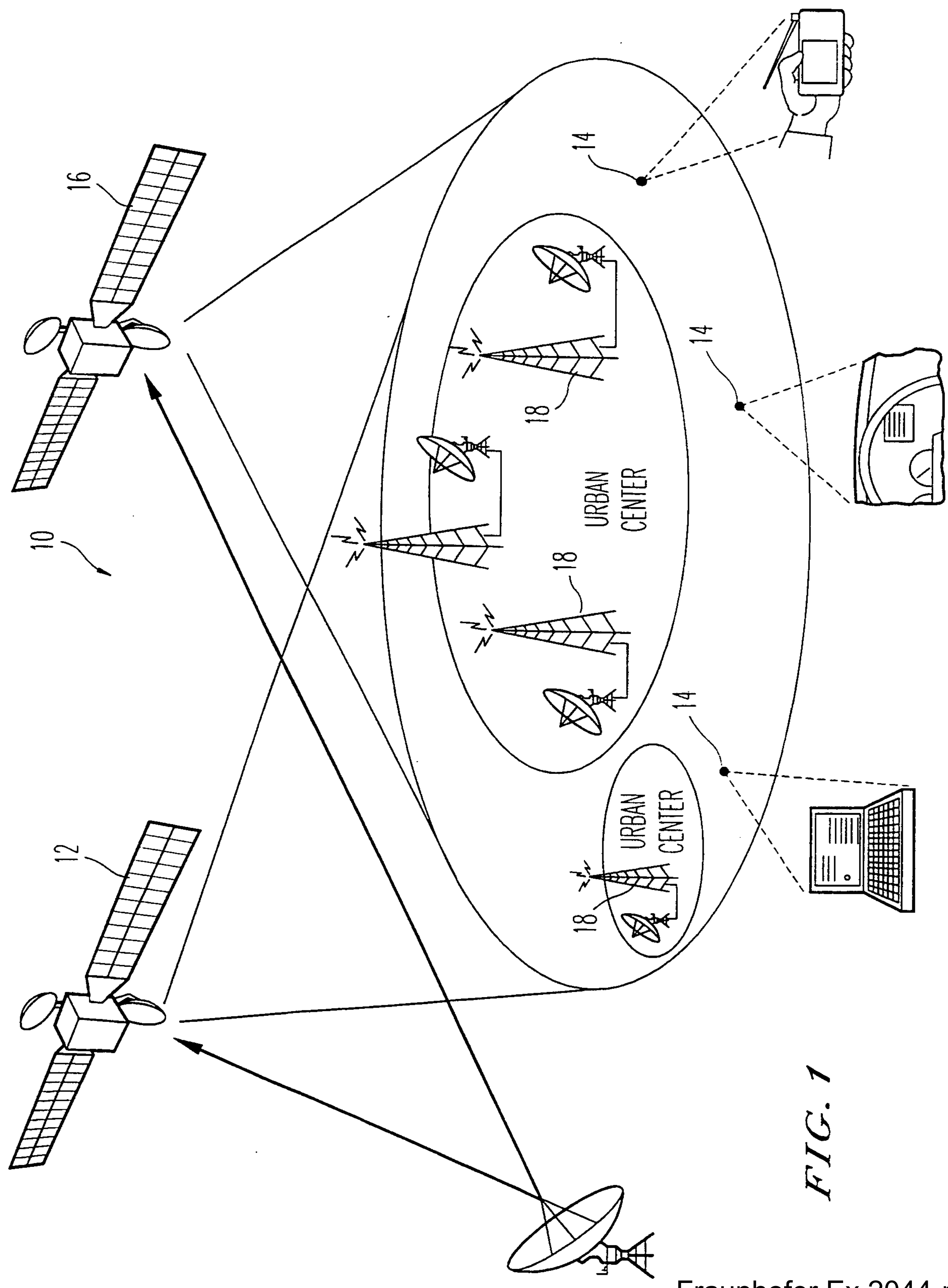
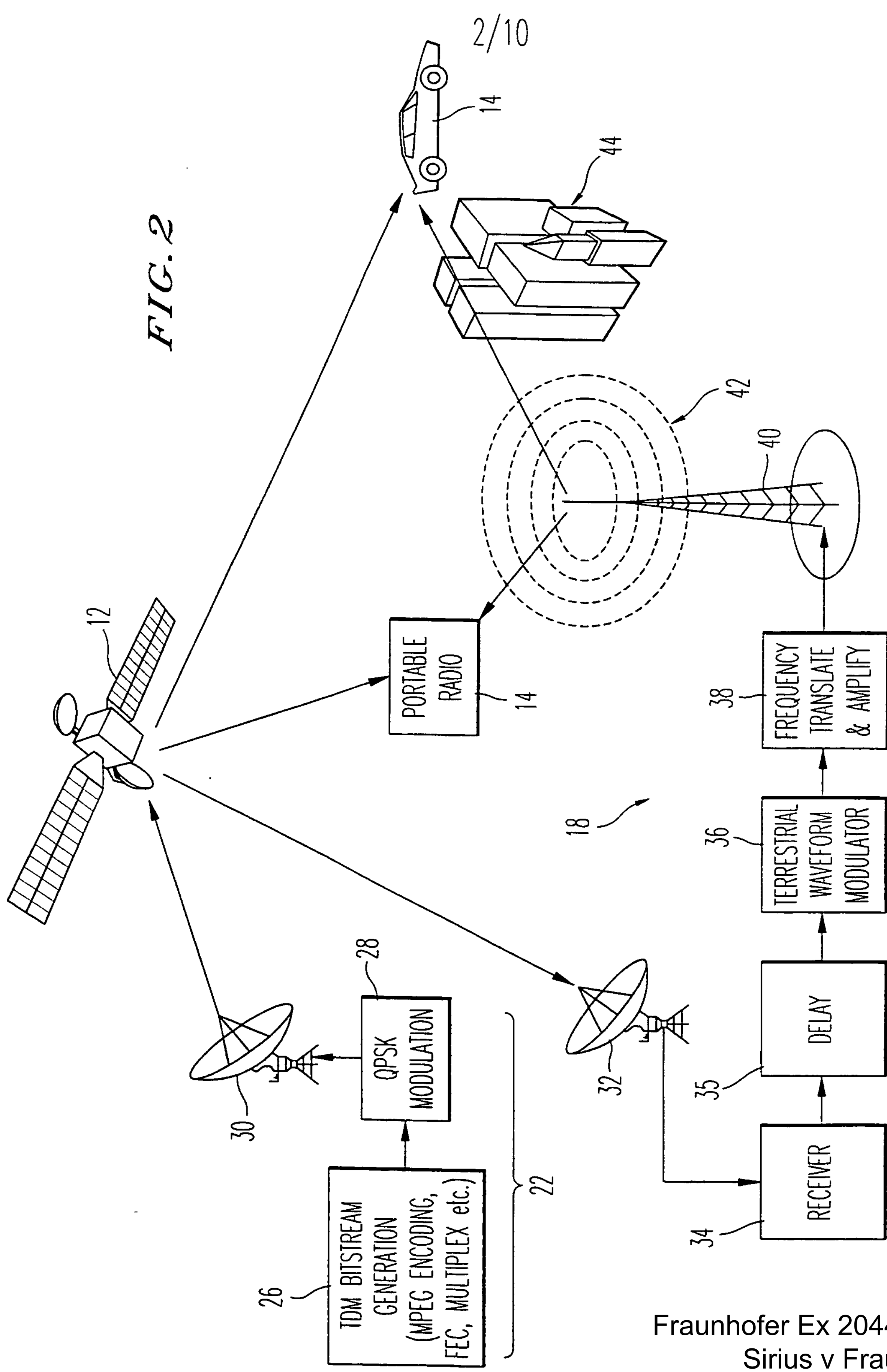


FIG. 1

FIG. 2


12
14
44
42
40
PORTABLE RADIO
14
38
FREQUENCY TRANSLATE & AMPLIFY
36
TERRESTRIAL WAVEFORM MODULATOR
18
28
QPSK MODULATION
30
32
35
DELAY
34
RECEIVER
26
TDM BITSTREAM GENERATION (MPEG ENCODING, FEC, MULTIPLEX etc.)
22

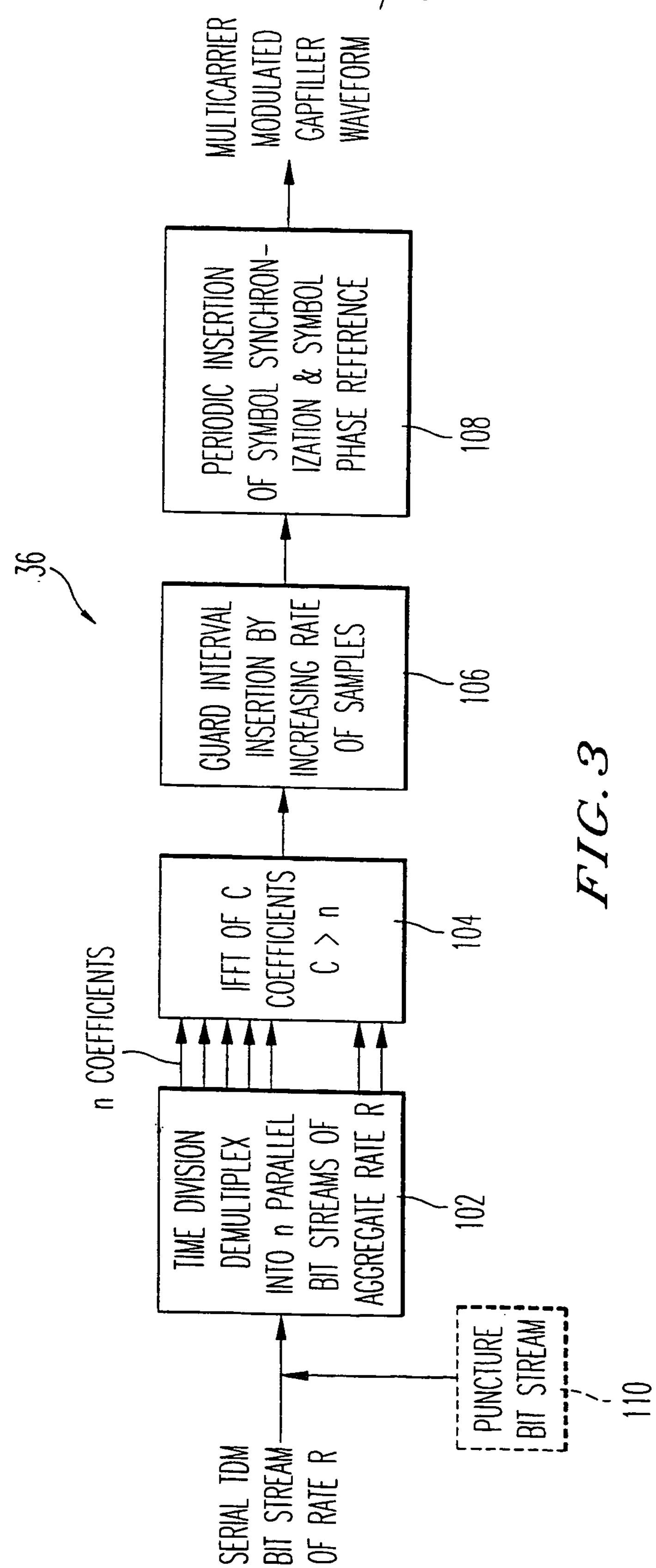

MULTICARRIER MODULATED GAPFILLER WAVEFORM
PERIODIC INSERTION OF SYMBOL SYNCHRON-IZATION & SYMBOL PHASE REFERENCE
108
36
GUARD INTERVAL INSERTION BY INCREASING RATE OF SAMPLES
106
IFFT OF C COEFFICIENTS C > n
104
n COEFFICIENTS
TIME DIVISION DEMULTIPLEX INTO n PARALLEL BIT STREAMS OF AGGREGATE RATE R
102
PUNCTURE BIT STREAM
110
SERIAL TDM BIT STREAM OF RATE R

FIG. 3

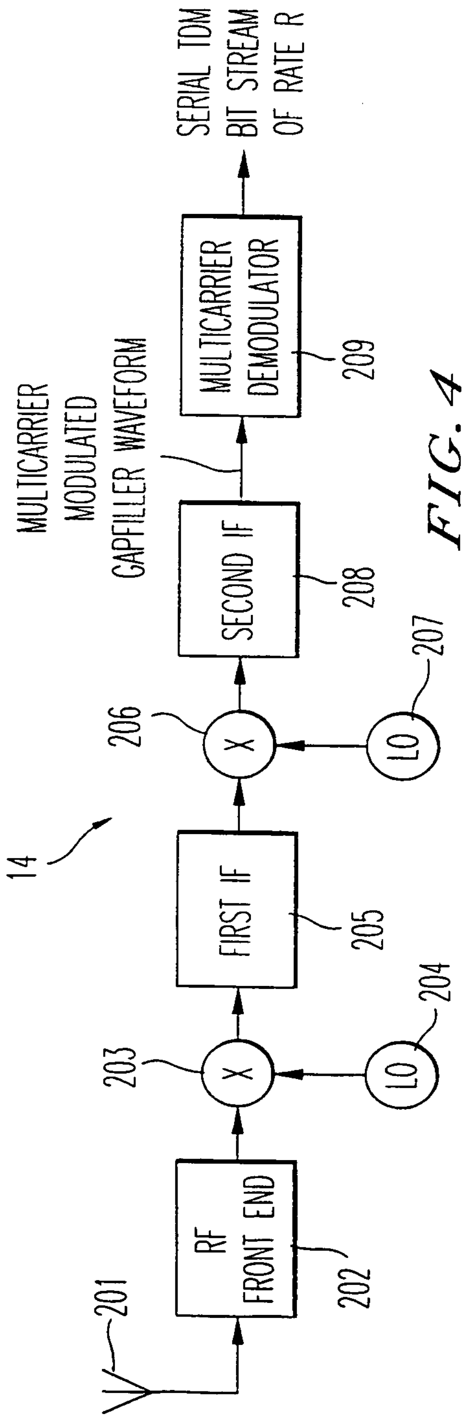

14
201
RF FRONT END
202
203
X
LO
204
FIRST IF
205
206
X
LO
207
SECOND IF
208
MULTICARRIER MODULATED GAPFILLER WAVEFORM
MULTICARRIER DEMODULATOR
209
SERIAL TDM BIT STREAM OF RATE R

FIG. 4

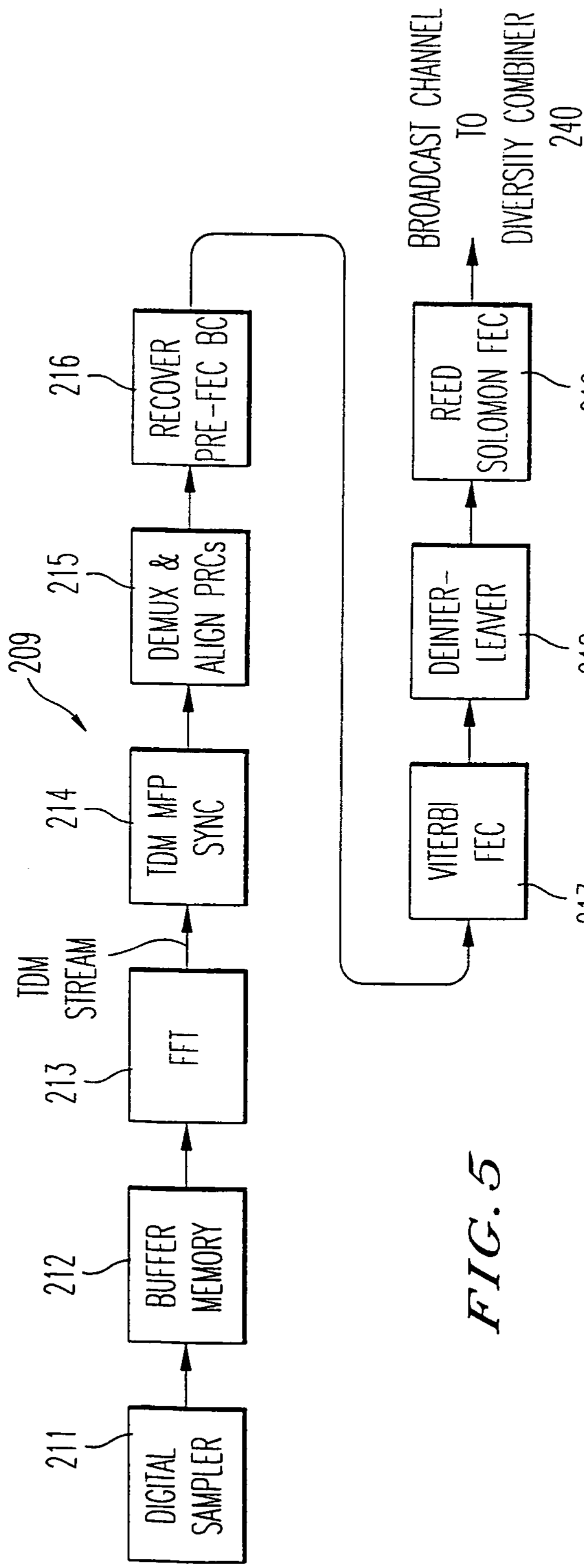

209
DIGITAL SAMPLER
211
BUFFER MEMORY
212
FFT
213
TDM STREAM
TDM MFP SYNC
214
DEMUX & ALIGN PRCs
215
RECOVER PRE-FEC BC
216
VITERBI FEC
217
DEINTER-LEAVER
218
REED SOLOMON FEC
219
BROADCAST CHANNEL TO DIVERSITY COMBINER 240

FIG. 5

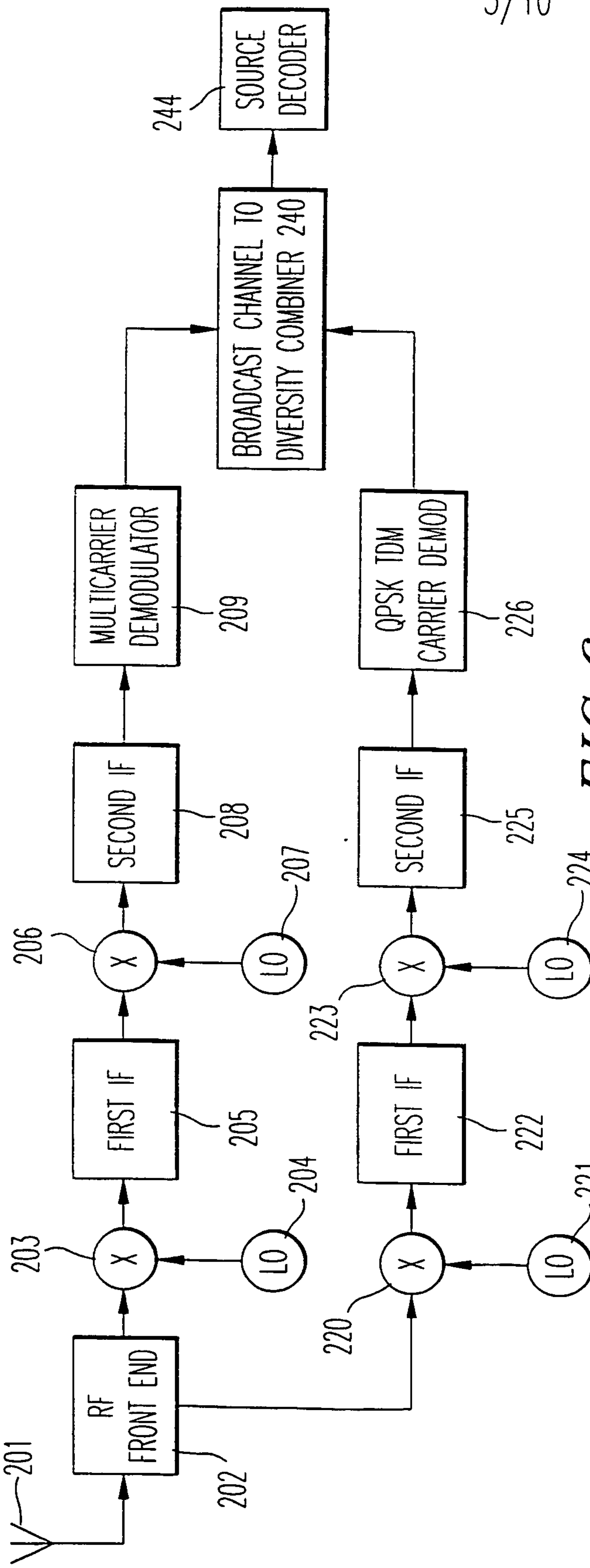

201
RF FRONT END
202
203
X
LO
204
FIRST IF
205
206
X
LO
207
SECOND IF
208
MULTICARRIER DEMODULATOR
209
220
X
LO
221
FIRST IF
222
223
X
LO
224
SECOND IF
225
QPSK TDM CARRIER DEMOD
226
BROADCAST CHANNEL TO DIVERSITY COMBINER 240
244
SOURCE DECODER

FIG. 6

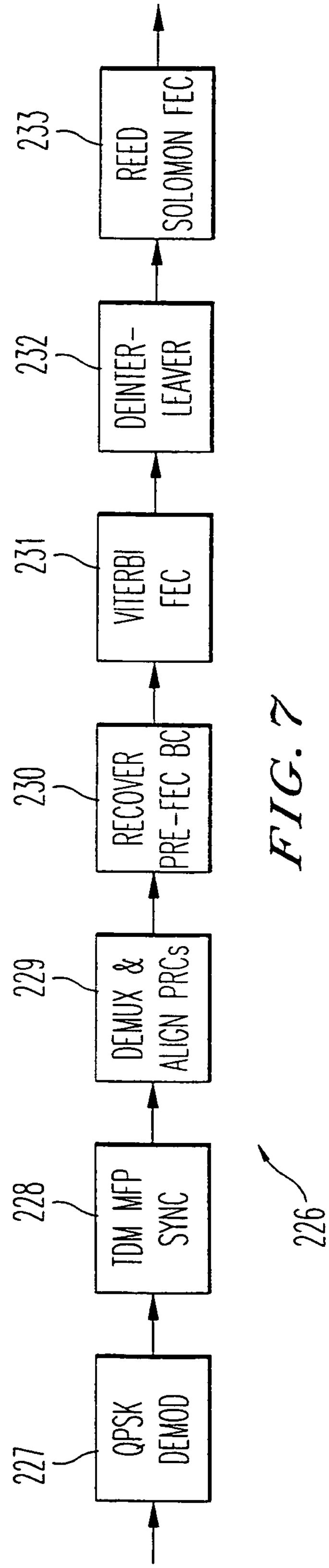

227
QPSK DEMOD
228
TDM MFP SYNC
229
DEMUX & ALIGN PRCs
230
RECOVER PRE-FEC BC
231
VITERBI FEC
232
DEINTER-LEAVER
233
REED SOLOMON FEC
226

FIG. 7

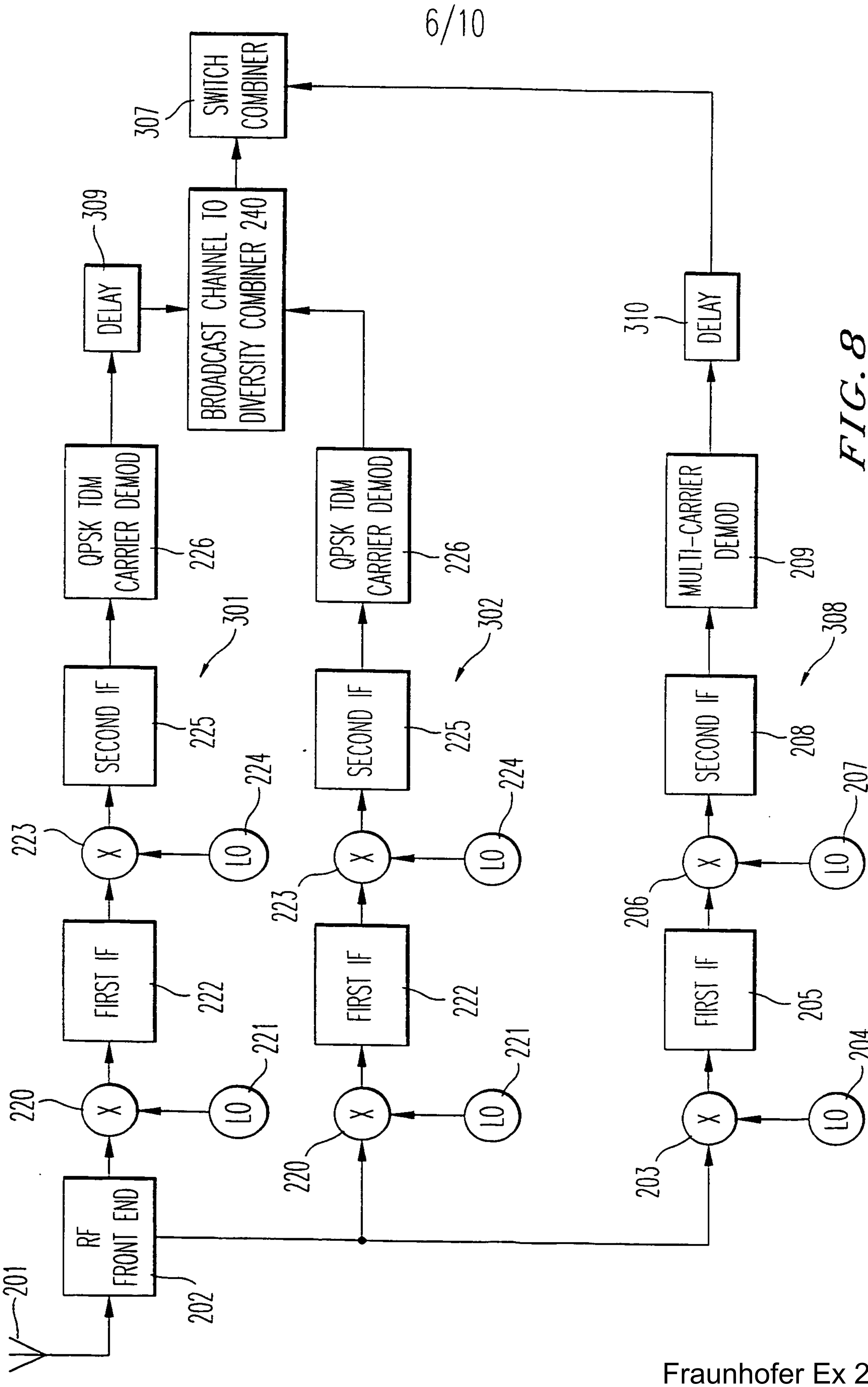
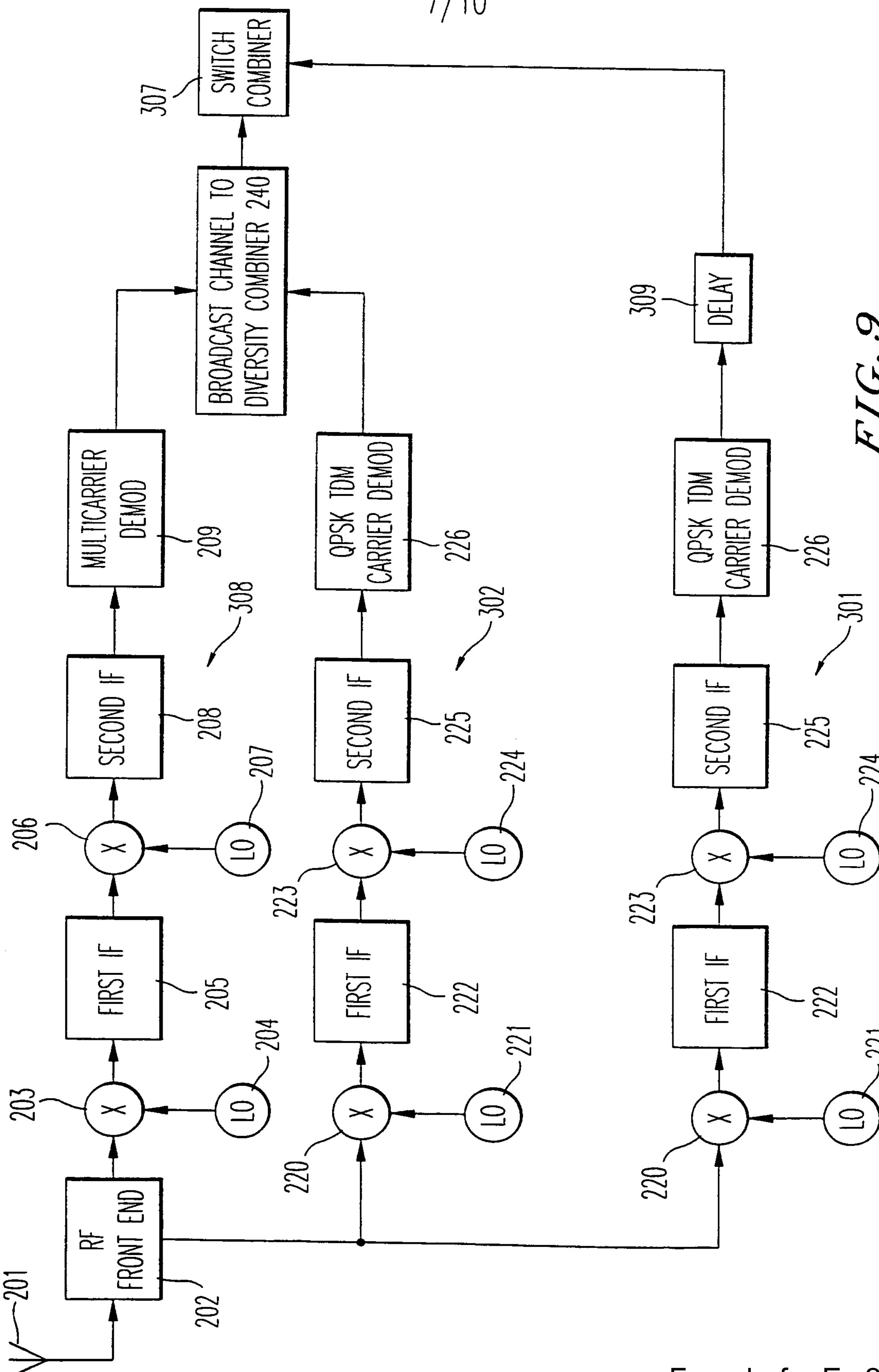

201
RF FRONT END
202
X
220
LO
221
FIRST IF
222
X
223
LO
224
SECOND IF
225
301
QPSK TDM CARRIER DEMOD
226
DELAY
309
X
220
LO
221
FIRST IF
222
X
223
LO
224
SECOND IF
225
302
QPSK TDM CARRIER DEMOD
226
BROADCAST CHANNEL TO DIVERSITY COMBINER 240
SWITCH COMBINER
307
X
203
LO
204
FIRST IF
205
X
206
LO
207
SECOND IF
208
308
MULTI-CARRIER DEMOD
209
DELAY
310

FIG. 8



201
RF FRONT END
202
203
X
LO
204
FIRST IF
205
206
X
LO
207
SECOND IF
208
308
MULTICARRIER DEMOD
209
220
X
LO
221
FIRST IF
222
223
X
LO
224
SECOND IF
225
302
QPSK TDM CARRIER DEMOD
226
BROADCAST CHANNEL TO DIVERSITY COMBINER 240
SWITCH COMBINER
307
220
X
LO
221
FIRST IF
222
223
X
LO
224
SECOND IF
225
301
QPSK TDM CARRIER DEMOD
226
DELAY
309

FIG. 9

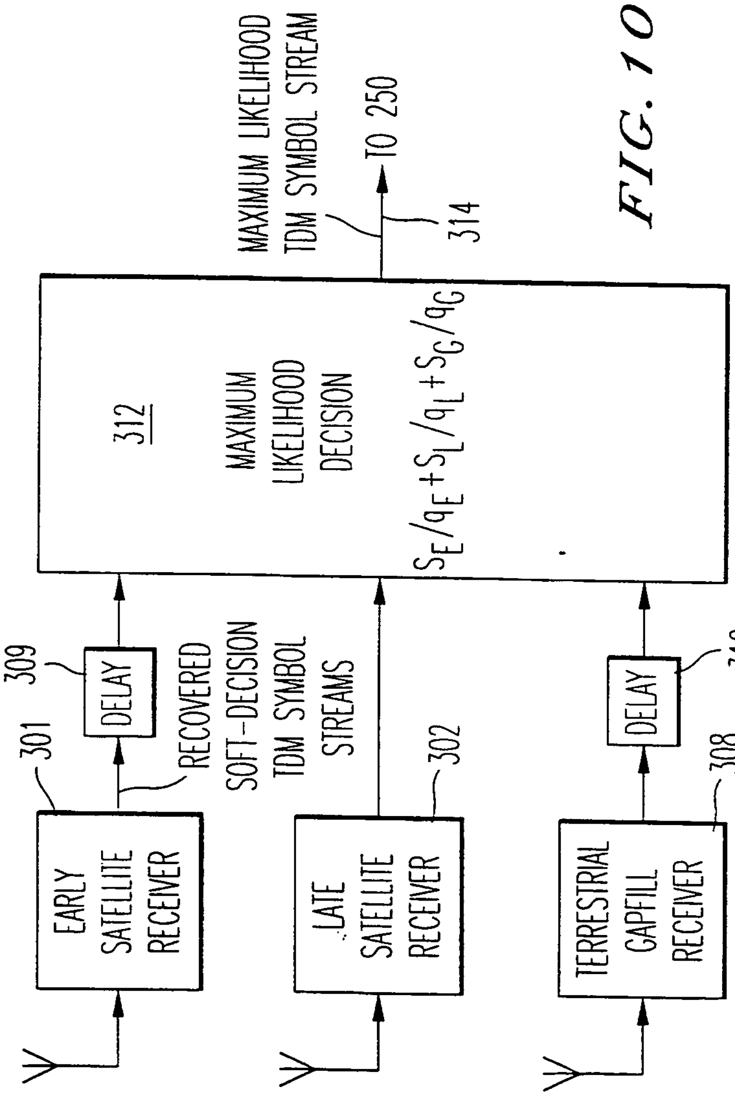

EARLY SATELLITE RECEIVER
301
RECOVERED SOFT-DECISION TDM SYMBOL STREAMS
DELAY
309
LATE SATELLITE RECEIVER
302
TERRESTRIAL GAPFILL RECEIVER
308
DELAY
310
312
MAXIMUM LIKELIHOOD DECISION
$S_E/q_E+S_L/q_L+S_G/q_G$
MAXIMUM LIKELIHOOD TDM SYMBOL STREAM
314
TO 250

FIG. 10

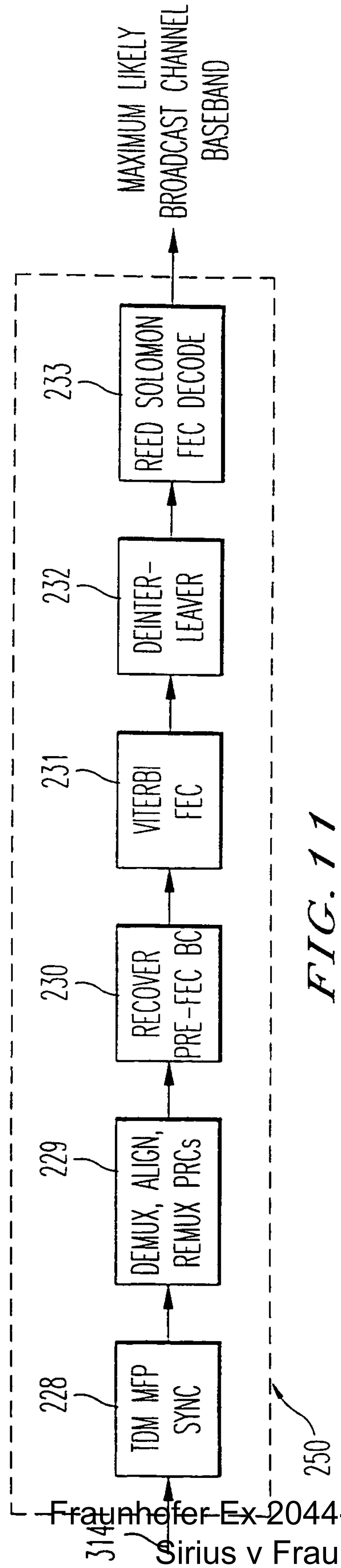

314
TDM MFP SYNC
228
DEMUX, ALIGN, REMUX PRCs
229
RECOVER PRE-FEC BC
230
VITERBI FEC
231
DEINTER-LEAVER
232
REED SOLOMON FEC DECODE
233
MAXIMUM LIKELY BROADCAST CHANNEL BASEBAND
250

FIG. 11

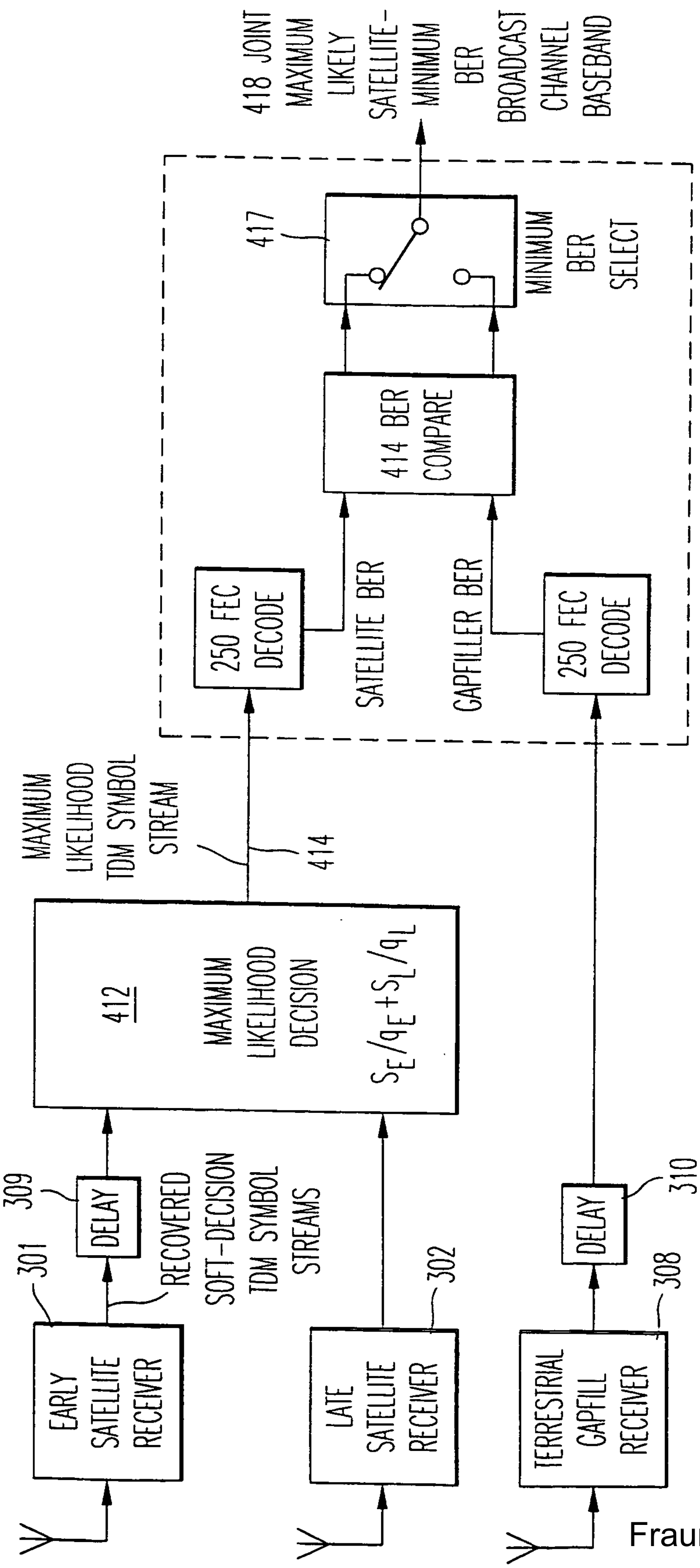

418 JOINT MAXIMUM LIKELY SATELLITE-MINIMUM BER BROADCAST CHANNEL BASEBAND
417
MINIMUM BER SELECT
414 BER COMPARE
250 FEC DECODE
SATELLITE BER
GAPFILLER BER
250 FEC DECODE
MAXIMUM LIKELIHOOD TDM SYMBOL STREAM
414
412
MAXIMUM LIKELIHOOD DECISION
$S_E/q_E+S_L/q_L$
309
DELAY
301
RECOVERED SOFT-DECISION TDM SYMBOL STREAMS
302
310
DELAY
308
EARLY SATELLITE RECEIVER
LATE SATELLITE RECEIVER
TERRESTRIAL GAPFILL RECEIVER

FIG. 12

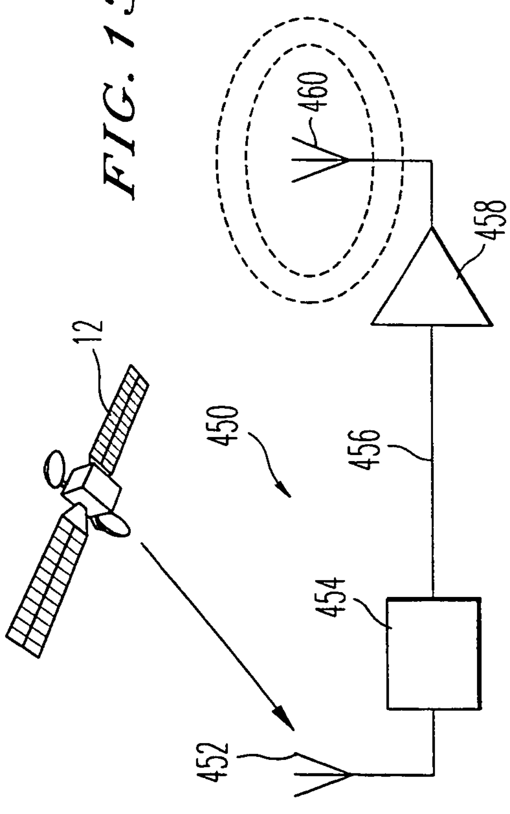

12
450
452
454
456
458
460

FIG. 13

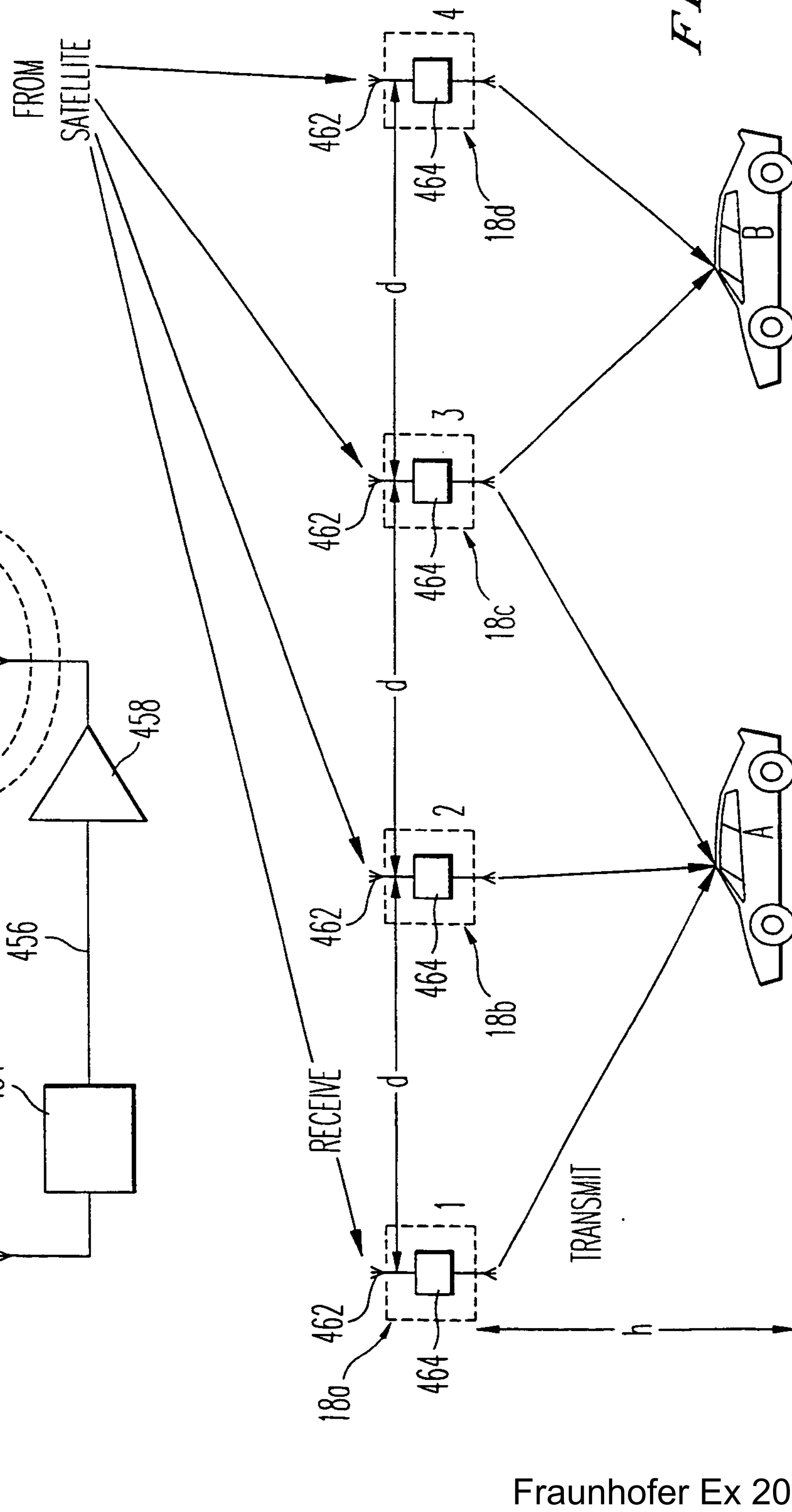

FROM SATELLITE
RECEIVE
TRANSMIT
1
2
3
4
462
464
18a
18b
18c
18d
d
h
A
B

FIG. 14

What is Claimed Is:

1. A digital broadcasting system for transmitting a broadcast program to radio receivers, the broadcast program being generated at an earth station, comprising:

a satellite for receiving said broadcast program from said earth station and transmitting at least one satellite signal comprising at least a portion of said broadcast program to said radio receivers on a first carrier frequency; and

at least one terrestrial repeater for receiving said satellite signal and generating and transmitting at least one terrestrial signal from said satellite signal comprising said at least a portion of said broadcast program on a second carrier frequency and modulated in accordance with a multipath-tolerant modulation technique.

REPLACE BY ART 34

2. A system as claimed in claim 1, wherein said satellite is operable to modulate said broadcast program in accordance with at least one of time division multiplexing and code division multiplexing, and said terrestrial repeater is operable to modulate said terrestrial signal using at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptively equalized time division multiplexing, multicarrier modulation and code division multiplexing.

3. A system as claimed in claim 1, wherein said terrestrial repeater is operable to modulate said terrestrial signal using multicarrier modulation.

4. A system as claimed in claim 3, wherein said terrestrial repeater is operable to receive said satellite signal and to demodulate said satellite signal into a baseband signal prior to modulating said baseband signal using multicarrier modulation.

5. A system as claimed in claim 1, wherein said satellite signal is assigned a first code division multiple access channel code and said terrestrial signal is assigned a second code division multiple access channel code.

6. A system as claimed in claim 1, further comprising a second satellite, said second satellite being operable to receive said broadcast program from said earth station and to

transmit at least one second satellite signal comprising said at least a portion of said broadcast program to said radio receivers on said first carrier frequency and delayed a predetermined period of time with respect to the transmission of the other said satellite signal.

7. A terrestrial repeater for re-radiating broadcast signals to radio receivers comprising:

a receiver for receiving said broadcast signals; and

a terrestrial waveform modulator for generating terrestrial signals comprising said broadcast signals, said terrestrial signals being modulated by said terrestrial waveform modulator in accordance with multicarrier modulation.

8. A terrestrial repeater as claimed in claim 7, wherein said broadcast signals are transmitted to said radio receivers from a satellite using a first carrier frequency, said terrestrial waveform modulator being operable to transmit said terrestrial signals to said radio receivers using a second carrier frequency.

9. A terrestrial repeater as claimed in claim 7, wherein said terrestrial waveform modulator comprises:

a time division demultiplexer for demultiplexing said broadcast signals from a serial time division multiplexed bit stream into a plurality of parallel bit streams; and

an inverse fast Fourier transform device for generating a digital analog signal comprising a plurality of discrete Fourier transform coefficients.

10. A method of converting a time division multiplexed bit stream into a plurality of multicarrier modulated signals at a terrestrial repeater comprising the steps of:

receiving said time division multiplexed bit stream from a satellite;

dividing said time division multiplexed bit stream into a plurality of parallel bit paths;

representing each of a predetermined number of bits in each of said plurality of bit paths as a symbol comprising an imaginary component and a real component;

providing said symbols to parallel inputs of an inverse Fourier transform converter as complex number frequency coefficient inputs to generate outputs which are narrow band, orthogonal carriers; and

re-radiating said narrow band, orthogonal carriers.

11. A method as claimed in claim 10, further comprising the step of generating a guard interval for said carriers.

12. A method as claimed in claim 11, wherein said generating step comprises the steps of:

allocating a fraction of the symbol period corresponding to the duration of each of said symbols to guard time; and

reducing the duration of each of said symbols.

13. A method as claimed in claim 12, wherein said reducing step comprises the steps of:

storing said outputs of said inverse Fourier transform converter in a memory device every said symbol period; and

reading from said memory device after each said fraction of said symbol period has elapsed.

14. A method as claimed in claim 11, wherein said generating step further comprises the step of filling said guard interval with a subset of said outputs of said inverse Fourier transform.

15. A method as claimed in claim 10, further comprising the step of inserting a synchronization symbol every predetermined number of said symbol periods to synchronize a sampling window corresponding to said fraction of said symbol period with respect to said carriers every said symbol period at a receiver for said plurality of multicarrier modulated signals.

16. A method as claimed in claim 10, further comprising the step of puncturing said time division multiplexed bit stream to reduce the total bandwidth associated with said carriers.

17. A method as claimed in claim 16, wherein said puncturing step comprises the step of selectively eliminating bits from said time division multiplexed bit stream prior to providing said symbols to parallel inputs of an inverse Fourier transform converter.

18. A digital broadcasting system for transmitting a broadcast program to radio receivers, the broadcast program being generated at an earth station, comprising:

a first satellite configured to receive said broadcast program from said earth station and to transmit at least one first satellite signal comprising at least a portion of said broadcast program to said radio receivers, said first satellite signal being formatted in accordance with at least one of time division multiplexing and code division multiplexing; and

at least one terrestrial repeater configured to receive said first satellite signal and to generate and transmit at least one terrestrial signal from said first satellite signal comprising at least a portion of said broadcast program, said terrestrial signal being formatted in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing and multicarrier modulation.

19. A digital broadcasting system as claimed in claim 18, wherein said first satellite signal is transmitted to said radio receivers using a first carrier frequency, and said at last one terrestrial signal is transmitted to said radio receivers using a second carrier frequency.

20. A digital broadcasting system as claimed in claim 18, wherein at least one of said radio receivers is configured to receive said first satellite signal and said terrestrial signal and comprises a diversity combiner to generate an output signal from said first satellite signal and said terrestrial signal.

21. A digital broadcasting system as claimed in claim 18, further comprising a second satellite configured to receive said broadcast program from said earth station and to transmit at least one second satellite signal comprising at least a portion of said broadcast program to said radio receivers, said second satellite signal being delayed with respect to said first satellite signal by a selected time delay, said second satellite signal being formatted in accordance with the corresponding at least one of time division multiplexing and code division multiplexing employed by said first satellite.

22. A digital broadcasting system as claimed in claim 21, wherein at least one of said radio receivers is configured to receive said first satellite signal, said second satellite signal and said terrestrial signal, to delay at least one of said first satellite signal and said terrestrial signal in accordance with said selected time delay, and to generate an output signal from first satellite signal, said second satellite signal and said terrestrial signal.

23. A digital broadcasting system as claimed in claim 22, wherein said radio receiver comprises a diversity combiner and a switched combiner, said radio receiver using said diversity combiner to perform maximum likelihood decision combining of said first satellite signal and said second satellite signals and said switch combiner to select between the output of said diversity combiner and said terrestrial signal depending on which of said output of said diversity combiner and said terrestrial signal comprises the least number of bit errors.

24. A digital broadcasting system as claimed in claim 22, wherein said radio receiver comprises a diversity combiner to perform maximum likelihood decision combining of said first satellite signal, said second satellite signals and said terrestrial signal.

25. A receiver for receiving a broadcast signal in a digital broadcasting system comprising:

a first receiver arm for receiving a first satellite signal transmitted from a first satellite on a first carrier frequency, said first satellite signal comprising at least a portion of said broadcast signal and being formatted in accordance with at least one of time division multiplexing and code division multiplexing, said first receiver arm comprising a demodulator for recovering said at least a portion of said broadcast signal;

a second receiver arm for receiving a terrestrial signal transmitted on a second carrier frequency, said terrestrial signal comprising said at least a portion of said broadcast signal and being formatted in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing and multicarrier modulation, said second receiver arm comprising a demodulator for recovering said at least a portion of said broadcast signal; and

a combiner for generating an output signal from said first satellite signal and said terrestrial signal.

26. A receiver as claimed in claim 25, further comprising:

a third receiver arm for receiving a second satellite signal from a second satellite and delayed with respect to said first satellite signal in accordance with a selected time delay, said second satellite signal comprising at least a portion of said broadcast signal and being formatted in accordance with the corresponding at least one of time division multiplexing and code division multiplexing employed by said first satellite, said first receiver arm comprising a demodulator for recovering said at least a portion of said broadcast signal; and

a delay device for delaying said first satellite signal in accordance with said selected time delay, said combiner being operable to generate an output signal from said first satellite signal, said second satellite signal and said terrestrial signal.

27. A method of transmitting a broadcast program to radio receivers comprising the steps of:

formatting a broadcast signal for transmission to said radio receivers as a first signal in accordance with one of time division multiplexing and code division multiplexing;

transmitting said first signal to said radio receivers from a first satellite on a first carrier frequency;

formatting said broadcast signal for transmission to said radio receivers as a second signal in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing and multicarrier modulation; and

transmitting said second signal to said radio receivers from a terrestrial repeater on a second carrier frequency.

28. A method as claimed in claim 27, wherein said formatting step for formatting said broadcast signal as said second signal comprises the steps of:

receiving said first signal at said terrestrial repeater; and

performing baseband processing of said first signal prior to formatting in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing and multicarrier modulation.

29. A method as claimed in claim 28, further comprising the step of receiving said first signal and said second signal at one of said radio receivers.

30. A method as claimed in claim 29, further comprising the step of demodulating each of said first signal and said second signal to remove said respective formatting and to recover a first recovered broadcast signal and a second recovered broadcast signal, respectively.

31. A method as claimed in claim 30, further comprising the steps of generating an output broadcast signal from said first recovered broadcast signal and said second recovered broadcast signal.

32. A method as claimed in claim 31, wherein said generating step comprises the step of performing maximum likelihood combining of said first recovered broadcast signal and said second recovered broadcast signal.

33. A method as claimed in claim 27, further comprising the steps of:

formatting a broadcast signal for transmission to said radio receivers as a third signal in accordance with at least one of time division multiplexing and code division multiplexing;

transmitting said third signal to said radio receivers from a second satellite, said transmission being delayed with respect to said first signal by a predetermined period of time.

34. A method as claimed in claim 33, further comprising the steps of:

receiving said first signal, said second signal and said third signal at one of said radio receivers;

demodulating each of said first signal, said second signal and said third signal to remove said respective formatting and to recover a first recovered broadcast signal, a second recovered broadcast signal and a third recovered broadcast signal, respectively; and

generating an output broadcast signal from said first recovered broadcast signal, said second recovered broadcast signal and said third recovered broadcast signal.

35. An indoor reinforcement system for receiving a satellite signals transmitted in a digital broadcasting system using a radio receiver located indoors, comprising:

a line of sight antenna for receiving line of sight satellite signals;

a radio frequency front-end unit connected to said line of sight antenna for passing frequency spectrum comprising said satellite signal with low noise;

at least one indoor amplifier;

at least one cable for connecting said radio frequency front-end unit to said indoor amplifier; and

at least one indoor re-radiating antenna connected to said indoor amplifier, said indoor re-radiating antenna having a power level selected to be sufficiently high to achieve satisfactory indoor reception of said satellite signals at radio receivers at indoor locations where line of sight reception of said satellite signals is not possible and sufficiently low to prevent interference by said satellite signals transmitted between said line of sight antenna and said indoor re-radiating antenna.

36. An indoor reinforcement system as claimed in claim 35, wherein said satellite signals are characterized by a selected symbol period, and the duration of the transmission of said satellite signals between said line of sight antenna and said indoor re-radiating antenna is maintained to be less than a selected amount of said symbol duration by limiting the length of said at least one cable.

37. An indoor reinforcement system as claimed in claim 36, wherein said duration of the transmission of said satellite signals between said line of sight antenna and said indoor re-radiating antenna is no more than between 20 percent and 25 percent of said selected symbol period.

38. A reinforcement system for receiving a satellite signals transmitted in a digital broadcasting system using a radio receiver located outdoors, wherein said satellite signals are characterized by a selected symbol period, comprising at least two terrestrial repeaters, said terrestrial repeaters being characterized by a height *h* and being spaced apart by a distance *d*, the slant distance $(d^2 + h^2)^{1/2}$ from one of said terrestrial repeaters to said radio receiver being selected to limit a delay in reception of said satellite signals at said radio receiver from one of said terrestrial repeaters to between 20 percent and 25 percent of said symbol period.

39. A digital broadcasting system for transmitting a broadcast program to radio receivers, the broadcast program being generated at an earth station, comprising:

a first satellite configured to receive said broadcast program from said earth station and to transmit at least one satellite signal comprising at least a portion of said broadcast program to said radio receivers; and

at least one terrestrial repeater configured to receive said first satellite signal and to generate and transmit at least one terrestrial signal from said first satellite signal comprising at least a portion of said broadcast program, wherein said satellite signal and said terrestrial signal are each modulated using a multipath-tolerant modulation technique.

40. A system as claimed in claim 39, wherein said first satellite signal is formatted in accordance with at least one of time division multiplexing and code division multiplexing.

41. A system as claimed in claim 39, wherein said terrestrial signal is formatted in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing and multicarrier modulation.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 36010	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
International application No. PCT/US98/14280	International filing date *(day/month/year)* 10 JULY 1998	(Earliest) Priority Date *(day/month/year)* 27 MARCH 1998
Applicant WORLDSPACE MANAGEMENT CORPORATION		

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 3 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. [ ] **Certain claims were found unsearchable** (See Box I).

2. [ ] **Unity of invention is lacking** (See Box II).

3. [ ] The international application contains disclosure of a **nucleotide and/or amino acid sequence listing** and the international search was carried out on the basis of the sequence listing
   - [ ] filed with the international application.
   - [ ] furnished by the applicant separately from the international application,
     - [ ] but not accompanied by a statement to the effect that it did not include matter going beyond the disclosure in the international application as filed.
   - [ ] transcribed by this Authority.

4. With regard to the **title**,
   - [X] the text is approved as submitted by the applicant.
   - [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,
   - [ ] the text is approved as submitted by the applicant.
   - [X] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. **The figure of the drawings** to be published with the abstract is:

   Figure No. 2
   - [X] as suggested by the applicant.
   - [ ] because the applicant failed to suggest a figure.
   - [ ] because this figure better characterizes the invention.
   - [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/14280

Box III TEXT OF THE ABSTRACT (Continuation of item 5 of the first sheet)

The technical features mentioned in the abstract do not include a reference sign between parentheses (PCT Rule 8.1(d)).

A digital broadcast system (Fig. 2) is provided which uses a satellite direct radio broadcast system having different downlink modulation options in combination with a terresterial repeater network employing different re-broadcasting modulation options to achieve high availabilty 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 terresterial signals, and for maximum likelihood combining of received signals for diversity purposes. A terresterial repeater is provided for reformatting a TDM satellite signal as a multicarrier modulated terresterial signal. Configuratios for indoor and outdoor terresterial repeaters are also provided.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/14280

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04H 1/00; H04B 7/155
US CL :370/315; 375/347; 455/17, 500, 504
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. : 370/315; 375/347, 211, 349; 455/17, 500, 504, 427

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.
A	US 5,485,485 A (BRISKMAN et al.) 16, January 1996, see entire documant.	1-41
A	US 5,303,393 A (NOREEN et al.) 12 april 1994, see entire document.	1-41
A	US 5,319,673 A (BRISKMAN) 07 June 1994, see entire document.	1-41
A	US 5,659,353 A (KOSTRESKI et al.) 19 August 1997, see entire document.	1-41

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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

"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

"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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
30 JANUARY 1999

Date of mailing of the international search report
27 APR 1999

Name and mailing address of the ISA/US
Commissioner of Patents and Trademarks
Box PCT
Washington, D.C. 20231
Facsimile No. (703) 305-3230

Authorized officer
MIN JUNG
Telephone No. (703) 305-4363

Form PCT/ISA/210 (second sheet)(July 1992)★

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: JOHN E. HOLMES
ROYLANCE, ABRAMS, BERDO & GOODMAN, LLP
1225 CONNECTICUT AVE., NW
WASHINGTON, DC 20036

Doc'd ________ File 36010
Rec'd
APR 28 1999
ROYLANCE, ABRAMS
BERDO & GOODMAN, L.L.P.
BY ________

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

	Date of Mailing (day/month/year) **27 APR 1999**
Applicant's or agent's file reference 36010	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/US98/14280	International filing date (day/month/year) 10 JULY 1998
Applicant WORLDSPACE MANAGEMENT CORPORATION	

1. [X] The applicant is hereby notified that the international search report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the international search report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] With regard to the protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after 18 months from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in rules 90 *bis* 1 and 90 *bis* 3, respectively, before the completion of the technical preparations for international publication.

Within 19 months from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within 20 months from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer MIN JUNG Telephone No. (703) 305-4363

Form PCT/ISA/220 (January 1994)★

(See notes on accompanying sheet)

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To: JOHN E. HOLMES
ROYLANCE, ABRAMS, BERDO & GOODMAN, LLP
1225 CONNECTICUT AVE., NW
WASHINGTON, DC 20036

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

	Date of Mailing (*day/month/year*) 27 APR 1999
Applicant's or agent's file reference 36010	FOR FURTHER ACTION See paragraphs 1 and 4 below
International application No. PCT/US98/14280	International filing date (*day/month/year*) 10 JULY 1998
Applicant WORLDSPACE MANAGEMENT CORPORATION	

1. [X] The applicant is hereby notified that the international search report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the international search report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:**

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in rules 90 *bis* 1 and 90 *bis* 3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	MIN JUNG
Facsimile No. (703) 305-3230	Telephone No. (703) 305-4363

Form PCT/ISA/220 (January 1994)★ (See notes on accompanying sheet)

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Assistant Commissioner for Patents
United States Patent and Trademark Office
Box PCT
Washington, D.C.20231
ÉTATS-UNIS D'AMÉRIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 30 November 1999 (30.11.99)	
International application No. PCT/US98/14280	**Applicant's or agent's file reference** 36010
International filing date (day/month/year) 10 July 1998 (10.07.98)	**Priority date** (day/month/year) 27 March 1998 (27.03.98)
Applicant CAMPANELLA, S., Joseph	

1. The designated Office is hereby notified of its election made:

   [X] in the demand filed with the International Preliminary Examining Authority on:

   26 October 1999 (26.10.99)

   [ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was [ ] was not

   made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland** Facsimile No.: (41-22) 740.14.35	Authorized officer Kiwa Mpay Telephone No.: (41-22) 338.83.38

Form PCT/IB/331 (July 1992)

2983034

PATENT COOPERATION TREATY

PCT

RECD 03 MAY 2000

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

16

Applicant's or agent's file reference 36010	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US98/14280	International filing date *(day/month/year)* 10 JULY 1998	Priority date *(day/month/year)* 27 MARCH 1998
International Patent Classification (IPC) or national classification and IPC IPC(7): H04H 1/00; H04B 7/155 and US Cl.: 370/315; 375/347; 455/17, 500, 504		
Applicant WORLDSPACE MANAGEMENT CORPORATION		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 0 sheets.

3. This report contains indications relating to the following items:

   I ☒ Basis of the report

   II ☐ Priority

   III ☐ Non-establishment of report with regard to novelty, inventive step or industrial applicability

   IV ☐ Lack of unity of invention

   V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

   VI ☒ Certain documents cited

   VII ☐ Certain defects in the international application

   VIII ☐ Certain observations on the international application

Date of submission of the demand 26 OCTOBER 1999	Date of completion of this report 18 APRIL 2000
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer MIN JUNG Telephone No. (703) 305-4363

Form PCT/IPEA/409 (cover sheet) (July 1998) ★

I. Basis of the report

1. With regard to the **elements** of the international application:*

[X] the international application as originally filed

[X] the description:
pages 1-25, as originally filed
pages NONE, filed with the demand
pages NONE, filed with the letter of ________

[X] the claims:
pages 26-35, as originally filed
pages NONE, as amended (together with any statement) under Article 19
pages NONE, filed with the demand
pages NONE, filed with the letter of ________

[X] the drawings:
pages 1-10, as originally filed
pages NONE, filed with the demand
pages NONE, filed with the letter of ________

[X] the sequence listing part of the description:
pages NONE, as originally filed
pages NONE, filed with the demand
pages NONE, filed with the letter of ________

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language ________ which is:

[ ] the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

[ ] the language of publication of the international application (under Rule 48.3(b)).

[ ] the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

[ ] contained in the international application in printed form.

[ ] filed together with the international application in computer readable form.

[ ] furnished subsequently to this Authority in written form.

[ ] furnished subsequently to this Authority in computer readable form.

[ ] The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

[ ] The statement that the information recorded in computer readable form is identical to the writen sequence listing has been furnished.

4. [X] The amendments have resulted in the cancellation of:

[X] the description, pages none
[X] the claims, Nos. none
[X] the drawings, sheets/~~fig~~ none

5. [ ] This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

***Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. statement

Novelty (N)	Claims	1-41	YES
	Claims	none	NO
Inventive Step (IS)	Claims	1-41	YES
	Claims	none	NO
Industrial Applicability (IA)	Claims	1-41	YES
	Claims	none	NO

2. citations and explanations (Rule 70.7)

Claims 1-41 meet the criteria set out in PCT Article 33(2)-(4), because the prior art does not teach or fairly suggest a digital broadcasting system for transmitting a broadcast program to radio receivers, the broadcast program being generated at an earth station, comprising a satellite for receiving said broadcast program from said earth station and transmitting at least one satellite signal comprising at least a portion of said broadcast program to said radio receivers on a first carrier frequency; and at least one terrestrial repeater for receiving said satellite signal comprising said at least a portion of said broadcast program on a second carrier frequency and modulated in accordance with a multipath-tolerant modulation technique.

-------------------- NEW CITATIONS --------------------

US 5,726,980 A (RICKARD) 10 March 1998, see Abstract.

US 5,636,246 A (TZANNES) 03 June 1997, see entire document.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US98/14280

VI. Certain documents cited

1. Certain published documents (Rule 70.10)

Application No. Patent No.	Publication Date *(day/month/year)*	Filing Date *(day/month/year)*	Priority date (valid claim) *(day/month/year)*
US, A, 5,864,579	26 JANUARY 1999	25 JULY 1996	NONE
US, A, 5,953,311	14 SEPTEMBER 1999	18 FEBRUARY 1997	NONE

2. Non-written disclosures (Rule 70.9)

Kind of non-written disclosure	Date of non-written disclosure *(day/month/year)*	Date of written disclosure referring to non-written disclosure *(day/month/year)*

PATENT COOPERATION TREATY

PCT

REC'D 17 AUG 2000

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
36010		
International application No. PCT/US98/14280	International filing date (*day/month/year*) 10 JULY 1998	Priority date (*day/month/year*) 27 MARCH 1998
International Patent Classification (IPC) or national classification and IPC IPC(7): H04H 1/00; H04B 7/155 and US Cl.: 370/315; 375/347; 455/17, 500, 504		
Applicant WORLDSPACE MANAGEMENT CORPORATION		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets.

[1] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 9 sheets.

3. This report contains indications relating to the following items:

- I [X] Basis of the report
- II [ ] Priority
- III [ ] Non-establishment of report with regard to novelty, inventive step or industrial applicability
- IV [ ] Lack of unity of invention
- V [X] Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI [X] Certain documents cited
- VII [ ] Certain defects in the international application
- VIII [ ] Certain observations on the international application

CORRECTED VERSION

Date of submission of the demand	Date of completion of this report
26 OCTOBER 1999	18 APRIL 2000
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer MIN JUNG *Rugenia Logan* Telephone No. (703) 305-4363

Form PCT/IPEA/409 (cover sheet) (July 1998) ★

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US98/14280

I. Basis of the report

1. With regard to the **elements** of the international application:*

☐ the international application as originally filed

☒ the description:
pages (See Attached), as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

☒ the claims:
pages (See Attached), as originally filed
pages ______, as amended (together with any statement) under Article 19
pages ______, filed with the demand
pages ______, filed with the letter of ______

☒ the drawings:
pages (See Attached), as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

☒ the sequence listing part of the description:
pages (See Attached), as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language ______ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the writen sequence listing has been furnished.

4. ☒ The amendments have resulted in the cancellation of:

☒ the description, pages none

☒ the claims, Nos. NONE

☒ the drawings, sheets/~~fig~~ none

5. ☒ This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

***Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. statement

Novelty (N)	Claims	1-41	YES
	Claims	none	NO
Inventive Step (IS)	Claims	1-41	YES
	Claims	none	NO
Industrial Applicability (IA)	Claims	1-41	YES
	Claims	none	NO

2. citations and explanations (Rule 70.7)

Claims 1-41 meet the criteria set out in PCT Article 33(2)-(4), because the prior art does not teach or fairly suggest a digital broadcasting system for transmitting a broadcast program to radio receivers, the broadcast program being generated at an earth station, comprising a satellite for receiving said broadcast program from said earth station and transmitting at least one satellite signal comprising at least a portion of said broadcast program to said radio receivers on a first carrier frequency; and at least one terrestrial repeater for receiving said satellite signal comprising said at least a portion of said broadcast program on a second carrier frequency and modulated in accordance with a multipath-tolerant modulation technique.

-------------------- NEW CITATIONS --------------------

US 5,726,980 A (RICKARD) 10 March 1998, see Abstract.

US 5,636,246 A (TZANNES) 03 June 1997, see entire document.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US98/14280

VI. Certain documents cited

1. Certain published documents (Rule 70.10)

Application No. Patent No.	Publication Date *(day/month/year)*	Filing Date *(day/month/year)*	Priority date (valid claim) *(day/month/year)*
US, A, 5,864,579	26 JANUARY 1999	25 JULY 1996	NONE
US, A, 5,953,311	14 SEPTEMBER 1999	18 FEBRUARY 1997	NONE

2. Non-written disclosures (Rule 70.9)

Kind of non-written disclosure	Date of non-written disclosure *(day/month/year)*	Date of written disclosure referring to non-written disclosure *(day/month/year)*

Form PCT/IPEA/409 (Box VI) (July 1998)★

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

Sheet 10

I. BASIS OF REPORT:

This report has been drawn on the basis of the description,
page(s) 1-25, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
NONE

This report has been drawn on the basis of the claims,
page(s) none, as originally filed.
page(s) NONE, as amended under Article 19.
page(s) NONE, filed with the demand.
and additional amendments:
Pages 26-34, filed with the letter dated March 24, 2000.

This report has been drawn on the basis of the drawings,
page(s) 1-10, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
NONE

This report has been drawn on the basis of the sequence listing part of the description:
page(s) NONE, as originally filed.
pages(s) NONE, filed with the demand.
and additional amendments:
NONE

5. (Some) amendments are considered to go beyond the disclosure as filed:
NONE

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: JOHN E. HOLMES
ROYLANCE, ABRAMS, BERDO & GOODMAN, LLP
1225 CONNECTICUT AVE., NW
SUITE 315
WASHINGTON, DC 20036

Doc'd ______ File ______
Rec'd
MAY 5 2000
ROYLANCE, ABRAMS
BERDO & GOODMAN, L.L.P.
BY ______

36010

PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

	Date of Mailing (*day/month/year*) 04 MAY 2000
Applicant's or agent's file reference 36010	IMPORTANT NOTIFICATION

International application No.	International filing date (*day/month/year*)	Priority Date (*day/month/year*)
PCT/US98/14280	10 JULY 1998	27 MARCH 1998

Applicant
WORLDSPACE MANAGEMENT CORPORATION

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	MIN JUNG
Facsimile No. (703) 305-3230	Telephone No. (703) 305-4363

Form PCT/IPEA/416 (July 1992)★

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: JOHN E. HOLMES
ROYLANCE, ABRAMS, BERDO & GOODMAN, LLP
1225 CONNECTICUT AVE., NW
SUITE 315
WASHINGTON, DC 20036

PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

		Date of Mailing *(day/month/year)* **04 MAY 2000**
Applicant's or agent's file reference 36010		**IMPORTANT NOTIFICATION**
International application No. PCT/US98/14280	International filing date *(day/month/year)* 10 JULY 1998	Priority Date *(day/month/year)* 27 MARCH 1998
Applicant WORLDSPACE MANAGEMENT CORPORATION		

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

   The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

   Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

   For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer MIN JUNG Telephone No. (703) 305-4363

Form PCT/IPEA/416 (July 1992)★

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 36010	**FOR FURTHER ACTION** See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/US98/14280	International filing date *(day/month/year)* 10 JULY 1998	Priority date *(day/month/year)* 27 MARCH 1998
International Patent Classification (IPC) or national classification and IPC IPC(7): H04H 1/00; H04B 7/155 and US Cl.: 370/315; 375/347; 455/17, 500, 504		
Applicant WORLDSPACE MANAGEMENT CORPORATION		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 0 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of report with regard to novelty, inventive step or industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☒ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand 26 OCTOBER 1999	Date of completion of this report 18 APRIL 2000
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer MIN JUNG Telephone No. (703) 305-4363

Form PCT/IPEA/409 (cover sheet) (July 1998) ★

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/US98/14280

I. Basis of the report

1. With regard to the **elements** of the international application:*
   - [X] the international application as originally filed
   - [X] the description:
     - pages 1-25, as originally filed
     - pages NONE, filed with the demand
     - pages NONE, filed with the letter of ______
   - [X] the claims:
     - pages 26-35, as originally filed
     - pages NONE, as amended (together with any statement) under Article 19
     - pages NONE, filed with the demand
     - pages NONE, filed with the letter of ______
   - [X] the drawings:
     - pages 1-10, as originally filed
     - pages NONE, filed with the demand
     - pages NONE, filed with the letter of ______
   - [X] the sequence listing part of the description:
     - pages NONE, as originally filed
     - pages NONE, filed with the demand
     - pages NONE, filed with the letter of ______

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
   These elements were available or furnished to this Authority in the following language ______ which is:
   - [ ] the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
   - [ ] the language of publication of the international application (under Rule 48.3(b)).
   - [ ] the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:
   - [ ] contained in the international application in printed form.
   - [ ] filed together with the international application in computer readable form.
   - [ ] furnished subsequently to this Authority in written form.
   - [ ] furnished subsequently to this Authority in computer readable form.
   - [ ] The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - [ ] The statement that the information recorded in computer readable form is identical to the writen sequence listing has been furnished.

4. [X] The amendments have resulted in the cancellation of:
   - [X] the description, pages none
   - [X] the claims, Nos. none
   - [X] the drawings, sheets/~~fig~~ none

5. [ ] This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

***Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

Form PCT/IPEA/409 (Box I) (July 1998)★

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. statement

Novelty (N)	Claims	1-41	YES
	Claims	none	NO
Inventive Step (IS)	Claims	1-41	YES
	Claims	none	NO
Industrial Applicability (IA)	Claims	1-41	YES
	Claims	none	NO

2. citations and explanations (Rule 70.7)

Claims 1-41 meet the criteria set out in PCT Article 33(2)-(4), because the prior art does not teach or fairly suggest a digital broadcasting system for transmitting a broadcast program to radio receivers, the broadcast program being generated at an earth station, comprising a satellite for receiving said broadcast program from said earth station and transmitting at least one satellite signal comprising at least a portion of said broadcast program to said radio receivers on a first carrier frequency; and at least one terrestrial repeater for receiving said satellite signal comprising said at least a portion of said broadcast program on a second carrier frequency and modulated in accordance with a multipath-tolerant modulation technique.

-------------------- NEW CITATIONS --------------------

US 5,726,980 A (RICKARD) 10 March 1998, see Abstract.

US 5,636,246 A (TZANNES) 03 June 1997, see entire document.

VI. Certain documents cited

1. Certain published documents (Rule 70.10)

Application No. Patent No.	Publication Date *(day/month/year)*	Filing Date *(day/month/year)*	Priority date (valid claim) *(day/month/year)*
US, A, 5,864,579	26 JANUARY 1999	25 JULY 1996	NONE
US, A, 5,953,311	14 SEPTEMBER 1999	18 FEBRUARY 1997	NONE

2. Non-written disclosures (Rule 70.9)

Kind of non-written disclosure	Date of non-written disclosure *(day/month/year)*	Date of written disclosure referring to non-written disclosure *(day/month/year)*

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To: JOHN E. HOLMES
ROYLANCE, ABRAMS, BERDO & GOODMAN, LLP
1225 CONNECTICUT AVE., NW
SUITE 315
WASHINGTON, DC 20036

Doc'd KXD File 36010
Rec'd
AUG 14 2000
ROYLANCE, ABRAMS
BERDO & GOODMAN, L.L.P.
BY

PCT

NOTIFICATION OF TRANSMITTAL OF INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Rule 71.1)

Date of Mailing *(day/month/year)*	10 AUG 2000	
Applicant's or agent's file reference: 36010	IMPORTANT NOTIFICATION	
International application No.: PCT/US98/14280	International filing date *(day/month/year)*: 10 JULY 1998	Priority Date *(day/month/year)*: 27 MARCH 1998
Applicant: WORLDSPACE MANAGEMENT CORPORATION		

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices)(Article 39(1))(see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer MIN JUNG *Eugenia Logan*
Facsimile No. (703) 305-3230	Telephone No. (703) 305-4363

Form PCT/IPEA/416 (July 1992)★

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 36010	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/US98/14280	International filing date *(day/month/year)* 10 JULY 1998	Priority date *(day/month/year)* 27 MARCH 1998

International Patent Classification (IPC) or national classification and IPC
IPC(7): H04H 1/00; H04B 7/155 and US Cl.: 370/315; 375/347; 455/17, 500, 504

Applicant
WORLDSPACE MANAGEMENT CORPORATION

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets.

   [✓] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority. (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 9 sheets.

3. This report contains indications relating to the following items:

   - I [X] Basis of the report
   - II [ ] Priority
   - III [ ] Non-establishment of report with regard to novelty, inventive step or industrial applicability
   - IV [ ] Lack of unity of invention
   - V [X] Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI [X] Certain documents cited
   - VII [ ] Certain defects in the international application
   - VIII [ ] Certain observations on the international application

Date of submission of the demand 26 OCTOBER 1999	Date of completion of this report 18 APRIL 2000
Name and mailing address of the IPEA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer MIN JUNG *Eugenia Logan* Telephone No. (703) 305-4363

Form PCT/IPEA/409 (cover sheet) (July 1998) ★

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US98/14280

I. Basis of the report

1. With regard to the **elements** of the international application:*

☐ the international application as originally filed

☒ the description:
pages (See Attached), as originally filed
pages ____, filed with the demand
pages ____, filed with the letter of ____

☒ the claims:
pages (See Attached), as originally filed
pages ____, as amended (together with any statement) under Article 19
pages ____, filed with the demand
pages ____, filed with the letter of ____

☒ the drawings:
pages (See Attached), as originally filed
pages ____, filed with the demand
pages ____, filed with the letter of ____

☒ the sequence listing part of the description:
pages (See Attached), as originally filed
pages ____, filed with the demand
pages ____, filed with the letter of ____

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language ____ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in printed form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the writen sequence listing has been furnished.

4. ☒ The amendments have resulted in the cancellation of:

☒ the description, pages none

☒ the claims, Nos. NONE

☒ the drawings, sheets/~~fig~~ none

5. ☒ This report has been drawn as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

** Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

***Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.*

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. **statement**

Novelty (N)	Claims	1-41	YES
	Claims	none	NO
Inventive Step (IS)	Claims	1-41	YES
	Claims	none	NO
Industrial Applicability (IA)	Claims	1-41	YES
	Claims	none	NO

2. **citations and explanations (Rule 70.7)**

Claims 1-41 meet the criteria set out in PCT Article 33(2)-(4), because the prior art does not teach or fairly suggest a digital broadcasting system for transmitting a broadcast program to radio receivers, the broadcast program being generated at an earth station, comprising a satellite for receiving said broadcast program from said earth station and transmitting at least one satellite signal comprising at least a portion of said broadcast program to said radio receivers on a first carrier frequency; and at least one terrestrial repeater for receiving said satellite signal comprising said at least a portion of said broadcast program on a second carrier frequency and modulated in accordance with a multipath-tolerant modulation technique.

------------------- NEW CITATIONS -------------------

US 5,726,980 A (RICKARD) 10 March 1998, see Abstract.

US 5,636,246 A (TZANNES) 03 June 1997, see entire document.

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/US98/14280

VI. Certain documents cited

1. Certain published documents (Rule 70.10)

Application No. Patent No.	Publication Date *(day/month/year)*	Filing Date *(day/month/year)*	Priority date (valid claim) *(day/month/year)*
US, A, 5,864,579	26 JANUARY 1999	25 JULY 1996	NONE
US, A, 5,953,311	14 SEPTEMBER 1999	18 FEBRUARY 1997	NONE

2. Non-written disclosures (Rule 70.9)

Kind of non-written disclosure	Date of non-written disclosure *(day/month/year)*	Date of written disclosure referring to non-written disclosure *(day/month/year)*

Form PCT/IPEA/409 (Box VI) (July 1998)★

Supplemental Box
(To be used when the space in any of the preceding boxes is not sufficient)

Continuation of: Boxes I - VIII

Sheet 10

I. BASIS OF REPORT:

This report has been drawn on the basis of the description,
page(s) 1-25, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
NONE

This report has been drawn on the basis of the claims,
page(s) none, as originally filed.
page(s) NONE, as amended under Article 19.
page(s) NONE, filed with the demand.
and additional amendments:
Pages 26-34, filed with the letter dated March 24, 2000.

This report has been drawn on the basis of the drawings,
page(s) 1-10, as originally filed.
page(s) NONE, filed with the demand.
and additional amendments:
NONE

This report has been drawn on the basis of the sequence listing part of the description:
page(s) NONE, as originally filed.
pages(s) NONE, filed with the demand.
and additional amendments:
NONE

5. (Some) amendments are considered to go beyond the disclosure as filed:
NONE

What is Claimed Is:

1. A digital broadcasting system for transmitting a broadcast signal, said broadcast signal being transmitted from an earth station, comprising:

a satellite for receiving said broadcast signal from said earth station and for transmitting a satellite signal comprising said broadcast signal on a first carrier frequency; and

a terrestrial repeater for receiving said satellite signal and for generating and transmitting a terrestrial signal from said satellite signal comprising said broadcast signal on a second carrier frequency that is different from said first carrier frequency, said terrestrial signal being modulated by said terrestrial repeater in accordance with a multipath-tolerant modulation technique.

2. A system as claimed in claim 1, wherein said terrestrial repeater is operable to modulate said terrestrial signal using at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptively equalized time division multiplexing, multicarrier modulation, and code division multiplexing.

3. A system as claimed in claim 1, wherein said satellite signal is modulated in accordance with at least one of time division multiplexing and code division multiplexing.

4. A system as claimed in claim 1, wherein said terrestrial repeater is operable to modulate said terrestrial signal using multicarrier modulation.

5. A system as claimed in claim 4, wherein said terrestrial repeater is operable to receive said satellite signal and to demodulate said satellite signal into a baseband signal prior to modulating said baseband signal using multicarrier modulation.

6. A system as claimed in claim 1, wherein said satellite signal is assigned a first code division multiple access channel code and said terrestrial signal is assigned a second code division multiple access channel code.

7. A system as claimed in claim 1, further comprising a second satellite, said second satellite being operable to receive said broadcast signal from said earth station and to

transmit a second satellite signal comprising said broadcast signal on said first carrier frequency and delayed by a predetermined period of time with respect to the transmission of the first satellite signal.

8. A terrestrial repeater for retransmitting satellite signals to radio receivers, comprising:

a terrestrial receiver for receiving said satellite signals; and

a terrestrial waveform modulator for generating terrestrial signals from said satellite signals, said terrestrial signals being modulated by said terrestrial waveform modulator in accordance with multicarrier modulation;

wherein said satellite signals are transmitted from a satellite using a first carrier frequency, and said terrestrial waveform modulator is operable to transmit said terrestrial signals to said radio receivers using a second carrier frequency that is different from said first carrier frequency.

9. A terrestrial repeater as claimed in claim 8, wherein said terrestrial waveform modulator comprises:

a time division demultiplexer for demultiplexing said satellite signals from a serial time division multiplexed bit stream into a plurality of parallel bit streams; and

an inverse fast Fourier transform device for generating a digital analog signal comprising a plurality of discrete Fourier transform coefficients.

10. A method for converting a time division multiplexed bit stream into a plurality of multicarrier modulated signals at a terrestrial repeater, comprising the steps of:

receiving said time division multiplexed bit stream from a satellite;

dividing said time division multiplexed bit stream into a plurality of parallel bit paths;

representing each of a predetermined number of bits in each of said plurality of bit paths as a symbol comprising an imaginary component and a real component;

providing said symbols to parallel inputs of an inverse Fourier transform converter as complex number frequency coefficient inputs to generate outputs which comprise modulated, narrow-band, orthogonal carriers; and

transmitting said modulated, narrow-band, orthogonal carriers from said terrestrial repeater.

11. A method as claimed in claim 10, further comprising the step of generating a guard interval for said carriers.

12. A method as claimed in claim 11, wherein said generating step comprises the steps of:

allocating a fraction of the symbol period corresponding to the duration of each of said symbols to guard time; and

reducing the duration of each of said symbols.

13. A method as claimed in claim 12, wherein said reducing step comprises the steps of:

storing said outputs of said inverse Fourier transform converter in a memory device every said symbol period; and

reading from said memory device after each said fraction of said symbol period has elapsed.

14. A method as claimed in claim 11, wherein said generating step further comprises the step of filling said guard interval with a subset of said outputs of said inverse Fourier transform.

15. A method as claimed in claim 10, further comprising the step of inserting a synchronization symbol every predetermined number of said symbol periods to synchronize a sampling window corresponding to said fraction of said symbol period with respect to said carriers every said symbol period at a receiver for said plurality of multicarrier modulated signals.

16. A method as claimed in claim 10, further comprising the step of puncturing said time division multiplexed bit stream to reduce the total bandwidth associated with said carriers.

17. A method as claimed in claim 16, wherein said puncturing step comprises the step of selectively eliminating bits from said time division multiplexed bit stream prior to providing said symbols to said parallel inputs of said inverse Fourier transform converter.

AMENDED SHEET

18. A digital broadcasting system for transmitting a broadcast signal, said broadcast signal being transmitted from an earth station, comprising:

a first satellite configured to receive said broadcast signal from said earth station and to transmit a time division multiplexed satellite signal comprising said broadcast signal;

a terrestrial repeater configured to receive said satellite signal and to generate and transmit a terrestrial signal from said satellite signal comprising said broadcast signal, said terrestrial signal being modulated by said terrestrial repeater in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing, and multicarrier modulation.

19. A digital broadcasting system as claimed in claim 18, wherein said satellite signal is transmitted using a first carrier frequency, and said terrestrial signal is transmitted using a second carrier frequency that is different from said first carrier frequency.

20. A digital broadcasting system as claimed in claim 18, further comprising at least one radio receiver configured to receive said satellite signal and said terrestrial signal, said radio receiver comprising a diversity combiner for generating an output signal from at least one of said satellite signal and said terrestrial signal.

21. A digital broadcasting system as claimed in claim 18, further comprising a second satellite configured to receive said broadcast signal from said earth station and to transmit a second time division multiplexed satellite signal comprising said broadcast signal, said second satellite signal being delayed with respect to said first satellite signal by a selected time delay.

22. A digital broadcasting system as claimed in claim 21, further comprising at least one radio receiver configured to receive said first satellite signal, said second satellite signal and said terrestrial signal, to delay at least one of said first satellite signal and said terrestrial signal in accordance with said selected time delay, and to generate an output signal from at least one of first satellite signal, said second satellite signal and said terrestrial signal.

23. A digital broadcasting system as claimed in claim 22, wherein said radio receiver comprises a diversity combiner and a switched combiner, said radio receiver using said diversity combiner to perform maximum likelihood decision combining of said first satellite

signal and said second satellite signal and said switched combiner to select between the output of said diversity combiner and said terrestrial signal depending on which of said output of said diversity combiner and said terrestrial signal has the least number of bit errors.

24. A digital broadcasting system as claimed in claim 22, wherein said radio receiver comprises a diversity combiner to perform maximum likelihood decision combining of said first satellite signal, said second satellite signals and said terrestrial signal.

25. A receiver for receiving a broadcast signal in a combined satellite and terrestrial digital broadcasting system, comprising:

a first receiver arm for receiving a first satellite signal transmitted from a first satellite on a first carrier frequency, said first satellite signal comprising said broadcast signal and being modulated in accordance with at least one of time division multiplexing and code division multiplexing, said first receiver arm comprising a demodulator for recovering said broadcast signal;

a second receiver arm for receiving a terrestrial signal transmitted from a terrestrial station on a second carrier frequency, said terrestrial signal comprising said broadcast signal and being modulated in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing, and multicarrier modulation, said second receiver arm comprising a demodulator for recovering said broadcast signal; and

a combiner for generating an output signal from at least one of said third satellite signal and said terrestrial signal.

26. A receiver as claimed in claim 25, further comprising:

a third receiver arm for receiving a second satellite signal from a second satellite that is delayed with respect to said first satellite signal in accordance with a selected time delay, said second satellite signal comprising said broadcast signal and being modulated in accordance with the corresponding at least one of time division multiplexing and code division multiplexing employed by said first satellite signal, said third receiver arm comprising a demodulator for recovering said broadcast signal; and a delay device for delaying said first satellite signal in accordance with said selected time delay, said combiner being operable to generate an output signal from at least one of said first satellite signal, said second satellite signal and said terrestrial signal.

27. A method for transmitting a broadcast signal to a radio receiver, comprising the steps of:

modulating said broadcast signal for transmission to said radio receiver as a first signal in accordance with at least one of time division multiplexing and code division multiplexing;

transmitting said first signal to said radio receiver from a first satellite on a first carrier frequency;

modulating said broadcast signal at a terrestrial station for transmission to said radio receiver as a second signal in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing, and multicarrier modulation; and

transmitting said second signal to said radio receiver from said terrestrial station on a second carrier frequency that is different from said first carrier frequency.

28. A method as claimed in claim 27, wherein the step of modulating said broadcast signal as said second signal comprises the steps of:

receiving said first signal at said terrestrial station; and

performing baseband processing of said first signal prior to modulating in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing, and multicarrier modulation.

29. A method as claimed in claim 28, further comprising the step of receiving said first signal and said second signal at said radio receiver.

30. A method as claimed in claim 29, further comprising the step of demodulating each of said received first signal and said received second signal to remove said respective modulations and to recover a first recovered broadcast signal and a second recovered broadcast signal, respectively.

AMENDED SHEET

31. A method as claimed in claim 30, further comprising the step of generating an output broadcast signal from said first recovered broadcast signal and said second recovered broadcast signal.

32. A method as claimed in claim 31, wherein said generating step comprises the step of performing maximum likelihood combining of said first recovered broadcast signal and said second recovered broadcast signal.

33. A method as claimed in claim 27, further comprising the steps of:

modulating a broadcast signal for transmission to said radio receiver as a third signal in accordance with at least one of time division multiplexing and code division multiplexing;

transmitting said third signal to said radio receiver from a second satellite, said transmission being delayed with respect to the transmission of said first signal by a predetermined period of time.

34. A method as claimed in claim 33, further comprising the steps of:

receiving said first signal, said second signal and said third signal at said radio receiver;

demodulating each of said first signal, said second signal and said third signal to remove said respective modulations and to recover a first recovered broadcast signal, a second recovered broadcast signal and a third recovered broadcast signal, respectively; and

generating an output broadcast signal from at least one of said first recovered broadcast signal, said second recovered broadcast signal and said third recovered broadcast signal.

35. An indoor reinforcement system for receiving satellite signals transmitted by a digital broadcasting system using a radio receiver located indoors, comprising:

a line of sight antenna for receiving line of sight satellite signals;

a radio frequency front-end unit connected to said line of sight antenna for passing frequency spectrum comprising said satellite signals with low noise;

an indoor amplifier;

a cable for connecting said radio frequency front-end unit to said indoor amplifier; and

an indoor re-radiating antenna connected to said indoor amplifier, said indoor re-radiating antenna having a power level selected to be sufficiently high to achieve satisfactory indoor reception of said satellite signals at radio receivers at indoor locations where line of sight reception of said satellite signals is not possible and sufficiently low to prevent interference by said satellite signals transmitted between said indoor re-radiating antenna and said line of sight antenna.

36. An indoor reinforcement system as claimed in claim 35, wherein said satellite signals are characterized by a selected symbol period, and the duration of the transmission of said satellite signals between said line of sight antenna and said indoor re-radiating antenna is maintained to be less than a selected amount of said symbol duration by limiting the length of said cable.

37. An indoor reinforcement system as claimed in claim 36, wherein said duration of the transmission of said satellite signals between said line of sight antenna and said indoor re-radiating antenna is no more than between 20 percent and 25 percent of said selected symbol period.

38. A reinforcement system for receiving satellite signals transmitted by a digital broadcasting system using a radio receiver located outdoors, wherein said satellite signals are characterized by a selected period, said reinforcement system comprising at least two terrestrial repeaters, said terrestrial repeaters being characterized by a height h and being spaced apart by a distance d, the slant distance $(d^2 + h^2)^{1/2}$ from one of said terrestrial repeaters to said radio receiver being selected to limit a delay in reception of said satellite signals at said radio receiver from one of said terrestrial repeaters to between 20 percent and 25 percent of said symbol period.

39. A digital broadcasting system for transmitting a broadcast signal to a radio receiver, said broadcast signal being transmitted by an earth station, comprising:

a satellite configured to receive said broadcast signal from said earth station and to transmit a satellite signal comprising said broadcast signal to said radio receiver on a first carrier frequency; and

at least one terrestrial repeater configured to receive said satellite signal and to generate and transmit a terrestrial signal from said satellite signal comprising said broadcast signal to said radio receiver on a second carrier frequency that is different from said first carrier frequency, wherein said satellite signal and said terrestrial signal are each modulated using a multipath-tolerant modulation technique.

40. A system as claimed in claim 39, wherein said satellite signal is modulated in accordance with code division multiplexing.

41. A system as claimed in claim 39, wherein said terrestrial signal is modulated in accordance with at least one of adaptive equalized time division multiplexing, coherent frequency hopping adaptive equalized time division multiplexing, code division multiplexing, and multicarrier modulation.