

To:	Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
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In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Southern District of California on the following: X Patents or Trademarks:

DOCKET NO.	DATE FILED	US District Court Southern District of California
3:16-cv-00118-H-KSC	1/19/16	San Diego, CA
PLAINTIFF		DEFENDANT
Carucel Investments, L.P.		Novatel Wireless Inc. et al
PATENT OR TRADEMARK NO.	PATENT OR TRADEMARK NO.	PATENT OR TRADEMARK NO.
1. 7,221,904	6.	11.
2. 7,848,701	7.	12.
3. 7,979,023	8.	13.
4. 8,463,177	9.	14.
5. 8,718,543	10.	15.

In the above-entitled case, the following patents(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY	
	<input type="checkbox"/> Amendment <input type="checkbox"/> Answer <input type="checkbox"/> Cross Bill <input type="checkbox"/> Other Pleading	
PATENT OR TRADEMARK NO.	PATENT OR TRADEMARK NO.	PATENT OR TRADEMARK NO.
1.	6.	11.
2.	7.	12.
3.	8.	13.
4.	9.	14.
5.	10.	15.

In the above-entitled case, the following decision has been rendered or judgment issued:

DECISION/JUDGMENT
Judgment - Pursuant to jury verdict, Court enters judgment in favor of Defendants and against Plaintiff.

CLERK	(BY) DEPUTY CLERK	DATE
John Morrill	s/ J. Diaz	4/28/2017

To:	Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
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In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Southern District of California on the following: X Patents or Trademarks:

DOCKET NO.	DATE FILED	US District Court Southern District of California
3:16-cv-00118-LAB-BLM	1/19/16	San Diego, CA
PLAINTIFF		DEFENDANT
Carucel Investments, L.P.		Novatel Wireless Inc. et al.
PATENT OR TRADEMARK NO.	PATENT OR TRADEMARK NO.	PATENT OR TRADEMARK NO.
1. 7,221,904	6.	11.
2. 7,848,701	7.	12.
3. 7,979,023	8.	13.
4. 8,463,177	9.	14.
5. 8,718,543	10.	15.

In the above-entitled case, the following patents(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY	
	Amendment <u> </u> Answer <u> </u> Cross Bill <u> </u> Other Pleading <u> </u>	
PATENT OR TRADEMARK NO.	PATENT OR TRADEMARK NO.	PATENT OR TRADEMARK NO.
1.	6.	11.
2.	7.	12.
3.	8.	13.
4.	9.	14.
5.	10.	15.

In the above-entitled case, the following decision has been rendered or judgment issued:

DECISION/JUDGMENT

CLERK	(BY) DEPUTY CLERK	DATE
John Morrill		

AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
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In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Southern District of Florida (Fort Lauderdale) on the following

☐ Trademarks or ☒ Patents. (☐ the patent action involves 35 U.S.C. § 292.);

DOCKET NO. 15-cv-61116-BB	DATE FILED 5/27/2015	U.S. DISTRICT COURT Southern District of Florida (Fort Lauderdale)
PLAINTIFF Carucel Investments, L.P.		DEFENDANT Novatel Wireless, Inc. AT&T Mobility LLC Verizon Communications, Inc. et al
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 7,221,904	5/22/2007	
2 7,848,701	12/7/2010	
3 7,979,023	7/12/2011	
4 8,463,177	6/11/2013	
5 8,718,543	5/6/2014	

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY <input type="checkbox"/> Amendment <input type="checkbox"/> Answer <input type="checkbox"/> Cross Bill <input type="checkbox"/> Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 8,849,191	9/30/2014	
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT	Case transferred to the Southern District of California
--------------------	---

CLERK Steven M. Larimore	(BY) DEPUTY CLERK S. Reid	DATE 5/27/2015
-----------------------------	------------------------------	-------------------

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
 Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

Print

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Reset

AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
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In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Southern District of Florida (Fort Lauderdale) on the following

☐ Trademarks or ☒ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO. 15-cv-61116-BB	DATE FILED 5/27/2015	U.S. DISTRICT COURT Southern District of Florida (Fort Lauderdale)
PLAINTIFF Carucel Investments, L.P.		DEFENDANT Novatel Wireless, Inc. AT&T Mobility LLC Verizon Communications, Inc. et al
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 7,221,904	5/22/2007	
2 7,848,701	12/7/2010	
3 7,979,023	7/12/2011	
4 8,463,177	6/11/2013	
5 8,718,543	5/6/2014	

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY <input type="checkbox"/> Amendment <input type="checkbox"/> Answer <input type="checkbox"/> Cross Bill <input type="checkbox"/> Other Pleading		
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK	
1 8,849,191	9/30/2014		
2			
3			
4			
5			

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK Steven M. Larimore	(BY) DEPUTY CLERK S. Reid	DATE
-----------------------------	------------------------------	------

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
 Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

Print

Save As...

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AO 120 (Rev. 08/10)

TO: Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
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In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been
 filed in the U.S. District Court Southern District of Florida on the following

☐ Trademarks or ☒ Patents. (☐ the patent action involves 35 U.S.C. § 292.);

DOCKET NO. 14-cv-60363-RSR	DATE FILED 2/13/2014	U.S. DISTRICT COURT Southern District of Florida
PLAINTIFF Carucel Investments, L.P.		DEFENDANT Gogo, Inc. et al
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 7,221,904 B1	5/22/2007	
2 7,848,701 B2	12/7/2010	
3 7,979,023 B2	7/12/2011	
4 8,463,177 B2	6/11/2013	
5		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY <input type="checkbox"/> Amendment <input type="checkbox"/> Answer <input type="checkbox"/> Cross Bill <input type="checkbox"/> Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK Steven M. Larimore	(BY) DEPUTY CLERK Valerie Kemp	DATE 2/14/2014
-----------------------------	-----------------------------------	-------------------

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
 Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/733,069	12/07/2010	7848701	CAR100C3	7533

35083 7590 11/17/2010

CHARLES D. GAVRILOVICH, JR.,
GAVRILOVICH, DODD & LINDSEY, LLP
985 PASEO LA CRESTA, SUITE B
CHULA VISTA, CA 91910-6729

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (application filed on or after May 29, 2000)

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

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

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

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site <http://pair.uspto.gov> for additional applicants):

Charles D. Gavrilovich, Naperville, IL;



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/733,069	04/09/2007	Charles D. Gavrilovich	CAR100C3	7533
35083 7590 10/28/2010 CHARLES D. GAVRILOVICH, JR., GAVRILOVICH, DODD & LINDSEY, LLP 985 PASEO LA CRESTA, SUITE B CHULA VISTA, CA 91910-6729			EXAMINER TRAN, TUAN A	
			ART UNIT	PAPER NUMBER
			2618	
			MAIL DATE	DELIVERY MODE
			10/28/2010	PAPER

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

The time period for reply, if any, is set in the attached communication.

Supplemental Notice of Allowability	Application No.	Applicant(s)	
	11/733,069	GAVRILOVICH, CHARLES D.	
	Examiner	Art Unit	
	TUAN A. TRAN	2618	

-- 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 06/27/2010.
2. ☒ The allowed claim(s) is/are 1-6, 8-16 and 18-44 renumbered 1-42.
3. ☐ 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.

4. ☐ 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.
5. ☐ 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).
6. ☐ 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. <input type="checkbox"/> Notice of References Cited (PTO-892) | 5. <input type="checkbox"/> Notice of Informal Patent Application |
| 2. <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 6. <input type="checkbox"/> Interview Summary (PTO-413),
Paper No./Mail Date _____. |
| 3. <input type="checkbox"/> Information Disclosure Statements (PTO/SB/08),
Paper No./Mail Date _____ | 7. <input checked="" type="checkbox"/> Examiner's Amendment/Comment |
| 4. <input type="checkbox"/> Examiner's Comment Regarding Requirement for Deposit
of Biological Material | 8. <input type="checkbox"/> Examiner's Statement of Reasons for Allowance |
| | 9. <input type="checkbox"/> Other _____. |

/Tuan A Tran/
Primary Examiner, Art Unit 2618

DETAILED ACTION

EXAMINER'S AMENDMENT

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.

The application has been amended as follows:

IN THE SPECIFICATION:

Page 1, first paragraph: the phrase "which is a National Phase Application" has been changed to "which is a continuation"

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to TUAN A. TRAN whose telephone number is (571)272-7858. The examiner can normally be reached on Mon-Fri, 10:00AM-6:30PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Matthew Anderson can be reached on (571) 272-4177. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Art Unit: 2618

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). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Tuan A Tran/
Primary Examiner, Art Unit 2618

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** (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as 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" for maintenance fee notifications.

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

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

35083 7590 09/17/2010

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

Charles D. Gavrilovich, Jr. (Depositor's name)
Charles D. Gavrilovich, Jr. (Signature)
September 20, 2010 (Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/733,069	04/09/2007	Charles D. Gavrilovich	CAR100C3	7533

TITLE OF INVENTION: MOBILE COMMUNICATION SYSTEM WITH MOVING BASE STATION

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	\$755	\$300	\$0	\$1055	12/17/2010

EXAMINER	ART UNIT	CLASS-SUBCLASS
TRAN, TUAN A	2618	455-011100

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 Gavrilovich, Dodd & Lindsey, LLP

2 Charles D. Gavrilovich, Jr.

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 for 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

Carucel Investments L.P.

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Park Ridge, IL

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

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

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

4b. Payment of Fee(s): (Please first reapply any previously paid issue fee shown above)

☐ A check is enclosed.
☒ Payment by credit card. Form PTO-2038 is attached.
☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number (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).

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 party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature

Charles D. Gavrilovich, Jr.

Date

September 20, 2010

Typed or printed name

Charles D. Gavrilovich, Jr.

Registration No. 41,031

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 process) 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, and 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 complete 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.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450 Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Electronic Patent Application Fee Transmittal				
Application Number:		11733069		
Filing Date:		09-Apr-2007		
Title of Invention:		MOBILE COMMUNICATION SYSTEM WITH MOVING BASE STATION		
First Named Inventor/Applicant Name:		Charles D. Gavrilovich		
Filer:		Charles Dan Gavrilovich		
Attorney Docket Number:		CAR100C3		
Filed as Small Entity				
Utility under 35 USC 111(a) Filing Fees				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl issue fee	2501	1	755	755
Publ. Fee- early, voluntary, or normal	1504	1	300	300

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				1055

Electronic Acknowledgement Receipt

EFS ID:	8458713
Application Number:	11733069
International Application Number:	
Confirmation Number:	7533
Title of Invention:	MOBILE COMMUNICATION SYSTEM WITH MOVING BASE STATION
First Named Inventor/Applicant Name:	Charles D. Gavrilovich
Customer Number:	35083
Filer:	Charles Dan Gavrilovich
Filer Authorized By:	
Attorney Docket Number:	CAR100C3
Receipt Date:	20-SEP-2010
Filing Date:	09-APR-2007
Time Stamp:	22:24:15
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	\$1055
RAM confirmation Number	6801
Deposit Account	
Authorized User	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
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1	Issue Fee Payment (PTO-85B)	PartBsigned.pdf	1496541 a8c14d4512b5938268f693405393cbad1f1ac318	no	1
Warnings:					
Information:					
2	Fee Worksheet (PTO-875)	fee-info.pdf	31803 cc11629e56181f5d39c72d3366bb9db02dfe3b8f	no	2
Warnings:					
Information:					
Total Files Size (in bytes):			1528344		
<p>This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.</p> <p><u>New Applications Under 35 U.S.C. 111</u> If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.</p> <p><u>National Stage of an International Application under 35 U.S.C. 371</u> If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.</p> <p><u>New International Application Filed with the USPTO as a Receiving Office</u> If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.</p>					



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

35083 7590 09/17/2010

CHARLES D. GAVRILOVICH, JR.,
GAVRILOVICH, DODD & LINDSEY, LLP
985 PASEO LA CRESTA, SUITE B
CHULA VISTA, CA 91910-6729

EXAMINER

TRAN, TUAN A

ART UNIT

PAPER NUMBER

2618

DATE MAILED: 09/17/2010

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/733,069	04/09/2007	Charles D. Gavrilovich	CAR100C3	7533
TITLE OF INVENTION: MOBILE COMMUNICATION SYSTEM WITH MOVING BASE STATION				

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	\$755	\$300	\$0	\$1055	12/17/2010

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. **PROSECUTION ON THE MERITS IS CLOSED.** THIS NOTICE OF ALLOWANCE 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.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. **THIS STATUTORY PERIOD CANNOT BE EXTENDED.** SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

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 now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to 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 of 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
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as 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" for maintenance fee notifications.

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

35083 7590 09/17/2010

CHARLES D. GAVRILOVICH, JR.,
 GAVRILOVICH, DODD & LINDSEY, LLP
 985 PASEO LA CRESTA, SUITE B
 CHULA VISTA, CA 91910-6729

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/733,069	04/09/2007	Charles D. Gavrilovich	CAR100C3	7533
TITLE OF INVENTION: MOBILE COMMUNICATION SYSTEM WITH MOVING BASE STATION				

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	YES	\$755	\$300	\$0	\$1055	12/17/2010
EXAMINER	ART UNIT	CLASS-SUBCLASS				
TRAN, TUAN A	2618	455-011100				

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 _____

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 for 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

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

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

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

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

4b. Payment of Fee(s): (Please first reapply any previously paid issue fee shown above)

- ☐ A check is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number _____ (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).

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 party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature _____

Date _____

Typed or printed name _____

Registration No. _____

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 process) 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, and 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 complete 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.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/733,069	04/09/2007	Charles D. Gavrilovich	CAR100C3	7533
35083	7590	09/17/2010	EXAMINER	
CHARLES D. GAVRILOVICH, JR., GAVRILOVICH, DODD & LINDSEY, LLP 985 PASEO LA CRESTA, SUITE B CHULA VISTA, CA 91910-6729			TRAN, TUAN A	
			ART UNIT	PAPER NUMBER
			2618	

DATE MAILED: 09/17/2010

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)

(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

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

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

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

Notice of Allowability	Application No.	Applicant(s)	
	11/733,069	GAVRILOVICH, CHARLES D.	
	Examiner	Art Unit	
	TUAN A. TRAN	2618	

-- 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 06/27/2010.
2. ☒ The allowed claim(s) is/are 1-6, 8-16 and 18-44 renumbered 1-42.
3. ☐ 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.

4. ☐ 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.
5. ☐ 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).
6. ☐ 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. <input type="checkbox"/> Notice of References Cited (PTO-892) | 5. <input type="checkbox"/> Notice of Informal Patent Application |
| 2. <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 6. <input type="checkbox"/> Interview Summary (PTO-413),
Paper No./Mail Date _____. |
| 3. <input type="checkbox"/> Information Disclosure Statements (PTO/SB/08),
Paper No./Mail Date _____ | 7. <input checked="" type="checkbox"/> Examiner's Amendment/Comment |
| 4. <input type="checkbox"/> Examiner's Comment Regarding Requirement for Deposit
of Biological Material | 8. <input checked="" type="checkbox"/> Examiner's Statement of Reasons for Allowance |
| | 9. <input type="checkbox"/> Other _____. |

/Tuan A Tran/
Primary Examiner, Art Unit 2618

DETAILED ACTION

EXAMINER'S AMENDMENT

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.

The application has been amended as follows:

IN THE SPECIFICATION:

Page 1, first paragraph: please fill U.S. Pat. No. **7,221,904** into the blank.

Allowable Subject Matter

1. Claims 1-6, 8-16 and 18-44 are allowed.

The following is an examiner's statement of reasons for allowance:

The applicant's response (See Appeal Brief, Argument section, page 15) clearly states the inventive steps of the instant application.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion


Any inquiry concerning this communication or earlier communications from the examiner should be directed to TUAN A. TRAN whose telephone number is (571)272-7858. The examiner can normally be reached on Mon-Fri, 10:00AM-6:30PM.

Art Unit: 2618

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Matthew Anderson can be reached on (571) 272-4177. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Tuan A Tran/
Primary Examiner, Art Unit 2618


Search Notes 	Application/Control No. 11733069	Applicant(s)/Patent Under Reexamination GAVRILOVICH, CHARLES D.
	Examiner TUAN A. TRAN	Art Unit 2618

SEARCHED			
Class	Subclass	Date	Examiner
455	11.1, 13.1, 25, 561, 562.1, 91, 101	9/7/10	TT
375	346, 347, 295, 299	9/7/10	TT

SEARCH NOTES		
Search Notes	Date	Examiner
EAST (USPAT, USPGPUB, USOCR, FPRS, JPO, EPO, DERWENT) updating search	9/7/10	TT

INTERFERENCE SEARCH			
Class	Subclass	Date	Examiner
	Interference text search	9/7/10	TT


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Issue Classification 	Application/Control No. 11733069	Applicant(s)/Patent Under Reexamination GAVRILOVICH, CHARLES D.
	Examiner TUAN A TRAN	Art Unit 2618

ORIGINAL						INTERNATIONAL CLASSIFICATION												
CLASS		SUBCLASS				CLAIMED					NON-CLAIMED							
455		11.1				H	0	4	B	7 / 15 (2006.01.01)								
CROSS REFERENCE(S)																		
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)																	
455	13.1	25	561	562.1	101													
375	295	299	347															

<input type="checkbox"/> Claims renumbered in the same order as presented by applicant <input type="checkbox"/> CPA <input type="checkbox"/> T.D. <input type="checkbox"/> R.1.47															
Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1		17	31	33										
2	2	16	18	32	34										
3	3	17	19	33	35										
4	4	18	20	34	36										
5	5	19	21	35	37										
6	6	20	22	36	38										
	7	21	23	37	39										
7	8	22	24	38	40										
8	9	23	25	39	41										
9	10	24	26	40	42										
10	11	25	27	41	43										
11	12	26	28	42	44										
12	13	27	29												
13	14	28	30												
14	15	29	31												
15	16	30	32												


NONE		Total Claims Allowed:	
		42	
(Assistant Examiner)	(Date)		
/TUAN A TRAN/ Primary Examiner.Art Unit 2618	09/13/2010	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

Index of Claims 	Application/Control No. 11733069	Applicant(s)/Patent Under Reexamination GAVRILOVICH, CHARLES D.
	Examiner TUAN A. TRAN	Art Unit 2618

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	+	Restricted	I	Interference	O	Objected

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

CLAIM		DATE									
Final	Original	08/18/2008	12/08/2008	02/27/2009	10/26/2009	09/13/2010					
1	1	=	✓	✓	✓	=					
2	2	=	✓	✓	✓	=					
3	3	=	✓	✓	✓	=					
4	4	=	✓	✓	✓	=					
5	5	=	✓	✓	✓	=					
6	6	=	✓	✓	✓	=					
	7	=	-	-	-	-					
7	8	=	✓	✓	✓	=					
8	9	=	✓	✓	✓	=					
9	10	=	✓	✓	✓	=					
10	11	=	✓	✓	✓	=					
11	12	=	✓	✓	✓	=					
12	13	=	✓	✓	✓	=					
13	14	=	✓	✓	✓	=					
14	15	=	✓	✓	✓	=					
15	16	=	✓	✓	✓	=					
	17	=	-	-	-	-					
16	18	=	✓	✓	✓	=					
17	19	=	✓	✓	✓	=					
18	20	=	✓	✓	✓	=					
19	21	=	✓	✓	✓	=					
20	22	=	✓	✓	✓	=					
21	23	=	✓	✓	✓	=					
22	24	=	✓	✓	✓	=					
23	25	=	✓	✓	✓	=					
24	26	=	✓	✓	✓	=					
25	27	✓	✓	✓	✓	=					
26	28	✓	✓	✓	✓	=					
27	29	✓	✓	✓	✓	=					
28	30	✓	✓	✓	✓	=					
29	31	✓	✓	✓	✓	=					
30	32	✓	✓	✓	✓	=					
31	33	=	✓	✓	✓	=					
32	34	=	✓	✓	✓	=					
33	35	=	✓	✓	✓	=					
34	36	=	✓	✓	✓	=					

<i>Index of Claims</i> 	Application/Control No. 11733069	Applicant(s)/Patent Under Reexamination GAVRILOVICH, CHARLES D.
	Examiner TUAN A. TRAN	Art Unit 2618

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	+	Restricted	I	Interference	O	Objected

<input type="checkbox"/> Claims renumbered in the same order as presented by applicant		<input type="checkbox"/> CPA		<input type="checkbox"/> T.D.		<input type="checkbox"/> R.1.47			
CLAIM		DATE							
Final	Original	08/18/2008	12/08/2008	02/27/2009	10/26/2009	09/13/2010			
35	37	=	✓	✓	✓	=			
36	38	✓	✓	✓	✓	=			
37	39	✓	✓	✓	✓	=			
38	40	✓	✓	✓	✓	=			
39	41	✓	✓	✓	✓	=			
40	42	✓	✓	✓	✓	=			
41	43	✓	✓	✓	✓	=			
42	44	✓	✓	✓	✓	=			

**PETITION TO MAKE SPECIAL BASED ON AGE FOR ADVANCEMENT OF EXAMINATION
UNDER 37 CFR 1.102(c)(1)**

Application Information

Application Number	11/733,069	Confirmation Number	7533	Filing Date	2007-04-09
Attorney Docket Number (optional)	CAR100C3	Art Unit	2618	Examiner	TRAN, Tuan A
First Named Inventor	Charles D. Gavrilovich				
Title of Invention	MOBILE COMMUNICATION SYSTEM WITH MOVING BASE STATION				

Attention: Office of Petitions

An application may be made special for advancement of examination upon filing of a petition showing that the applicant is 65 years of age, or more. No fee is required with such a petition. See 37 CFR 1.102(c)(1) and MPEP 708.02 (IV).

APPLICANT HEREBY PETITIONS TO MAKE SPECIAL FOR ADVANCEMENT OF EXAMINATION IN THIS APPLICATION UNDER 37 CFR 1.102(c)(1) and MPEP 708.02 (IV) ON THE BASIS OF THE APPLICANT'S AGE.

A grantable petition requires one of the following items:

- (1) Statement by one named inventor in the application that he/she is 65 years of age, or more; or
- (2) Certification by a registered attorney/agent having evidence such as a birth certificate, passport, driver's license, etc. showing one named inventor in the application is 65 years of age, or more.

Name of Inventor who is 65 years of age, or older

Given Name	Middle Name	Family Name	Suffix
Charles	Dan	Gavrilovich	

A signature of the applicant or representative is required in accordance with 37 CFR 1.33 and 10.18.
Please see 37 CFR 1.4(d) for the format of the signature.

Select (1) or (2) :

- ☐ (1) I am an inventor in this application and I am 65 years of age, or more.
- ☒ (2) I am an attorney or agent registered to practice before the Patent and Trademark Office, and I certify that I am in possession of evidence, and will retain such in the application file record, showing that the inventor listed above is 65 years of age, or more.

Signature	/Charles D. Gavrilovich, Jr./	Date (YYYY-MM-DD)	2010-06-27
Name	Charles D. Gavrilovich, Jr.	Registration Number	41031

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.



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

In re Application of
Charles D. Gavrilovich

:
:

Application No. 11733069

:DECISION ON PETITION TO MAKE SPECIAL
:UNDER 37 CFR 1.102(c)(1)
:

Filed: April 9, 2007

Attorney Docket No. CAR100C3

This is a decision on the electronic petition under 37 CFR 1.102 (c)(1), filed 27-JUN-2010 to make the above-identified application special based on applicant's age as set forth in MPEP § 708.02, Section IV.

The petition is **GRANTED**.

A grantable petition to make an application special under 37 CFR 1.102(c)(1), MPEP § 708.02, Section IV: Applicant's Age must include a statement by applicant or a registered practitioner having evidence that applicant is at least 65 years of age. No fee is required.

Accordingly, the above-identified application has been accorded "special" status and will be taken up for action by the examiner upon the completion of all pre-examination processing.

Telephone inquiries concerning this electronic decision should be directed to the Electronic Business Center at 866-217-9197.

All other inquiries concerning either the examination or status of the application should be directed to the Technology Center.

Electronic Acknowledgement Receipt

EFS ID:	7900298
Application Number:	11733069
International Application Number:	
Confirmation Number:	7533
Title of Invention:	Mobile Communication System With Moving Base Station
First Named Inventor/Applicant Name:	Charles D. Gavrilovich
Customer Number:	35083
Filer:	Charles Dan Gavrilovich
Filer Authorized By:	
Attorney Docket Number:	CAR100C3
Receipt Date:	27-JUN-2010
Filing Date:	09-APR-2007
Time Stamp:	14:49:38
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Petition automatically granted by EFS	petitionage2.pdf	751855	no	2
			091c75e31b3c5d0885367c432170379e187a c164b		

Warnings:

Information:

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s) : GAVRILOVICH, Charles D.	Group Art Unit: 2618
App. No.: 11/733,069	Examiner: TRAN, Tuan A
Filed: April 09, 2007	Conf.: 7533
Title: MOBILE COMMUNICATION SYSTEM WITH MOVING BASE STATION	

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Alexandria, VA 22313-1450

Sir:

APPELLANTS' APPEAL BRIEF UNDER 37 CFR §41.37

In accordance with the Notice of Appeal to the Board of Patent Appeals and Interferences dated February 27, 2010 in the above-identified U.S. Patent Application, Appellants hereby present the Appellants' Appeal Brief under 37 CFR §41.37. The APPELLANTS' APPEAL BRIEF is submitted with copies of each reference discussed and a copy of the Final Office Action as well as the appropriate fees required under 37 CFR §41.20(b)(2).

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REAL PARTY IN INTEREST

Carucel Investments Limited Partnership is the real party in interest as the assignee and 100 percent owner of the above-identified application.

RELATED APPEALS AND INTERFERENCES

Appellants are not aware of any prior or pending appeals, judicial proceedings, or interferences that may be related to, directly affect, or be directly affected by or have a bearing on the Board's decision in the pending appeal.

STATUS OF CLAIMS

Claims 1-6, 8-16, and 18-44 stand rejected. Claims 7 and 17 have been canceled. The claims on appeal include claims 1-6, 8-16, and 18-44.

STATUS OF AMENDMENTS

The Amendment submitted on September 01, 2008 has been entered. Appellants have not submitted any amendments since the September 01, 2008 response.

SUMMARY OF CLAIMED SUBJECT MATTER

In accordance with 37 CFR § 41.37(v), Appellants provide a brief summary of each independent claim involved in the appeal, where each summary refers to the specification by page and line number and to the drawings by reference number. Appellants note that this "Summary of claimed subject matter" is provided only to assist the Board in identifying some portions of the specification related to the particular claims. In the interest of brevity, each claim summary does not necessarily include all references to all relevant portions of the specification and drawings. Accordingly, omission of any reference to the specification or to the drawings should not be construed in any way as an intent to relinquish claim scope, or as an implication or statement regarding the conformance with 35 U.S.C. §112. Appellants respectfully submit that the claims should not be construed as being limited to the embodiments described or referenced in any claim summary, and further submit that other embodiments, as well as the Doctrine of Equivalents, may apply in determining claim scope.

Claim 1

The subject matter of independent claim 1 is directed to a movable base station configured to move relative to Earth. (Specification, paragraphs [0021], [0030]; Fig. 1, Fig. 4, reference character 30). The movable base station includes a plurality of spatially separated antennas (Specification, paragraphs [0025], [0029]; Fig. 4, reference character 100), a receiver (Specification, paragraphs [0030]; Fig. 4, reference character 132), controller (Specification, paragraphs [0030]; Fig. 4, reference character 130), and a transmitter (Specification, paragraphs [0030]; Fig. 4, reference character 132). The receiver is configured to receive mobile device signals from a mobile device through the plurality of spatially separated antennas. (Specification, paragraphs [0025]). The controller is configured to align and combine the received mobile device signals (Specification, paragraphs [0046]) and the transmitter (Specification, paragraphs [0030]; Fig. 4, reference character 132) is configured to transmit radio frequency signals corresponding to the mobile device signals to a base station.

Claim 4

The subject matter of dependent claim 4 is directed to a movable base station that comprises another plurality of spatially separated antennas. The transmitter is configured to transmit the radio frequency signals through the another plurality of spatially separated antennas. (Specification, paragraphs [0025], [0029]; Fig. 4, reference character 101)

Claim 10

The subject matter of dependent claim 10 is directed to a movable base station, where the movable base station is conveyed by an automotive vehicle. (Specification, paragraph [0021], line 9)

Claim 11

The subject matter of independent claim 11 is directed to a movable base station configured to move relative to Earth. (Specification, paragraphs [0021], [0030]; Fig. 1, Fig. 4, reference character 30). The movable base station includes a plurality of spatially separated antennas (Specification, paragraphs [0025], [0029]; Fig. 4, reference character 101), a receiver (Specification, paragraphs [0030]; Fig. 4, reference character 132), controller (Specification, paragraphs [0030]; Fig. 4, reference character 130), and a transmitter (Specification, paragraphs [0030]; Fig. 4, reference character 132). The receiver is configured to receive fixed port signals from a fixed port through the plurality of spatially separated antennas. (Specification, paragraphs [0025]). The controller is configured to align and combine the received fixed port signals. (Specification, paragraphs [0046]). The transmitter is configured to transmit radio frequency signals to a mobile device corresponding to the received fixed port signals. (Specification, paragraphs [0030]; Fig. 4, reference character 132)

Claim 14

The subject matter of dependent claim 14 is directed to a movable base station, where the movable base station comprises another plurality of spatially separated antennas. The transmitter is configured to transmit the radio frequency signals through the another plurality of spatially separated antennas. (Specification, paragraphs [0025], [0029]; Fig. 4, reference character 100).

Claim 20

The subject matter of dependent claim 20 is directed to a movable base station, where the movable base station is conveyed by an automotive vehicle. (Specification, paragraph [0021], line 9)

Claim 21

The subject matter of independent claim 21 is directed to a movable base station configured to move relative to Earth. (Specification, paragraphs [0021], [0030]; Fig. 1, Fig. 4, reference character 30). The movable base station includes a plurality of spatially separated antennas (Specification, paragraphs [0025], [0029]; Fig. 4, reference character 100), a receiver (Specification, paragraphs [0030]; Fig. 4, reference character 132), and a transmitter (Specification, paragraphs [0030]; Fig. 4, reference character 132). The receiver is configured to receive mobile device signals from a mobile device through the plurality of spatially separated antennas. The transmitter is configured to transmit radio frequency signals corresponding to the mobile device signals to a base station. (Specification, paragraphs [0030]; Fig. 4, reference character 132). The radio frequency signals are transmitted within time slots of time-division multiplex channels. (Specification, paragraphs [0031]).

Claim 26

The subject matter of dependent claim 26 is directed to a movable base station, where the movable base station is conveyed by an automotive vehicle. (Specification, paragraph [0021], line 9)

Claim 27

The subject matter of independent claim 27 is directed to a movable base station configured to move relative to Earth. (Specification, paragraphs [0021], [0030]; Fig. 1, Fig. 4, reference character 30). The movable base station includes a plurality of spatially separated antennas (Specification, paragraphs [0025], [0029]; Fig. 4, reference character 100), a receiver (Specification, paragraphs [0030]; Fig. 4, reference character 132), and a transmitter (Specification, paragraphs [0030]; Fig. 4, reference character 132). The spatially separated

antennas are configured as a plurality of phased array antennas to provide directional radio frequency beams. (Specification, paragraphs [0029]). The receiver is configured to receive mobile device signals from a mobile device through the plurality of spatially separated antennas. (Specification, paragraphs [0030]; Fig. 4, reference character 132). The transmitter is configured to transmit radio frequency signals corresponding to the mobile device signals to a base station. (Specification, paragraphs [0030]; Fig. 4, reference character 132).

Claim 28

The subject matter of dependent claim 28 is directed to a movable base station that further comprises another plurality of spatially separated antennas. The transmitter is configured to transmit the radio frequency signals through the another plurality of spatially separated antennas. (Specification, paragraphs [0025], [0029]; Fig. 4, reference character 101).

Claim 32

The subject matter of dependent claim 32 is directed to a movable base station, where the movable base station is conveyed by an automotive vehicle. (Specification, paragraph [0021], line 9).

Claim 33

The subject matter of independent claim 33 is directed to a movable base station configured to move relative to Earth. (Specification, paragraphs [0021], [0030]; Fig. 1, Fig. 4, reference character 30). The movable base station includes a plurality of spatially separated antennas (Specification, paragraphs [0025], [0029]; Fig. 4, reference character 101), a receiver (Specification, paragraphs [0030]; Fig. 4, reference character 132), and a transmitter (Specification, paragraphs [0030]; Fig. 4, reference character 132). The receiver is configured to receive fixed port signals from a fixed port through the plurality of spatially separated antennas. (Specification, paragraphs [0025], [0029]; Fig. 4, reference character 101). The transmitter is configured to transmit radio frequency signals to a mobile device corresponding to the received fixed port signals. (Specification, paragraph [0029]). The radio frequency signals are transmitted within time slots of time-division multiplex channels. (Specification, paragraphs [0031]).

Claim 37

The subject matter of dependent claim 37 is directed to a movable base station, where the movable base station is conveyed by an automotive vehicle. (Specification, paragraph [0021], line 9).

Claim 38

The subject matter of independent claim 38 is directed to a movable base station configured to move relative to Earth. (Specification, paragraphs [0021], [0030]; Fig. 1, Fig. 4, reference character 30). The movable base station includes a plurality of spatially separated antennas (Specification, paragraphs [0025], [0029]; Fig. 4, reference character 101), a receiver (Specification, paragraphs [0030]; Fig. 4, reference character 132), and a transmitter (Specification, paragraphs [0030]; Fig. 4, reference character 132). The plurality of spatially separated antennas is configured as a plurality of phased array antennas to provide directional radio frequency beams. The receiver is configured to receive fixed port signals from a fixed port through the plurality of spatially separated antennas. The transmitter is configured to transmit radio frequency signals to a mobile device corresponding to the received fixed port signals.

Claim 39

The subject matter of dependent claim 39 is directed to a movable base station that further comprises another plurality of spatially separated antennas. The transmitter is configured to transmit the radio frequency signals through the another plurality of spatially separated antennas. (Specification, paragraphs [0025], [0029]; Fig. 4, reference character 101).

Claim 44

Claim 44 is a dependent claim directed at a movable base station in accordance with claim 38, where the movable base station is conveyed by an automotive vehicle. (Specification, paragraph [0021], line 9).

GROUND OF REJECTION TO BE REVIEWED ON APPEAL

Appellants wish the Board of Patent Appeals and Interferences to review the following grounds of rejection on appeal:

1) Whether claims 1-6, 8-16 18-44 are unpatentable under 35 U.S.C. §103(a) over US Patent No. 5,404,570 to Charas, et al. (“Charas”) in view of U.S. Patent No. 5,260,968 to Gardner, et al. (“Gardner”).

ARGUMENT

REJECTION OF CLAIMS 1-6, 8-16, AND 18-44 UNDER 35 U.S.C. §103(A) OVER CHARAS IN VIEW OF GARDNER IS IMPROPER

The Examiner rejected claims 1-6, 8-16, and 18-44 under 35 U.S.C. 103(a) as being unpatentable over Charas in view of Gardner. Appellants respectfully submit that this rejection is improper because 1) the combination of references is improper, and 2) the references do not teach or suggest all of the limitations of any one of the claims,

I. COMBINATION OF CHARAS AND GARDNER IS IMPROPER

Appellant respectfully submits that the combination of references is an improper application of 35 U.S.C. § 103 because the Examiner has not presented any evidence that the Examiner's combination of Charas and Gardner is a combination of familiar elements according to known methods that yields predictable results, the combination was applied using impermissible hindsight, and the motivation to combine the references asserted by the Examiner is improper.

A. Combination Of Charas And Gardner Is Not A Combination Of Familiar Elements According To Known Methods That Yields Predictable Results

Appellant respectfully submits that the combination is an improper application of 35 U.S.C. § 103 and that the Examiner has not presented any evidence that the Examiner's combination of Charas and Gardner is a combination of familiar elements according to known methods that yields predictable results.

Summary of the References

Charas

Charas describes a repeater system for providing a communications link between a base station and a mobile unit when the mobile unit is located in an environment that is substantially closed off to high radio frequency communication between the base station and the mobile unit. Such a condition occurs when the mobile unit is on a train traveling through a tunnel and the base station is outside of the tunnel. The repeater system has a first frequency converter

including a high frequency port for two-way coupling to the base station and a low frequency port for two-way coupling to a low frequency signal that is capable of distributing radio frequency power through the closed environment such as tunnel. The low frequency port is connected to a cable which propagates and receives low radio frequency power within the closed environment. Accordingly, low frequency signals are transmitted and received through the cable. A second frequency converter has first antenna for transmitting and receiving low frequency signals to and from the cable and has a second antenna for communicating with the mobile unit using high frequency signals. The repeater system includes a first antenna for low frequency wireless coupling to the cable and a second antenna for high frequency coupling to mobile units. A base station uses frequency duplex to transmit and receive signals in a high frequency band. Since the second converter extends the base station cell, the second converter also uses frequency duplex to transmit and receive signals in the high frequency band to communicate with the mobile units. Therefore, transmission from the second antenna to mobile units is at frequencies different than frequencies of reception at the second antenna from the mobile units.

Gardner

Gardner describes multiplexing communication signals and increasing spectral capacity by blind adaptive spatial filtering of spectrally overlapping signals. An antenna with a large number of elements is used for transmission to mobile units and for reception from the mobile units. Spatial filtering adaptation is performed during transmission from the mobile unit to the base station. Transmission from the base station to the mobile unit must use a spatial filter developed during the spatial filtering adaptation. (Gardner, Column 5, Lines 34-37). Gardner uses time division duplex (TDD) so that the spatial filtering adaptation can be performed during transmission from the mobile unit to the base station.

Combination of Charas and Gardner

The Supreme Court stated that "[t]he combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results." *KSR Int'l Co. v. Teleflex Inc.*, 127 S. Ct. 1727, 1739 (2007). In a precedential BPAI opinion, the Board explained that "the operative question in this 'functional approach' is, therefore, 'whether the improvement is more than the predictable use of prior art elements according to their established

functions.’” *Ex Parte Smith (BPAI, June 25, 2995, per curium)*, Page 13. (citing *KSR*, Page 1740). Appellant respectfully submits that the Examiner’s combination of Charas and Gardner is not a combination of familiar elements according to known methods that yields predictable results. The Examiner proposes to significantly alter the teachings of Gardner by modifying the single frequency multi-element antenna system of Gardner to operate in a dual frequency single antenna system of Charas. Gardner explicitly states that the same frequency **MUST** be used for transmission and reception. (Gardner, Column 5, Lines 39-41). On the other hand, Charas teaches to use different frequencies for transmission and reception. (See Charas, Column 4, Lines 8-11). For the multi-element antenna system of Gardner to operate, spatial filtering adaptation is performed during transmission from the mobile unit to the base station and transmission from the base station to the mobile unit **MUST** use a spatial filter developed during the spatial filtering adaptation. (Gardner, Column 5, Lines 34-37). Such adaptation cannot occur in Charas since different frequencies are used for transmission and reception between the mobile unit and repeater. The multi-element antenna in Gardner is not a “familiar element.” On the contrary, it was the subject of the Gardner patent application. Charas uses a single antenna and different frequencies for transmission and reception for communication between the mobile unit and the repeater. Accordingly, the case at hand is not a situation where one with ordinary skill in the art would replace a dual frequency single antenna with any other type antenna that uses a single frequency in both directions. The substitution of the multi-element spatial filtering antenna system of Gardner in a frequency division duplex system of Charas is not a “predictable use of prior art elements according to their established functions.”

In addition, using the Gardner TDD system as taught by Gardner would require that the mobile units in Charas operate in accordance with TDD not in accordance with FDD. This would require modification of GSM mobile units which operate in the FDD mode to be converted to operate in the TDD and thus be incompatible with cellular systems. As a result, this obviates the intended invention of Charas by modifying the mobile units in such a way that they could no longer communicate with the GSM base stations outside of the tunnel and there would be no need for a repeater system as described by Charas.

In the Final Office Action, the Examiner attempts to rebut one of Appellant’s arguments by stating that Charas and Gardner are capable of utilizing TDMA communication protocol and therefore, are combinable. (See Final Office Action, Page 4, lines 19-20). Appellant respectfully

submits that the capability of the references to use TDMA communications does not make the references combinable. TDMA (Time Division Multiple Access) provides a technique for allowing multiple mobile units to share a channel by designating particular times for each mobile unit to transmit signals. Accordingly, TDMA provides a way to share a channel between mobile units and is not related to whether the system uses time division duplex (TDD) or frequency division duplex (FDD) for managing signals transmitted between the base station and the mobile unit. As explained above, Gardner must use time division duplex (TDD) for the antenna to function. With TDD, the same frequency is used for transmission and reception and the channel must be shared by the mobile unit and the base station. The mobile can only transmit part of the time. The allegation that the mobile may use TDMA when transmitting does not mean that the mobile can be modified to use FDD where communications between the mobile and the base station are separated in frequency. The repeater in Charas is provided in order to connect the mobile unit to the GSM system which uses FDD (not TDD). Modification of the Charas system to a TDD system results in a system that no longer meets the intended purpose of providing a connection to a GSM system.

B. Combination Is Applied Using Improper Hindsight

The Supreme Court warned that “[a] fact finder should be aware, of course, of the distortion caused by hindsight bias and must be cautious of arguments reliant upon *ex post* reasoning.” *KSR*, at 1742. Appellant respectfully submits that the cited prior art is only combined in retrospect, in light of the present invention. That is, the obviousness rejection is based upon characterization of Charas and Gardner in view of the Appellant’s own invention description. Appellant respectfully submits that the Examiner has combined the references by observing that Charas does not teach or suggest using a plurality of antennas and that Gardner includes a discussion of a multi-element antenna system. Appellant submits that the Examiner is constructing the claimed invention by using Appellant’s teaching of a moving base station with a plurality of antennas to form a combination within Charas that significantly alters the operation of Charas to the point that the Charas mechanism will not perform its intended function of frequency division duplex. MPEP § 2142 states that “impermissible hindsight must be avoided and the legal conclusion must be reached on the basis of the **facts gleaned from the prior art**”

(emphasis added). The only reasoning provided by the Examiner for combining the references is for “the advantage of enhancing the communication signal quality”. (Office Action dated October 29, 2009, Page 3, Line 14) There is no evidence in the record other than Appellant’s specification that supports the reasoning behind combining the references. On the contrary, as discussed herein, the evidence of record indicates that the communication signal quality would decrease with the combination. Therefore, not only is the reasoning to combine the references found only in Appellant’s specification, but the evidence of record teaches away from combining the references. Appellant respectfully submits that the Examiner’s stated reason to combine is not found in the evidence of record and, as a result, the legal conclusion of obviousness is based on impermissible hindsight.

C. Improper Motivation For Combining The References

Further, the evidence of record does not support the proposition by the Examiner that “[i]t would be obvious to one of ordinary skill in the art at the time of the invention was made to apply the teaching of Gardner in modifying the moveable base station, as described by Charas, with the spatially separated antenna system for the advantage of enhancing the communication signal quality. (Office Action dated October 29, 2009, Page 3, Lines 11-14, emphasis added). On the contrary, the evidence clearly indicates that the combination will not function or, will operate at a reduced data rate, at best. Since Gardner requires TDD, the use of the Gardner antenna with the teachings of Charas would require Charas to use TDD instead of FDD as Charas teaches. The data rate will be reduced if the communication link between the repeater and the mobile unit in Charas is changed to a time division duplex (TDD) interface since the channel must be shared for transmission. The data rate would be less for both transmissions since the mobile unit and the repeater could only transmit a portion of the time rather than continuously as in FDD. As a result, there would be no “advantage of enhancing the communication” as the Examiner alleges. Accordingly, Appellant respectfully submits that the combination is improper and the rejection should be withdrawn.

II. ALL LIMITATIONS OF ANY ONE OF CLAIMS 1-6, 8-16, and 18-44 ARE NOT TAUGHT OR SUGGESTED BY THE REFERENCES

Appellant respectfully submits that all of the limitations of any one of claims 1-6, 8-16, and 18-44 are not taught or suggested by Charas, Gardner, or a combination of the two. The failure of the cited art to teach or suggest each and every feature of a claim is fatal to an obviousness rejection under 35 U.S.C. § 103. For example, section 2143.03 of the MPEP requires the “consideration” of every claim feature in an obviousness determination. For a proper rejection, this “consideration” requires that the Examiner find that Gardner and Charas teach or suggest each and every claim feature. See *In re Royka*, 490 F.2d 981, 180 USPQ 580 (CCPA 1974) (emphasis added) (to establish *prima facie* obviousness of a claimed invention, all the claim features must be taught or suggested by the prior art). As the Board of Patent Appeal and Interferences has recently confirmed, a proper obviousness determination requires that an Examiner make “a searching comparison of the claimed invention—including all its limitations—with the teaching of the prior art.” See *In re Wada and Murphy*, Appeal 2007-3733, citing *In re Ochiai*, 71 F.3d 1565, 1572 (Fed. Cir. 1995) (emphasis in original). Further, the necessary presence of all claim features is axiomatic, since the Supreme Court has long held that obviousness is a question of law based on underlying factual inquiries, including . . . ascertaining the differences between the claimed invention and the prior art. *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966) (emphasis added).

Appellant submits that this is why Section 904 of the MPEP instructs Examiners to conduct an art search that covers “the invention as described and claimed.” (Emphasis added). Further, Appellant respectfully directs attention to MPEP § 2143, the instructions of which buttress the conclusion that obviousness requires at least a suggestion of all of the features of a claim, since the Supreme Court in *KSR Int’l v. Teleflex Inc.* stated that “there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.” *KSR Int’l v. Teleflex Inc.*, 127 S. Ct. 1727, 1741 (2007) (quoting *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006)). Accordingly, it remains well-settled law that an obviousness rejection requires at least a suggestion of all of the features in a claim. See *In re Wada and Murphy*, citing *CFMT, Inc. v. Yieldup Intern. Corp.*, 349 F.3d 1333, 1342 (Fed. Cir. 2003) and *In re Royka*, 490 F.2d 981, 985 (CCPA 1974).

Claims 1, 21, and 27

Claims 1, 21, and 27 recite a movable base station comprising “a receiver configured to receive mobile device signals from a mobile device through the plurality of spatially separated antennas.” Charas does not suggest this feature. Gardner does not disclose a movable base station with a plurality of antennas. The combination of Gardner and Charas results in a device that **cannot** receive signals from a mobile device. For example, simply replacing the single antenna of Charas with a multi-element antenna results in a system that cannot receive signals. Charas does not teach how to process an output of a multi-element antenna. Accordingly, signals reaching a multi-element antenna in Charas will not be received. This deficiency is not solved by applying the antenna processing teachings of Gardner to a multi-element antenna incorporated into Charas. For example, the antenna processing techniques of Gardner require time division duplex switching. (See Gardner, Column 15, Lines 9-13). In the GSM system of Charas, the mobile unit will transmit signals during times when the Gardner multi-element system is in the transmit mode and cannot receive signals. For the Gardner antenna to operate, TDD must be used. (Gardner, Column 5, Lines 34-37). Since the mobile transmits continuously in Charas, there will be times when the Gardner antenna is not receiving mobile signals when combined with Charas. Accordingly, the mobile unit signals will not be received. The Examiner has provided no evidence that the combination results in a receiver that is configured to receive signals through a plurality of antennas as claimed. Accordingly, Appellant respectfully submits that the Examiner has not presented a *prima facie* case for obviousness since all of the elements of any one of claims 1, 21, or 27 are not taught or suggested by the references.

Claims 11, 33, and 38

Claim 11, 33, and 38 recite a movable base station comprising “a receiver configured to receive fixed port signals from a fixed port through the plurality of spatially separated antennas.” Appellant respectfully submits that neither Charas, nor Gardner, nor a combination of the two, teaches or suggest this feature. Charas does not mention a plurality of antennas. Gardner does not mention a moveable base station. Further, Gardner does not teach to receive signals from a fixed port through a plurality of spatially separated antennas. Gardner explicitly states that the plurality of antennas is used to receive signals from mobile units.

It appears that the Examiner is alleging that the single antenna (118) receiving signals from the amplifiers (208) connected to the cable transmission means (110) of Charas can be replaced with the multi-element antenna of Gardner to result in “a receiver configured to receive fixed port signals from a fixed port through the plurality of spatially separated antennas.” Appellant respectfully submits that such a combination does not result in a receiver that can receive signals from a fixed port. Simply replacing the Charas antenna (118) with the multi-element antenna array of Gardner results in a device that cannot receive signals. Charas does not teach how to process an output of a multi-element antenna. Accordingly, signals reaching a multi-element antenna in Charas will not be received. This problem is not solved by applying the antenna processing teachings of Gardner to a multi-element antenna incorporated into Charas. For example, the antenna processing techniques of Gardner require time division duplex switching. (See Gardner, Column 15, Lines 9-13). In the GSM system of Charas, amplifiers 208 transmit GSM signals that are linearly converted to a lower frequency. The signals, therefore, have the same timing as GSM signals. As a result, the amplifiers transmit signals during times when the Gardner multi-element system is in the transmit mode and not receiving. Accordingly, the signals from the amplifiers will not be received. Accordingly, Appellant respectfully submits that the Examiner has not presented a *prima facie* case for obviousness since all of the elements of claim 1 are not taught or suggested by the references.

Claims 2-6, 8-10, 12-16, 18-19, 22, 26, 28-32, 34-37, and 39-44

Regarding claims 2-6, 8-10, 12-16, 18-19, 22, 26, 28-32, 34-37, and 39-44, these claims depend from one of independent claims 1, 11, 21, 27, 33, or 38 which Appellant submits are allowable. Accordingly, claims 2-6, 8-10, 12-16, 18-19, 22, 26, 28-32, 34-37, and 39-44 are at least allowable for the reason that they depend from an allowable base claim.

Claims 4, 14, 28, and 39

Further regarding claims 4, 14, 28, and 39, these claims recite “another plurality of spatially separated antennas, the transmitter configured to transmit the radio frequency signals through the another plurality of spatially separated antennas.” Appellant respectfully submits that neither, Charas, nor Gardner, nor a combination of the two, teaches or suggests this feature. Charas does not discuss spatially separated antennas. Gardner discusses only a single multi-

element antenna. The Examiner has provided no support for the allegation that the limitation is shown.

Claims 10, 20, 26, 32, 37, and 44

Further regarding claims 10, 20, 26, 32, 37, and 44, these claims recite that the movable base station is conveyed by a vehicle “wherein the vehicle is an automotive vehicle.” Appellant respectfully submits that neither, Charas nor Gardner, nor a combination of the two, teaches or suggests this feature. Gardner does not disclose moveable base stations. Charas discusses a repeater on a train and does not suggest automobiles.

CONCLUSION

Appellants respectfully submit that the pending claims are allowable and that the rejections should be reversed.

Respectfully Submitted,

Dated: June 27, 2010

/Charles D. Gavrilovich, Jr/
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APPENDIX

Claims

1. A movable base station configured to move relative to Earth, the movable base station comprising:
 - a plurality of spatially separated antennas;
 - a receiver configured to receive mobile device signals from a mobile device through the plurality of spatially separated antennas;
 - a controller configured to align and combine the received mobile device signals;
 - and
 - a transmitter configured to transmit radio frequency signals corresponding to the mobile device signals to a base station.
2. A movable base station in accordance with claim 1, wherein the plurality of spatially separated antennas is configured as directional antenna sectors.
3. A movable base station in accordance with claim 1, wherein the plurality of spatially separated antennas is configured as a plurality of phased array antennas with directional radio frequency beams.
4. A movable base station in accordance with claim 1, further comprising another plurality of spatially separated antennas, the transmitter configured to transmit the radio frequency signals through the another plurality of spatially separated antennas.
5. A movable base station in accordance with claim 4, wherein the another plurality of spatially separated antennas is configured to transmit spatially separated radio frequency beams separated in time with a predefined time delay.

6. A movable base station in accordance with claim 1, further comprising a controller configured to compare the received mobile device signals received through the spatially separated antennas and to select a best signal.

7. (Cancelled)

8. A movable base station in accordance with claim 1, the transmitter further configured to transmit the radio frequency signals within time slots of time-division multiplex channels.

9. A movable base station in accordance with claim 1, wherein the movable base station is conveyed by a vehicle.

10. A movable base station in accordance with claim 9, wherein the vehicle is an automotive vehicle.

11. A movable base station configured to move relative to Earth, the movable base station comprising:

a plurality of spatially separated antennas;

a receiver configured to receive fixed port signals from a fixed port through the plurality of spatially separated antennas;

a controller configured to align and combine the received fixed port signals; and

a transmitter configured to transmit radio frequency signals to a mobile device corresponding to the received fixed port signals.

12. A movable base station in accordance with claim 11, wherein the plurality of spatially separated antennas is configured as directional antenna sectors.

13. A movable base station in accordance with claim 11, wherein the plurality of spatially separated antennas is configured as a plurality of phased array antennas with directional radio frequency beams.

14. A movable base station in accordance with claim 11, further comprising another plurality of spatially separated antennas, the transmitter configured to transmit the radio frequency signals through the another plurality of spatially separated antennas.

15. A movable base station in accordance with claim 14, wherein the another plurality of spatially separated antennas is configured to transmit spatially separated radio frequency beams separated in time with a predefined time delay.

16. A movable base station in accordance with claim 11, further comprising a controller configured to compare the received fixed port signals received through the spatially separated antennas and to select a best signal.

17. (Cancelled)

18. A movable base station in accordance with claim 11, the transmitter further configured to transmit the radio frequency signals within time slots of time-division multiplex channels.

19. A movable base station in accordance with claim 11, wherein the movable base station is conveyed by a vehicle.

20. A movable base station in accordance with claim 19, wherein the vehicle is an automotive vehicle.

21. A movable base station configured to move relative to Earth, the movable base station comprising:

a plurality of spatially separated antennas;

a receiver configured to receive mobile device signals from a mobile device through the plurality of spatially separated antennas; and

a transmitter configured to transmit radio frequency signals corresponding to the mobile device signals to a base station, the radio frequency signals transmitted within time slots of time-division multiplex channels.

22. A movable base station in accordance with claim 21, wherein the plurality of spatially separated antennas is configured as directional antenna sectors.

23. A movable base station in accordance with claim 21, wherein the plurality of spatially separated antennas is configured as a plurality of phased array antennas with directional radio frequency beams.

24. A movable base station in accordance with claim 21, further comprising a controller configured to compare the received mobile device signals received through the spatially separated antennas and to select a best signal.

25. A movable base station in accordance with claim 21, wherein the movable base station is conveyed by a vehicle.

26. A movable base station in accordance with claim 25, wherein the vehicle is an automotive vehicle.

27. A movable base station configured to move relative to Earth, the movable base station comprising:

a plurality of spatially separated antennas configured as a plurality of phased array antennas to provide directional radio frequency beams;

a receiver configured to receive mobile device signals from a mobile device through the plurality of spatially separated antennas; and

a transmitter configured to transmit radio frequency signals corresponding to the mobile device signals to a base station.

28. A movable base station in accordance with claim 27, further comprising another plurality of spatially separated antennas, the transmitter configured to transmit the radio frequency signals through the another plurality of spatially separated antennas.

29. A movable base station in accordance with claim 28, wherein the another plurality of spatially separated antennas is configured to transmit spatially separated radio frequency beams separated in time with a predefined time delay.

30. A movable base station in accordance with claim 27, the transmitter further configured to transmit the radio frequency signals within time slots of time-division multiplex channels.

31. A movable base station in accordance with claim 27, wherein the movable base station is conveyed by a vehicle.

32. A movable base station in accordance with claim 31, wherein the vehicle is an automotive vehicle.

33. A movable base station configured to move relative to Earth, the movable base station comprising:

a plurality of spatially separated antennas;

a receiver configured to receive fixed port signals from a fixed port through the plurality of spatially separated antennas; and

a transmitter configured to transmit radio frequency signals to a mobile device corresponding to the received fixed port signals, the radio frequency signals transmitted within time slots of time-division multiplex channels.

34. A movable base station in accordance with claim 33, wherein the plurality of spatially separated antennas is configured as directional antenna sectors.

35. A movable base station in accordance with claim 33, further comprising a controller configured to compare the received fixed port signals received through the spatially separated antennas and to select a best signal.

36. A movable base station in accordance with claim 33, wherein the movable base station is conveyed by a vehicle.

37. A movable base station in accordance with claim 36, wherein the vehicle is an automotive vehicle.

38. A movable base station configured to move relative to Earth, the movable base station comprising:

a plurality of spatially separated antennas configured as a plurality of phased array antennas to provide directional radio frequency beams;

a receiver configured to receive fixed port signals from a fixed port through the plurality of spatially separated antennas; and

a transmitter configured to transmit radio frequency signals to a mobile device corresponding to the received fixed port signals.

39. A movable base station in accordance with claim 38, further comprising another plurality of spatially separated antennas, the transmitter configured to transmit the radio frequency signals through the another plurality of spatially separated antennas.

40. A movable base station in accordance with claim 39, wherein the another plurality of spatially separated antennas is configured to transmit spatially separated radio frequency beams separated in time with a predefined time delay.

41. A movable base station in accordance with claim 38, further comprising a controller configured to compare the received fixed port signals received through the spatially separated antennas and to select a best signal.

42. A movable base station in accordance with claim 38, the transmitter further configured to transmit the radio frequency signals within time slots of time-division multiplex channels.

43. A movable base station in accordance with claim 38, wherein the movable base station is conveyed by a vehicle.

44. A movable base station in accordance with claim 43, wherein the vehicle is an automotive vehicle.

APPENDIX

Evidence

- 1) U.S. Patent No. 5,404,570 to Charas et al. (“Charas”)
- 2) U.S. Patent No. 5,260,968 to Gardener et al. (“Gardener”)
- 3) Final Office Action dated October 29, 2009

[54] RADIO COVERAGE IN CLOSED ENVIRONMENTS

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- [21] Appl. No.: 979,909
- [22] Filed: Nov. 23, 1992
- [51] Int. Cl.⁶ H04Q 7/02; H04B 7/26;
H04B 7/15
- [52] U.S. Cl. 455/22; 455/33.3;
455/33.4; 455/56.1; 455/70; 379/59
- [58] Field of Search 455/14-16,
455/41, 66, 20, 22, 31.1, 1.1, 33.2, 54.1, 33.4,
33.3, 70; 379/59, 60

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Primary Examiner—Edward F. Urban

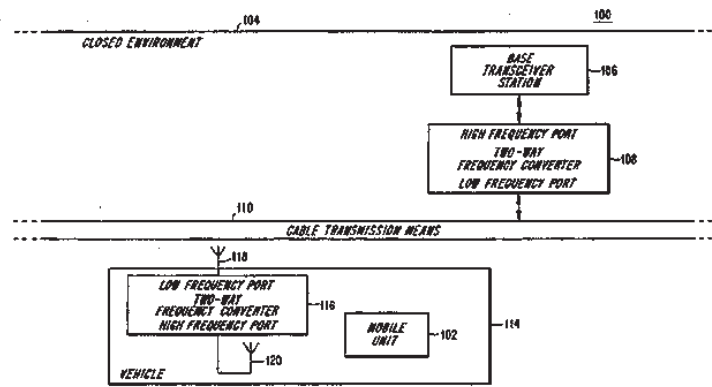
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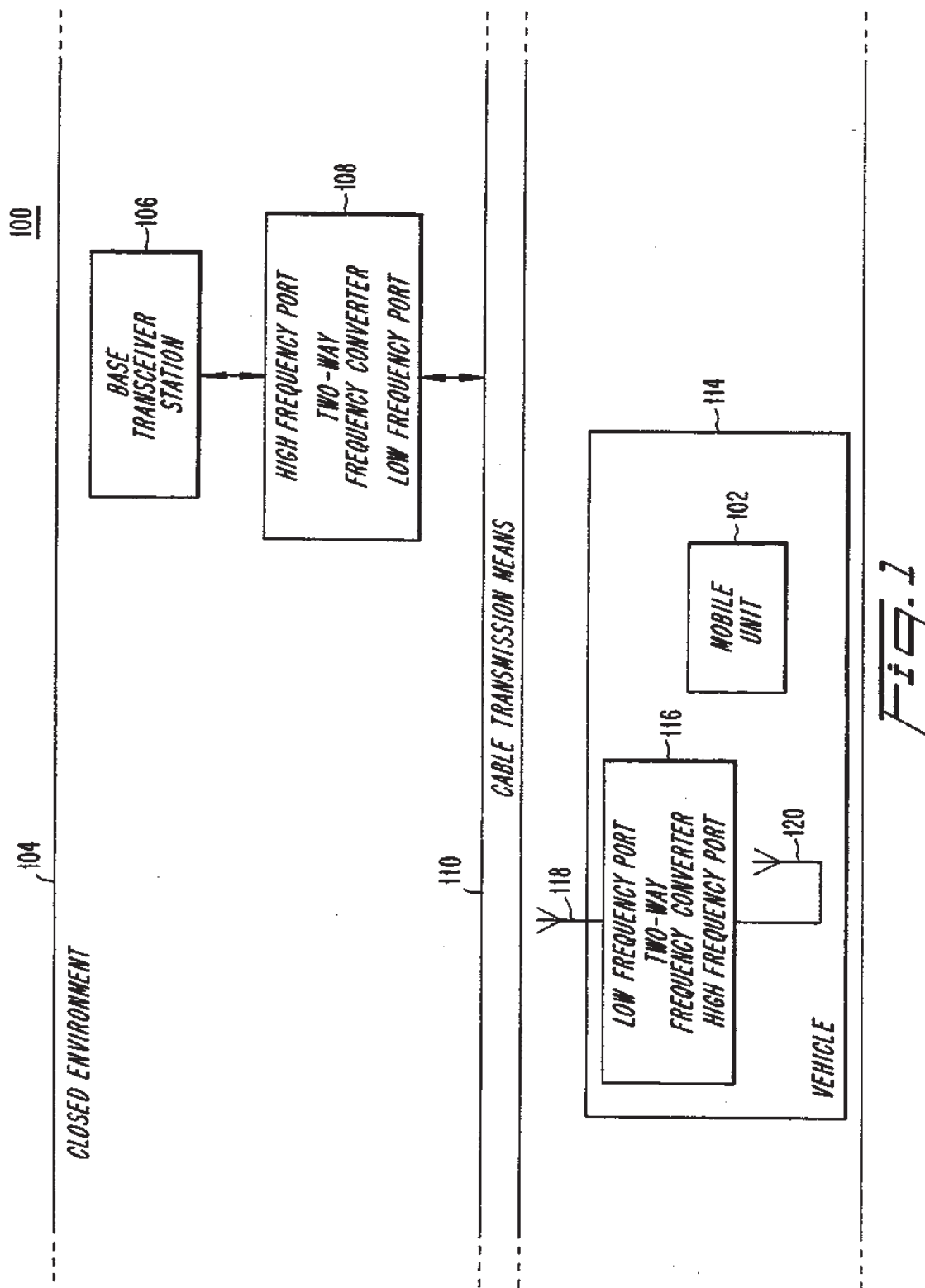
Attorney, Agent, or Firm—Burns, Doane, Swecker & Mathis

[57] ABSTRACT

A repeater system in a communication system including a base station and a mobile unit provides a communications link between the base station and the mobile unit when the mobile unit is located in an environment that is substantially closed off to high radio frequency communication between the base station and the mobile unit. The repeater system has a first linear two-way frequency converter including a high frequency port for two-way coupling to the base station and a low frequency port for two-way coupling to a low frequency signal that is capable of distributing radio frequency power through the closed environment. The low frequency port is connected to a cable which propagates and receives low radio frequency power within the closed environment. The repeater system also includes a first antenna for wireless coupling to the cable, and a second linear two-way frequency converter having a low frequency port connected to the first antenna for two-way coupling to a low frequency signal and a high frequency port for two-way coupling to a signal that is compatible with the high radio frequency signal used by the communications system. A second antenna is connected to the high frequency port of the second linear two-way frequency converter for wireless coupling of the second linear two-way frequency converter to a nearby mobile unit.

19 Claims, 3 Drawing Sheets





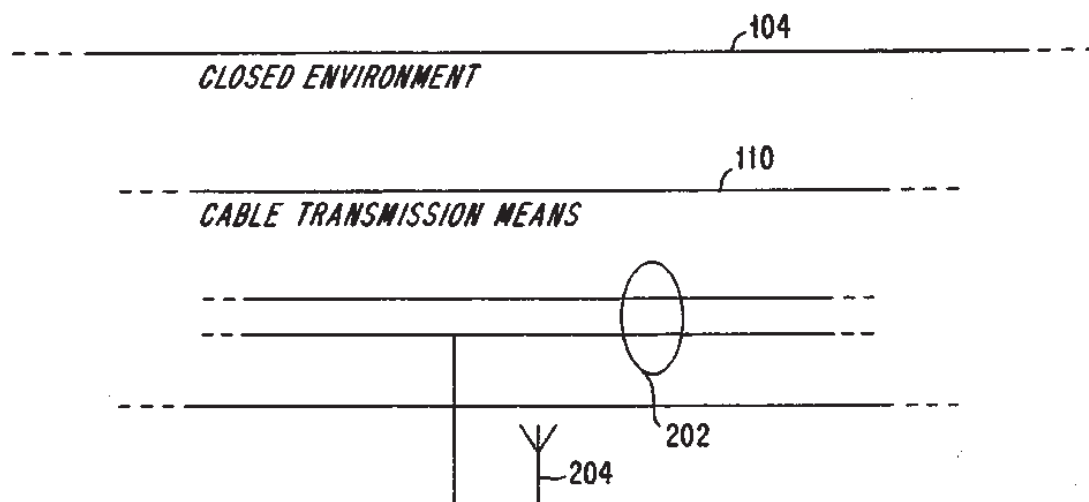


Fig. 2a

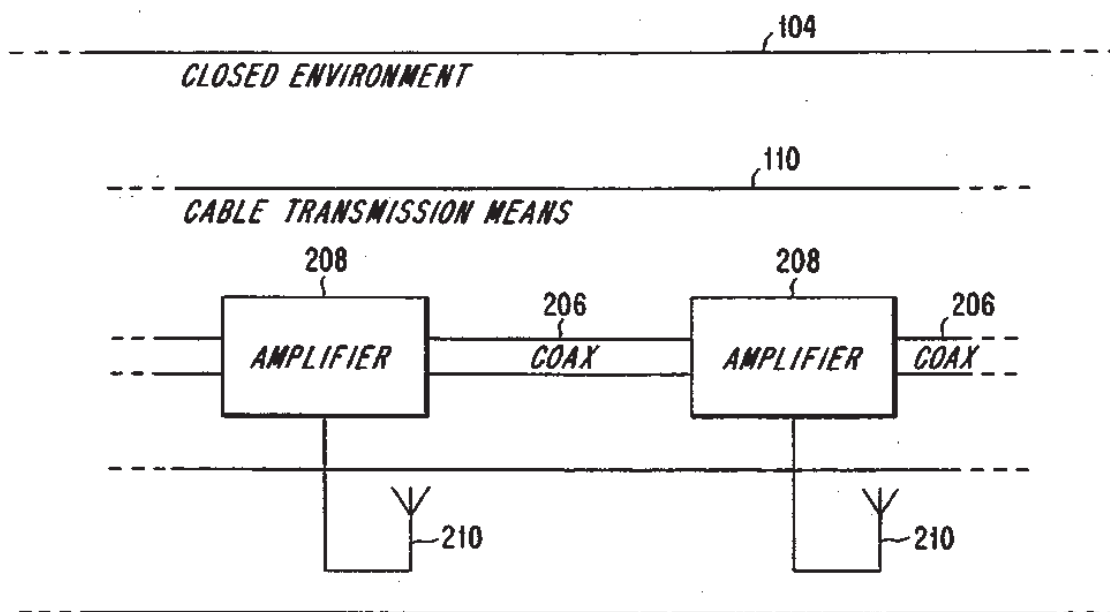
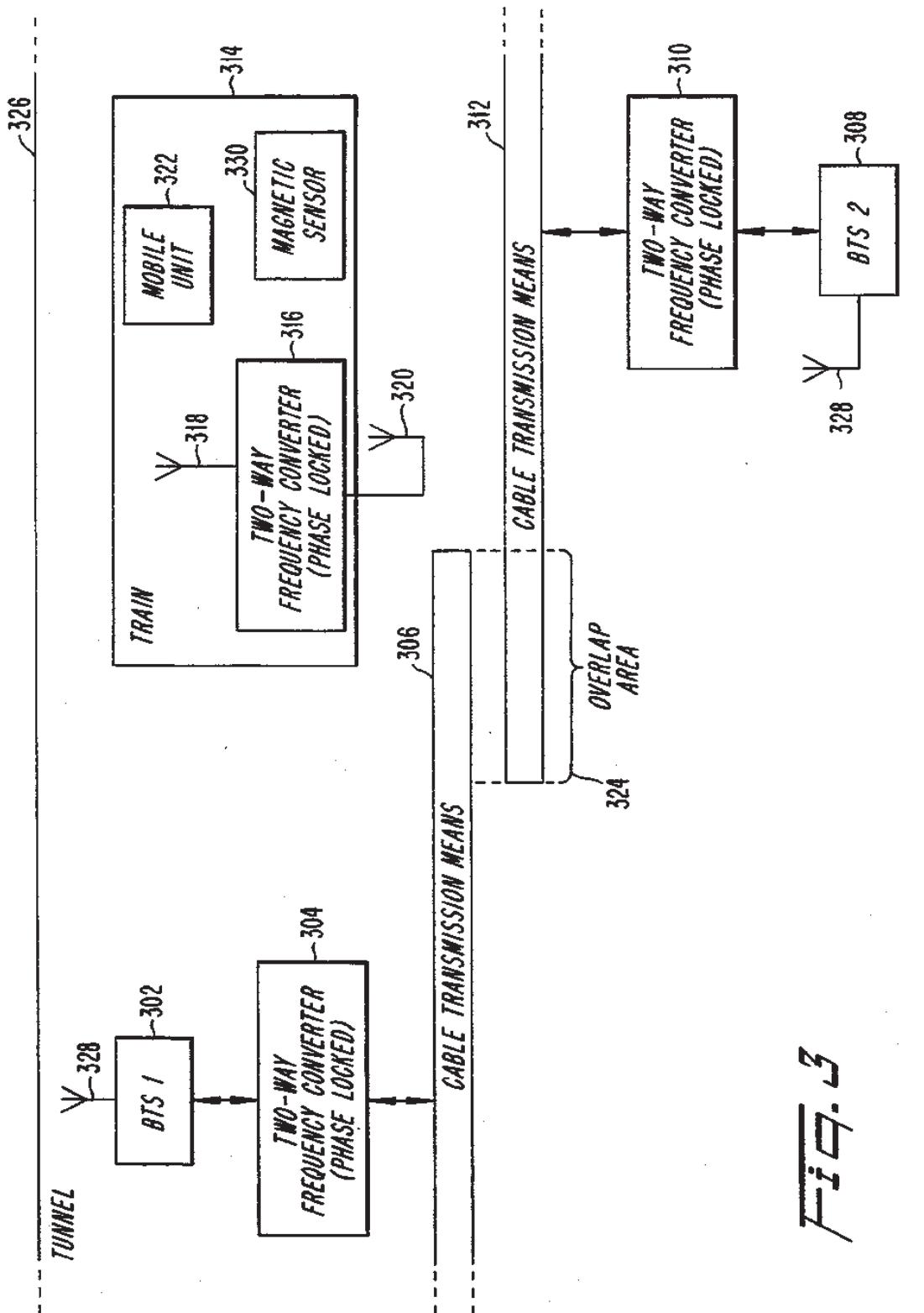


Fig. 2b



RADIO COVERAGE IN CLOSED ENVIRONMENTS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to radio coverage in environments that are otherwise closed off to such coverage, and more particularly to cellular radio communications coverage in such closed off environments by means of repeaters, and even more particularly to a repeater system which converts communications system high radio frequency signals into low radio frequency signals for propagation in the closed off environment, and then back into high radio frequency signals.

2. Related Art

In a cellular telephone system, each portable telephone, referred to here as a mobile unit, is able to function only to the extent that it is able to send and receive radio signals to and from a base station associated with the system. However, in the real world environment there are impediments to normal radio communication. For example, at frequencies of approximately 1 GHz or higher, obstructions such as tunnels can attenuate the radio signal 50 dB/km up to total cut-off. The amount of attenuation will depend on circumstances such as the shape of the tunnel, and the presence of obstructions like trains. This attenuation makes the radio propagation environment erratic and unreliable.

Prior attempts to radiate radio frequency (RF) power into problematic isolated structures, referred to here as closed environments, include the use of leaky coaxial cable in the structure, and also the brute force approach of directing a large RF power level into the structure. However, such approaches have proven to be both expensive and prohibitively complicated.

SUMMARY OF THE INVENTION

It is therefore one object of the present invention to provide a simple and cost effective approach to providing radio coverage in closed environments.

Another object of the invention is to extend a cellular telephone architecture into a closed environment so that the closed environment is subdivided into several cells, and to provide for the hand off of frequencies between them as a mobile unit moves from one cell to another.

A further object of the invention is to offer a simple and cost effective solution which can be implemented as an "add-on kit" to present radio hardware without substantial change or extra cost to this hardware.

According to the present invention, the foregoing and other objects are attained in a repeater system for use in a communication system that includes a base station and a mobile unit, both operating at a high radio frequency. The repeater system provides a communications link between the base station and the mobile unit when the mobile unit is located in an environment that is substantially closed off to high radio frequency communication between the base station and the mobile unit. The repeater system comprises a first linear two-way frequency converter including a high frequency port for two-way coupling to the base station, and a low frequency port for two-way coupling to a low frequency signal that is capable of distributing frequency power through the closed environment. The repeater system also includes cable transmission means con-

nected to the low frequency port of the first linear two-way frequency converter. The cable transmission means is located within the closed environment for radiating the low frequency converted signals within the closed environment. The repeater system also includes a first antenna for wireless coupling to the cable transmission means, and a second linear two-way frequency converter including a low frequency port connected to the first antenna for two-way coupling to a low frequency signal, and a high frequency port for two-way coupling to a signal that is compatible with the high radio frequency signal used by the communications system. The repeater system also has a second antenna connected to the high frequency port of the second linear two-way frequency converter.

With the above-described structure, a mobile unit in the vicinity of the second antenna can communicate with the base station in a normal fashion. The conversion of the high frequency signal into a low frequency signal and then back again into a high frequency signal is completely transparent to both the mobile unit and the base station.

In another embodiment of the above-described repeater system, the first antenna, second linear two-way frequency converter, and second antenna are located within a vehicle, and the cable transmission means is distributed along an anticipated path of the vehicle through the closed environment. As used throughout this specification, the term "vehicle" is used to represent a conveyance within which a mobile unit is to be able to operate. For example, the vehicle may be a train car travelling through a tunnel as part of a subway system. In this example, a passenger on the train is able to use a mobile unit to communicate with the base station by means of the repeater system. This is because a train car so equipped becomes a mobile base station that services a moving cell that is defined by the confines of the train itself. A passenger on the train may use a mobile unit the same as he or she would outside of the subway system.

Besides providing normal communications service to a mobile unit located on a vehicle that is travelling within a closed environment, a further advantage of the described mobile base station is that the high radio frequency power level need only be strong enough to propagate through the train car (i.e., the moving cell). This keeps the total radiated power in the closed environment at a low level compared to the high level of output power that would be required to propagate the high radio frequency signal throughout the tunnel for direct reception by a mobile unit on a train. Other environmental benefits are achieved by not having to subject passengers and other equipment to high levels of radio wave energy. Instead, passengers are only subjected to the lower power signal transmitted by the second antenna on board the train.

Another feature of the repeater system is useful, for example, when a communication system has a base station located in each of adjacent subway stations. Here, the cable transmission means is associated with a first base station, and a terminal portion of the cable transmission means overlaps a corresponding terminal portion of a cable transmission means that is associated with a second base station. The region of overlap should be sufficient to permit the vehicle, in this case a train car, to simultaneously pass by the terminal portions of both cable transmission means for at least several sec-

onds when the vehicle is travelling at a typical speed away from the first base station and toward the second base station. This avoids the problem of having all mobile units on board the train, travelling away from the first base station and toward the second base station, handed off from the first base station to the second base station at the same time.

Also, in the example of a mobile unit located on a moving vehicle, the above-described repeater system may further include a sensor coupled to the second linear two-way frequency converter for alternatively turning the second linear two-way frequency converter on and off in response to respectively sensing the vehicle entering and exiting the closed environment.

In another embodiment of the repeater system, the high radio frequency is in a range of 900 to 2000 megahertz, and the low frequency is in a range of 30 to 300 megahertz.

In yet another embodiment of the repeater system, the cable transmission means is a bifilar cable.

In still another embodiment of the repeater system, the cable transmission means comprises a coaxial cable connected to the first linear two-way frequency converter, an amplifier having an input connected to the coaxial cable, and a third antenna connected to an output of the amplifier.

In another embodiment of the repeater system, the first and second linear two-way frequency converters are phase locked to a system clock. This avoids interference problems if two or more vehicles are close to each other and are receiving signals from the same base station.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of one embodiment of the system in accordance with the present invention.

FIGS. 2a and 2b are more detailed block diagrams showing two preferred embodiments of the cable transmission means for use in the present invention.

FIG. 3 is a block diagram showing another embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention provides radio coverage to closed environments by recognizing that the radio frequency environment consists of two parts: a first environment in which the radio signal is propagated up to, but not within, the closed environment; and a second environment consisting of the area located within the closed environment. Methods for propagating a radio signal in the first environment, which does not present the above-described signal obstruction problems, are well known to those of ordinary skill in the art, and need not be described here. Cellular telephone systems functioning in this first environment typically radiate RF power in the 900-2000 megahertz (MHz) range. Both the mobile units and the base stations of such a system are adapted to transmit and receive in this frequency range.

Propagation of the signal within the second, closed environment can be accomplished by propagating a low radio frequency signal, preferably in the range 30-300 MHz, through either a coaxial or a bifilar conductor located within the closed environment. However, it should be readily apparent that a typical mobile unit is not capable of operating in this frequency range, and cannot directly take advantage of such a signal.

Referring to FIG. 1, a preferred embodiment of a system 100 for enabling a mobile unit 102 to continue to operate within a closed environment 104 is shown. The system 100 includes a multi-channel Base Transceiver Station (BTS) 106 associated with a cellular telephone system (not shown). The BTS 106 operates on a frequency that is compatible with the cellular telephone system. For the purposes of this description, it will be presumed that the BTS 106 transmits and receives RF power in the 1500 MHz band with a 45 MHz duplex distance between uplink and downlink frequencies.

The closed environment 104 may be a tunnel that is part of a subway system. In such a case, a BTS 106 is preferably placed in each underground station, with BTS's 106 located at adjacent underground stations operating at different frequencies in accordance with frequency allocation requirements for ordinary cell planning.

In order to communicate with the mobile unit 102 located in the closed environment 104, the BTS 106 is connected to the high-frequency port of a first linear two-way frequency converter 108. The low frequency port of the first frequency converter 108 is connected to cable transmission means 110. The function of the first frequency converter 108 is to convert the 1500 MHz signal that is output by the BTS 106 into a low frequency RF signal which can be propagated into the closed environment 104 by means of the cable transmission means 110 which is distributed throughout the closed environment 104, preferably along an anticipated path of the vehicle 114 containing a mobile unit 102. For purposes of discussion, it will be assumed that this low frequency RF signal is 200 MHz.

The first frequency converter 108 also converts low frequency RF signals, which may be received from another source and propagated by the cable transmission means 110, into high frequency signals for reception by the BTS 106. Thus, in the illustrative example, a 200 MHz signal propagated by the cable transmission means 110 would be converted to a 1500 MHz signal for use by the BTS 106.

It has been mentioned that the function of the cable transmission means 110 is to propagate a low frequency RF signal throughout the closed environment 104. FIGS. 2a and 2b illustrate two different embodiments for accomplishing this. FIG. 2a shows the cable transmission means 110 implemented as a simple bifilar cable 202 connected to simple radiators 204, such as dipole antennas, that are located throughout the closed environment 104. Power from the low frequency RF signal is then radiated into the closed environment 104 through the simple radiators 204 as well as through the bifilar cable 202 itself. The same bifilar cable 202 may be used to propagate a low frequency RF signal that is received, as described below, within the closed environment 104, for reception by the low frequency port of the first frequency converter 108.

An alternative embodiment of the cable transmission means 110 is shown in FIG. 2b. Here, an inexpensive coaxial cable 206 distributes the low frequency RF signal to a series of simple low cost amplifiers 208, each connected to an antenna 210. The amplifier 208/antenna 210 combinations can be placed at every 100 m along the closed environment. Output power can be maintained at a very low level that is amplified by each successive amplifier 208. Each amplifier 208 should be capable of amplifying signals travelling in two directions, that is, into and out of the first frequency con-

verter 108. The purpose of this two way signal propagation is to permit bidirectional communication between a mobile unit 102 and the BTS 106. This is described in greater detail below.

Another alternative embodiment of the cable transmission means 110 is to use two cables in parallel, each dedicated to propagating a signal in only one direction. For example, the cable transmission means 110 may be embodied by two bifilar cable 202/radiator 204 combinations which are both distributed along the same path in the closed environment 104. In this case, each bifilar cable 202 is dedicated to propagation of a low frequency RF signal in only one direction, either into or out of the first frequency converter 108.

Referring back to FIG. 1, the mobile unit 102 is located inside a vehicle 114, which may be a train car. Associated with the vehicle 114 is a second linear two-way frequency converter 116. The second frequency converter 116 is connected at its low frequency port to a first antenna 118. The first antenna 118 is located on the outside of the vehicle 118 as close as possible to the radiating cable transmission means 110, to enable it to receive and transmit the low frequency RF signal.

The second frequency converter 116 is connected at its high frequency port to a second antenna 220, which transmits and receives the high RF signal inside the vehicle 118.

The first and second frequency converters 108, 116 are phase locked to the system clock so that their output frequencies will be synchronized with one another. This is necessary in order to avoid interference problems if two or more vehicles 114 (only one shown) are close to each other and are receiving signals from the same BTS 106.

With the configuration described above, each vehicle 114 is treated as an extended BTS cell, allowing hand held cellular telephones to be used in the ordinary way.

The above-described system 100, involving the use of frequency conversion, is preferably part of a digital communications system that utilizes a Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), or Code Division Multiple Access (CDMA) method of transmission. However, it could also be used in an analog communications system.

Referring now to FIG. 3, an example is shown in which the vehicle 114 is one car in a train 314 in a subway system. A first BTS 302 is located at a first subway station, and a second BTS 308 is located at a second subway station that is adjacent the first. The first BTS 302 communicates with a mobile unit 322 located on the train 314 by propagating its low RF frequency signal along the first cable transmission means 306, which may preferably be either of the embodiments described above with respect to FIGS. 2a and 2b. As the train 314 moves away from the first station toward the second station, it will be necessary for the first BTS 302 to hand off the call to the second BTS 308. In order to prevent all mobile units 322 from making hand offs at the same time, terminal portions of the first and second cable transmission means 306, 312 should overlap one another. The amount of overlap 324 should be designed to permit the second antenna 320, mounted on the vehicle, to be near both the first and second cable transmission means 306, 312 for several seconds when the train 314 is travelling at a typical speed. For example, the system may be designed to permit the second antenna 320 to be near both the first and second cable transmission means 306 for about 5 seconds when the train 314 is travelling

at a speed of 20 meters per second by allowing terminal portions of the first and second cable transmission means 306, 312 to overlap one another for a length of about 100 meters. This will allow the second antenna 320 to experience a gradual decrease in received power as it leaves the coverage area of the first BTS 302 while at the same time experiencing a gradual increase in received power as it approaches the coverage area of the second BTS 308.

In another feature of the present invention, the two-way frequency converter 316 located inside the train 314 is switched off when the train 314 leaves the tunnel 326 and comes under the coverage of another BTS cell that does not provide service to the closed environment (not shown). Similarly, the frequency converter 316 located inside the train 314 is switched on when the train 314 enters a tunnel 326. The switching on and off of the frequency converter 316 is activated by a magnetic sensor 330, or the like, in the train that senses the emerging entrance into and exit from the tunnel 326, and sends appropriate signals to the frequency converter 316.

It is important to note that when the train 314 leaves the tunnel 326, causing the two-way frequency converter 316 to be switched off, a mobile unit 322 in use at the time must quickly be handed off to an outside BTS cell that does not provide service to the closed environment (not shown). Thus, the outside BTS cell should provide good coverage to the area just outside the tunnel. To achieve this, an outside BTS cell may preferably be placed at the exit of the tunnel 326.

In another feature of the present invention, each BTS 302, 308 has a third antenna 328 which enables it to directly serve any mobile unit being operated at the subway station. Thus, a passenger who is utilizing a mobile unit 322 at a subway station may continue to be serviced by the same BTS 302, 308 as he or she moves from the station platform to the train 322. The same is true when a passenger who is using a mobile unit 322 leaves the train 322 and steps onto a station platform.

The invention has been described with reference to particular embodiment. However, it will be readily apparent to those skilled in the art that it is possible to embody the invention in specific forms other than those of the preferred embodiment described above. This may be done without departing from the spirit of the invention. For example, if only one-way communication is required, then the two linear frequency converters need only be capable of converting signals in one direction. The preferred embodiment is merely illustrative and should not be considered restrictive in any way. The scope of the invention is given by the appended claims, rather than the preceding description, and all variations and equivalents which fall within the range of the claims are intended to be embraced therein.

What is claimed is:

1. In a communications system including a base station and a mobile unit, both operating at a high radio frequency, a repeater system for providing a communications link between the base station and the mobile unit when the mobile unit is located in an environment that is substantially closed off to high radio frequency communication between the base station and the mobile unit, the repeater system comprising:

a first linear two-way frequency converter including:
a high frequency port for two-way coupling to the base station; and

a low frequency port for two-way coupling to a low frequency signal having a frequency that is capable of radiating radio frequency power through the closed environment, the low frequency signal being in a frequency band that is lower than a frequency band of the high frequency port;

cable transmission means connected to the low frequency port of the first linear two-way frequency converter, and located within the closed environment for radiating and receiving the low frequency signal within the closed environment;

a first antenna for wireless coupling to the cable transmission means;

a second linear two-way frequency converter including:

a low frequency port connected to the first antenna for two-way coupling to the low frequency signal; and

a high frequency port for two-way coupling to a high radio frequency signal having a frequency that is compatible with the high radio frequency used by the communications system; and

a second antenna connected to the high frequency port of the second linear two-way frequency converter.

2. The repeater system of claim 1 wherein the first antenna, second linear two-way frequency converter, and second antenna are disposed on a vehicle, and the cable transmission means is distributed along an anticipated path of the vehicle through the closed environment.

3. The repeater system of claim 2 wherein the cable transmission means is associated with a first base station, and a terminal portion of the cable transmission means overlaps, for a predetermined length, a corresponding terminal portion of a cable transmission means associated with a second base station, the predetermined length being sufficient to permit the vehicle to simultaneously pass by the terminal portions of both cable transmission means for at least several seconds when the vehicle is travelling at a predetermined speed away from the first base station and toward the second base station.

4. The repeater system of claim 2 wherein the vehicle further includes a sensor coupled to the second linear two-way frequency converter for alternatively turning the second linear two-way frequency converter on and off in response to respectively sensing the vehicle entering and exiting the closed environment.

5. The repeater system of claim 2 wherein the high radio frequency is in a range of 900 to 2000 megahertz, and the low frequency is in a range of 30 to 300 megahertz.

6. The repeater system of claim 2 wherein the cable transmission means is a bifilar cable.

7. The repeater system of claim 2 wherein the cable transmission means comprises:

a coaxial cable, connected to the first linear two-way frequency converter;

an amplifier having an input connected to the coaxial cable; and

a third antenna connected to an output of the amplifier.

8. The repeater system of claim 2 wherein the first and second linear two-way frequency converters are phase locked to a system clock.

9. The repeater system of claim 2

wherein the base station is located at a passenger station situated along an anticipated path of the vehicle, the base station is coupled to the high frequency port of the first linear two-way frequency converter, and wherein the base station includes a fourth antenna for wireless, high radio frequency coupling to a mobile unit.

10. The repeater system of claim 1 wherein the high radio frequency is in a range of 900 to 2000 megahertz, and the low frequency is in a range of 30 to 300 megahertz.

11. The repeater system of claim 1 wherein the cable transmission means is a bifilar cable.

12. The repeater system of claim 1 wherein the cable transmission means comprises:

a coaxial cable, connected to the first linear two-way frequency converter;

an amplifier having an input connected to the coaxial cable; and

a third antenna connected to an output of the amplifier.

13. The repeater system of claim 1 wherein the first and second linear two-way frequency converters are phase locked to a system clock.

14. In a communications system including a base station and a mobile unit, both operating at a high radio frequency, a method for communicating between the base station and the mobile unit when the mobile unit is located in an environment that is substantially closed off to high radio frequency communication between the base station and the mobile unit, comprising the steps of:

linearly converting a base station high radio frequency signal into a low frequency signal that is capable of radiating radio frequency power into the closed environment, the low frequency signal being in a frequency band that is lower than a frequency band of the high radio frequency signal; using cable transmission means to distribute the low frequency signal within the closed environment; receiving the distributed low frequency signal in a first antenna;

linearly converting the received low frequency signal into a reconverted high radio frequency signal; and using a second antenna to transmit the reconverted high radio frequency signal to the mobile unit.

15. The method of claim 14 wherein the steps of receiving, linearly converting the received low frequency signal, and using a second antenna to transmit are performed on a vehicle.

16. In a communications system including a base station and a mobile unit, both operating at a high radio frequency, a method for communicating between the base station and the mobile unit when the mobile unit is located in an environment that is substantially closed off to high radio frequency communication between the base station and the mobile unit, comprising the steps of:

using a second antenna to receive a high radio frequency signal from the mobile unit;

linearly converting the received high radio frequency signal into a low frequency signal that is capable of radiating radio frequency power into the closed environment, the low frequency signal being in a frequency band that is lower than a frequency band of the high radio frequency signal;

radiating the low frequency signal from a first antenna;

using cable transmission means to receive the low frequency signal within the closed environment;

linearly converting the received low frequency signal into a base station high radio frequency signal; and outputting the base station high radio frequency signal to the base station.

17. The method of claim 16 wherein the steps of using a second antenna to receive, linearly converting the received high radio frequency signal, and radiating are performed on a vehicle.

18. In a communications system including at least one stationary base station and a mobile unit, both operating at a high radio frequency, a mobile base station for providing communication system service to the mobile unit when the mobile unit is located in a vehicle that is travelling in an environment that is substantially closed off to high radio frequency communication between the stationary base station and the mobile unit, the mobile base station comprising:

first means, disposed on the vehicle, for wireless coupling to a cable transmission means, coupled to a stationary base station, for two-way, low fre-

quency signal propagation within the closed environment;

a linear two-way frequency converter, disposed on the vehicle, including:

a low frequency port connected to the first wireless coupling means for two-way coupling to a low frequency signal; and

a high frequency port for two-way coupling to a high radio frequency signal that is compatible with the high radio frequency used by the communications system, the high radio frequency signal being in a frequency band that is higher than a frequency band of the low frequency signal; and

second means, disposed on the vehicle and connected to the high frequency port of the linear two-way frequency converter, for wireless high radio frequency coupling to the mobile unit located in the vehicle.

19. The mobile base station of claim 18 wherein the first wireless coupling means and second wireless coupling means are, respectively, first and second antennas.

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US005260968A

United States Patent [19]

Gardner et al.

[11] Patent Number: 5,260,968

[45] Date of Patent: Nov. 9, 1993

[54] METHOD AND APPARATUS FOR
MULTIPLEXING COMMUNICATIONS
SIGNALS THROUGH BLIND ADAPTIVE
SPATIAL FILTERING[75] Inventors: William A. Gardner, Yountville;
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Calif.[73] Assignee: The Regents of the University of
California, Oakland, Calif.

[21] Appl. No.: 903,627

[22] Filed: Jun. 23, 1992

[51] Int. Cl.⁵ H04K 1/00

[52] U.S. Cl. 375/1

[58] Field of Search 375/1

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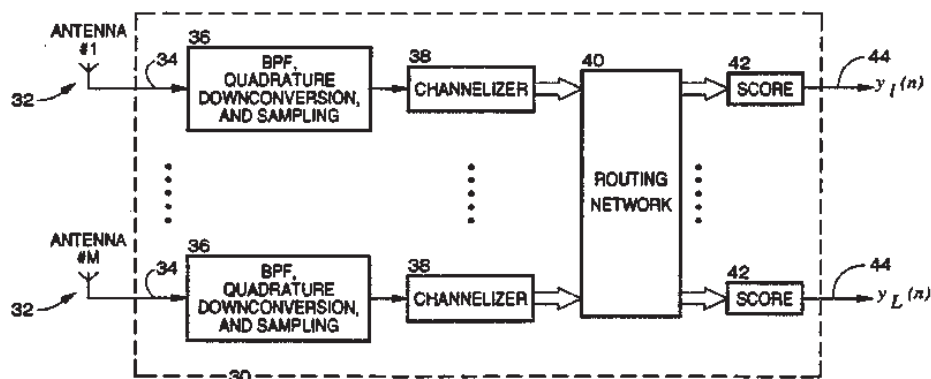
Primary Examiner—David C. Cain

Attorney, Agent, or Firm—John P. O'Banion

[57] ABSTRACT

A method and apparatus for spatial multiplexing of spectrally overlapping communications signals which does not require use of a training signal, computationally intensive direction-finding methods, or antenna calibration is presented. An adaptive antenna array at a base station is used in conjunction with signal processing through self coherence restoral to separate the temporally and spectrally overlapping signals of users that arrive from different specific locations within the locale and to mitigate multipath fading and shadowing at the base station and, by reciprocity, to transmit directly to minimize interfering signals arriving at the mobile (or portable or stationary) units and to mitigate multipath fading and shadowing at the mobile units. The radiation pattern of transmitted signal is matched to the adapted reception pattern of the signal received at the base station.

21 Claims, 10 Drawing Sheets



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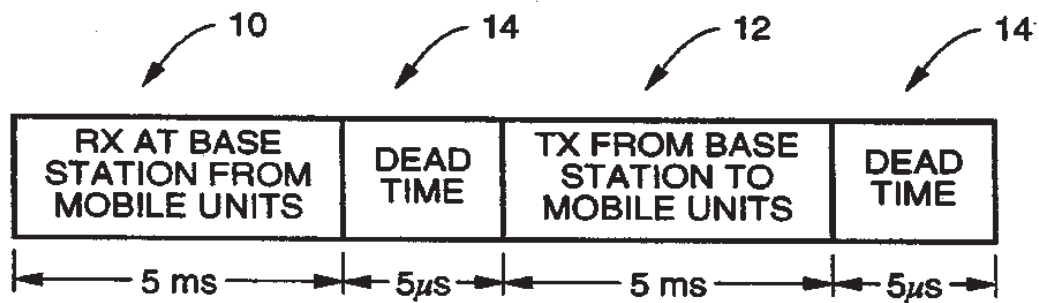


FIG.-1

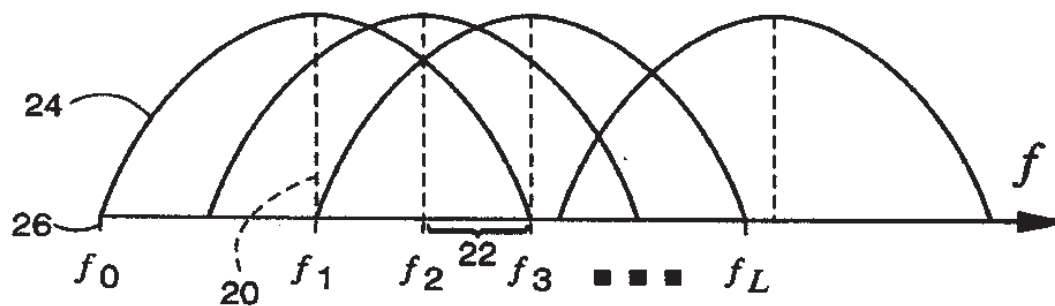


FIG.-2

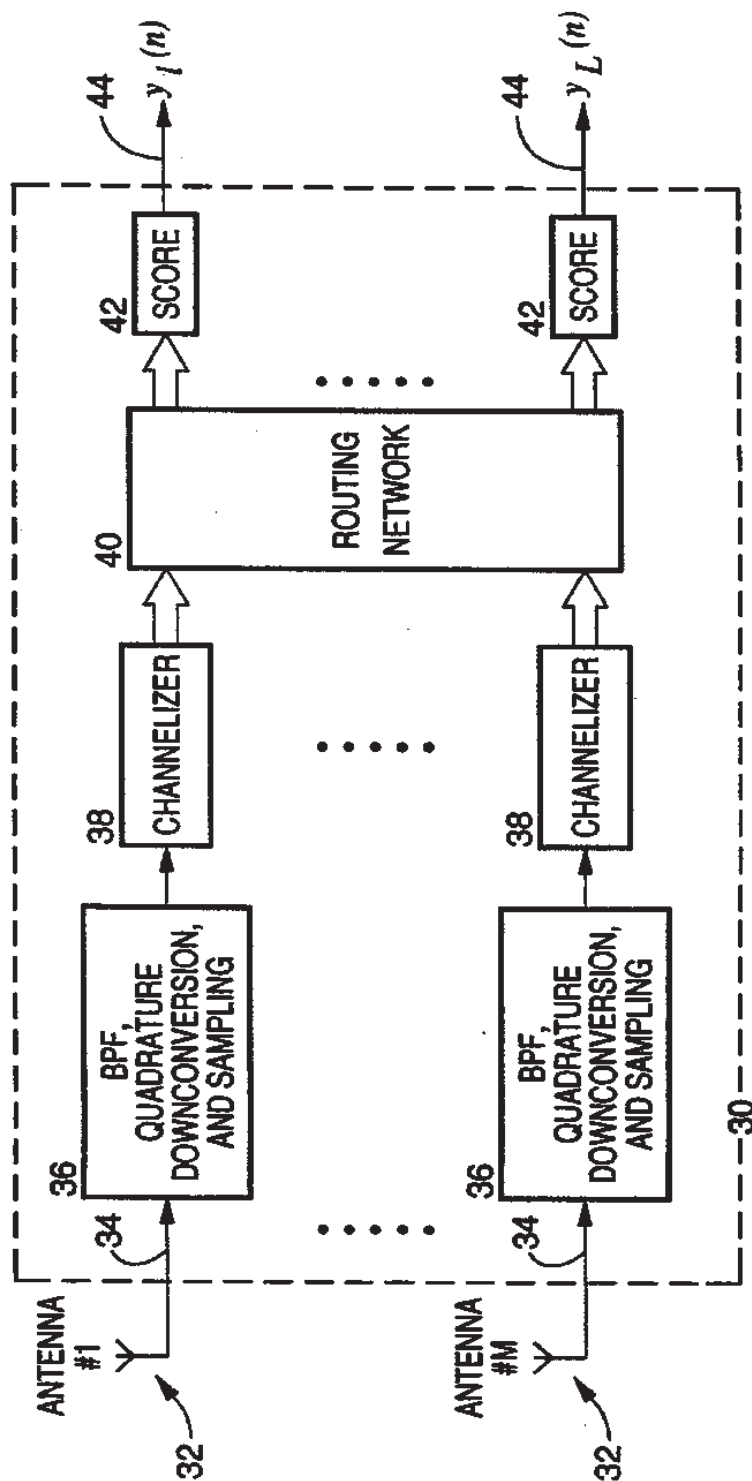


FIG.-3

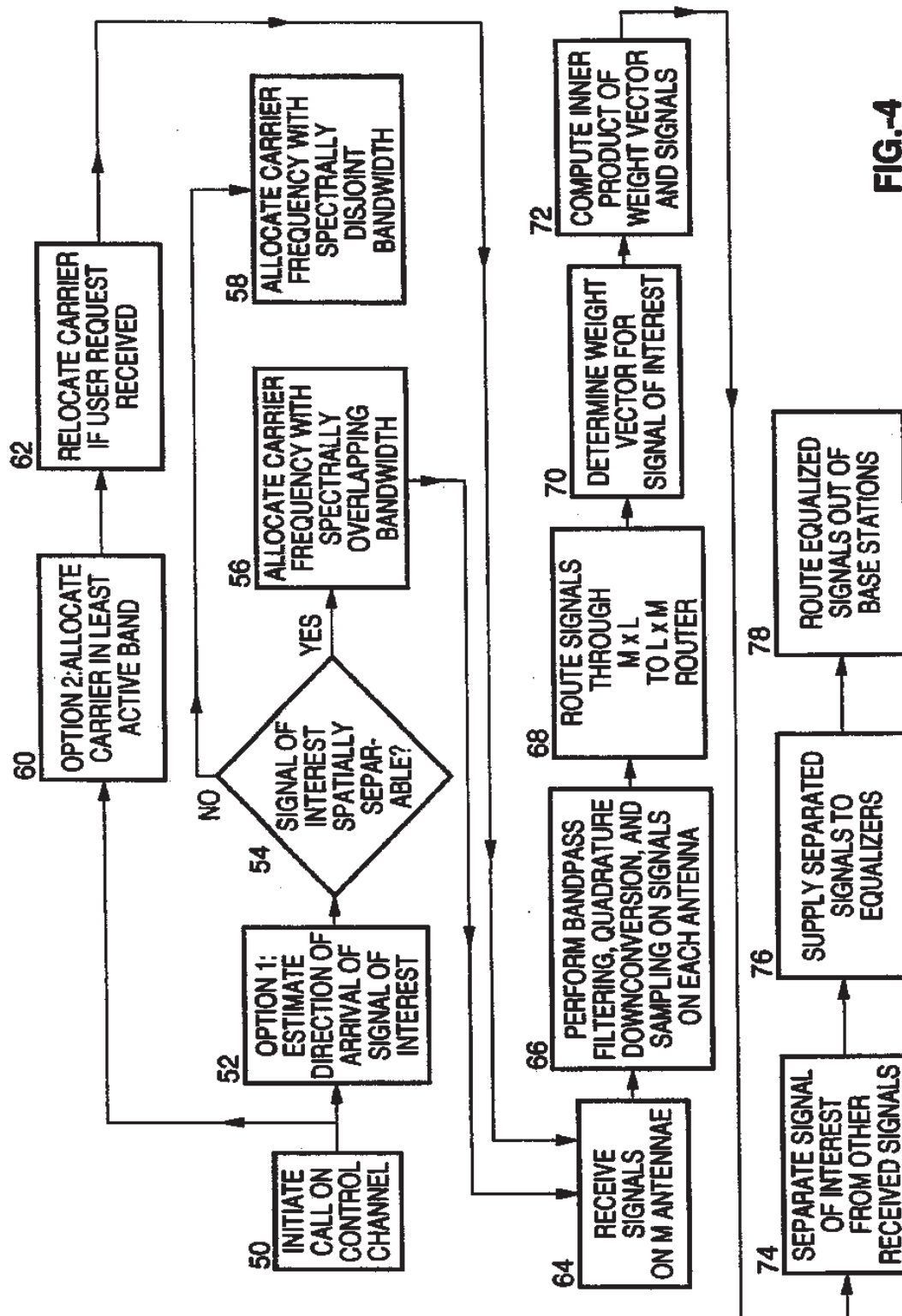


FIG. 4

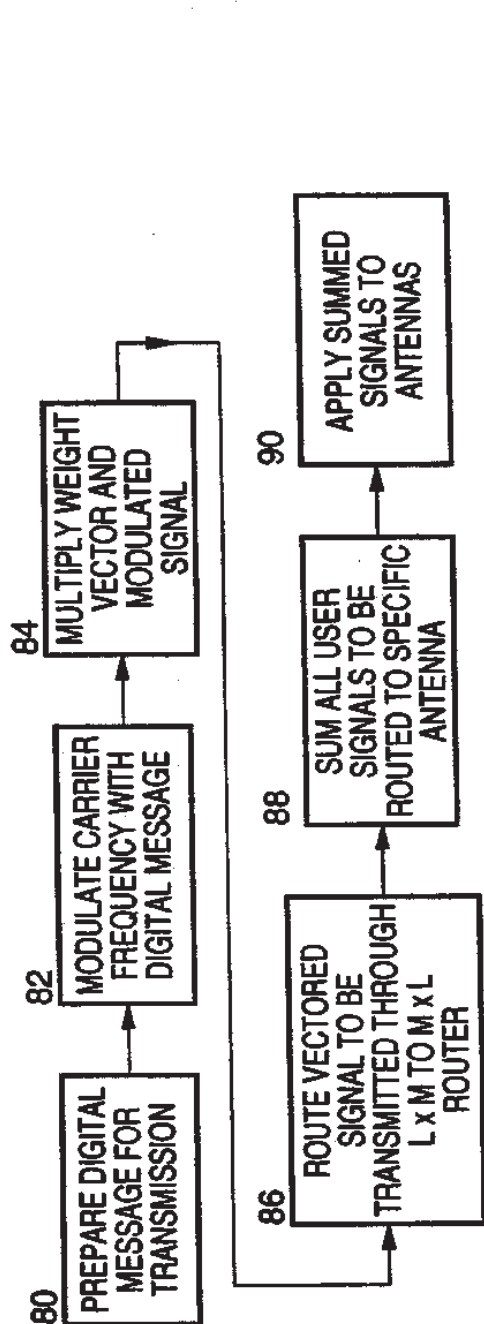


FIG.-5

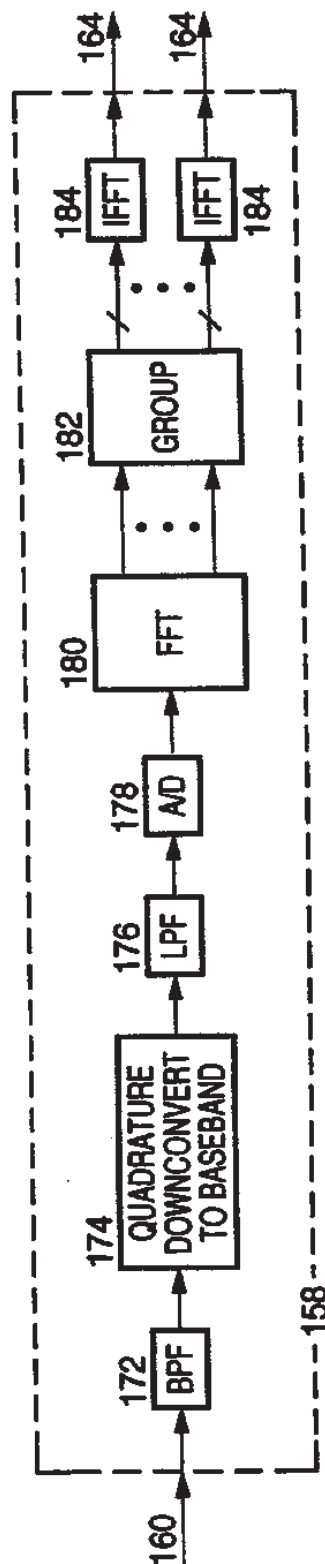


FIG.-9

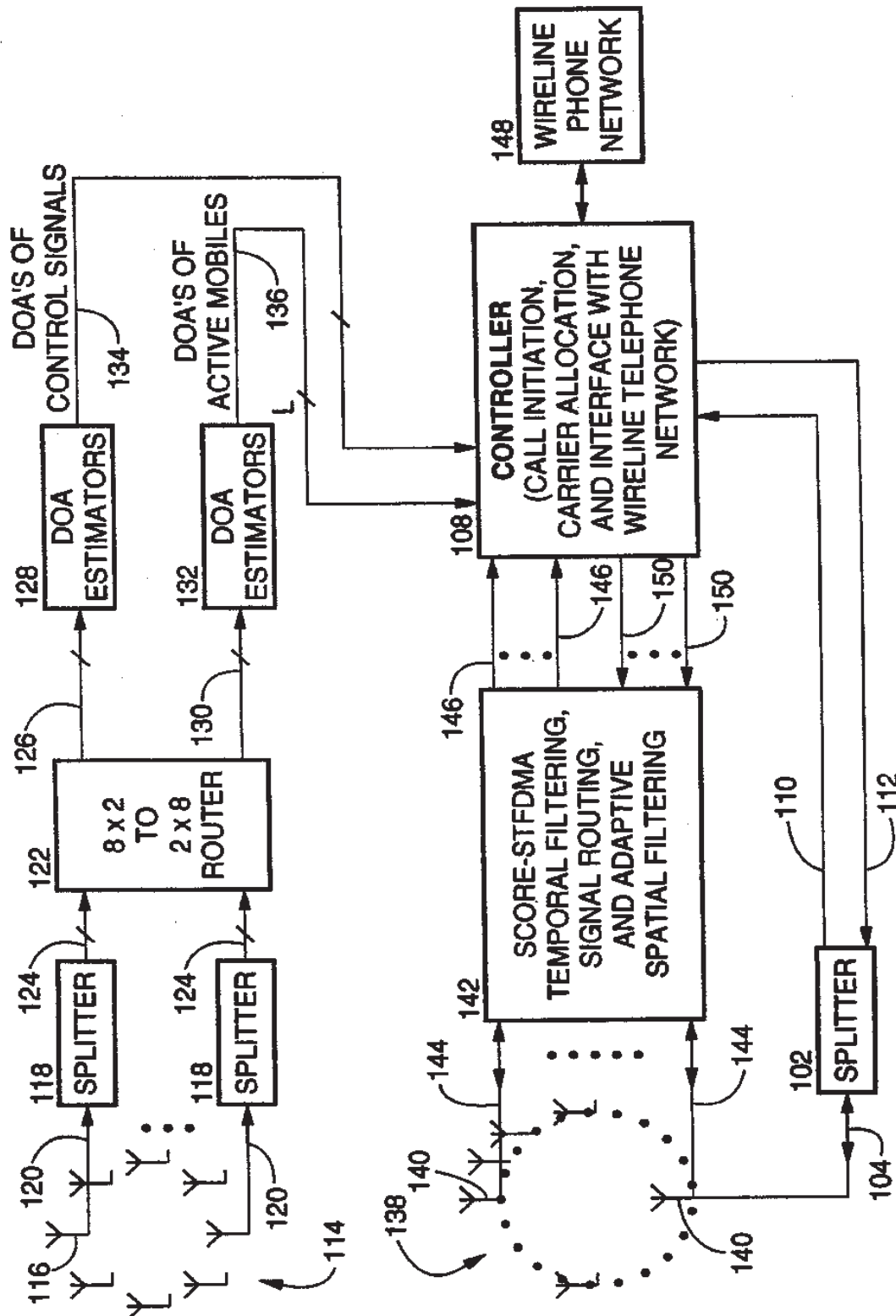


FIG. 6

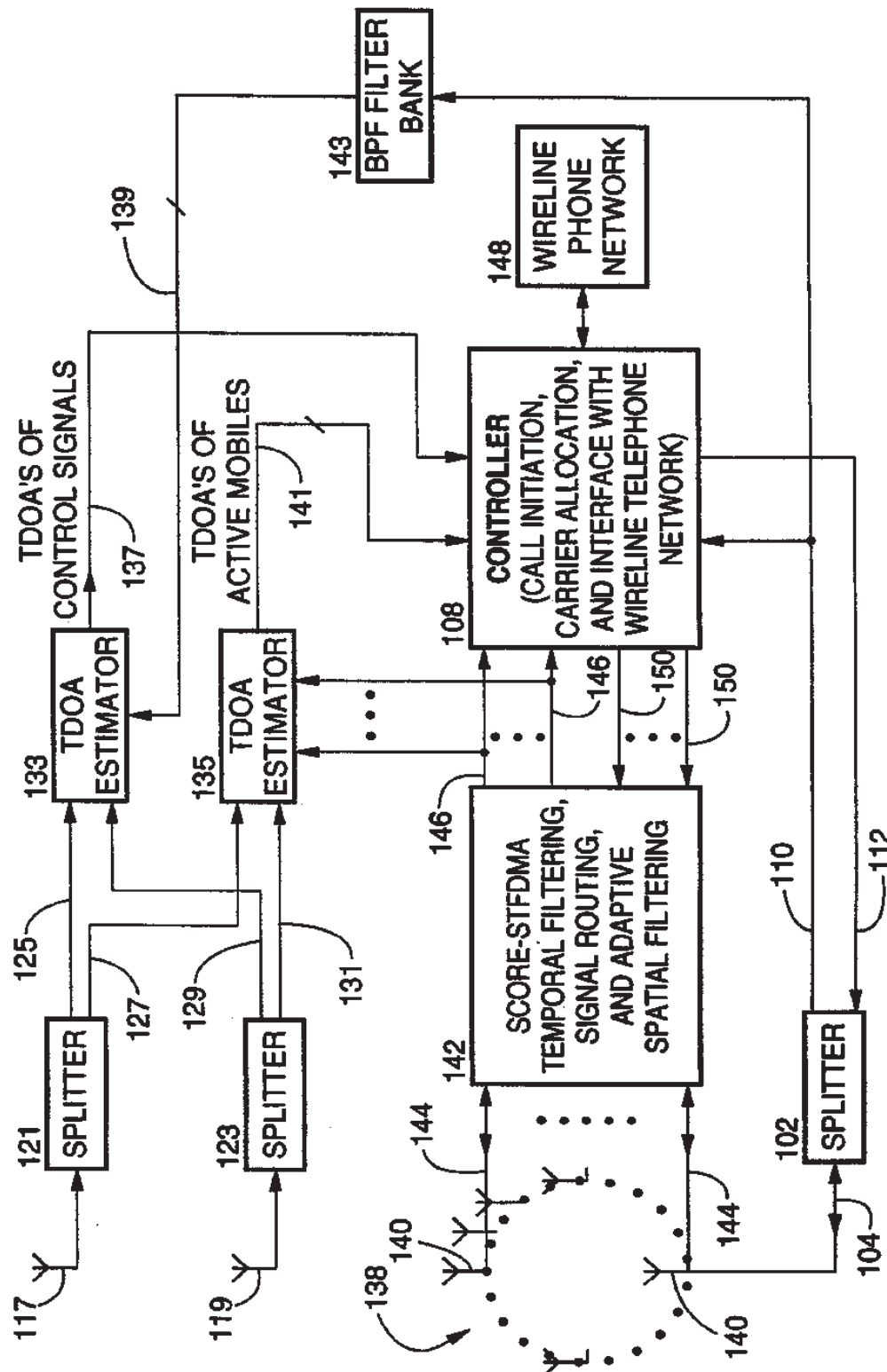


FIG.-7

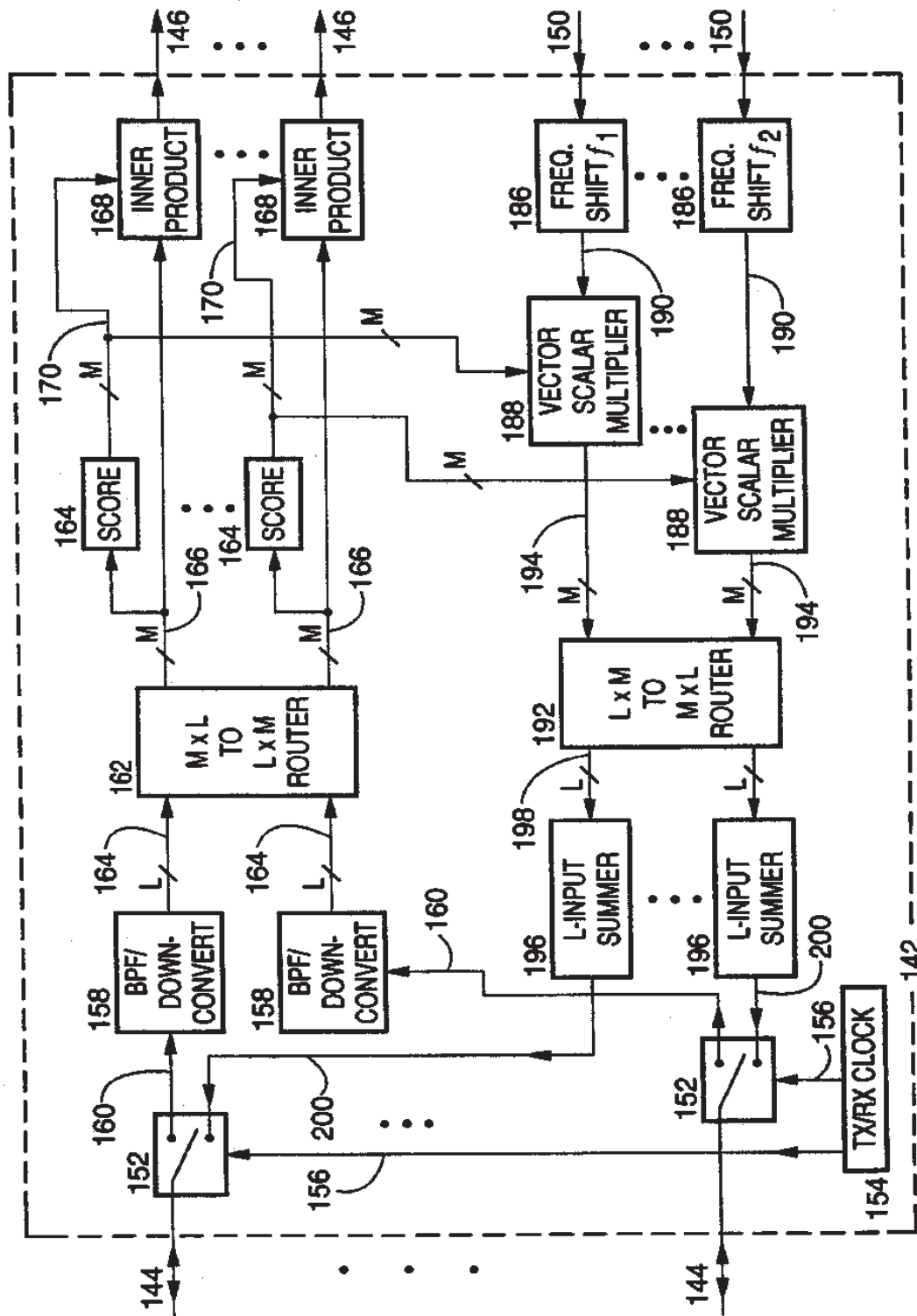


FIG.-8

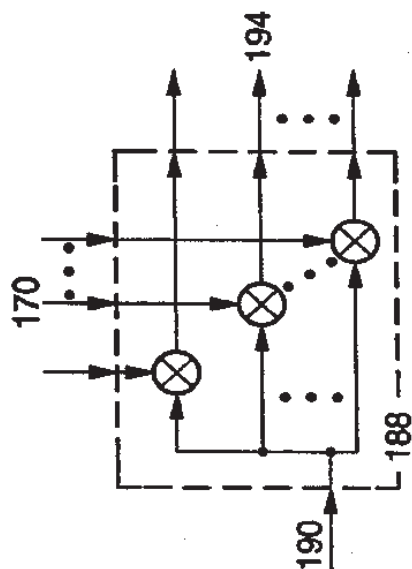


FIG.-10

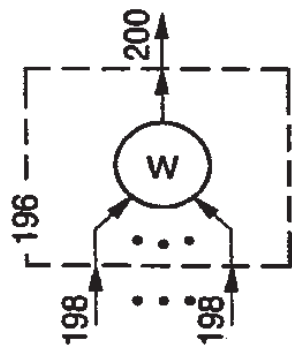


FIG.-11

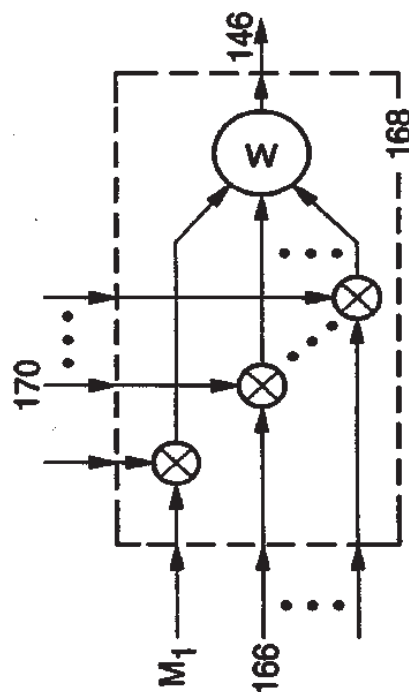


FIG.-12

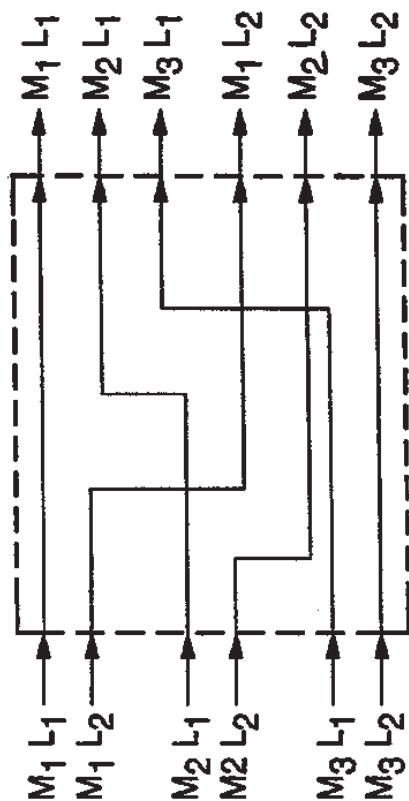


FIG.-13

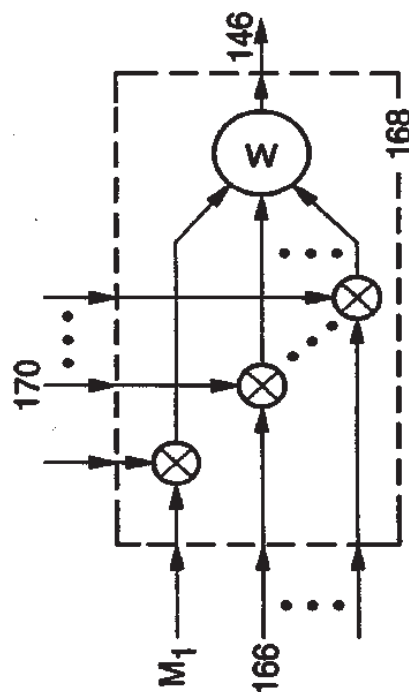


FIG.-14

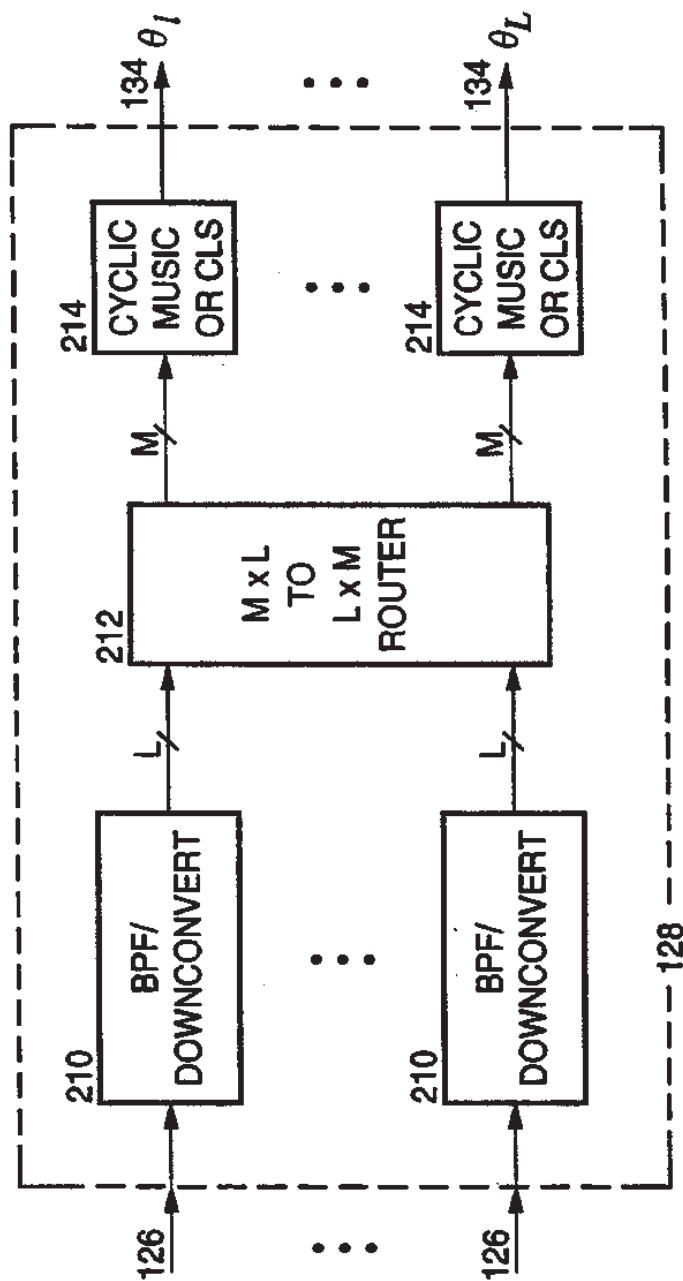


FIG.-15

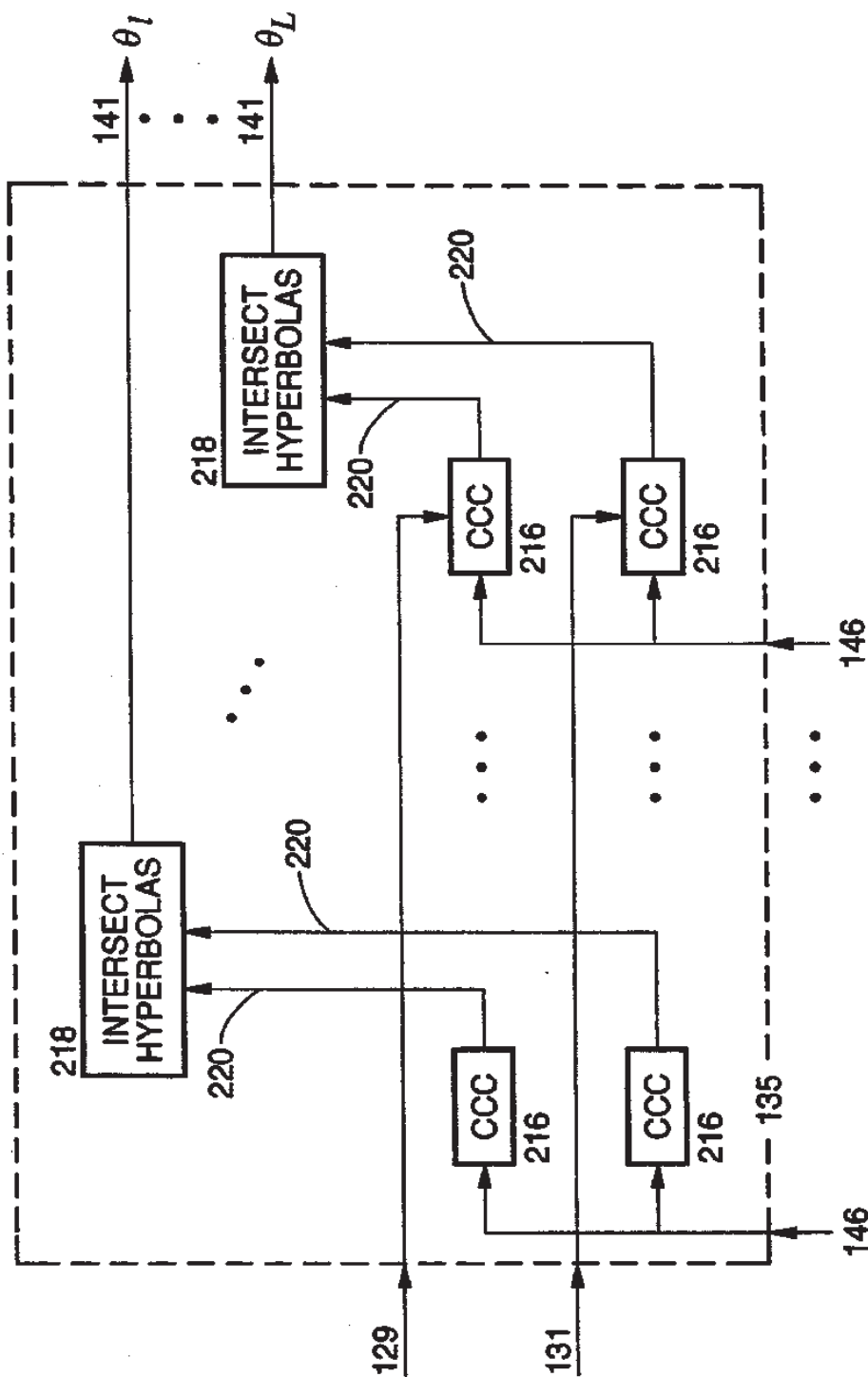


FIG.-16

METHOD AND APPARATUS FOR MULTIPLEXING COMMUNICATIONS SIGNALS THROUGH BLIND ADAPTIVE SPATIAL FILTERING

BACKGROUND OF THE INVENTION

The Government has rights in this invention pursuant to Grant No. MIP-88-12902 awarded by the National Science Foundation.

FIELD OF THE INVENTION

This invention pertains generally to multiplexing radio communications signals, and more particularly to increasing spectral capacity by blind adaptive spatial filtering of spectrally overlapping signals.

DESCRIPTION OF THE BACKGROUND ART

Demand for mobile, portable and stationary personal communication continues to increase as these communication modes become easier to use and more widely available, as they offer a greater variety of services, and as their benefits become more visible. As a result of the increasing demand for a limited number of radio spectrum allocations, new multiplexing techniques that will increase spectral efficiency over conventional multiplexing techniques have been widely sought.

Conventional multiplexing techniques rely solely on frequency, time, or code division to allow multiple users in the same locale to communicate simultaneously with the base station in that locale. These techniques include frequency division multiplexing (FDM)—also called frequency division multiple access (FDMA); time division multiplexing (TDM)—also called time division multiple access (TDMA); and code division multiplexing (CDM)—also called code division multiple access (CDMA).

For FDM, each user's signals occupy separate frequency bands (one for transmit and one for receive) and no other user is assigned to those bands. FDM alone offers very restricted opportunities for increasing spectral efficiency, namely different spectrally efficient modulation schemes, but the potential of such schemes is limited by the severity of the radio communications environment and, even in the most benign environment, the maximum capacity is relatively low.

For TDM, all users occupy the same frequency band, and each is allocated a time slot within which transmission and reception can occur. The frequency bandwidth of each user's signal can be much greater than that in FDM, but a synchronized access scheme is needed to prevent multiple users' signals from being active simultaneously. TDM alone offers no increase in spectral efficiency and requires a complicated access protocol. The inactivity time in typical speech is already exploited in many speech compression methods, so this redundancy has already been used up.

For CDM (using direct-sequence spread spectrum signals), all users' signals occupy the same band and can be active simultaneously. Each user is assigned a unique spreading code which is used at the receiver to separate a desired user's signal from the rest. CDM offers some limited increases in spectral efficiency but requires power control methods that can be difficult to implement in severe fading environments. There can also be some burden in managing the distinct codes that are assigned to the users.

As a result, space division multiplexing (SDM)—also called space division multiple access (SDMA)—was developed to employ spatial filtering to separate spectrally overlapping signals from different users. For SDM, a system can separate a desired user's signal from the rest if its spatial characteristics (e.g., direction of arrival) are sufficiently different from those of the other users. SDM can multiply spectral efficiency by a factor equal to the number of spatially separable channels sharing a spectral band. Since this number can be roughly equal to the number of elements in the antenna array (which can practically be on the order of 100 depending on physical and/or cost limitations at the base station), potentially large increases in spectral efficiency are possible. Transmission power can be reduced, thereby reducing the interference level for other users and increasing mobile (or portable) battery life. Also, reduction or elimination of multipath fading can improve the received signal quality. However, except for variations of these techniques that use fixed multibeam or multisector antennas to further increase capacity, none of them fully exploits the multiplicity of spatial channels that arises because each user occupies a unique spatial location. SDM techniques adapt the antenna array either by estimating the directions of arrival of the spectrally overlapping signals and then using these estimates to compute appropriate weights for the spatial filter, or by minimizing the time-averaged squared error between a known training signal and the output of the spatial filter.

Several methods for adaptively adjusting spatial filters based on antenna arrays have been heretofore developed.

For example, in the "known reference signal" approach, a reference signal is transmitted in addition to the message signal. As a result, channel capacity for the message is reduced, especially as the severity of the environment increases the need for adaptation and as the number of elements in the antenna array is increased. When TDM of reference and message signal is used, receiver complexity is increased, some start-up overhead is incurred in assigning training codes, and signal bandwidth must be increased to compensate for reduced message capacity.

With the "time redundancy" approach, each user has a unique message block length (which is an extra complication), and a given block is transmitted twice (which reduces effective capacity by 50 percent).

With the "frequency redundancy" approach, the message is transmitted at two different carrier frequencies, which reduces effective capacity by 50 percent.

With the "DF-based beamforming" approach, for moderately to widely separated multipath reflections, and for a large number of sources in a frequency band (which is desirable for increased spectral efficiency), direction-finding (DF) based methods are impractical or unusable and incur prohibitive computational expense. Array calibration problems also arise.

It can be seen therefore, that SDM versions based on direction estimation have numerous disadvantages, including computationally intensive algorithms, poor performance in the presence of multipath signals arriving from different directions, the need to measure, store, and update array calibration data, and considerable sensitivity to errors in the array calibration data. Versions that require a training signal have different disadvantages, including the need to use spectral capacity to periodically transmit the training signal, the need to

synchronize the received and locally generated copies of the training signal, and the need to adaptively increase or decrease the duration of the training signal to accommodate varying levels of interference.

Therefore, there is a need for a spatial filtering method of multiplexing communications signals which overcomes the foregoing deficiencies. The present invention fulfills that need.

SUMMARY OF THE INVENTION

The present invention pertains generally to spatial filtering techniques, and more specifically to adaptive space, time and frequency multiplexing. This multiplexing method is neither dependent on direction of arrival estimation nor on use of a reference or training signal.

By way of example and not of limitation, an adaptive antenna array at a base station separates temporally and spectrally overlapping received signals of different users and transmits directly to each user, exploiting multipath when present. The invention uses the technique of restoring the spectral coherence of a received signal of interest impinging on an array of antennas in order to adapt the spatial filter for reception at the base station and determine the optimum reception pattern for the signal, which filter can be reused for transmission with a radiation pattern equal to that of the adapted reception pattern. Unlike schemes that rely solely on frequency, time, or code division multiplexing and thus use only one spatial channel, the present invention exploits space as well as partial time and frequency division multiplexing (STFDMA) and thus uses multiple spatial, temporal, and spectral channels. Users whose signals arriving at the base station are spatially separable are assigned to spectral bands that overlap, and users whose signals arriving at the base station are spatially inseparable are assigned to disjoint spectral bands. Also, signals coming from the individual users can be assigned to time intervals that are interleaved with those assigned to signals coming from the base station. Under the assumption that users are sufficiently well distributed throughout a geographical area, all available spatial and spectral channels can be used effectively. Since the number of multiple spatial channels that can be separated from each other by the antenna array is approximately equal to the number of antenna elements in the array (which can be quite large), overall capacity can be much greater than schemes using a single spatial channel. Also, unlike adaptive array schemes that require direction estimation processors or known training signals, the present invention uses a property restoral method to exploit some property, such as the spectral redundancy (cyclostationarity or spectral correlation or spectral coherence), that is already present in essentially all digital communication signals and thus does not require array calibration data or computationally intensive multidimensional searches for direction finding (DF). Nor does it waste channel capacity by transmitting a training signal.

An object of the invention is to increase the communications capacity of limited spectral allocations.

Another object of the invention is to provide for overlapping spectral channels without unacceptable interference between users.

Another object of the invention is to spatially filter communications signals without the need for a training signal.

Another object of the invention is to spatially filter communications signals without the need to determine direction of arrival.

Another object of the invention is to blindly adapt an antenna array.

Another object of the invention is to mitigate multipath fading and shadowing of received signals.

Another object of the invention is to directly transmit signals to users from a base station without employing direction finding techniques.

Further objects and advantages of the invention will be brought out in the following portions of the specification, wherein the detailed description is for the purpose of fully disclosing preferred embodiments of the invention without placing limitations thereon.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more fully understood by reference to the following drawings which are for illustrative purposes only:

FIG. 1 diagrammatically shows the typical time multiplexing windows employed in the present invention.

FIG. 2 diagrammatically shows the partial frequency division multiplexing employed in the present invention.

FIG. 3 is a functional block diagram showing a generalized receiver employing the present invention.

FIG. 4 is a flow diagram showing the general reception steps of the present invention.

FIG. 5 is a flow diagram showing the general transmission steps of the present invention.

FIG. 6 is a functional block diagram of one embodiment of an overall communications system employing the present invention.

FIG. 7 is a functional block diagram of an alternative embodiment of an overall communications system employing the present invention.

FIG. 8 is a schematic block diagram of one embodiment of the temporal filtering, signal routing and adaptive spatial filtering element shown in FIG. 6 and FIG. 7.

FIG. 9 is a schematic block diagram of one embodiment of a bandpass filtering and downconversion element shown in FIG. 8.

FIG. 10 is a schematic block diagram of one embodiment of a splitter element shown in FIG. 6 and FIG. 7.

FIG. 11 is a schematic block diagram of one embodiment of an input summer element shown in FIG. 8.

FIG. 12 is a schematic block diagram of one embodiment of a vector scalar multiplier element shown in FIG. 8.

FIG. 13 is a schematic block diagram of one embodiment of an inner product element shown in FIG. 8.

FIG. 14 is a partial schematic diagram showing the typical configuration of a signal router element shown in FIG. 8.

FIG. 15 is a schematic block diagram of one embodiment of a direction of arrival estimator element shown in FIG. 6.

FIG. 16 is a schematic block diagram of one embodiment of a time difference of arrival estimator elements shown in FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring more specifically to the drawings, for illustrative purposes the present invention is embodied in the drawings of FIG. 1 through FIG. 16. It will be appreciated that the method of the present invention

may vary as to specific steps and their order of implementation, and that the apparatus of the present invention may vary as to configuration and as to details of the parts without departing from the basic concepts as disclosed herein.

The conventional transmit/receive configuration for multiuser cellular communication consists of a base station through which all users in a given cell communicate. The base station then communicates with other base stations and with a central switching office to provide cell-to-cell communication and cell-to-wire-line communication, respectively, for the individual users. Communication among base stations is not, in the usual sense, multiuser communication and, therefore, is not presented herein.

Communication between individual users in a cell and the base station in that cell can, in principle, exploit SDMA by performing adaptive spatial filtering at either each user's location or the base station or both. However, adaptive arrays at the mobile unit (or the portable or stationary personal unit) are prohibitively expensive and subject to neglect or abuse by the users. Also, adaptive spatial filtering at the mobile unit is unlikely to be effective since the signals from the base station and the other interferers can arrive from a nearly uniform angular spread over 360 degrees (due to scattering, for example, from buildings, other cars, and the ground in the mobile communication environment). Therefore, in the present invention the existing single omnidirectional antenna at the mobile unit is retained, but a multi-element antenna array is used at the base station.

Spatial filtering as disclosed herein requires the use of a multi-element antenna array with a large number of elements. Therefore spatial adaptation occurs only during the transmission from the mobile unit to the base station; transmission from the base station to the mobile unit must use a spatial filter that is developed during said adaptation. In addition, the spatial filtering method of the present invention is frequency dependent and, therefore, both directions of transmission must use the same carrier frequency. In order to use the same frequency for duplex communications, the present invention also employs time division multiplexing of the signals from the base station and the users. That is, reception at the base station from all mobile units is temporally separated from transmission from the base station to all mobile units. The base station transmits to the user unit for some time period T , the user then transmits to the base station for time period T , and the cycle repeats.

Therefore, spatial filtering at the base station separates spectrally and temporally overlapping signals of multiple users during transmission from and reception at the base station. The lack of direct spatial filtering at the mobile unit does not imply, however, that mobile units must be prevented from interfering with each other, because the TDM scheme employed by the present invention insures that all mobile units transmit at the same time during one time period, and that they all receive at the same time in another time period.

During the time period that the signals are received by the base station, the base station blindly adapts its antenna array using the spectral coherence restoral (SCORE) method of the present invention. With SCORE, spectral redundancy already present in the signal is exploited and the weights of spatial filters are computed while the received data is saved.

To understand use of the SCORE method for blindly adapting an antenna array, let the vector $x(n)$ denote the

sampled complex envelopes of the output signals of M antennas having an arbitrary geometric arrangement and arbitrary directional characteristics (but preferably omnidirectional). To maximize spatial resolution while preventing grating lobes (ambiguities), the antennas are typically separated by approximately one half of the wavelength corresponding to the highest frequency in the reception band. It should be noted that this geometry is fundamentally different from that used in most space diversity systems, in which antennas are spaced many wavelengths apart so as to decorrelate multipath propagation parameters at the different antennas. Also, let $y(n) \triangleq w^H x(n)$ be the output of the spatial filter, where w is referred to as the weight vector representing a set of weights that realize the reception pattern of the signal of interest as it impinges on the array of antennas and which are used to extract the signal of interest. By choosing w appropriately, an adaptive receiver can enhance (steer beams in the direction of) desired signals, attenuate (steer nulls in the direction of) undesired signals, and minimize the contribution of additive noise (through coherent processing gain and by minimizing the height of sidelobes in the antenna pattern). In general, the sum of the number of beams and the number of nulls that can be controlled is equal to one less than the number M of antenna elements.

Instead of choosing w to maximize the degree of correlation between $y(n)$ and a known training signal as is typically done in conventional schemes, the SCORE method chooses w and an auxiliary spatial filter c to maximize the degree of correlation (correlation coefficient) between $y(n)$ and an auxiliary output signal $u(n) \triangleq c^H x(n - \tau) e^{j2\pi\alpha n}$.

$$\max_{w, c} \frac{|R_{yu}|^2}{R_{yy}R_{uu}} \rightarrow \max_{w, c} \frac{|w^H R_{yx}^H(\tau) c|^2}{[w^H R_{xx} w] [c^H R_{xx}^* c]} \quad (1)$$

Since R_{yu} is the cyclic cross-correlation between the spatial filter output $w^H x(n) = y(n)$ and the conjugated auxiliary spatial filter output $c^H x^*(n - \tau)$, then the quantity being maximized in equation (1) is a measure of the degree of conjugate spectral coherence between these two spatial-filter outputs. Since the presence of interfering signals and noise that corrupt the signal of interest in $x(n)$ decreases the degree of conjugate spectral coherence by increasing the denominator in equation (1) relative to the degree exhibited by the uncorrupted signal of interest, then spatial filtering with w and c to maximize the correlation coefficient as in equation (1) can be interpreted as restoring conjugate spectral coherence. Thus, the criterion in equation (1) is referred to as spectral coherence restoral (SCORE). Also, since R_{yu} can be interpreted as the Fourier coefficient for the regenerated sine wave at frequency α in the product waveform $[w^H x(n)][c^H x^*(n - \tau)]$, then the SCORE method can be seen to maximize the average power of this sine wave relative to the average powers of the waveforms $w^H x(n)$ and $c^H x^*(n - \tau)$. Under the assumption that L_α signals have cycle frequency α , it can be shown that the solutions to the equation in (1) are given by the L_α most dominant eigenvectors w_l , for $l = 1, \dots, L_\alpha$ that satisfy

$$R_{xx} e^{j\alpha\tau} R_{xx}^* x_{\alpha-1} R_{xx} e^{j\alpha\tau} w_l = \lambda_l R_{xx} w_l \quad (2)$$

and similarly for c .

It should be noted that only the most dominant eigenvector of equation (2) is needed when only one signal

exhibits cyclic conjugate correlation at the chosen value of α , in which case the matrix product on the left-hand side of equation (2) has rank equal to one, and thus this eigenvector can be found using a simple iteration based on the power method of computation. In the present invention, this is true in the absence of multipath reflections of the desired signal. In the presence of K spatially separable multipath reflections of the desired signal, each of the $K+1$ most dominant eigenvectors extracts a linear combination of the multipath reflections; thus, the most dominant eigenvector can still be used to extract the desired signal, although an adaptive equalizer might be required to mitigate the smearing of the signal in time if the delay spread of the multipath is too great.

Alternatively, note that the desired signals (those having cycle frequency α) are the only ones common to both $x(n)$ and $x(n-\tau)^*e^{j2\pi\alpha n}$ in the sense that the correlation between these two data sets is asymptotically equal to the correlation between the components due to the desired signals and their frequency-shifted and conjugated versions. From this point of view, estimating the desired signals is equivalent to estimating the common factors of the two data sets $x(n)$ and $x(n-\tau)^*e^{j2\pi\alpha n}$. Common factor analysis (also called canonical correlation analysis) is a well-known technique in multivariate analysis. Formulating the problem in this way leads to exactly the same solution of equation (2). The SCORE method can also estimate the desired signals that are common to both $x(n)$ and $x(n-\tau)e^{j2\pi\alpha n}$, in which case the conjugation symbols $*$ are dropped from equation (2), although this variation is not required in the present invention.

It should be noted that the SCORE method is based upon the cyclostationarity exhibited by a signal. A vector-valued complex envelope $x(n)$ exhibits cyclostationarity if it is correlated with either a frequency-shifted version of itself (i.e., if it exhibits spectral coherence) for any nonzero frequency shift α or a conjugated and frequency-shifted version of itself for any frequency shift α . Mathematically, this correlation (or spectral coherence) is expressed in terms of the cyclic autocorrelation matrix

$$R_{xx}^{\alpha}(\tau) \quad (3)$$

or the cyclic conjugate correlation matrix

$$R_{xx}^{*\alpha}(\tau) \quad (4)$$

respectively, where

$$R_{xx}^{\alpha}(\tau) \triangleq [x(n)x(n-\tau)H e^{-j2\pi\alpha n}]_{xx} \quad (5)$$

$$R_{xx}^{*\alpha}(\tau) \triangleq [x(n)x(n-\tau)^*e^{-j2\pi\alpha n}]_{xx} \quad (6)$$

with

$$\langle f(n) \rangle_N = \frac{1}{N} \sum_{n=0}^{N-1} f(n) \quad (7)$$

and where $(\cdot)^T$ and $(\cdot)^H$ denote the matrix transposition and matrix conjugate transposition operators, respectively. The values of α for which either of these correlation matrices are nonzero are the cycle frequencies of the signals comprising $x(n)$. Since equations (3) and (4) can be reinterpreted as the Fourier coefficients for the matrices of conjugate and nonconjugate lag-product waveforms $x(n)x(n-\tau)^H$ and $x(n)x(n-\tau)^T$, then it can be seen that $x(n)$ exhibits cyclostationarity (or spectral

coherence) if and only if the lag-product waveforms contain finite-strength additive sine-wave components with frequency equal to the cycle frequency α . That is, cyclostationarity means that sine waves can be generated by multiplying the signal by a delayed and possibly conjugated version of itself. Most digital communication signals exhibit cyclostationarity as a result of the periodic sampling, gating, keying, and mixing operations in the modulator. For example, the cycle frequencies of binary phase shift keying (BPSK) are equal to the doubled carrier frequency offset, harmonics of the baud rate, and sums and differences of these. More specifically, if $x(n)$ contains a BPSK signal having carrier offset f_c (relative to the frequency of the downconverter) and baud rate f_b , then $R_{xx}^{\alpha}(\tau)$ is not identically zero for $\alpha = kf_b$ for integers k , and $R_{xx}^{*\alpha}(\tau)$ is not identically zero for $\alpha = 2f_c + kf_b$ for integers k . The useful values of τ in the correlation matrices are typically between 0 and $\frac{1}{f_b}$. The only case of particular interest in the present invention is the fact that for a scalar BPSK signal having carrier frequency offset f_c , the magnitude of the cyclic conjugate correlation $R_{xx}^{*\alpha}(\tau)$ is maximized at $\tau=0$ regardless of the pulse shape. Measurements of these two types of cyclic correlations are useful because they select contributions from only the signal components that exhibit the specified cyclostationarity property and discriminate against all others. This is analogous to the property that measurements of the correlation between a desired signal corrupted by additive interference and noise and an uncorrupted version of the desired signal (e.g., the training signal) select only the contributions from the desired signal and discriminate against all others. The utility of exploiting cyclostationarity to gain signal-selectivity has been demonstrated for many applications, including adaptation of antenna arrays, estimation of directions of arrival, estimation of time difference of arrival, detection, and the like.

Referring to FIG. 1, during the receiving and adaptation phase 10, the weights of the spatial filters are computed. At the end of that phase, the weights are applied to the received data to separate the signals sent by the mobile units. During the transmission phase 12, the weights computed in the receiving phase 10 are used to direct the transmission of each outgoing signal to the appropriate mobile unit. The duration of the phases is limited here primarily by the reciprocal of the fast fading rate (the maximum rate is approximately 100 fades/second, so the duration of each phase can be about half the reciprocal, or 5 milliseconds) because the propagation conditions must remain relatively constant over this time for the spatial filtering to be effective. A "dead time" 14 during which neither reception nor transmission occurs is inserted between each phase to allow the trailing edges of the signal from or to the farthest mobile unit to arrive at their destination and to allow the microwave hardware at the base station and the mobile unit to switch between transmission and reception modes (since the same spectral band is used for both). This dead time is negligible (approximately 5 microseconds in a cell having radius of 1 mile) compared to the reception and transmission times (approximately 5 milliseconds). The cycle summarized in FIG. 1 is then repeated.

To avoid the waste of channel capacity and additional synchronization difficulties that occur when a training signal is used to adapt the array, the SCORE method of blind adaption is used to separate signals

based on their differing carrier frequencies. Thus, the SCORE method represented by equation (2) is implemented for each active user in the cell. Although it is conceivable that differing baud rates could also be used to separate signals, the additional complexity of accommodating a unique baud rate for each user is prohibitive.

Consequently, as can be seen in FIG. 2, each mobile unit is assigned a unique carrier frequency (accomplished during call initiation and hookup) according to the relationship

$$f_1 = f_0 + (l) f_{sep} \text{ for } l = 1, \dots, L \quad (8)$$

where f_1 is the carrier frequency 20 of the user numbered 1, f_0 is the lowest frequency 26 in the reception band, f_{sep} is the separation 22 between adjacent carrier frequencies, and L is the maximum number of users that can be accommodated in the cell. The choice of f_{sep} is determined by the maximum Doppler shift (about 100 Hertz in the land mobile cellular radio environment), and by some convergence-time considerations in the SCORE method, namely the time required for an estimate of a cyclic conjugate correlation to adequately reject contributions from signals having adjacent carrier frequencies (at least 100 Hertz separation is required for adequate rejection in the 5 milliseconds during which adaptation occurs; this follows because the cycle resolution of the measurement of the cyclic conjugate correlation matrix, and thus the minimum separation of the doubled carriers, is equal to the reciprocal of the averaging time). The value of f_{sep} is also limited by the maximum number of spectrally overlapping signals 24 that can be separated by the antenna array. Because transmission from the base station to each mobile unit is highly directional, a smaller frequency reuse distance, such as three, can be tolerated in the present invention than in the conventional analog frequency modulation (FM) scheme in which it is seven. The success of the SCORE-STFDMA method depends on the ability to use spatial filters to spatially separate spectrally overlapping signals and the ability to use conventional spectral filters to separate spatially inseparable signals. This frequency allocation method coupled with the use of the SCORE method accomplishes this under the assumption that spatially inseparable users can be assigned to disjoint spectral bands. One approach to accomplish this is to obtain and use knowledge of the directions of arrival of the signals from the mobile units. This in turn can be accomplished either by using a location sensing device (e.g., global positioning system) in each mobile unit, which could be prohibitively expensive, or by using the signal-selective Cyclic MUSIC or Cyclic Least Squares (CLS) direction estimation methods at the base station, or by using the signal-selective Cyclic Cross Correlation (CCC) time-difference-of-arrival (TDOA) estimation algorithm at the base station and one or two auxiliary reception sites within the cell.

In the Cyclic MUSIC approach, we measure

$$R_{xx}^{\alpha}(\tau) = \langle x(n)x(n-\tau)^T e^{-j2\pi\alpha n} \rangle_N$$

where α equals twice the carrier frequency of the desired user. We then compute the singular value decomposition

$$R_{xx}^{\alpha}(\tau) = U \Sigma V^H$$

of $R_{xx}^{\alpha}(\tau)$ where U and V are $M \times M$ unitary matrices and Σ is diagonal with elements $\sigma_1, \dots, \sigma_M$ arranged in

descending order $\sigma_1 \geq \dots \geq \sigma_M \geq 0$. Then, we search for the highest peak in the function

$$P(\theta) = |U_1^H a(\theta)|$$

where the corresponding value of θ is the estimated direction of arrival of the desired user, U_1 is the first column of U , and $a(\theta)$ is the array response vector for angle θ and is typically known for many values of θ equally spaced from 0 degrees to 360 degrees.

In the CLS method, we measure

$$R_{xx}^{\alpha}(\tau) = \langle x(n)x(n-\tau)^T e^{-j2\pi\alpha n} \rangle_N$$

where α equals twice the carrier frequency of the desired user. We also measure $R_{xx}^{\alpha}(\tau) = \langle x(n)x(n)^T \rangle_N$ and compute

$$R = R_{xx}^{\alpha}(\tau) R_{xx}^{\alpha}(\tau)^{-1} R_{xx}^{\alpha}(\tau)^H$$

and search for the highest peak in the function $P(\theta) = a(\theta)^H R a(\theta)$. The corresponding value of θ is the estimated direction of arrival of the desired user.

The Cyclic MUSIC and CLS approaches, however, require the use of a calibrated array, but this array can be much smaller (e.g., only 4 elements) than the one used for spatial filtering because a unique carrier frequency is assigned to each mobile unit and these methods are signal selective.

In the CCC method of TDOA estimation, we compute a cross conjugate cyclic spectrum estimate $S_{yz}^{\alpha}(f)$ and then minimize the weighted inverse Discrete Fourier Transform (DFT)

$$\sum_f S_{yz}^{\alpha}(f) |P(f)|^2 e^{j2\pi f d}$$

with respect to the TDOA estimate d , where $P(f)$ is the raised-cosine pulse-transform used in the BPSK signal. Multipath propagation will result in multiple peaks. One of several possible methods for estimating the cross conjugate cyclic spectrum is to frequency smooth the cross conjugate cyclic periodogram

$$\sum_f W(f) Y(\alpha/2 + f) Z(\alpha/2 - f)$$

Where Y and Z are the DFT's of the signals received at main and auxiliary stations and $W(f)$ is a smoothing window.

To actually locate a user would require intersection of the two location-hyperbolas determined by two such TDOA estimates obtained from two pairs of reception stations, each pair of which includes the same base station and a unique auxiliary reception site. However, a single TDOA estimate for a set of estimates corresponding to multipath propagation from a single pair of reception stations could be adequate for determining spatial separability.

Also, it is possible to forego the task of locating mobile units and to assign frequencies in the least active bands (or at random) and make reassignments whenever co-channel interference is detected after the spatial filter has converged. This detection can possibly be accomplished using the SCORE method or, alternatively, can be readily detected by the user at the mobile unit and reported (by the push of a button) to the base station.

Although there is some flexibility in the choice of a modulation type, the type chosen for the present invention for several reasons is BPSK using Nyquist-shaped pulses having 100% excess bandwidth. The strength of the cyclic conjugate correlation $R_{xx} \propto 2/c$ for a BPSK signal having carrier offset f_c is the same as the strength of the signal itself, which speeds convergence of the SCORE adaptation method. Although BPSK having 100% excess bandwidth is not as spectrally efficient as modulation types using less excess bandwidth and/or higher-order alphabets, it is less susceptible to noise, easier to synchronize to, and its 200% spectral redundancy (100% due to double sideband and 100% due to excess bandwidth) can be effectively exploited for equalization and reduction of residual co-channel interference. Since the cyclic conjugate correlation characteristics of differential phase shift keying (DPSK) are identical to those of BPSK, DPSK can be used for transmission from the base station so as to simplify the receiver in the mobile unit. The actual baud rate and thus the bandwidth of the BPSK signal depend on the rate of the vocoder used. In the present invention, a vocoder rate of 8 kilobaud/second is used. Since transmission and reception are multiplexed in time, the actual rate that must be supported by the channel is 16 kilobaud/second, which yields a BPSK bandwidth of 32 KHz. In general, for a total system-bandwidth B_t , single-user channel-bandwidth B_c , and frequency-reuse factor r , the maximum number L of users that can be accommodated by the frequency allocation scheme in equation (8) is $L = (B_t/r - B_c)/f_{sep} + 1$. The number M of antenna elements required to separate these signals is bounded from below by the number K of users whose signals are spectrally overlapping with any given user's signal, where $M > K = 2(B_c/f_{sep} - 1)$. Using $B_c = 32$ KHz and $f_{sep} = 1$ KHz, at least 63 antenna elements (which can be omnidirectional) are needed to separate the signals of all users, assuming that the energy from each user arrives at the base station from a single direction, and assuming that the users are approximately uniformly distributed throughout the cell. In practice, more antenna elements might be required to achieve adequate performance at full capacity in the presence of spatially separable multipath, although fewer antenna elements can suffice if a lower capacity is opted for and appropriate channel allocation is done. Also, adaptive equalization should follow the spatial filtering to mitigate the time-smearing effects of multipath.

A block diagram of a generalized receiver 30 at the base station is shown in FIG. 3. The output signals 34 of the M antenna elements 32 are processed by individual preprocessing systems 36 that perform bandpass filtering, quadrature downconversion, sampling, and channelization on each output signal at each antenna. Channelizers 38 transform the resultant scalar input signal to a $L \times 1$ vector of signals, each of which is obtained by bandpass filtering (centered on a particular user's carrier frequency and having bandwidth equal to that of this user's signal) the input signal and downconverting it to baseband, where L is the maximum number of users that the system can accommodate. The outputs of the M channelizers 38 then pass through a routing network 40 that routes the M channelizer outputs corresponding to each user to a SCORE processor 42. That is, the M vector inputs each having dimension L and corresponding to a particular antenna element are rearranged to yield L vector outputs each having dimension M and corresponding to a particular user's carrier frequency.

An example of a 3×2 to 2×3 router can be seen in FIG. 14. Each $M \times 1$ vector is then processed by a corresponding SCORE processor device 42 to extract the signal of the user that is assigned the corresponding carrier frequency and separate that signal into a usable output signal 44.

Referring now to FIG. 4, a typical implementation of the invention would begin with call initiation on the control channel at step 50. Here a call can be initiated either by the base station or by the user. Call initiation is preferably performed on separate control channels so that communication channels are not wasted. These control channels would typically occupy distinct, non-overlapping spectral bands. If the user initiates the call then the reception cycle can proceed. On the other hand, if the base station initiates the call the user must first respond on the control channel before the reception cycle can proceed.

If direction of arrival information is to be used for frequency allocation, then the reception cycle proceeds with step 52 where an estimation of the direction of arrival of the signal from the user (signal of interest) is made. This option is useful because the signals from users who are not sufficiently separated geographically may not be spatially separable and, therefore, should be allocated disjoint carrier frequencies. At step 54 the determination of spatial separation is made. If the signal of interest is spatially separable from the other users' signals, then at step 56 that user is assigned a carrier frequency which, when modulated, results in a signal having a bandwidth which spectrally overlaps with that of other users, but whose carrier frequency is sufficiently separated from the carrier frequencies of the other users that signal-selective spatial filtering can be performed. If the signal of interest is not spatially separable, then at step 58 the user is assigned a carrier frequency which is sufficiently removed from those of the other users that the signals will not overlap. It should be clarified that the direction of arrival estimation system will not necessarily locate each mobile unit; rather it will determine possible multiple apparent locations for each unit that result from multipath propagation due to reflections and shadowing. But, it is these apparent locations—not the actual location—that are relevant in assessing spatial separability.

Steps 52 through 58 are optional and can be omitted. If carrier frequencies assigned without an initial determination of spatial separability, then the reception cycle would proceed from step 50 to step 60. At step 60, carrier frequencies are allocated in the least active band. If interference between users results, then a reassignment of carrier frequencies can be made at step 62 if requested by the user. As can be seen, therefore, direction of arrival information is neither required nor it is a necessary element of the SCORE-STFDMA method of signal processing.

Once the user is assigned a carrier frequency which may or may not result in spectral overlap of the modulated signal with those of others, communications begins. At step 64, the signal of interest together with interfering signals is received on each antenna in an array of M antennas. At step 66, bandpass filtering, quadrature downconversion, and sampling of the signal of interest and interference occurs for each antenna in the array. Since a particular user's signal will be separated from signals of other users by processing the M output signals of the M bandpass filters that are centered on the particular user's signal, each group of M

corresponding bandpass filter outputs is routed to a different SCORE processor at step 68.

Once the signals of interest and interference are routed, at step 70 the SCORE method of adaption based on restoring spectral coherence is applied to determine the weight vector w . Then, at step 72, the inner product of the weight vector w and the signal of interest and interference is determined. This inner product will be separate and distinct for the signals of all users and, therefore, the signal of interest is separated from those of other users at step 74.

It is important to note that the foregoing steps result in an implicit determination of an optimum reception pattern for the signal of interest as it impinged on the antennas in the array. This reception pattern can have single or multiple beams and multiple nulls determined by multipath reflections from buildings and by locations of interfering users. The present invention uses that reception pattern, as represented by the SCORE weight vector, as the foundation of spatial multiplexing.

Once the signal of interest is separated from those of other users, the signal is equalized at step 76 and routed out of the base station at step 78 where it interfaces directly with the wireline phone network or is passed to another base station for interconnection with the wireline phone network.

Referring now to FIG. 5, a responsive message from the wireline phone network (which may be routed through the base station directly or through multiple base stations) is digitized for transmission at step 80. The carrier frequency is then modulated with the digital message at step 82. At step 84, the modulated signal is then multiplied by the weight vector w developed in step 70. At step 86, the vectored signal is passed through a $L \times M$ to $M \times L$ router for routing to a corresponding antenna. At step 88, the signals from all users to be routed to specified antennas are summed. The summed signals are applied to the antennas at step 90.

The overall effect of this process is that the radiation pattern of the signal transmitted by the base station to the user will match the reception pattern of the user's signal as seen by the antenna array at the base station. Therefore, the output signals and phasing of those signals may vary from antenna to antenna in the array.

FIG. 6 shows a block diagram of one embodiment of an overall system which implements the steps described above. One of the antennas 140 in the antenna array 138 is coupled to a splitter/combiner 102 through interconnection 104 and is used to transmit and receive on the control channel. Splitter 102, which can be seen in more detail in FIG. 10, includes a pair of bandpass filters 106, the outputs of which are coupled to controller 108 through interconnections 110 and 112, respectively. Splitter 102 is used to separate the spectrally disjoint control signals received from the mobile user and the control signals transmitted to the mobile user, and to separate the control channel from the band occupied by active users. The control channel is used for call initiation and coordination between the user and the base station as previously described.

A calibrated antenna array 114 contains a plurality of antennas 116 (more than 4) which are separately coupled to a plurality of splitters 118 through interconnections 120. Splitters 118 are similar in configuration to splitter 102 previously described and, where eight antennas are used, the outputs of splitters 118 are coupled to an 8×2 to 2×8 router 122 as shown through interconnections 124. Referring also to FIG. 14, a typical

router configured for 3×2 to 2×3 can be seen. As previously described, the function of a router is that the M vector inputs each having dimension L and corresponding to a particular antenna element are rearranged to yield L vector outputs each having dimension M and corresponding to a particular user's carrier frequency.

Router 122 permits separation of a set of signals from the eight antennas in antenna array 114, one set representing control signals and the other representing user signals. Control output 126 is coupled to control direction of arrival (DOA) estimator 128, and user output 130 is coupled to user DOA estimator 132. The DOA data corresponding to the control signals is coupled to controller 108 through interconnections 134, while similar data corresponding to users is coupled to controller 108 through bus 136. Controller 108, which can be a microcomputer or the like, performs the functions of call initiation, carrier allocation, and interfacing with the telephone network 148.

Optionally, elements 114 through 136 which comprise the apparatus needed to estimate directions of arrival can be omitted or replaced by other elements appropriate to the implementation of a TDOA estimator such as CCC.

FIG. 7 shows an alternative embodiment of an overall communications system employing the present invention. Elements 102, 104, 108, 110, 112, 138, 140, 142, 144, 146, 148, and 150 in FIG. 7 are identical to the corresponding elements in FIG. 6. The embodiment shown in FIG. 7 differs from that shown in FIG. 6 in the details of how the directions of arrival of the active mobile units and control signals are determined. Elements 117, 119, 121, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, and 143 shown in FIG. 7 comprise alternate means for estimating the directions of arrival. Two auxiliary antennas 117, 119 are located in different areas of the cell and should be as far as possible from the base station. Splitters 121, 123 are similar in configuration to splitters 102 previously described and separate the signals received at antennas 117 and 119 into control signals and signals from active mobile units. The outputs of splitters 121, 123 are separately coupled to two TDOA estimators 133, 135 through interconnections 125, 127, 139, and 131 as shown. TDOA estimators 133, 135 can be seen in more detail in FIG. 16. The TDOA estimators measure the DOA's using methods that differ from the methods used in the DOA estimators 128, 132 shown in FIG. 6. The received control signals are routed from splitter 102 through interconnection 110 to a bank of bandpass filters 143 that splits their inputs into a plurality of control signals occupying disjoint spectral bands and routes them through interconnection 139 to TDOA estimator 133. The resulting DOA's of the control signals are coupled through interconnection 137 to the controller 108. The received and spatially filtered signals of the active mobile users are routed through interconnections 146 to TDOA estimator 135. The resulting DOA's of the active mobile users are coupled through interconnections 141 to the controller 108.

For normal communications, the users' signals are preferably received and transmitted using an antenna array 138 (for example, a circular array) which contains M antennas 140 (for example, omnidirectional antennas). Antennas 140 are coupled to SCORE-STFDMA module 142 through interconnections 144, there being one input (output) for each antenna M . SCORE-STFDMA module 142 performs the temporal filtering, signal routing, and adaptive spatial filtering functions of

the system. SCORE-STFDMA module 142 has a plurality of output lines 146 to route communications from the users to the wireline phone network 148, and a plurality of input lines 150 to receive communications from the wireline phone network 148 for transmission to the users. Controller 108 provides the interface to the wireline phone network 148.

Referring now to FIG. 8, SCORE-STFDMA module 142 includes a transmit/receive switch 152 for each of its connections to an antenna 140. Transmit/receive switches 152 are coupled to a clock 154 which controls the time division multiplexing windows of the transmitted and received signals through interconnections 156. Signals received from a particular antenna 140 are subjected to bandpass filtering, quadrature downconversion and sampling by a processing module 158 through interconnections 160. The output of each processing module 158 contains information for each of the L users of the system received on a particular antenna. Since there are M antennas in the base station antenna array 138, it is necessary to select each of M received signals for a particular user and route them for processing. This is performed by router 162 which is coupled to processing module 164 through interconnections 164.

The output of router 162 contains, for each user, the signals from each of the M antennas. For each user therefore, there are M signal components which must be processed by a SCORE processor 164 which is coupled to router 162 through interconnections 166. SCORE processor 164, which has M outputs and inputs, determines the weight vector w for each user's signals as previously described. The outputs of a SCORE processor 164 are then applied to that user's received signals in an inner product multiplier 168 which is coupled to the SCORE processor 164 through interconnections 170. There, the signals are also summed and the composite signal is output to controller 108 on an interconnection 146.

FIG. 13 schematically shows an inner product multiplier 168. The output signals on interconnections 146 are represented by $w^H x(n)$ for the particular user.

Referring now to FIG. 9, processing module 158 includes a bandpass filter 172 which is coupled to a quadrature downconverter 174 for conversion to baseband for preconditioning and anti-aliasing. The resultant signal is filtered by low pass filter 176 and converted into digital data by analog to digital converter 178. Transformation module 180 performs a 1024-point Fast Fourier Transform to split the band into 1024 bands which are 1 KHz wide. Grouping module 182 groups the bands into 64 KHz subbands prior to a 64-point inverse Fast Fourier Transform by inverse transformation modules 184. Therefore, the function of processing module 158 is typically to split a spectral band having a width of 1024 KHz into several overlapping bands having a width of 64 KHz whose centers are separated by 1 KHz.

Referring again to FIG. 8, digital information which is to be transmitted to the user is input to SCORE-STFDMA module 142 through interconnections 150. Modulators 186 place that data on the carrier signal, assigned to the user. Modulators 186 are coupled to vector scalar multipliers 188 through interconnections 190, where the weight vector w is applied to the transmitted signal. In other words, the weight vector w developed from that user's received signal by the SCORE processors 164 is used to condition the transmitted signal and separate it into components which

will be separately routed to the M antennas in antenna array 138. FIG. 12 schematically shows a typical vector scalar multiplier used herein.

Vector scalar multipliers 188 are coupled to an $L \times M$ to $M \times L$ router 192 through interconnections 194. Router 192 takes the M signal components for each user and reorganizes that information so that each antenna 140 will have the its corresponding information for all users. L -input summers 196, which are coupled to router 192 through interconnections 198, sum the signal information for all users for a given antenna so that the composite signal can be transmitted through transmit/receive switches 152 through interconnections 200 and on to antennas 140.

FIG. 11 shows a schematic of a typical L -input summer used with the present invention. FIG. 14 shows an example of a 3×2 to 2×3 router configuration which can be expanded to any number of users and antennas.

Once all of the signals are applied to the antennas in antenna array 138, the radiation pattern of the signal transmitted to the user will match the reception pattern of the signal received from the user as that signal impinging on the antenna array 138.

Referring to FIG. 15, one embodiment of a DOA estimator 128 is shown (which is the same as for DOA estimator 132). Bandpass filtering and downconversion is performed by filter/converter module 210 and signals are routed through an $M \times L$ to $L \times M$ router 212. The directions of arrival θ are determined by DOA processors 214 using, for example, the Cyclic MUSIC or CLS methods previously described.

Referring to FIG. 16, one embodiment of TDOA estimator 135 is shown (which is the same for TDOA estimator 133). Each CCC processor 216 (which implements in a straightforward manner the CCC method previously described) measures the TDOA between a signal on interconnections 129, 131 from an auxiliary antenna and a signal on interconnections 146 from the SCORE-STFDMA processor 142. The two TDOA estimates from a pair of CCC processors interconnected to a particular signal line in interconnections 146 are routed via interconnections 220 to a hyperbola intersect processor 218 that combines the two TDOA estimates to form a DOA estimate as previously described in conjunction with the description of the CCC method. The resulting DOA estimates from the plurality of hyperbola intersect processors 218 are routed out of TDOA estimator 135 on interconnections 141.

For the purpose of comparing the potential increase in capacity due to the SCORE-STFDMA method of the present invention relative to the analog FM-FDMA, TDMA, and CDMA schemes previously described, consider a total system-bandwidth of $B_T = 1.25$ Mhz. In the following comparison, the number of channels needed by each user in the analog FM-FDMA, TDMA, and CDMA schemes is two (one for transmission and one for reception), and one channel is needed by each user in the present invention because transmission and reception are multiplexed in time. With FM-FDMA, using a channel bandwidth of 30 KHz, 2 channels per user, and a cell reuse factor of 7 yields 3 users per cell. With TDMA, using a channel bandwidth of 30 KHz with three time slots for TDMA, 2 channels per user, and a cell reuse factor of 4 yields 15 users per cell. With CDMA, using 2 channels per user, a frequency reuse factor of 1, sectorization of 3, and voice activity factor of $\frac{1}{3}$ yields 120 channels per cell or 60 users per cell. With the SCORE-STFDMA method of the pres-

ent invention, using a channel bandwidth of 32 KHz, 1 channel per user, a cell reuse factor of 3, and a carrier separation of 1 KHz yields up to 385 users per cell. Decreasing the carrier separation to 500 Hz allows up to 770 users per cell at the expense of doubling the number of antennas. By decreasing the frequency reuse factor from three to one, the user capacity would triple.

Accordingly, it will be seen that this invention provides for significant increases in user capacity of radio communications systems by space, time and frequency multiplexing of communications signals. The spatial filtering method of the present invention blindly adapts an array of antennas in accordance with the reception pattern of a signal received from a mobile or portable unit by restoring its spectral coherence. To accomplish this, the signal is correlated with a time and frequency shifted version of itself. The resultant weighting factors that realize the reception pattern of the signal are also applied to the signal to be transmitted to the mobile or portable unit, whereby the reception pattern of the user's signal is reproduced in the radiation pattern of the signal transmitted to the user. This results in radiation of maximum power to the user and minimum power to unintended users, by combining directivity with multipath radiation.

Although the description above contains many specificities, these should not be construed as limiting the scope of the invention but as merely providing illustrations of some of the presently preferred embodiments of this invention. Thus the scope of this invention should be determined by the appended claims and their legal equivalents.

I claim:

1. A method of spatially filtering spectrally overlapping communications signals, comprising the
 - (a) receiving a plurality of radio frequency signals on an array of antennas;
 - (b) determining an optimum reception pattern for a signal of interest in said received signals as said received signals impinge on said array of antennas by restoring the spectral self-coherence of said signal of interest, said signal of interest corresponding to communications from a specified user; and
 - (c) transmitting a signal to said user, said transmitted signal having a radiation pattern from said array of antennas substantially identical to said reception pattern of said signal of interest.
2. The method recited in claim 1, further comprising the step of time division multiplexing steps (a) through (c).
3. The method recited in claim 1, further comprising the step of modulating said transmitted signal with digital data.
4. The method recited in claim 3, wherein said transmitted signal is modulated with binary phase shift keying.
5. The method recited in claim 1, further comprising the step of concurrently performing steps (a) through (c) for a plurality of users.
6. The method recited in claim 1, wherein said step of determining the optimum reception pattern for a signal of interest in said received signals as said received signals impinge on said array of antennas by restoring the spectral self-coherence of said signal of interest includes the step of computing a weight vector w representing a set of weights that realize said reception pattern for said signal of interest where w is the solution to

$$R_{xx} \alpha(\tau) R_{xx}^* \alpha^* - {}^1 R_{xx} \alpha^* H(\tau) w_1 = \lambda_1 R_{xx} w_1$$

where α is the cycle frequency, $R_{xx} \alpha(\tau)$ is the conjugate cyclic autocorrelation matrix at lag τ for the vector $x(t)$ of said received signals, $R_{xx} \alpha^* H(\tau)$ is its Hermetian transpose, R_{xx} is the autocorrelation matrix for $x(t)$ at lag zero, $R_{xx} \alpha^* \alpha - {}^1$ is the inverse of the autocorrelation matrix for the conjugated vector $x^*(t)$ of said received signals, and w_1 is the solution to this eigenequation corresponding to the largest eigenvalue λ_1 .

7. The method recited in claim 6, further comprising the steps of:

- (a) computing the inner product of said signal of interest and said weight vector w ; and
 - (b) extracting communications data from said user from said inner product.
8. The method recited in claim 7, further comprising the step of computing the scalar vector product of said weight vector w and said transmitted signal.
9. A method for multiplexing communications signals having overlapping spectral bands, comprising the steps of:
- (a) receiving a plurality of digital radio communications signals on an array of antennas, each of said communications signals having a distinct carrier frequency corresponding to a specified user;
 - (b) identifying a signal of interest from said plurality of communications signals using the carrier frequency of said signal of interest, said signal of interest corresponding to communications from a specified user;
 - (c) determining a weight factor for each antenna in said array of antennas through spectral coherence restoral for said signal of interest to realize an optimum reception pattern for said signal of interest and the remainder of interfering signals in said plurality of signals; and
 - (d) transmitting a signal to said user over said array of antennas, said transmitted signal adjusted at each of said antennas by the corresponding weight factor, whereby the radiation pattern of said transmitted signal from said array of antennas is substantially identical to said reception pattern for said received signal of interest.
10. The method recited in claim 9, further comprising the steps of:
- (a) determining discrete weight factors for each of said communications signals received at each of said antennas through spectral coherence restoral of said communications signals; and
 - (b) transmitting a plurality of communications signals over said array of antennas, each of said transmitted signals having a radiation pattern substantially identical to said reception pattern of the corresponding signal received at said array of antennas.
11. The method recited in claim 9, further comprising the step of temporally separating said received signals from said transmitted signals.
12. The method recited in claim 9, wherein the step of determining a weight factor for each antenna in said array of antennas through spectral coherence restoral of said signal of interest comprises the step of computing a weight vector w representing a set of weights corresponding to the optimum reception pattern of said signal of interest where w is the solution to

$$R_{xx} \alpha(\tau) R_{xx}^* \alpha^* - {}^1 R_{xx} \alpha^* H(\tau) w_1 = \lambda_1 R_{xx} w_1$$

where α is the cycle frequency, $R_{xx}^{\alpha}(\tau)$ is the conjugate cyclic autocorrelation matrix at lag τ for the vector $x(t)$ of said received signals, $R_{xx}^{\alpha H}(\tau)$ is its Hermetian transpose, R_{xx} is the autocorrelation matrix for $x(t)$ at lag zero, R_{xx}^{-1} is the inverse of the autocorrelation matrix for the conjugated vector $x^*(t)$ of said received signals, and w_1 is the solution to this eigenequation corresponding to the largest eigenvalue λ_1 .

13. A method of reducing co-channel interference between radio communications signals, comprising the steps of:

- (a) initiating radio communications between a user and a base station coupled to an array of antennas;
- (b) determining if radio communications signals transmitted from said user to said base station are spatially separable from signals transmitted by other users to said base station;
- (c) allocating to a user with a spatially separable signal a distinct communications channel which spectrally overlaps that of another user;
- (d) allocating to a user with a spatially non-separable signal a distinct communications channel which is spectrally disjoint with those of other users;
- (e) receiving communications signals from a plurality of users on said array of antennas;
- (f) determining the optimum reception patterns of each of said received signals at said array of antennas; and
- (g) transmitting signals from said base station to said users wherein the radiation pattern of the signal transmitted to a user corresponds to the optimum reception pattern of the signal received from that user at said base station.

14. The method recited in claim 13, further comprising the step of restoring the spectral coherence of said received signals to adapt said array of antennas.

15. The method recited in claim 14, wherein the step of restoring the spectral coherence of said received signals to adapt said array of antennas comprises the step of computing a weight vector w representing a set of weights corresponding to the optimum reception pattern of said signal of interest where w is the solution

$$R_{xx}^{\alpha}(\tau)R_{xx}^{\alpha}(\tau)^{-1}R_{xx}^{\alpha H}(\tau)w_1 = \lambda_1 R_{xx}w_1$$

where α is the cycle frequency, $R_{xx}^{\alpha}(\tau)$ is the conjugate cyclic autocorrelation matrix at lag τ for the vector $x(t)$ of said received signals, $R_{xx}^{\alpha H}(\tau)$ is its Hermetian transpose, R_{xx} is the autocorrelation matrix for $x(t)$ at lag zero, R_{xx}^{-1} is the inverse of the autocorrelation matrix for the conjugated vector $x^*(t)$ of said received signals, and w_1 is the solution to this eigenequation corresponding to the largest eigenvalue λ_1 .

16. An apparatus for spatial multiplexing of communications signals, comprising:

- (a) a plurality of antennas arranged in an array;

- (b) receiving means for receiving radio frequency signals, said receiving means coupled to said array of antennas;
- (c) spectral coherence processor means for restoring spectral coherence of signals received by said array of antennas and generating weight factors for each of said antennas, said processor means coupled to said receiving means;
- (d) transmitting means for transmitting radio frequency signals, said transmitting means coupled to said array of antennas; and
- (e) means for adapting radio frequency signals transmitted from said transmitting means by said weight factors, whereby the radio frequency radiation pattern of a signal transmitted to a user corresponds to the optimum reception pattern for the signal transmitted by said user measured at said array of antennas.

17. The apparatus recited in claim 16, further comprising means for time division multiplexing said received signals and said transmitted signals.

18. The apparatus recited in claim 17, further comprising means for allocation of spectrally overlapping communications channels to users having spatially separable signals.

19. The apparatus recited in claim 18, further comprising means for allocation of spectrally disjoint communications channels to users having spatially non-separable signals.

20. The apparatus recited in claim 19, further comprising signal conditioning means for bandpass filtering and quadrature downconversion of said received signals, said signal conditioning means coupled to said array of antennas.

21. A space, time and frequency multiplexed communications system, comprising:

- (a) a base station, said base station including an array of antennas;
- (b) call initiation and control means for establishing a radio frequency link between said base station and a plurality of users;
- (c) direction of arrival estimating means for estimating the direction of arrivals of radio frequency signals transmitted from said users to said base station and the multipath reflections of said signals;
- (d) channel allocation means for allocating spectrally overlapping communications channels to users having spatially separable signals and allocating spectrally disjoint communications channels to users having spatially non-separable signals; and
- (e) adapting means for adapting said array of antennas using spectral coherence properties of said received signals; and
- (f) transmission means for transmitting signals to said users, said signals emanating from said array of antennas, the radiation pattern of a signal intended for a given user being substantially identical to the optimum reception pattern for the signal received from said user at said array of antennas.

* * * * *



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
11/733,069	04/09/2007	Charles D. Gavrilovich	CAR100C3	7533
35083 7590 10/29/2009 CHARLES D. GAVRILOVICH, JR., GAVRILOVICH, DODD & LINDSEY, LLP 985 PASEO LA CRESTA, SUITE B CHULA VISTA, CA 91910-6729			EXAMINER TRAN, TUAN A	
			ART UNIT	PAPER NUMBER
			2618	
			MAIL DATE	DELIVERY MODE
			10/29/2009	PAPER

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

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 11/733,069	Applicant(s) GAVRILOVICH, CHARLES D.	
	Examiner TUAN A. TRAN	Art Unit 2618	

– 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) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, 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 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 01 July 2009.
- 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) 1-6, 8-16 and 18-44 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-6, 8-16 and 18-44 is/are rejected.
- 7) ☐ Claim(s) _____ 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) <input type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413) |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | Paper No(s)/Mail Date. _____ |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08) | 5) <input type="checkbox"/> Notice of Informal Patent Application |
| Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

Claim Rejections - 35 USC § 103

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 negated by the manner in which the invention was made.

1. Claims 1-6, 8-16, 18-44 are rejected under 35 U.S.C. 103(a) as being unpatentable over Charas et al. (5,404,570) in view of Gardner et al. (5,260,968).

Regarding claims 1-6, 8-16 and 18-20, Charas discloses a movable base station 116 configured to move relative to Earth wherein the movable base station 116 is conveyed by an automotive vehicle 114 (i.e. train) (See fig. 1), the movable base station 116 comprising: antennas 118, 120; a receiver configured to receive mobile device signals from a mobile device 102 through the antenna 120 and to receive fixed port signals from a fixed port 108, 208 through the antenna 118; and a transmitter configured to transmit RF signals corresponding to the received mobile device signals to a base station 106 through the antenna 118 and to transmit RF signals corresponding to the received fixed port signals to the mobile device 102, wherein the transmitter further configured to transmit RF signals within time slots of time-division multiplex channels (TDMA communication) (See figs. 1-3 and col. 4 line 1 to col. 5 line 44). However, Charas does not explicitly mention that each of the antenna 118, 120 used by the movable base station is a plurality of spatially separated antennas as specified in claims

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and the movable base station further comprises a controller configured to align, combine and compare received signals through the spatially separated antennas and to select a best signal. Gardner teaches a base station comprising: spatially separated antennas used for RF signals reception/transmission by respective receiver and transmitter of the base station, wherein the spatially separated antennas being configured a plurality of phased array antennas with directional RF beams allocating in sectors and wherein the RF beams are transmitted separated in time with a predetermined time delay (temporal) (See figs. 6-8 and col. 14 line 25 to col. 15 line 41); and a controller configured to align, combine and compare received signals through the spatially separated antennas and to select a best signal (See figs. 8, 13 and col. 5 line 60 to col. 6 line 26). It would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the teaching of Gardner in modifying the movable base station, as disclosed by Charas, with the spatially separated antenna system for the advantage of enhancing the communication signal quality.

Claims 21-44 are rejected for the same reasons as set forth in claims 1-6, 8-16 and 18-20.

Response to Arguments

Applicant's arguments filed 07/01/2009 have been fully considered but they are not persuasive.

In response to applicant's argument (See Remark, page 10) that the examiner's conclusion of obviousness is based upon improper hindsight reasoning, it must be recognized that any judgment on obviousness is in a sense necessarily a reconstruction

based upon hindsight reasoning. But so long as it takes into account only knowledge which was within the level of ordinary skill at the time the claimed invention was made, and does not include knowledge gleaned only from the applicant's disclosure, such a reconstruction is proper. See *In re McLaughlin*, 443 F.2d 1392, 170 USPQ 209 (CCPA 1971).

The applicant also argued that limitations recited in claims are not taught or suggested by the cited references (See Remark, page 11-13). The examiner respectfully disagrees with the applicant's argument. In this instant case, the difference between Charas and the claimed invention is the use of a plurality of spatially separated antennas (i.e. directional or diversity antennas) to receive and transmit a best signal. Since Gardner does teach a base station comprising: spatially separated antennas used for RF signals reception/transmission by respective receiver and transmitter of the base station, wherein the spatially separated antennas being configured a plurality of phased array antennas with directional RF beams allocating in sectors and wherein the RF beams are transmitted separated in time with a predetermined time delay (temporal) (See figs. 6-8 and col. 14 line 25 to col. 15 line 41); and a controller configured to align, combine and compare received signals through the spatially separated antennas and to select a best signal (See figs. 8, 13 and col. 5 line 60 to col. 6 line 26), and both communication systems of Charas & Gardner are capable of utilizing TDMA communication protocol; therefore, Charas and Gardner are combinable, and it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the teaching of Gardner in modifying the movable base station, as disclosed by

Charas, with the spatially separated antenna system for the advantage of enhancing the communication signal quality (See above rejections for details). For those reasons, the rejection(s) are proper and maintained.

Conclusion

THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than **SIX MONTHS** from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to **TUAN A. TRAN** whose telephone number is (571)272-7858. The examiner can normally be reached on Mon-Fri, 10:00AM-6:30PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Matthew Anderson can be reached on (571) 272-4177. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

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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). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Tuan A Tran/
Primary Examiner, Art Unit 2618

APPENDIX
Related Proceedings
None