

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 for the Eastern District of Texas - Marshall Division on the following

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

DOCKET NO. 2:24-cv-00009	DATE FILED 1/8/2024	U.S. DISTRICT COURT for the Eastern District of Texas - Marshall Division
PLAINTIFF PROCOMM INTERNATIONAL PTE. LTD.		DEFENDANT VERIZON COMMUNICATIONS, INC., CELLCO PARTNERSHIP D/B/A VERIZON WIRELESS, et al
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 8,583,100 B2	11/12/2013	PROCOMM INTERNATIONAL PTE. LTD.
2 7,103,377 B2	9/5/2006	PROCOMM INTERNATIONAL PTE. LTD.
3 7,834,721 B2	11/16/2010	PROCOMM INTERNATIONAL PTE. LTD.
4 8,497,813 B2	7/30/2013	PROCOMM INTERNATIONAL PTE. LTD.
5 7,724,512 B2	5/25/2010	PROCOMM INTERNATIONAL PTE. LTD.

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

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ 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	(BY) DEPUTY CLERK	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

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)

34206 7590 04/26/2006

FOGG AND ASSOCIATES, LLC
 P.O. BOX 581339
 MINNEAPOLIS, MN 55458-1339

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 Transmittal

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.
10/414,907	04/16/2003	Donald R. Bauman	100.453US01	6313

TITLE OF INVENTION: SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN DISTRIBUTED DIGITAL COMMUNICATIONS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	\$1400	\$300	\$1700	07/26/2006

EXAMINER	ART UNIT	CLASS-SUBCLASS
VO, NGUYEN THANH	2618	455-522000

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 Fogg & Associates, LLC
- 2 Fogg, David N.
- 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)

ADC Telecommunications, Inc.

Eden Prairie, MN

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 enclosed:

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

4b. Payment of Fee(s):

- ☐ A check in the amount of the fee(s) is enclosed.
- ☒ Payment by credit card. Form PTO-2038 is attached.
- ☒ The Director is hereby authorized by charge the required fee(s), or credit any overpayment, to Deposit Account Number 502432 (enclose an extra copy of this form).

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

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

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.

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

Authorized Signature

David N. Fogg

Date

June 25, 2006

Typed or printed name

David N. Fogg

Registration No.

35,138

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:		10414907		
Filing Date:		16-Apr-2003		
Title of Invention:		SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN DISTRIBUTED DIGITAL COMMUNICATIONS		
First Named Inventor:		Donald R. Bauman		
Filer:		David Fogg/Lisa Gentry		
Attorney Docket Number:		100.453US01		
Filed as Large Entity				
Utility 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	1501	1	1400	1400
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 (\$)				1700

Electronic Acknowledgement Receipt

EFS ID:	1125912
Application Number:	10414907
Confirmation Number:	6313
Title of Invention:	SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN DISTRIBUTED DIGITAL COMMUNICATIONS
First Named Inventor:	Donald R. Bauman
Customer Number:	34206
Filer:	David Fogg/Lisa Gentry
Filer Authorized By:	David Fogg
Attorney Docket Number:	100.453US01
Receipt Date:	25-JUL-2006
Filing Date:	16-APR-2003
Time Stamp:	11:19:34
Application Type:	Utility
International Application Number:	

Payment information:

Submitted with Payment	yes
Payment was successfully received in RAM	\$ 1700
RAM confirmation Number	823
Deposit Account	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)	Multi Part	Pages
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1	Issue Fee Payment Recorded	00077669.pdf	99882	no	1
Warnings:					
Information:					
2	Fee Worksheet (PTO-875)	fee-info.pdf	8313	no	2
Warnings:					
Information:					
Total Files Size (in bytes):			108195		
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. <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. <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.					



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

NOTICE OF ALLOWANCE AND FEE(S) DUE

34206 7590 04/26/2006
FOGG AND ASSOCIATES, LLC
P.O. BOX 581339
MINNEAPOLIS, MN 55458-1339

EXAMINER

VO, NGUYEN THANH

ART UNIT PAPER NUMBER

2618

DATE MAILED: 04/26/2006

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/414,907	04/16/2003	Donald R. Bauman	100.453US01	6313

TITLE OF INVENTION: SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN DISTRIBUTED DIGITAL COMMUNICATIONS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	\$1400	\$300	\$1700	07/26/2006

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 REFLECTS A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE APPLIED IN THIS APPLICATION. THE PTOL-85B (OR AN EQUIVALENT) MUST BE RETURNED WITHIN THIS PERIOD EVEN IF NO FEE IS DUE OR THE APPLICATION WILL BE REGARDED AS ABANDONED.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

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

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

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

If the SMALL ENTITY is shown as NO:

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

B. If applicant claimed SMALL ENTITY status before, or is 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 should be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). Even if the fee(s) have already been paid, Part B - Fee(s) Transmittal should be completed and returned. 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.

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)

34206 7590 04/26/2006
FOGG AND ASSOCIATES, LLC
P.O. BOX 581339
MINNEAPOLIS, MN 55458-1339

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.
10/414,907	04/16/2003	Donald R. Bauman	100.453US01	6313

TITLE OF INVENTION: SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN DISTRIBUTED DIGITAL COMMUNICATIONS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	\$1400	\$300	\$1700	07/26/2006

EXAMINER	ART UNIT	CLASS-SUBCLASS
VO, NGUYEN THANH	2618	455-522000

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, 1 _____
(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. 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 enclosed:

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

4b. Payment of Fee(s):

- ☐ A check in the amount of the fee(s) is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☐ The Director is hereby authorized by charge the required fee(s), 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).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other 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.

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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.
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10/414,907

04/16/2003

Donald R. Bauman

100.453US01

6313

34206

7590

04/26/2006

FOGG AND ASSOCIATES, LLC
P.O. BOX 581339
MINNEAPOLIS, MN 55458-1339

EXAMINER

VO, NGUYEN THANH

ART UNIT

PAPER NUMBER

2618

DATE MAILED: 04/26/2006

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 475 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 475 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)	
	10/414,907	BAUMAN ET AL.	
	Examiner	Art Unit	
	Nguyen T. Vo	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 applicant's request for a RCE filed on 12/21/2005.
2. ☒ The allowed claim(s) is/are 1-22.
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. ☐ Notice of References Cited (PTO-892) 2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948) 3. ☒ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date _____ 4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material	5. ☐ Notice of Informal Patent Application (PTO-152) 6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____. 7. ☐ Examiner's Amendment/Comment 8. ☒ Examiner's Statement of Reasons for Allowance 9. ☐ Other _____.
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REASONS FOR ALLOWANCE

1. The following is an examiner's statement of reasons for allowance: after carefully reviewing all of the documents cited in applicant's IDS submitted on 12/21/2005, none of the cited documents discloses nor render obvious comparing at least one of the plurality of signal levels from an antenna with a dynamic range fair share threshold; and attenuating each of the at least one of the compared signal levels that is greater than the dynamic range fair share threshold with a gain factor that is determined in response to a remaining portion of the total system dynamic range after attenuation of other signal levels of the plurality of signal levels, as specified in the independent claims 1, 7, 10, 13-14, 18, 21 and 22.

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."

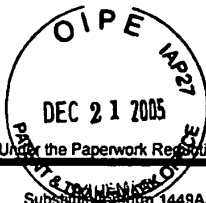
2. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Nguyen T. Vo whose telephone number is (571) 272-7901. The examiner can normally be reached on Monday-Friday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Edward Urban can be reached on (571)272-7899. 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).

Nguyen Vo


4-4-2006



PTO/SB/08a (08-03)

Approved for use through 07/31/2005. OMB 0851-0031

U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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.

Submittal Form 1449A/PTO			Complete if Known			
INFORMATION DISCLOSURE STATEMENT BY APPLICANT			Application Number	10/414,907		
(Use as many sheets as necessary)			Filing Date	4/16/2003		
			First Named Inventor	Bauman		
			Art Unit	2685		
			Examiner Name	Vo, Nguyen Thanh		
Sheet	1	of 3	Attorney Docket Number	100.453US01		
U.S. PATENT DOCUMENTS						
Examiner Initials*	Cite No. ¹	Document Number Number - Kind Code ² (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	
nvo		US-4,144,411	March 13, 1979	Frenkiel		
		US-4,812,990	September 23, 1988	Halpern		
		US-4,451,699	May 29, 1984	Gruenberg		
		US-4,475,010	October 2, 1984	Huensch, et al.		
		US-4,485,488	November 27, 1984	Webb et al.		
		US-4,558,760	December 3, 1985	Goldman		
		US-4,849,963	July 18, 1989	Kawano, et al.		
		US-4,916,460	April 10, 1990	Powell		
		US-5,067,173	November 19, 1991	Gordon et al.		
		US-5,278,690	January 11, 1994	Vella-Coleiro		
		US-5,621,786	April 15, 1997	Fischer et al.		
		US-5,627,879	May 6, 1997	Russell et al.		
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		US-5,644,622	July 1, 1997	Russell et al.		
		US-5,657,374	August 12, 1997	Russell et al.		
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		US-5,774,789	June 30, 1998	van der Kaay et al.		
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		US-5,809,395	September 15, 1998	Hamilton-Piercy et al.		
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	US-6,112,086	August 29, 2000	Wala			
	US-6,122,529	September 19, 2000	Sabat, Jr. et al.			
	US-6,223,021	April 24, 2001	Silvia et al.			
nvo		US-6,349,200	February 19, 2002	Sabat, Jr. et al.		
FOREIGN PATENT DOCUMENTS						
Examiner Initials*	Cite No. ¹	Foreign Patent Document Country Code ³ - Number ⁴ - Kind Code ⁵ (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T ⁶
nvo		EP-0346925-A2	12-20-1989	Takagi		
nvo		EP-0368673-A1	05-16-1990	Motley, et al.		
nvo		EP-0468688-A2	01-29-1992	Russell, et al.		
nvo		FR-2345865 (English Language Abstract included)	10-21-1977	Sina SPA (IT)		

Examiner Signature	nguyenVo	Date Considered	4-4-2006
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*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. ¹Applicant's unique citation designation number (optional). ²See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. ³Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). ⁴For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁵Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. ⁶Applicant is to place a check mark here if English language Translation is attached.

This collection of information is required by 37 CFR 1.97 and 1.98. 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 2 hours 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, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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Substitute for form 1449A/PTO			Complete if Known		
INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)			Application Number	10/414,907	
			Filing Date	4/16/2003	
			First Named Inventor	Bauman	
			Art Unit	2685	
			Examiner Name	Vo, Nguyen Thanh	
Sheet	2	of	3	Attorney Docket Number	100.453US01

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T ²
nvo		"And now a few words from your Customers . . ." Four pages. ADC Kentrox.COPYRG.T. A Subsidiary of ADC Telecommunications, Inc. Aug. 1992.	
		ADC Kentrox, News Release, "ADC Kentrox Introduces Innovative Wireless Network Access Solution Cellular Subscribers Offered a New Level of Portable Services," Mar. 1, 1993 (3 pages).	
		ADC Kentrox, News Release, "First Field Trial Results Exceeds Expectations," Mar. 2, 1993 (2 pages).	
		ADC Kentrox Wireless System Group CityCell.TM. 824-A Positioning white paper, (Mar. 1993) CITA Trade Show.	
		"ADC Kentrox Introduces CityCell 824, A Replacement For Conventional Cell Sites; Company's Original Goal Was To Improve Fiber Optic T1 Links Between Cells, MTSOs," Telocator Bulletin, Feb. 1993 (1 page).	
		Akos et al., July 1999, IEEE Transactions on Communications, 47:983-988, "Direct Bandpass Sampling of Multiple Distinct RF Signals."	
		1998 Foxcom Wireless Proprietary Information, pp. 1-8, "Litenna In-Building RF Distribution System."	
		Kobb, "Personal Wireless," Special Report/Communications, IEEE Spectrum, Jun. 1993, pages 20-25.	
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		Merrett et al., 41st IEEE Vehicular Technology Conference, May 19-22, 1991, Gateway to the Future Technology, 91CH2944-7, British Telecom Research Laboratories, "A Cordless Access System Using Radio-Over-Fibre Techniques," pp. 921-924.	
		Microwaves & RF, "Digital Transport for Cellular," Feb. 1993.	
		Russell, "New Microcell Technology Sets Cellular Carriers Free, Telephony, Mar. 1993, pp 40, 42 and 46.	
nvo		R. Steele. Towards a High-Capacity Digital Cellular Mobile Radio System. "Towards a High Capacity Digital Cellular Mobile Radio System," IEE Proceedings, Vol. 132, Pt.F, No. 5, Aug. 1985, pages 405-415.	

Examiner Signature	<i>Nguyen Vo</i>	Date Considered	4-4-2006
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*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. *Applicant's unique citation designation number (optional). *See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. *Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). *For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. *Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. *Applicant is to place a check mark here if English language Translation is attached.

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)		Application Number	10/414,907
		Filing Date	4/16/2003
		First Named Inventor	Bauman
		Art Unit	2685
		Examiner Name	Vo, Nguyen Thanh
Sheet 3 of 3	Attorney Docket Number	100.453US01	

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T ²
nVo		Tang, Fiber Optic Antenna Remoting for Multi-Sector Cellular Cell Sites. GTE Laboratories--Abstract (Conference Jun. 14-18, 1992).	
nVo		Urban Microcell System Layout. GTE Laboratories (Conference Jun. 14-18, 1992)	
nVo		Wala, 1993 43rd IEEE Vehicular Technology Conference, May 18-20, 1993, Personal Communication--Freedom Through Wireless Technology, Waseca Technology Inc., published May 18, 1993, "A New Microcell Architecture Using Digital Optical Transport," pp. 585-588.	
nVo		"ZoneMaster.TM.--Maximum Coverage For High-Capacity Locations". Decibel Multi Media MicroCELL System. 4 pages. 1993 Decibel Products. 2-83-5M.	

Examiner Signature	nguyenVo	Date Considered	4-4-2006
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 †Applicant's unique citation designation number (optional). ‡Applicant is to place a check mark here if English language Translation is attached.
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Bib Data Sheet

CONFIRMATION NO. 6313

SERIAL NUMBER 10/414,907	FILING DATE 04/16/2003 RULE	CLASS 435	GROUP ART UNIT 2685	ATTORNEY DOCKET NO. 100.453US01
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APPLICANTS

Donald R. Bauman, Waseca, MN;
Philip M. Wala, Waseca, MN;
Jerry Edward Toms, Shakopee, MN;

** CONTINUING DATA *****
This appln claims benefit of 60/430,435 12/03/2002 *yes n/a*

** FOREIGN APPLICATIONS ***** *none n/a*

IF REQUIRED, FOREIGN FILING LICENSE GRANTED
** 06/11/2003

Foreign Priority claimed 35 USC 119 (a-d) conditions met Verified and Acknowledged	☐ yes ☒ no ☒ yes ☐ no ☐ Met after Allowance Examiner's Signature <i>[Signature]</i> Initials	STATE OR COUNTRY MN	SHEETS DRAWING 11	TOTAL CLAIMS 22	INDEPENDENT CLAIMS 8
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ADDRESS
34206
FOGG AND ASSOCIATES, LLC
P.O. BOX 581339
MINNEAPOLIS , MN
55458-1339

TITLE
Small signal threshold and proportional gain distributed digital communications

FILING FEE RECEIVED 1206	FEES: Authority has been given in Paper No. _____ to charge/credit DEPOSIT ACCOUNT No. _____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue)
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<http://neo:8000/PrexServlet/PrexAction?serviceName=BibDataSheet&Action=display&browserType=IE&...> 9/17/05

Issue Classification 	Application/Control No.	Applicant(s)/Patent under Reexamination	
	10/414,907	BAUMAN ET AL.	
	Examiner	Art Unit	
	Nguyen T. Vo	2618	

ISSUE CLASSIFICATION											
ORIGINAL					CROSS REFERENCE(S)						
CLASS	SUBCLASS				CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)					
455	522				455	562.1	127.2	249.1	250.1		
INTERNATIONAL CLASSIFICATION											
H	0	4	B	7/00							
H	0	4	B	1/06							
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_____ (Assistant Examiner) (Date)					<i>Nguyen Vo</i> 4-4-2006 NGUYEN T. VO PRIMARY EXAMINER (Primary Examiner) (Date)					Total Claims Allowed: 22	
<i>fx</i> 4/17/06 (Legal Instruments Examiner) (Date)										O.G. Print Claim(s) 1	
										O.G. Print Fig. 10	

☒ Claims renumbered in the same order as presented by applicant												☐ CPA		☐ T.D.		☐ R.1.47	
Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
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U.S. Patent and Trademark Office

Part of Paper No. 04042006

Nguyen T. Vo

2618

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Claim		Date
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Search Notes 	Application/Control No. 10/414,907 Examiner Nguyen T. Vo	Applicant(s)/Patent under Reexamination BAUMAN ET AL. Art Unit 2618
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SEARCHED			
Class	Subclass	Date	Examiner
above	UPDATED	4/4/2006	NVO

INTERFERENCE SEARCHED			
Class	Subclass	Date	Examiner
PGPUB Text Search - See Interference Search Printout		4/4/2006	NVO

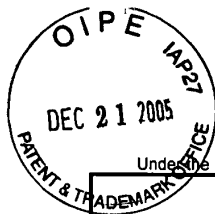
SEARCH NOTES (INCLUDING SEARCH STRATEGY)		
	DATE	EXMR
EAST - See Search History Printout	4/4/2006	NVO
EAST - See Interference Search Printout	4/4/2006	NVO

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	25912	(distribut\$3 plural\$3 first) adj2 antenna	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2006/04/04 15:45
L2	606	attenuat\$3 same 1	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2006/04/04 15:46
L3	18	(remain\$3 residue rest) same 2	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2006/04/04 15:50
L4	95884	"455"/\$.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2006/04/04 15:50
L5	170	2 and 4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2006/04/04 15:50

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	62	("20010031014" "20030133182" "20030162516" "20040203339" "4144411" "4451699" "4475010" "4485486" "4556760" "4612990" "4849963" "4916460" "5067173" "5278690" "5621786" "5627879" "5642405" "5644622" "5657374" "5765099" "5774085" "5774789" "5802173" "5809395" "5852651" "5969837" "6112086" "6122529" "6128470" "6223021" "6308085" "6349200" "6580905" "6643498").PN.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2006/04/04 14:00
L2	17753	(antenna).clm.	US-PGPUB	OR	ON	2006/04/04 14:03
L3	22586	(gain attenuat\$3).clm.	US-PGPUB	OR	ON	2006/04/04 14:04
L4	75601	(remain\$3 residue).clm.	US-PGPUB	OR	ON	2006/04/04 14:04
L5	98	2 and 3 and 4	US-PGPUB	OR	ON	2006/04/04 14:04
L6	23278	"455"/\$.ccls.	US-PGPUB	OR	ON	2006/04/04 14:04
L7	30	5 and 6	US-PGPUB	OR	ON	2006/04/04 14:04



12-23-05

RCE \$
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Request for Continued Examination (RCE) Transmittal Address to: Mail Stop RCE Commissioner for Patents P.O. Box 1450 Alexandria, VA 22313-1450	Application Number	10/414,907
	Filing Date	4/16/2003
	First Named Inventor	Bauman
	Art Unit	2685
	Examiner Name	Vo, Nguyen Thanh
	Attorney Docket Number	100.453US01

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. See Instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. **Submission required under 37 CFR 1.114** Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).
- a. ☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.
- i. ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____
- ii. ☐ Other _____
- b. ☒ Enclosed
- i. ☐ Amendment/Reply
- iii. ☒ Information Disclosure Statement (IDS)
- ii. ☐ Affidavit(s)/Declaration(s)
- iv. ☐ Other _____
2. **Miscellaneous**
- a. ☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of _____ months. (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)
- b. ☐ Other _____
3. **Fees** The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.
- a. ☒ The Director is hereby authorized to charge the following fees, or credit any overpayments, to Deposit Account No. 502432. I have enclosed a duplicate copy of this sheet.
- i. ☐ RCE fee required under 37 CFR 1.17(e) 12/28/2005 DTESSEM1 00000078 10414907
- ii. ☐ Extension of time fee (37 CFR 1.136 and 1.17) 01 FC:1801 790.00 OP
- iii. ☐ Other _____
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- c. ☒ Payment by credit card (Form PTO-2038 enclosed) \$ 790.00 for

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED			
Signature	<i>David N. Fogg</i>	Date	December 22, 2005
Name (Print/Type)	David N. Fogg	Registration No.	35,138

CERTIFICATE OF MAILING OR TRANSMISSION	
"Express Mail" mailing label number: <u>EV534353907US</u>	Date of Deposit: <u>December 22, 2005</u>
These papers and fees are being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR §1.10 on the date indicated above and addressed to the Commissioner for Patents, ATTN: Box Patent Application, Washington, D.C. 20231.	
Signature	<i>David N. Fogg</i>
Name (Print/Type)	USA D. GENTY
Date	December 22, 2005

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34206 7590 09/29/2005

FOGG AND ASSOCIATES, LLC
P.O. BOX 581339
MINNEAPOLIS, MN 55458-1339

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.
10/414,907	04/16/2003	Donald R. Bauman	100.453US01	6313

TITLE OF INVENTION: SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN DISTRIBUTED DIGITAL COMMUNICATIONS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	\$1400	\$300	\$1700	12/29/2005

EXAMINER	ART UNIT	CLASS-SU BCLASS
VO, NGUYEN THANH	2685	455-522000

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 enclosed:

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

4b. Payment of Fee(s):

- ☐ A check in the amount of the fee(s) is enclosed.
- ☐ Payment by credit card. Form PTO-2038 is attached.
- ☐ The Director is hereby authorized by charge the required fee(s), 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).

The Director of the USPTO is requested to apply the Issue Fee and Publication Fee (if any) or to re-apply any previously paid issue fee to the application identified above.

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other 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.

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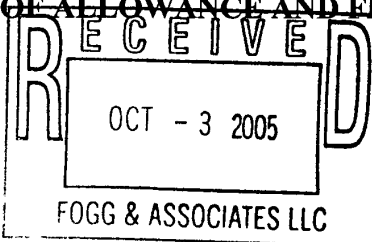


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34206 7590 09/29/2005
FOGG AND ASSOCIATES, LLC
P.O. BOX 581339
MINNEAPOLIS, MN 55458-1339

NOTICE OF ALLOWANCE AND FEE(S) DUE



EXAMINER	
VO, NGUYEN THANH	
ART UNIT	PAPER NUMBER

2685

DATE MAILED: 09/29/2005

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/414,907	04/16/2003	Donald R. Bauman	100.453US01	6313

TITLE OF INVENTION: SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN DISTRIBUTED DIGITAL COMMUNICATIONS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	\$1400	\$300	\$1700	12/29/2005

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 REFLECTS A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE APPLIED IN THIS APPLICATION. THE PTOL-85B (OR AN EQUIVALENT) MUST BE RETURNED WITHIN THIS PERIOD EVEN IF NO FEE IS DUE OR THE APPLICATION WILL BE REGARDED AS ABANDONED.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

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

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

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

If the SMALL ENTITY is shown as NO:

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

B. If applicant claimed SMALL ENTITY status before, or is 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 should be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). Even if the fee(s) have already been paid, Part B - Fee(s) Transmittal should be completed and returned. 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.

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.



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/414,907	04/16/2003	Donald R. Bauman	100.453US01	6313
34206	7590	09/29/2005	EXAMINER	
FOGG AND ASSOCIATES, LLC P.O. BOX 581339 MINNEAPOLIS, MN 55458-1339			VO, NGUYEN THANH	
			ART UNIT	PAPER NUMBER
			2685	

DATE MAILED: 09/29/2005

Bar PTA 10/29/05 DR

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 470 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 470 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 (703) 305-8283.

Notice of Allowability	Application No.	Applicant(s)	
	10/414,907	BAUMAN ET AL.	
	Examiner	Art Unit	
	Nguyen T. Vo	2685	

-- 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 _____.
2. ☒ The allowed claim(s) is/are 1-22.
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)

- | | |
|---|--|
| <ol style="list-style-type: none"> 1. ☒ Notice of References Cited (PTO-892) 2. ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 3. ☒ Information Disclosure Statements (PTO-1449 or PTO/SB/08),
Paper No./Mail Date _____ 4. ☐ Examiner's Comment Regarding Requirement for Deposit
of Biological Material | <ol style="list-style-type: none"> 5. ☐ Notice of Informal Patent Application (PTO-152) 6. ☐ Interview Summary (PTO-413),
Paper No./Mail Date _____ 7. ☐ Examiner's Amendment/Comment 8. ☒ Examiner's Statement of Reasons for Allowance 9. ☐ Other _____ |
|---|--|

NGUYEN T. VO
PRIMARY EXAMINER

REASONS FOR ALLOWANCE

1. The following is an examiner's statement of reasons for allowance: regarding independent claims 1, 7, 10, 13, 14, 18, 21 and 22, it is believed that Naidu (6,580,905) is closest prior art with respect to the claimed invention. Naidu discloses a system and method for controlling the gain of signals transported over transmission media in a distributed antenna network. The system includes a plurality of remote antenna units where each remote antenna unit includes a signal level comparator for comparing the level of the signals received by the respective antenna unit with a predetermined reference level, and a gain controller for reducing the gain of the remote antenna unit when the signal level comparator determines that the level of the received signal exceeds said predetermined reference level. See column 2 line 46 to column 3 line 8. Naidu, however, fails to disclose or render obvious comparing at least one of the plurality of signal levels from an antenna with a dynamic range fair share threshold; and attenuating each of the at least one of the compared signal levels that is greater than the dynamic range fair share threshold with a gain factor that is determined in response to a remaining portion of the total system dynamic range after attenuation of other signal levels of the plurality of signal levels, as specified in the claims.

None of other prior art cures the above deficiencies in Naidu.

In addition, application No. 10/308,854 (Publication No. US 2004/0203339 A1) has one common inventor with the present application. The above publication, however, fails to disclose or render obvious comparing at least one of the plurality of signal levels from an antenna with a dynamic range fair share threshold; and

attenuating each of the at least one of the compared signal levels that is greater than the dynamic range fair share threshold with a gain factor that is determined in response to a remaining portion of the total system dynamic range after attenuation of other signal levels of the plurality of signal levels, as specified in the claims.

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."

2. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Nguyen T. Vo whose telephone number is (571) 272-7901. The examiner can normally be reached on Monday-Friday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Edward Urban can be reached on (571)272-7899. 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).

Application/Control Number: 10/414,907
Art Unit: 2685

Page 4

Nguyen Vo

Nguyen Vo
9-17-2005

NGUYENT.VO
PRIMARY EXAMINER



INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 1

Complete if Known

Application Number	10/414,907
Filing Date	4/16/2003
First Named Inventor	Bauman et al.
Art Unit	Unknown
Examiner Name	Unknown
Attorney Docket Number	100.453US01

U.S. PATENT DOCUMENTS

[illegible]

FOREIGN PATENT DOCUMENTS

[illegible]

**Examiner
Signature**

Nguyen Vo

Date
Considered

9-17-2005

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. *Applicant's unique citation designation number (optional). *See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. *Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). *For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. *Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. *Applicant is to place a check mark here if English language Translation is attached.

This collection of information is required by 37 CFR 1.97 and 1.98. 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 2 hours 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, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Notice of References Cited	Application/Control No. 10/414,907	Applicant(s)/Patent Under Reexamination BAUMAN ET AL.	
	Examiner Nguyen T. Vo	Art Unit 2685	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-6,580,905	06-2003	Naidu et al.	455/522
*	B	US-6,128,470	10-2000	Naidu et al.	455/16
*	C	US-6,308,085	10-2001	Shoki, Hiroki	455/562.1
*	D	US-2004/0203339	10-2004	Bauman, Donald R.	455/007
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

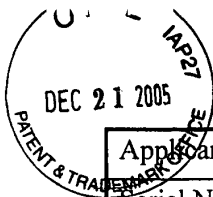
FOREIGN PATENT DOCUMENTS

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

NON-PATENT DOCUMENTS

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

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



RC

Applicant(s)	Donald R. Bauman	TRANSMITTAL FORM UNDER 37 CFR 1.10 (LARGE ENTITY)
Serial No.	10/414,907	
Filing Date	April 16, 2003	
Confirmation No.	6313	
Examiner Name	Vo, Nguyen Thanh	
Group Art Unit	2685	
Attorney Docket No.	100.453US01	
Title: SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN DISTRIBUTED DIGITAL COMMUNICATIONS		

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

Enclosures					
The following documents are enclosed:					
☒ A Request for Continued Examination Transmittal (RCE) (1 pg.).					
☒ An Information Disclosure Statement (1 pg.), Form 1449 (3 pgs.), and a copy of the 4 Foreign Patent Documents and a copy of the 17 Non Patent Literature Documents.					
☒ Credit Card Payment Form (PTO-2038) for the \$790.00 Filing Fee (1 pg.).					
☒ A return postcard.					
Please charge any additional fees or credit any overpayments to Deposit Account No. 502432.					
Submitted By					
Name	David N. Fogg	Reg. No.	35,138	Telephone	(612) 332-4720
Signature				Date	Dec 22, 2005
Attorneys for Applicant Fogg & Associates, LLC Customer No. 32406 P.O. Box 581339 Minneapolis, MN 55458-1339 T: 612-332-4720 F: 612-332-4731					
Certificate of Mailing					
"Express Mail" mailing label number: <u>EV534353907US</u> Date of Deposit: <u>December 22, 2005</u> These papers and fees are being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR §1.10 on the date indicated above and addressed to the Commissioner for Patents, MS RCE, Washington, D.C. 20231.					
Name	Lisa D. Gentry		Signature		



Applicant	Bauman	INFORMATION DISCLOSURE STATEMENT
Serial No.	10/414,907	
Filing Date	April 16, 2003	
Group Art Unit	2685	
Examiner	Vo, Nguyen Thanh	
Attorney Docket No.	100.453US01	
Title: SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN DISTRIBUTED DIGITAL COMMUNICATIONS		

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

In compliance with 37 C.F.R. §§ 1.56 and 1.97, *et seq.*, the enclosed materials are brought to the attention of the Examiner for consideration in connection with the above-identified Application. Applicant respectfully requests that this Information Disclosure Statement be entered and the references listed on the attached Form 1449 be considered by the Examiner and made of record. Pursuant to MPEP §609, Applicant further requests that the Examiner initial next to each reference on the Form 1449 to indicate that the listed references have been considered. Applicant further requests that a copy of the initialed Form 1449 be returned with the next official communication.

The Examiner is invited to contact the Applicant's Representative at the below-listed telephone number if they are any questions regarding this communication.

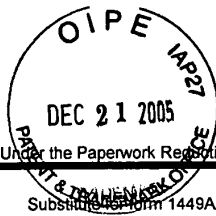
Respectfully submitted,

Date: December 22, 2005



David N. Fogg
Reg. No. 35,138

Attorneys for Applicant
Fogg and Associates, LLC
P.O. Box 581339
Minneapolis, MN 55458-1339
T – 612/332-4720
F – 612/332-4731



PTO/SB/08a (08-03)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)			Complete if Known		
			Application Number	10/414,907	
			Filing Date	4/16/2003	
			First Named Inventor	Bauman	
			Art Unit	2685	
Sheet	1	of	3	Examiner Name	Vo, Nguyen Thanh
				Attorney Docket Number	100.453US01

U.S. PATENT DOCUMENTS					
Examiner Initials*	Cite No. ¹	Document Number	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		Number - Kind Code ² (if known)			
		US-4,144,411	March 13, 1979	Frenkiel	
		US-4,612,990	September 23, 1986	Halpern	
		US-4,451,699	May 29, 1984	Gruenberg.	
		US-4,475,010	October 2, 1984	Huensch, et al.	
		US-4,485,486	November 27, 1984	Webb et al.	
		US-4,556,760	December 3, 1985	Goldman	
		US-4,849,963	July 18, 1989	Kawano, et al.	
		US-4,916,460	April 10, 1990	Powell	
		US-5,067,173	November 19, 1991	Gordon et al.	
		US-5,278,690	January 11, 1994	Vella-Coleiro	
		US-5,621,786	April 15, 1997	Fischer et al.	
		US-5,627,879	May 6, 1997	Russell et al.	
		US-5,642,405	June 24, 1997	Fischer et al.	
		US-5,644,622	July 1, 1997	Russell et al.	
		US-5,657,374	August 12, 1997	Russell et al.	
		US-5,765,099	June 9, 1998	Georges et al.	
		US-5,774,789	June 30, 1998	van der Kaay et al.	
		US-5,802,173	September 1, 1998	Hamilton-Piercy et al.	
		US-5,809,395	September 15, 1998	Hamilton-Piercy et al.	
		US-5,852,651	December 22, 1998	Fischer et al.	
		US-5,969,837	October 19, 1999	Farber et al.	
		US-6,112,086	August 29, 2000	Wala	
		US-6,122,529	September 19, 2000	Sabat, Jr. et al.	
		US-6,223,021	April 24, 2001	Silvia et al.	
		US-6,349,200	February 19, 2002	Sabat, Jr. et al.	

FOREIGN PATENT DOCUMENTS						
Examiner Initials*	Cite No. ¹	Foreign Patent Document	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear	T ⁶
		Country Code ³ - Number ⁴ - Kind Code ⁵ (if known)				
		EP-0346925-A2	12-20-1989	Takagi		
		EP-0368673-A1	05-16-1990	Motley, et al.		
		EP-0468688-A2	01-29-1992	Russell, et al.		
		FR-2345865 (English Language Abstract included)	10-21-1977	Sina SPA (IT)		

Examiner Signature	Date Considered
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			Application Number	10/414,907	
			Filing Date	4/16/2003	
			First Named Inventor	Bauman	
			Art Unit	2685	
			Examiner Name	Vo, Nguyen Thanh	
Sheet	2	of	3	Attorney Docket Number	100.453US01

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials*	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T ²
		"And now a few words from your Customers . . ." Four pages. ADC Kentrox.COPYRG.T. A Subsidiary of ADC Telecommunications, Inc. Aug. 1992.	
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		ADC Kentrox, News Release, "First Field Trial Results Exceeds Expectations," Mar. 2, 1993 (2 pages).	
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			First Named Inventor	Bauman	
			Art Unit	2685	
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Sheet	3	of	3	Attorney Docket Number	100.453US01

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		Tang, Fiber Optic Antenna Remoting for Multi-Sector Cellular Cell Sites. GTE Laboratories--Abstract (Conference Jun. 14-18, 1992).	
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Requested Patent: EP0346925A2

Title:

PRIVATE BRANCH RADIO COMMUNICATION SYSTEM USING OPTICAL FIBERS. ;

Abstracted Patent: EP0346925 ;

Publication Date: 1989-12-20 ;

Inventor(s): TAKAGI TASUKU ;

Applicant(s): SMALL POWER COMMUNICATION SYST (JP) ;

Application Number: EP19890110993 19890616 ;

Priority Number(s): JP19880148237 19880617 ;

IPC Classification: H04B7/00 ; H04B7/26 ; H04B9/00 ;

Equivalents: DE68922023D, DE68922023T, JP2002727, US5159479

ABSTRACT:

A private branch radio communication system includes a portable radio transmitter (1) and a portable radio receiver (4). The system further includes first and second repeaters (2, 3) respectively located in first and second areas (P1, P2) within a given premises and coupled to each other through an optical fiber cable (5). A radio signal output from the portable radio transmitter (1) is converted into an optical signal by the first repeater (2), and is then supplied to the second repeater (3) through the optical fiber cable (5), and converted into a radio signal which is received by the portable radio receiver (4).



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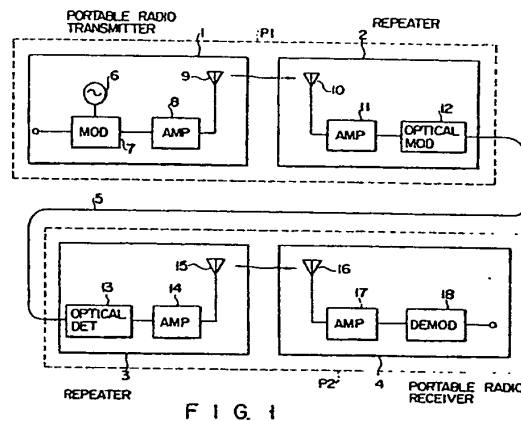
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54 Private branch radio communication system using optical fibers.

57 A private branch radio communication system includes a portable radio transmitter (1) and a portable radio receiver (4). The system further includes first and second repeaters (2, 3) respectively located in first and second areas (P1, P2) within a given premises and coupled to each other through an optical fiber cable (5). A radio signal output from the portable radio transmitter (1) is converted into an optical signal by the first repeater (2), and is then supplied to the second repeater (3) through the optical fiber cable (5), and converted into a radio signal which is received by the portable radio receiver (4).



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Private branch radio communication system using optical fibers

The present invention relates to a private branch radio communication system and, more particularly, to a private branch radio communication system using optical fibers.

On sites such as power plants or substations, large numbers of personnel may be engaged in jobs related to each other, but often doing so in widely separated locations throughout the site. For this reason, a radio communication system is generally used to enable personnel to communicate with each other, with each worker carrying a portable radio transceiver while doing his job, and exchanging information with other personnel, as and when required.

This type of radio communication system utilizes a relatively weak radio wave, this being because if a strong radio wave were to be used, it might interfere with the operation of various electronic devices located on the same premises.

If radio communication is to be performed in a building, especially in a so-called intelligent building in which various systems, such as the air conditioning system, for example, are computer-controlled, a very weak radio wave, e.g., a radio wave having a field intensity of 500 $\mu\text{V/m}$ or less which is measured at, for example, a position 3 m away from a radio wave source, should preferably be used in order to prevent erroneous operation of various electronic devices in the building, as a result of radio interference. However, in buildings, the transmitting of radio waves tends to be hindered by walls, pillars, and the like. Therefore, when a weak radio wave is, for the aforesaid reasons, used for communication within a building, satisfactory communication from the ground floor to the uppermost floor cannot be achieved. For this reason, radio communication using a weak radio wave can be employed only for private branch communication within a confined area, e.g., within one floor of a building, but not throughout all floors of the building. As a result, the range through which personnel can move and remain in communication is undesirably limited.

Accordingly, it is an object of the present invention to provide a private branch radio communication system using a weak radio wave but capable of providing excellent radio communication over a wide area, such as throughout a given premises or site.

According to the present invention, there is provided a private branch radio communication system comprising a portable radio transmitter for modulating a signal and outputting the modulated signal as a radio signal in a first area within a given premises, a first repeater, located in the first area,

for receiving the radio signal transmitted from the radio transmitter and outputting an optical signal corresponding to the signal received; an optical transmission medium for transmitting the optical signal output from the first repeater to a second area within the premises, a second repeater, located in the second area, for receiving the optical signal output from the first repeater and transmitting by the optical transmission medium, and generating a radio signal corresponding to the signal received in the second area, and a portable radio receiver for receiving the radio signal output from the second repeater in the second area and demodulating the signal received.

In the above-described private branch radio communication system, the first and second repeaters are, as described above, located in the first and second areas, respectively, and are coupled to each other through an optical fiber cable. As a result, a radio signal generated from the portable radio transmitter is not transmitted directly from the first area to the second area by radio transmission, but is first converted into an optical signal by the first repeater in the first area, the optical signal is then transmitted through the optical fiber cable to the second repeater in the second area, and is converted by the second repeater back into a radio signal which is received by the portable radio receiver.

As described above, since communication between the first and second areas is accomplished not by direct radio transmission but by means of an optical fiber cable, therefore even if the first and second areas are, for example, different floors in a building, or even different buildings, communication between the first and second areas is free from interference caused by obstacles to transmission, such as walls and pillars in the building or, in the latter case, other buildings in-between. Therefore, even when using a weak radio wave generated by a portable transmitter, the present invention is able to provide excellent private branch radio communication over a wide-ranging area.

In addition, since an optical signal transmitted through an optical fiber cable is not an electrical signal, such a signal is therefore free from electrical influences caused by various other electrical signal lines and it, in turn, does not adversely influence such signal lines.

Thus, the private branch radio communication system of the present invention, using a weak radio wave and an optical signal, provides excellent private branch radio communication while at the same time having minimal adverse influence on various other electrical devices and telephone lines.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a block diagram showing a private branch radio communication system according to a first embodiment of the present invention;

Fig. 2 is a block diagram showing a private branch radio communication system according to a second embodiment of the present invention;

Fig. 3 is a block diagram showing a private branch radio communication system according to a third embodiment of the present invention;

Fig. 4 is a circuit diagram showing an embodiment of an arrangement of an optical multiplexer used in the private branch radio communication system in Fig. 3;

Fig. 5 is a circuit diagram showing an embodiment of an arrangement of a first repeater used in the private branch radio communication system in Fig. 1;

Fig. 6 is a circuit diagram showing an embodiment of an arrangement of a second repeater used in the private branch radio communication system in Fig. 1;

Fig. 7 is a circuit diagram showing an embodiment of an arrangement of a repeater used in the private branch radio communication system in Fig. 3; and

Fig. 8 is a circuit diagram showing an arrangement of a portable radio transceiver used in the private branch radio communication system in Fig. 3.

Fig. 1 shows a private branch radio communication system according to a first embodiment of the present invention. Referring to Fig. 1, a first area P1 represents a specific place in a specific building or site, e.g., a specific floor in a building, and a second area P2 represents a place separated from the first area P1 by a relatively large distance, e.g., another floor in the same building as that of the first area P1, or another place within the same site as that of the first area P1.

This private branch communication system is designed to transmit a radio signal generated by a portable radio transmitter 1 used in the first area P1 to a portable radio receiver 4 used in the second area P2. In this system, the portable radio transmitter 1 and a repeater 2 are arranged in the first area P1. The radio transmitter 1 is carried by, e.g., a worker and is freely moved in the first area P1. The repeater 2 is fixed in a specific place of the first area P1. Similarly, the portable radio receiver 4 and a repeater 3 are arranged in the second area P2. The radio receiver 4 can be freely moved in the second area P2, and the repeater 3 is fixed in a specific place of the second area P2. The

repeaters 2 and 3 are coupled to each other through an optical fiber cable 5.

The portable radio transmitter 1 comprises a modulator 7 including an oscillator 6, an amplifier 8, and a transmitting antenna 9. The radio transmitter 1 modulates a carry signal by a modulation signal to be transmitted, e.g., a speech signal by using the modulator 7, and amplifying the modulated signal by using the amplifier 8, thus radiating the amplified signal in air as a radio signal through the antenna 9. The repeater 2 comprises a receiving antenna 10, an amplifier 11, and an optical modulator 12. The repeater 2 receives a radio signal output from the radio transmitter 1 through the antenna 10, amplifies the received signal by using the amplifier 11, and converts the signal into an optical signal by using the optical modulator 12, thus supplying the signal to the optical fiber cable 5.

The repeater 3 comprises an optical detector 13, an amplifier 14, and a transmitting antenna 15. The repeater 3 converts the optical signal, which is transmitted from the repeater 2 through the optical fiber cable 5, into an electrical signal by using the optical detector 13, and amplifies the electrical signal by using the amplifier 14, thereby radiating the amplified signal in air as a radio signal through the antenna 15. The portable radio receiver 4 comprises a receiving antenna 16, an amplifier 17, and a demodulator 18. The radio receiver 4 receives a radio signal output from the repeater 2 through the antenna 16, and amplifies the received signal by using the amplifier 17, thereby demodulating the signal by using the demodulator 18. As a result, the modulation signal (speech signal in this case) is extracted from the received signal.

Since both the radio transmitter 1 and the repeater 2 are present in the first area P1, communication therebetween can be satisfactorily performed by using a weak radio wave (e.g., a radio wave having a field intensity of 500 $\mu\text{V/m}$ or less which is measured at a position separated from the radio transmitter 1 by 3 m). Similarly, since both the radio receiver 4 and the repeater 3 are present in the second area P2, communication therebetween can be satisfactorily performed by using a weak radio wave (e.g., a radio wave having a field intensity of 500 $\mu\text{V/m}$ or less which is measured at a position separated from the repeater 3 by 3 m).

Since signal transmission over a relatively large distance from the first area P1 to the second area P2 is performed not by radio transmission but by means of the optical fiber cable 5, a signal from the first area P1 is transmitted to the second area P2 without loss caused by radio wave obstacles such as walls and pillars in a building, or buildings in a site. Therefore, even if a radio wave output from the radio transmitter 1 is weak, a radio signal can

satisfactorily be transmitted to the radio receiver 4 in an excellent state.

In addition, since an optical signal transmitted through the optical fiber cable 5 is not an electrical signal, the signal is free from electrical influences from various other electrical signal lines and does not influence them.

A signal to be transmitted by this private branch radio communication system is not limited to a speech signal, but may include image signals or various data signals. In addition, it may include analog or digital signals.

Fig. 5 shows a detailed arrangement of the repeater 2. As shown in Fig. 5, a circuit including a constant-voltage source 121 and a laser diode 122 is used as the optical modulator of the repeater 2. In this circuit, a light-emitting diode may be used in place of the laser diode 122.

Fig. 6 shows a detailed arrangement of the repeater 3. As shown in Fig. 6, a circuit including a photodiode 131 is used as the optical detector 13 of the repeater 13.

Since the repeaters 2 and 3 respectively perform only electrical/optical conversion and optical/electrical conversion, they can be realized by simple circuit arrangements respectively shown in Fig. 5 and Fig. 6.

Fig. 2 shows a private branch communication system according to a second embodiment of the present invention. This system is designed to realize duplex simultaneous communication between first and second areas P1 and P2. Referring to Fig. 2, a portable radio transceiver 21 and two-way repeater 22 are arranged in the first area P1. The radio transceiver 21 is carried by, e.g., a worker and is moved within the first area P1. The repeater 22 is fixed in a specific place of the first area P1. Similarly, a portable radio transceiver 24 and a two-way repeater 23 are arranged in the second area P2. The transceiver 24 is moved within the second area P2, and the repeater 23 is fixed in a specific place of the second area P2. The repeaters 22 and 23 are coupled to each other through optical fiber cables 5A and 5B.

The portable radio transceiver 21 includes a transmitting section 21A, a receiving section 21B, and a transmitting/receiving antenna 21C. The transmitting and receiving sections 21A and 21B respectively correspond to the transmitter 1 and the receiver 4 shown in Fig. 1. The radio transceiver 21 modulates and amplifies a signal to be transmitted, e.g., a speech signal by using the transmitting section 21A, and radiates the resultant signal in air as a radio signal having a carrier frequency f_1 through the antenna 21C. In addition, the radio transceiver 21 receives a radio signal having a carrier frequency f_1' through the antenna 21C, and amplifies and demodulates the received

signal by using the receiving section 21B. As a result, the modulation signal (speech signal in this case) is extracted from the received signal.

The two-way repeater 22 comprises a transmitting/receiving antenna 22C, an electrical/optical signal converting section 22A, and an optical/electrical signal converting section 22B. The electrical/optical converting section 22A and the optical/electrical modulator 22B respectively correspond to the repeaters 2 and 3 shown in Fig. 1. The repeater 22 receives a radio signal output from the transceiver 21 through the antenna 22C, and converts the received signal into an optical signal by using the electrical/optical converting section 22A, thereby supplying the signal to the optical fiber cable 5A. In addition, the repeater 22 converts an optical signal supplied through the optical fiber cable 5B into an electrical signal by using the optical/electrical converting section 22B, and radiates the converted signal in air as a radio signal having the carrier frequency f_1' through the antenna 22C.

The two-way repeater 23 comprises a transmitting/receiving antenna 23C, an optical/electrical converting section 23A and an electrical/optical signal converting section 23B. The electrical/optical signal converting section 23B and the optical/electrical modulator 23A respectively correspond to the repeaters 2 and 3 shown in Fig. 1. The repeater 23 converts an optical signal supplied through the optical fiber cable 5A into an electrical signal by using the optical/electrical signal converting section 23A, and radiates the converted signal in air as a radio signal having the carrier frequency f_1 through the antenna 23C. In addition, the repeater 23 receives a radio signal having the frequency f_1' output from the transceiver 24 through the antenna 23C, and converts the received signal into an optical signal by using the electrical/optical converting section 23B, thereby supplying the signal to the optical fiber cable 5B.

The portable radio transceiver 24 comprises a transmitting/receiving antenna 24C, a transmitting section 24A, and a receiving section 24B. The transmitting and receiving sections 24A and 24B respectively correspond to the transmitter 1 and the receiver 4 shown in Fig. 1. The radio transceiver 24 modulates and amplifies a signal to be transmitted, e.g., a speech signal by using the transmitting section 24A, and radiates the resultant signal in air as a radio signal having the carrier frequency f_1' through the antenna 24C. In addition, the transceiver 24 receives a radio signal having the carrier frequency f_1 through the antenna 24C, and amplifies and demodulates the received signal by using the receiving section 24B. As a result, the modulation signal (speech signal in this case) is

extracted from the received signal.

Since the private branch radio communication system of the second embodiment employs different carrier frequencies for transmission and reception, duplex communication can be realized. In addition, since the two-way repeaters 22 and 23 are respectively distributed in the first and second areas P1 and P2, communication between the portable transceivers 21 and 24 can be performed by using a weak radio wave as in the first embodiment.

In this embodiment, the two optical fiber cables 5A and 5B are used for signal transmission between the repeaters 22 and 23. However, by properly utilizing optical components, signal transmission between the repeaters can be realized by a single optical fiber cable. Also, with the arrangement of the second embodiment, one-way alternate communication can be realized.

Fig. 3 shows a private branch radio communication system according to a third embodiment of the present invention. This system is designed to realize duplex communication not only between the two areas P1 and P2 as described in the first and second embodiments but also between arbitrary areas of a plurality of areas. In this system, the premises are divided into five areas P11 to P15. A two-way repeater and one portable radio transceiver or more are arranged in each area. More specifically, a two-way repeater Ra and two portable radio transceivers Ka1 and Ka2 are arranged in the area P11, a two-way repeater Rb and two portable radio transceivers Kb1 and Kb2 are arranged in the area P12, a two-way repeater Rc and a portable radio transceiver Kc1 are arranged in the area P13, a two-way repeater Rd and two portable radio transceivers Kd1 and Kd2 are arranged in the area P14, and a two-way repeater Re and two portable radio transceivers Ke1 and Ke2 are arranged in the area P15. A each range of these areas P11 to P15 is setting so that a weak radio wave can sufficiently propagate in the each area.

The repeater Ra is coupled to transmitting and receiving optical fiber cables 30a and 30b. Similarly, the repeaters Rb, Rc, Rd, and Re are respectively coupled to transmitting and receiving optical fiber cables 30b and 31b, 30c and 31c, 30d and 31d, and 30e and 31e.

An optical multiplexer 32 includes input ports coupled to the optical fiber cables 30a to 30e, and output ports coupled to the optical fiber cables 31a to 31e. The multiplexer 32 multiplexes all the optical signal supplied through the cables 30a to 30e, and outputs a multiplexed signal to the optical fiber cables 31a to 31e, respectively.

An operation of the above-described system will be described below. Assume that ten frequencies f1 to f5 and f1' to f5' are respectively assigned

to the transceivers Ka1 to Ke1. In this system, if a specific portable radio transceiver transmits a radio signal having the frequency f1, another portable radio transceiver which receives the signal sends back a radio signal having the frequency f1' as a response signal. Therefore, in this system, five channels allowing simultaneous communication are ensured, i.e., a first channel using the frequencies f1 and f1', a second channel using the frequencies f2 and f2', a third channel using the frequencies f3 and f3', a fourth channel using the frequencies f4 and f4', and a fifth channel using the frequencies f5 and f5'.

Each of the radio transceivers Ka1 to Ke1 can radiate a radio signal having any one of the frequencies f1 to f5 and f1' to f5', and can receive a radio signal having any of the frequencies f1 to f5 and f1' to f5'. In addition, each of the units Ka1 to Ke1 has a function of detecting a frequency used by another unit. With this function, each of the units Ka1 to Ke1 can output a radio signal by using an unused frequency, i.e., a free channel, thus preventing radio interference.

Speech communication using the system shown in Fig. 3 will be described below in a state wherein all of the above-described first to fifth channels are used.

Radio signals generated by this system are ten signals denoted by V1 to V5 and V1' to V5' respectively corresponding to the carrier frequencies f1 to f5 and f1' and f5'. If these radio signals V1 to V5 and V1' to V5' are signals having amplitude-modified waves, the radio signals V1 to V5 and V1' to V5' can be represented as follows:

$$\begin{aligned} V1 &= A(1 + si(t)\sin(2\pi f1t)) \\ V2 &= A(1 + sj(t)\sin(2\pi f2t)) \\ V3 &= A(1 + sk(t)\sin(2\pi f3t)) \\ V4 &= A(1 + sp(t)\sin(2\pi f4t)) \\ V5 &= A(1 + sq(t)\sin(2\pi f5t)) \\ V1' &= A(1 + si'(t)\sin(2\pi f1't)) \\ V2' &= A(1 + sj'(t)\sin(2\pi f2't)) \\ V3' &= A(1 + sk'(t)\sin(2\pi f3't)) \\ V4' &= A(1 + sp'(t)\sin(2\pi f4't)) \\ V5' &= A(1 + sq'(t)\sin(2\pi f5't)) \end{aligned}$$

where A is a constant and si(t), sj(t), sk(t), sp(t), sq(t), si'(t), sj'(t), sk'(t), sp'(t), and sq'(t) are modulation signals such as speech signals. For example, with respect to the radio signal V1 for speech communication which is transmitted from a given transceiver, the radio signal V1' is sent back from another transceiver as a response signal. Similarly, with respect to the radio signals V2, V3, V4, and V5, the radio signals V2', V3', V4' and V5' are respectively sent back as response signals.

When the radio signals V1 to V5 are respectively generated in the areas P11 to P15, these signals are respectively converted into optical signals by the repeaters Ra to Re so as to be trans-

mitted to the optical fiber cables 30a to 30e. The signals V1 to V5 are multiplexed by the optical multiplexer 32, and the multiplexed signal $V1 + V2 + V3 + V4 + V5$ is supplied to the optical fiber cables 31a to 31e. As a result, the multiplexed signals $V1 + V2 + V3 + V4 + V5$ are received by the repeaters Ra to Re. Thereafter, the multiplexed signals $V1 + V2 + V3 + V4 + V5$ are generated as radio signals in the areas P11 to P15.

In this manner, a signal transmitted from each portable radio transceiver is commonly supplied to the respective areas P11 to P15. Since the transceivers Ka1 to Ke1 can receive radio signals of all the frequencies, a transceiver as a source, i.e., a source operator must specify a transceiver as a destination, i.e., a destination operator. If the source operator transmits a signal for specifying a destination operator, e.g., a specific call code like a telephone number prior to transmission of a radio signal for speech communication in the same manner as in a known normal paging system, this problem can be solved. More specifically, the source operator superposes a call signal for specifying a destination operator on the frequency of a free channel (one of the frequencies f1, f2, f3, f4, and f5) and transmits it. Since the call signal is distributed to all the areas P11 to P15, a destination operator in any area can receive the call signal.

When a specific portable radio transceiver calls another specific portable radio transceiver in this manner, the called transceiver sends back a response signal. In this case, if the call signal has the carrier frequency f1, the called radio transceiver sends back the response signal V1' having the carrier frequency f1'. Similarly, the response signal V2' having the carrier frequency f2' is sent back with respect to a call signal having carrier frequency f2.

Similar to the above-described transmission signals V1 to V5, the response signals V1' to V5' thus generated are supplied to the optical multiplexer 32 through the optical fiber cables 30a to 30e and are multiplexed by the multiplexer 32. The multiplexed signal $V1' + V2' + V3' + V4' + V5'$ is commonly supplied to all the areas P11 to P12.

As described above, in the system of the third embodiment, since transmission signals from the respective areas are multiplexed by the optical multiplexer 32, and the multiplexed signal is supplied to all the areas, duplex communication can be performed between arbitrary areas.

Fig. 4 shows a detailed arrangement of the optical multiplexer 32. The multiplexer 32 comprises optical/electrical signal converters 33a to 33e, an adder 34 including resistors R1a to R1e and R2, an amplifier 36, and electrical/optical signal converters 35a to 35e. In the optical multiplexer 32

having the above arrangement, the signals V1 to V5 input as optical signals are respectively converted into electrical signals by the converters 33a to 33e, and are added to each other by the adder 34. The added signal $V1 + V2 + V3 + V4 + V5$ is amplified by the amplifier 36. The amplified signal is then supplied to converters 35a to 35e, and hence the signals $V1 + V2 + V3 + V4 + V5$ are supplied to the optical fiber cables 31a to 31e as optical signals, respectively.

Fig. 7 shows a detailed arrangement of each of the repeaters Ra to Re used in the system of the third embodiment shown in Fig. 3. Since the repeaters Ra to Re have the same arrangement, Fig. 7 shows an arrangement corresponding to the repeater Ra. Referring to Fig. 7, a transmitting/receiving antenna 72, a receiving section including an amplifier 73 and an electrical/optical signal converter 74, and a transmitting section including an amplifier 78 and an optical/electrical signal converter 77 are coupled to a hybrid circuit 71. An optical fiber cable 30a is coupled to the electrical/optical signal converter 74. An optical fiber cable 31a is coupled to the optical/electrical signal converter 77. The amplifiers 73 and 78 are respectively designed to cover all the frequency bands used in this system. The hybrid circuit 71 is designed to cause a signal to flow in a direction indicated by a solid arrow and not to flow in a direction indicated by a broken arrow.

Fig. 8 shows a detailed arrangement of each of the portable radio transceivers Ka1 to Ke1 used in the system of the third embodiment shown in Fig. 3. Each transceiver includes a hybrid circuit 80, a transmitting/receiving antenna 81, a receiving section 82, and a transmitting section 83.

The receiving section 82 includes a tuner 87, a detector 84, a call code detector 86, and a channel selecting circuit 88. The tuner 87 is constituted by 10 resonators respectively corresponding to the carrier frequencies f1 to f5 and f1' to f5', as shown in Fig. 8. The tuner 87 selectively outputs a channel selection signal from one of terminals T1 to T5' in accordance with a received carrier frequency. For example, when a radio signal having the carrier frequency f1 is received, a channel selection signal is output from the terminal T1 and is supplied to the channel selecting circuit 88. Upon reception of the channel selection signal from the terminal T1, the circuit 88 turns on a lamp (not shown) for indicating that the frequency f1 is used, and at the same time, controls the tuner 87 not to receive signals other than the frequency f1 until the contents of a call code are checked by the call code detector 86. Similarly, when a channel selection signal is supplied from the terminal T2, the circuit 88 turns on a lamp (not shown) indicating that the

frequency f2 is used, and at the same time, controls the tuner 87 not to receive signals other than the frequency f2 until the contents of a call code are checked by the call code detector 86. Such a control operation for channel selection by the channel selecting circuit 88 can be realized by various methods, e.g., a method of selectively interrupting supply of a power source voltage VC to each portion of a resonator.

The detector 84 is used to extract a modulation signal such as a speech signal from a signal received by the tuner 87. The extracted modulation signal is output to a terminal 85, and at the same time, is supplied to the call code detector 86. The call code detector 86 has a pre-assigned self code and compares it with a call code supplied from another radio transceiver. If they coincide with each other, the detector 86 generates a signal for turning on a switch S2 of the transmitting section 83.

The transmitting section 83 includes an oscillator 90, a transmission frequency switching circuit 89, a modulator 91, and switches S1 and S2. The circuit 89 is used to manually select carrier frequencies for transmission. For example, when the lamp for indicating that the carrier frequency f1 is used is turned on by the channel selecting circuit 88, the frequency f1 will not be used (since the frequency f1' is also used, the frequency f1' will not be used) and an unused frequency is selected. The modulator 91 modulates a carrier wave having a frequency selected by the circuit 89 by using a modulation signal such as a speech signal. The modulated signal is then radiated in air from the transmitting/receiving antenna 81 when one of the switches S1 and S2 is ON. The switch S1 is manually operated and is set in an ON state when signal transmission is to be performed. The switch S2 is controlled by an output signal from the call code detector 86 and is automatically set in an ON state when a call code is transmitted from another radio transceiver to its own channel.

As has been described above, according to the private branch radio communication system of the present invention, by combining a transmission medium using radio waves with a transmission medium using optical fibers, excellent communication can be provided in a wide range covering the entire premises even when a weak radio wave is used.

Claims

1. A private branch radio communication system characterized by comprising:
a portable radio transmitter (1) for modulating a signal and outputting the modulated signal as a radio signal in a first area within a given premises;

a first repeater means (2), located in the first area, for receiving the radio signal transmitted from said radio transmitter (1) and outputting an optical signal corresponding to the signal received;

5 an optical transmission medium (5) for transmitting the optical signal output from said first repeater to a second area within said premises;

a second repeater means (3), located in the second area, for receiving the optical signal output from said first repeater means (2) and transmitted by said optical transmission medium, and generating a radio signal corresponding to the signal received in the second area;

10 and a portable radio receiver (4) for receiving the radio signal output from said second repeater (3) in the second area and demodulating the signal received.

2. A system according to claim 1, characterized in that said portable radio transmitter (1) outputs a radio signal having a field intensity allowing the signal to be received in any part of the first area.

3. A system according to claim 1, characterized in that said second repeater means (3) outputs a radio signal having a field intensity allowing the signal to be received in any part of the second area.

4. A system according to claim 1, characterized in that said first and second repeater means (2, 3) are located in the first and second areas, respectively.

5. A system according to claim 1, characterized in that said first repeater means (2) includes a receiving antenna (10) and an electrical/optical converting means (12) for converting a radio signal received by said receiving antenna (10) into an optical signal.

6. A system according to claim 1, characterized in that said second repeater means (3) includes an optical/electrical converting means (13) for converting an optical signal transmitted through said optical transmission medium (5) into an electrical signal, and a transmitting antenna (15) for outputting, as a radio signal, the electrical signal output from said optical/electrical converting means (13) in the second area.

7. A private branch radio communication system characterized by comprising:

a first portable radio transceiver (21) for modulating a signal and generating the modulated signal as a radio signal in a first area within a given premises, and for receiving the radio signal generated in the first area and demodulating the signal received;

55 a second portable radio transceiver (24), for modulating a signal and generating the modulated signal as a radio signal in a second area within said premises, and for receiving the radio signal generated in the second area and demodulating the

signal received;

an optical transmission medium (5A, 5B) for coupling the first and second areas to each other;
a first two-way repeater means (22), arranged in the first area, for receiving the radio signal output from said radio transceiver (21) and supplying an optical signal corresponding to the signal received to said optical transmission medium (5A, 5B) and for receiving an optical signal transmitted through said optical transmission medium (5A, 5B) and generating a radio signal corresponding to the signal received in the first area; and
a second two-way repeater means (23), arranged in the second area, for receiving the optical signal output from said first repeater means (22) and transmitted through said optical transmission medium (5A, 5B), and generating a radio signal corresponding to the signal received in the second area and for receiving the radio signal output from said radio transceiver (24) and supplying an optical signal corresponding to the signal received to said optical transmission medium (5A, 5B).

8. A system according to claim 7, characterized in that said first portable radio transceiver (21) outputs a radio signal having a field intensity allowing the signal to be received in any part of the first area.

9. A system according to claim 7, characterized in that said second portable radio transceiver (24) outputs a radio signal having a field intensity allowing the signal to be received in any part of the second area.

10. A system according to claim 7, characterized in that said first two-way repeater means (22) outputs a radio signal having a field intensity allowing the signal to be received in any part of the first area.

11. A system according to claim 7, characterized in that said second two-way repeater means (23) outputs a radio signal having a field intensity allowing the signal to be received in any part of the second area.

12. A system according to claim 7, characterized in that said first and second two-way repeaters (22, 23) are located in the first and second areas, respectively.

13. A system according to claim 7, characterized in that said first two-way repeater means (22) includes a transmitting/receiving antenna (22C), electrical/optical signal converting means (22A) for converting a radio signal received by said transmitting/receiving antenna (22C) into an optical signal, and optical/electrical signal converting means (22B) for converting, into an electrical signal, an optical signal transmitted through said optical transmission medium (5A, 5B) and supplying the electrical signal to said transmitting/receiving antenna (22C).

14. A system according to claim 7, characterized in that said second two-way repeater means (23) includes a transmitting/receiving antenna (23C), electrical/optical signal converting means (23A) for converting a radio signal received by said transmitting/receiving antenna (23C) into an optical signal, and optical/electrical signal converting means (23B) for converting, into an electrical signal, an optical signal transmitted through said optical transmission medium (5A, 5B) and supplying the electrical signal to said transmitting/receiving antenna (23C).

15. A private branch radio communicating system characterized by comprising:

a plurality of portable radio transceivers (Ka1 - K_n1);

a plurality of two-way repeater means (Ra - Re), distributed throughout a plurality of areas (P11 - P15) within a given premises, for receiving radio signals generated in the respective areas where the repeater means are distributed and supplying optical signals corresponding to the signals received to a first optical transmission medium (30a - 30e), and for receiving optical signals input through a second optical transmission medium (31a - 31e) and generating radio signals corresponding to the signals received in the respective areas; and
optical signal multiplexing means (32) for multiplexing the optical signals output from said plurality of two-way repeater means (Ra - Re) and supplied through said first optical transmission medium (30a - 30e), and supplying the multiplexed optical signal to said plurality of two-way repeater means (Ra - Re) through said second optical transmission medium (31a - 31e).

16. A system according to claim 15, characterized in that said plurality of portable radio transceivers (Ka1 - K_n1) are distributed throughout said plurality of areas (P11 - P15).

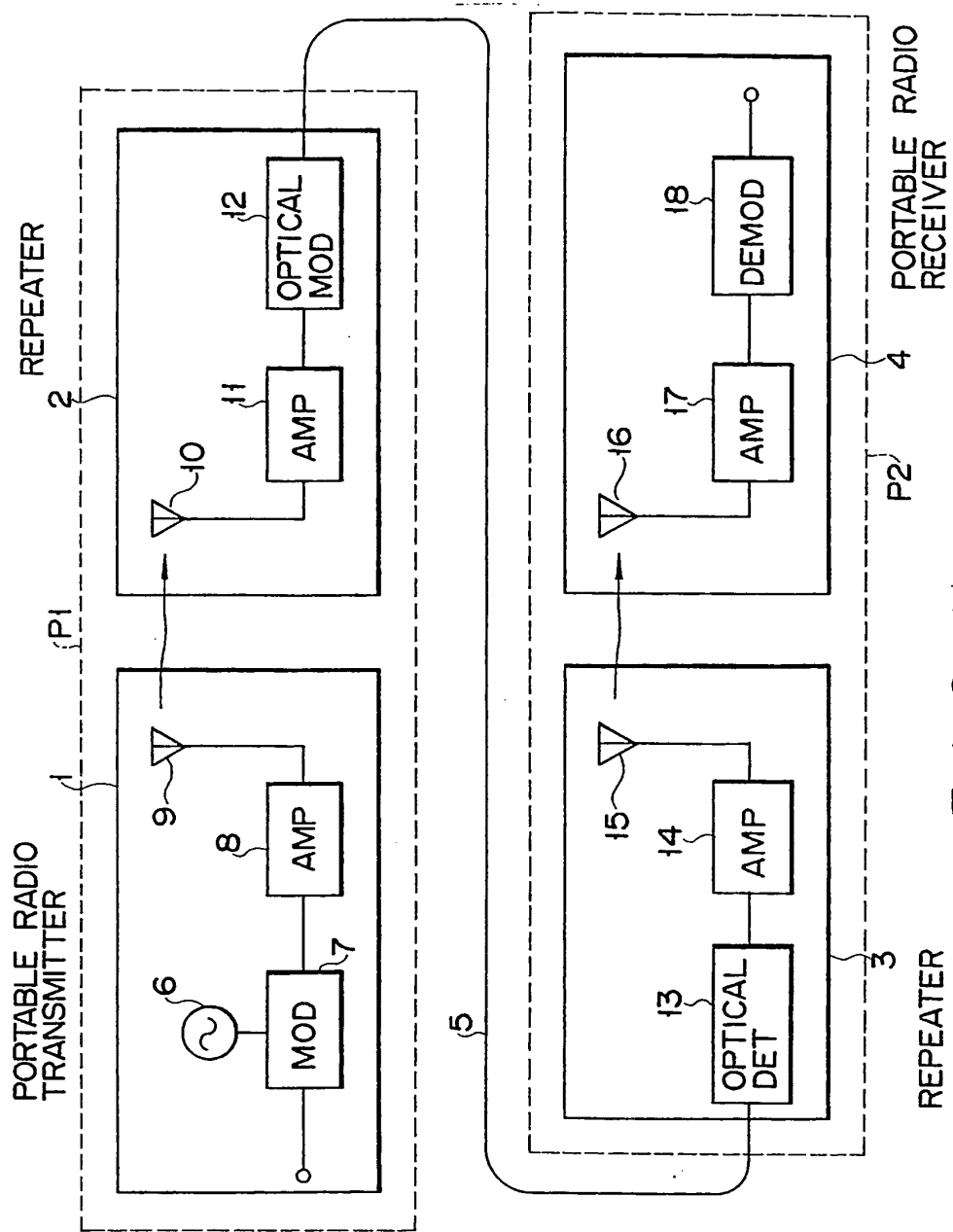


FIG. 1

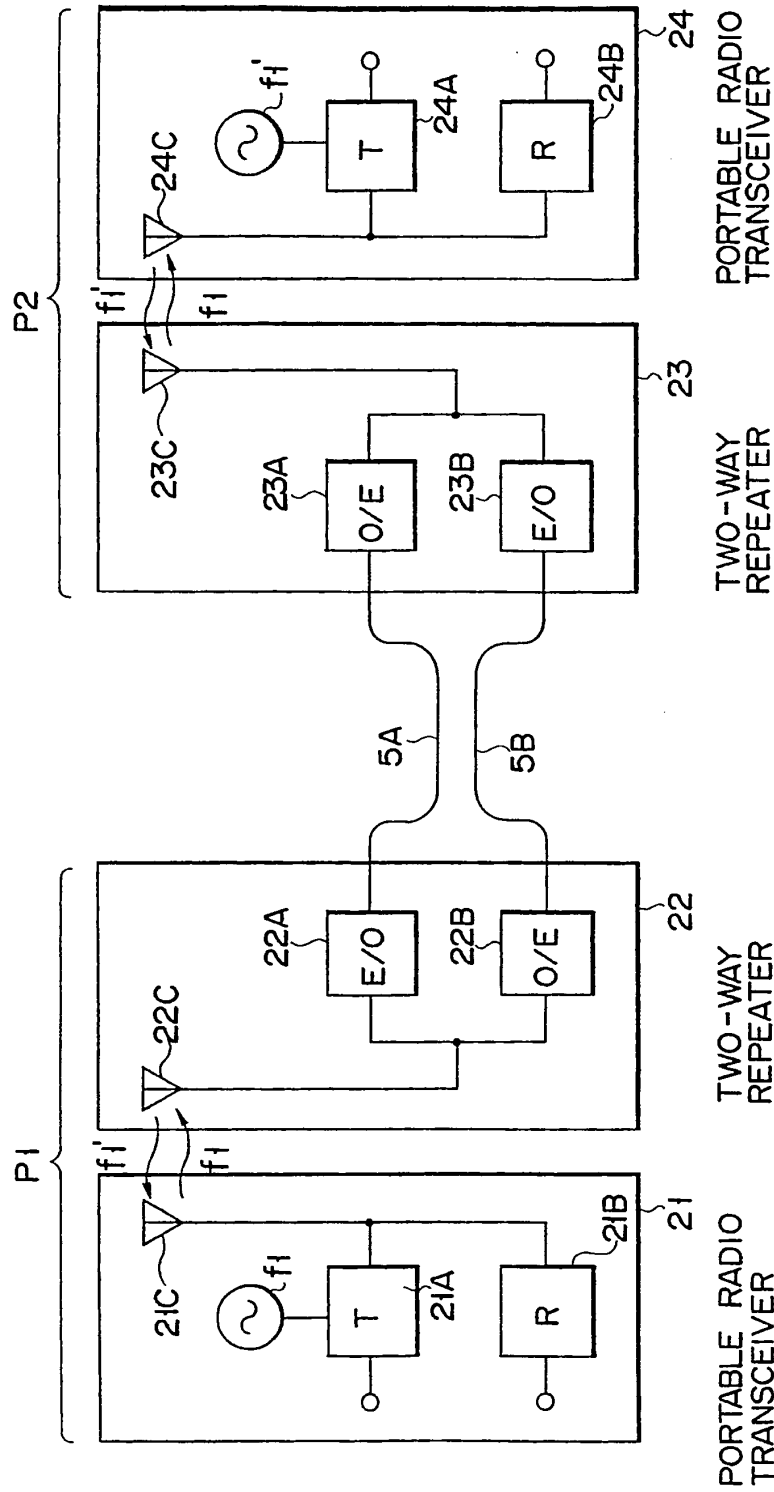


FIG. 2

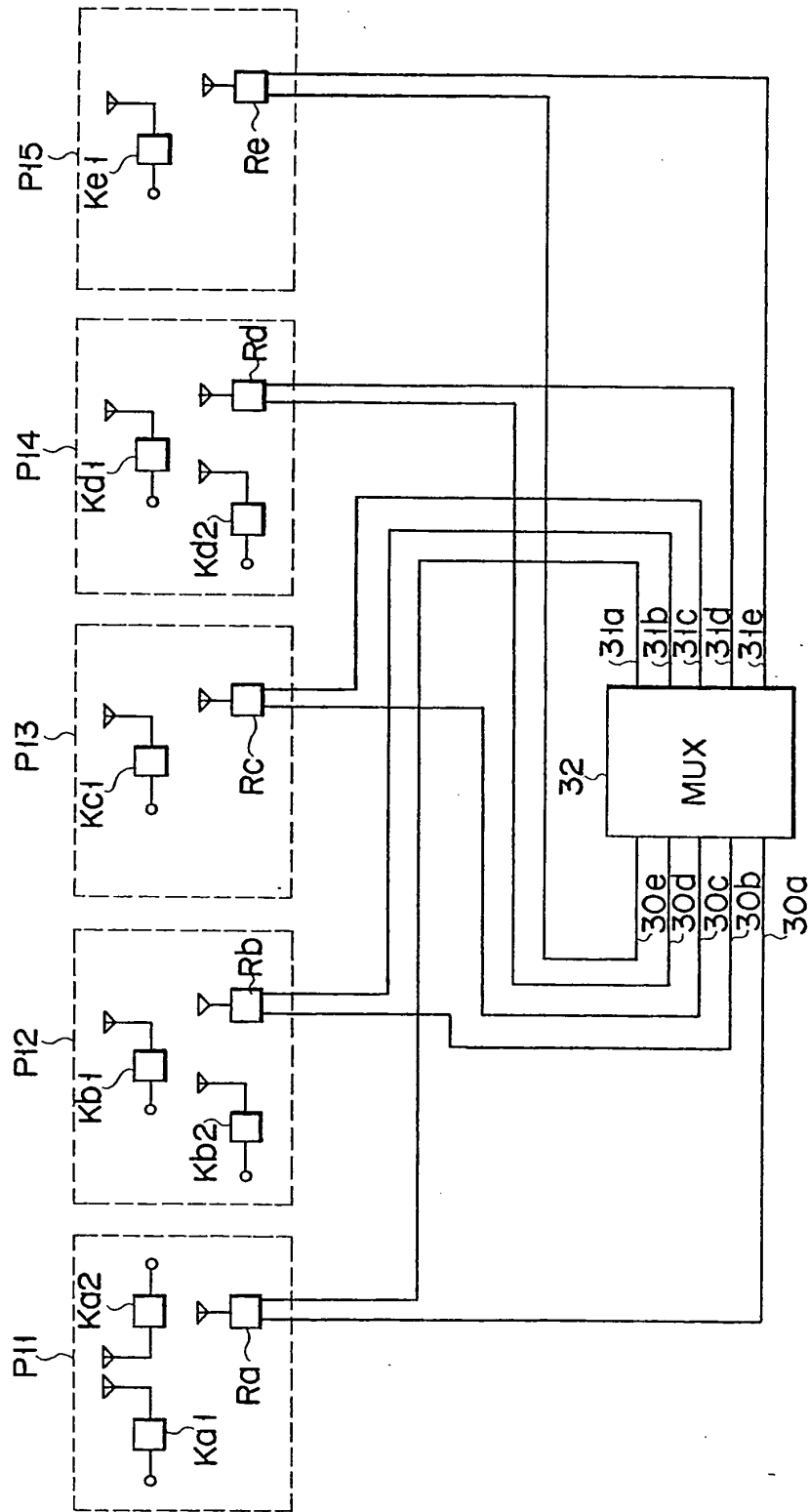


FIG. 3

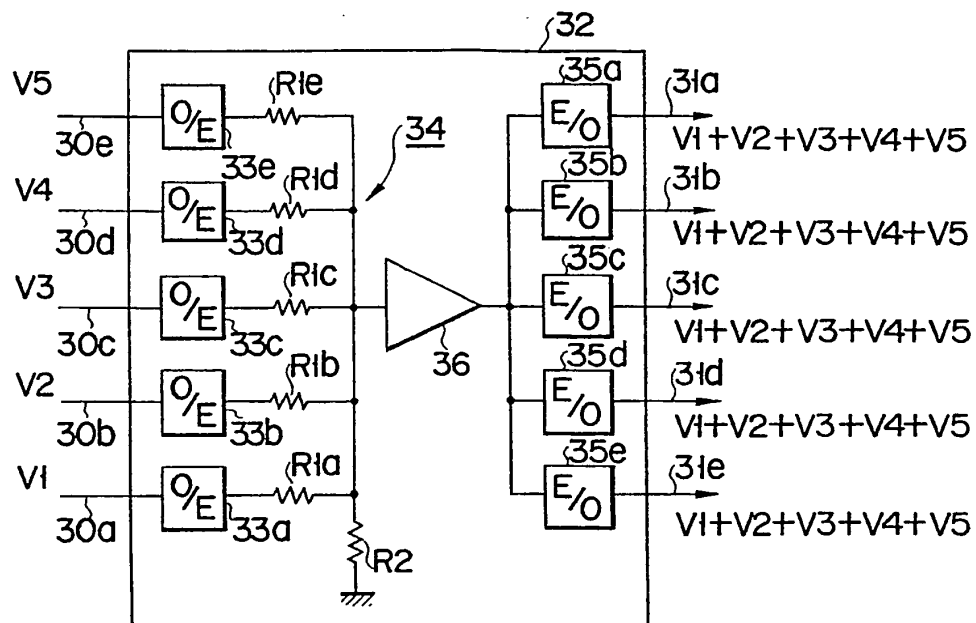


FIG. 4

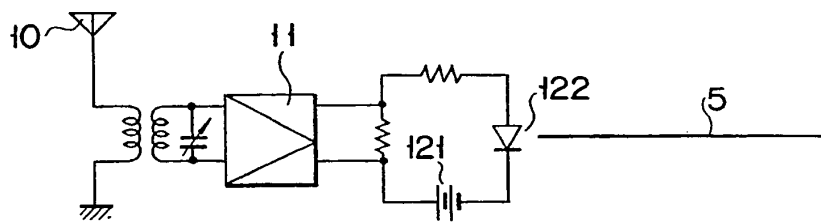


FIG. 5

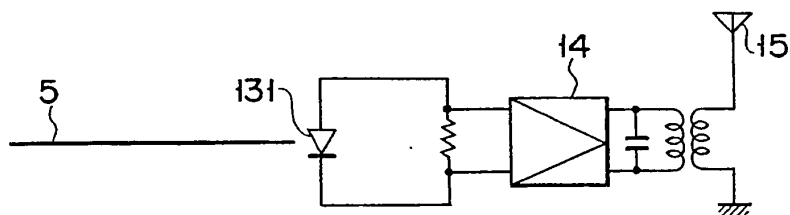


FIG. 6

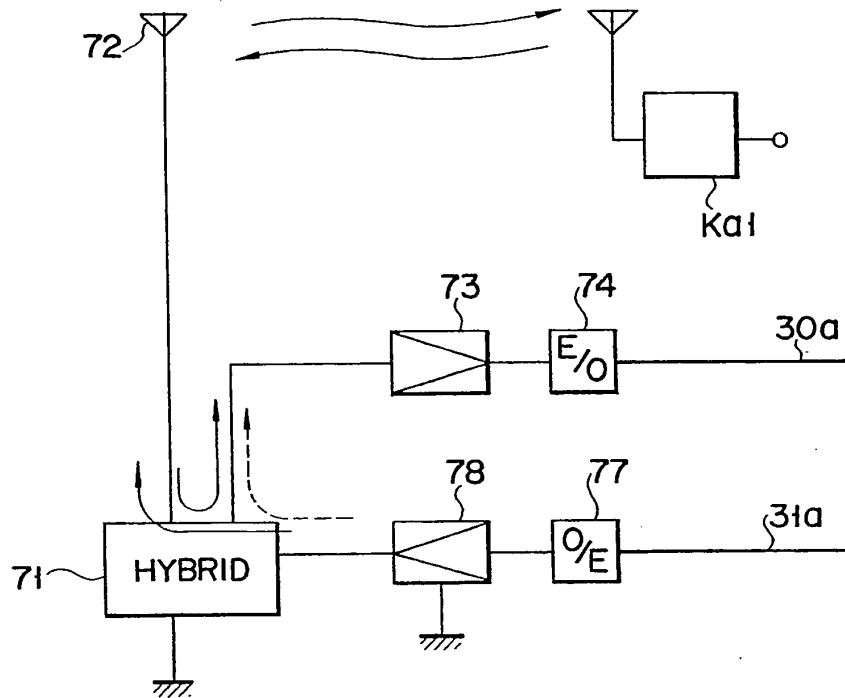


FIG. 7

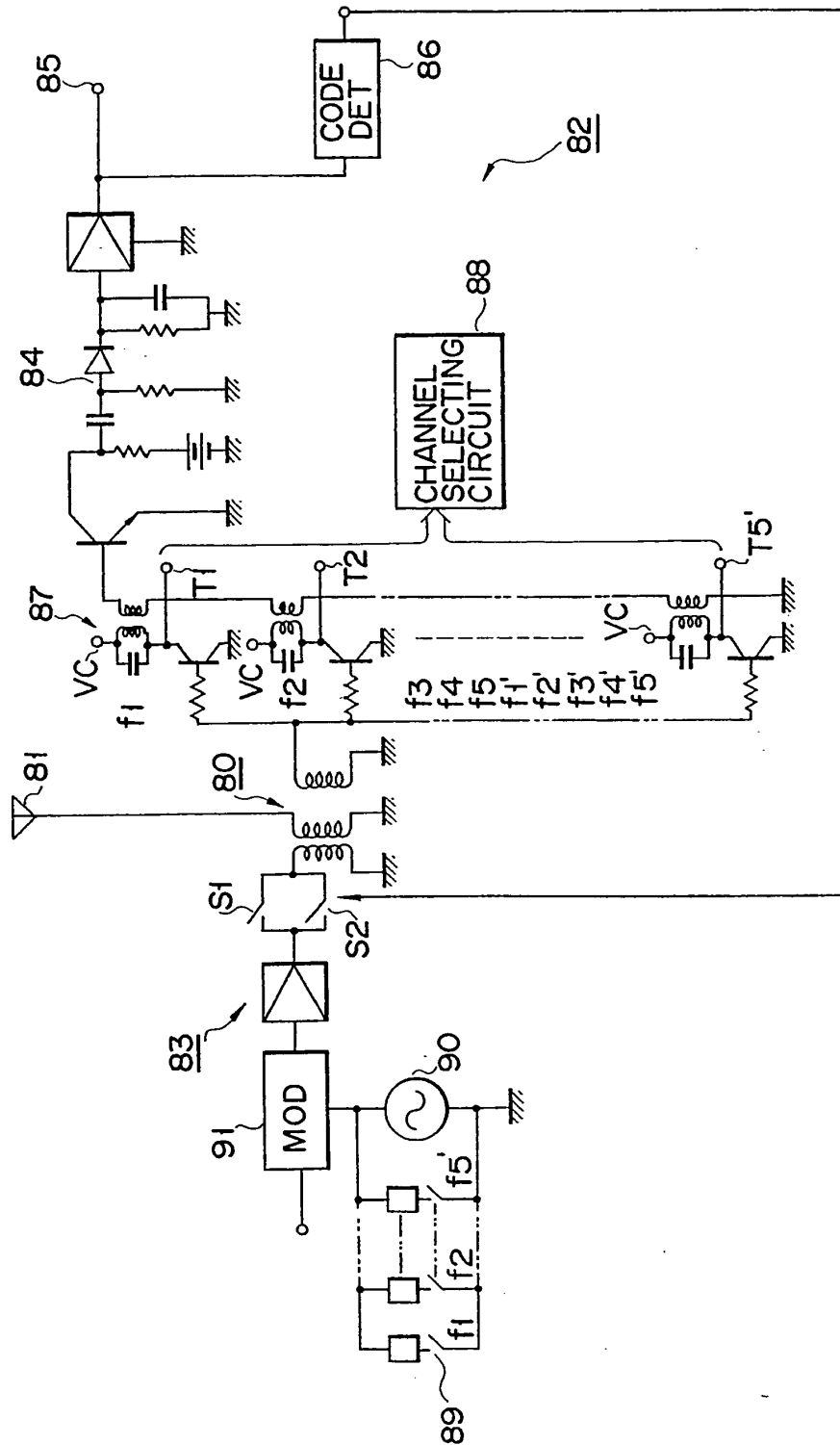


FIG. 8



65139

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ABSTRACT:

A communications system has a base centre with radio transceivers 15 for providing a number of radio frequency (RF) communications links and a plurality of fixed radio ports 1 through which RF signals can be transmitted and received over the air. A fibre optic network (2, 4) interconnects the RF transceivers 15 and the fixed radio ports 1, and carries the RF signals by means of optical signals. There are plurality of radio/optical interfaces by which RF signals can be modulated onto and demodulated from one or more optical signals, between the RF transceivers and the fibre optic network, and between the fibre optic network and the fixed radio ports. A matrix switch 13 selectively interconnects the transceivers and the radio ports through the fibre optic network.

12

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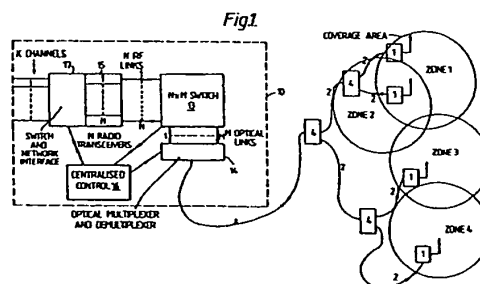
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54 **Communicationssystem.**

57 A communications system has a base centre with radio transceivers 15 for providing a number of radio frequency (RF) communications links and a plurality of fixed radio ports 1 through which RF signals can be transmitted and received over the air. A fibre optic network (2, 4) interconnects the RF transceivers 15 and the fixed radio ports 1, and carries the RF signals by means of optical signals. There are plurality of radio/optical interfaces by which RF signals can be modulated onto and de-modulated from one or more optical signals, between the RF transceivers and the fibre optic network, and between the fibre optic network and the fixed radio ports. A matrix switch 13 selectively interconnects the transceivers and the radio ports through the fibre optic network.



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COMMUNICATIONS SYSTEM

The present invention relates to a communications system, and in particular to a system for interconnecting mobile radio (RF) units to a fixed network or system e.g. PSN, ISDN, LAN or PBX.

At present, for example, in a cellular radio system mobile radio (RF) units communicate with fixed base stations which have radio transceivers that are connected to a switching control centre which is in turn coupled to the PSTN. In the proposed Telepoint system, cordless telephones (CTs) will be able to access the PSTN via radio communication with fixed base stations equipped with radio transceivers which are directly connected to the PSTN. In both these examples radio transceivers and base stations proliferate in the connection between the mobile user and the PSTN, or other network. These systems are therefore complicated and expensive. Future systems will want to provide improved coverage including the provision of many small radio "cells", and hence many base stations and radio transceivers will be required.

Difficulties in finding appropriate base station sites and the costs of equipping them may make such conventional developments impracticable; certainly they reduce the commercial attractiveness of such projects. The present invention seeks to provide a communication system of simplified structure and improved performance.

According to a first aspect the invention provides a communications system comprising: a base centre having one or more radio transceivers for providing a number of radio frequency (RF) communications links; a plurality of fixed radio ports through which RF signals can be transmitted and received over the air; a fibre optic network for interconnecting the RF transceivers and the fixed radio ports, and for carrying the RF signals by means of optical signals; a plurality of radio/optical interfaces by which RF signals can be modulated onto and demodulated from one or more optical signals, which interfaces are between the RF transceivers and the fibre optic network, and between the fibre optic network and the fixed radio ports.

The present invention also provides a communications system comprising: a base centre having one or more radio transceivers for providing a number of radio frequency (RF) communications links; a plurality of fixed radio ports through which RF signals can be transmitted and received over the air; a fibre optic network for interconnecting the RF transceivers and the fixed radio ports, and for carrying the RF signals by means of optical signals; a plurality of radio/optical interfaces by which RF signals can be modulated onto and demodulated from one or more optical signals, which interfaces

are between the RF transceivers and the fibre optic network, and between the fibre optic network and the fixed radio ports; and a matrix switch for selectively interconnecting the transceivers and the radio ports through the fibre optic network.

The present invention allows for centralisation of transceivers into base centres, and the consequent advantages in terms of technical and commercial gain, by having the transceivers selectively connectable through the fibre optic network to the RF ports.

The RF Communication linking may for example, be time division multiplexed (TDM) or frequency division multiplexed (FDM).

A preferred embodiment of the invention will now be described by way of example and with reference to the accompanying drawings, wherein:

- Figure 1 is a schematic block diagram of a communications system according to a preferred embodiment of the invention;

- Figure 2a is a schematic block diagram of an optical matrix switch which can form part of the preferred embodiment;

- Figure 2b is a schematic block diagram of an RF matrix switch which can form part of the preferred embodiment; and

- Figure 3 is a schematic view of another embodiment of the invention.

The preferred embodiment illustrated in Figure 1 is a multi-user, area coverage radio distribution system using an optical network 2,4 to link the fixed radio distribution ports 1 to a centralised radio and other signal processing base centre 10. An important feature of the system is the use of an optical carrier modulated, e.g. amplitude modulated, with a radio frequency (RF) signal.

In both the base centre 10 and RF ports 1 there are, arranged in different ways, radio/optical interfaces which can place an RF signal onto an optical carrier or conversely recover an RF signal from an optical carrier. The modulation of the optical carrier may be achieved by driving a suitable laser device with the input RF signal so that output of the laser is effectively intensity or amplitude modulated by the RF signal. With this method, a suitable optical detector receiving the amplitude modulated optical signal can produce a direct RF output. In the present specification, the term radio/optical interface is used in this context.

The radio ports 1 each have a radio/optical interface which receives and transmits radio carriers from and to roaming radio equipment. The radio carriers to be sent/received from the centralised location are placed onto/taken off an optical carrier, e.g. as described above. The optical net-

work 2,4 linking the radio ports 1 to the base centre 10 is generally conventional, having optical links carrying RF carrier/carriers on optical carrier/carriers. Each optical link is shown as bidirectional. However, separate links could be provided for each direction. Within the optical system are optical multiplexers/demultiplexers (M+D) 4. Each multiplexer concentrates a number of optical carriers, say X, onto a fewer number of optical links than X. The demultiplexers splits a number of optical carriers onto individual optical links.

At the base centre 10 the optical system 2,4 is connected to an optical multiplexer and demultiplexer (M+D) 14. The M+D 14 is connected (illustratively) by M optical lines to an NxM matrix switch 13, which will be described below in more detail. The NxM matrix switch 13 has N RF links to a number (N) radio transceivers 15. The radio transceivers 15 are connected through a switch 17 to a number (K) channels of another network which may be ISDN, cellular, LAN, PBX etc. K may be greater than or equal to N. Also in the base centre 10, a central unit 16 is connected to the switch 17, NxM matrix switch, and M+D 14 to control optical, RF, and baseband routing and switching, and co-ordinate the allocation of RF carriers and channels in conjunction with mobile equipment.

A central part of the base centre 10 is the NxM matrix switch 13. This multiplexes many of the N radio carriers onto any of the M optical transmission lines, i.e. none, one or more of the radio carriers may be on any one of the optical carriers at any one time. The NxM matrix switch 13 may be configured in one of two ways, as shown in Figures 2a and 2b. In each case, the radio/optical interface places the RF carriers to be transmitted from the central transceivers onto the optical carrier(s) and takes off, from the optical carrier(s), the RF carriers to be received by the central transceivers. The switching may be optical (Figure 2a), in which case the radio/optical interface is on the radio "side" of the switch, or the switch may be a radio (RF) matrix switch (Figure 2b), in which case the radio optical interface is on the optical system "side" of the switch. In either case, the overall result is that the N radio lines can be multiplexed onto the M optical lines.

The advantages of the system of the preferred embodiment are profound. A user can access the external network through any of the radio ports 1 with a suitable RF transceiver, e.g. a cordless telephone (CT), and be connected to a free one of the N transceivers 15. Provided the RF capacity was available, all N transceivers could be employed in calls to/from a particular one of the radio ports 1, or as would be more likely, the usage of the transceivers would be distributed among the radio ports of the system. Here lies a key advantage of

the system: the centralisation of the radio transceivers. In the present system the radio transceivers are centralised, allowing more economic use and facilitating maintenance etc. Other significant advantages include the possibility of handover between ports covering different zones or areas, by simply switching between optical carriers, i.e. by switching within the NxM matrix switch 13. Also the use of diversity can easily be achieved centrally through switching or combining links to 2 or more ports, to improve performance of mobiles covered by those ports. Further, advantageous use of the RF system can be achieved because any of the carriers allocated to the service, rather than a given subset, can be dynamically assigned by the centralised base, to a given zone or cell. Thus an RF carrier may be allocated to both zone 1 and zone 4, but to different users. At another time, RF carrier may be assigned to just zone 3. The total number of users may remain more or less constant for the whole system, but user density within the system may vary. For example, all the users may shift from zone 1 down to zone 4, with all the central transceivers continually active. If transceivers were placed remotely in each of the zones, the same number of transceivers as that at a central location would be required in each of the zones to meet the peak traffic demand during the day, even though they could remain idle for much of the time. Four times the number of transceivers of the centralised configuration would then be required for the system of Figure 1, hence the improved trunking performance of the centralised scheme, minimising the cost of providing transceivers, the quantity of equipment in the field and affording a potential reduction in maintenance and installation costs.

Handover requires a change of base transceiver as a mobile transits zones. This need no longer be necessary as the switch, block 3, simply switches the active transceiver for a given mobile from one zone to another as the mobile makes the transition. Thus handover break is reduced to a potentially very short optical or RF switch time compared to the much longer period required to switch between transceivers.

The spectrum efficiency of many radio distribution systems are increased if the RF transmissions within the system are synchronised. This is difficult if transceivers are spread over several locations, but more straightforward when they are centralised.

An alternative embodiment of the invention is shown in Figure 3 and is very similar to that of Figure 1, except that the optical system does not incorporate multiplexing/demultiplexing. Thus there are no M+Ds 4 and the M outputs of NxM switch 13 are connected directly to the radio ports 1. There is therefore a permanent 1 to 1 correspondence between the optical lines in the NxM switch

13 and the radio ports 1.

The embodiment of the invention described is based on the use of frequency division multiple access, where each communications link is on a separate radio frequency. As an alternative, time division multiple access could be used, where each communication link exists on separate time slots on a single radio channel. In this case there may still be multiple transceivers in the base centre 10 to cope with the traffic demand and hence provide frequency/timeslot reuse at the radio distribution ports 1. The connection from the transceivers 15 to the matrix switch 13 will then be by N radio links with P timeslots each, making NxP links in total to the matrix switch 13 from the transceivers 15. An extension of this approach is the possibility of a hybrid time and frequency division access system, with multiple radio carriers and several timeslots on each.

An example of a form of an RF switch is shown in Figure 4. The figure shows the RF matrix switch in a three distribution point system demonstrator. The RF matrix switch interconnects the four radio transceivers 51 (with their associated isolator circuits 52) to the three circuits each of which feeds a distribution point via a pair of fibres. Bi-directional RF connections for all the combinations of base unit and D.P. are made via switches that allow either through connection or isolation of the connection path. These switches are under computer control.

The signals from/to the radio transceiver 51 are split/combined in four 3 way combiners 53 (these are actually 4 way combiners with the spare output feeding to the scanning receiver 52) with each output/input passing through a switch that can isolate that output/input. From the switches the signals go to the inputs of one of the three 4 way combiners 55 and hence to/from the D.P.s via one of the three RF/optical interfaces 56.

These switches are under microprocessor control and allow the RF matrix to switch any transceiver to any combination of the distribution points and conversely a distribution point to any combination of the transceivers. Thus a base unit can feed all the distribution points simultaneously then by changing the switches feed only one distribution point.

Two examples of the elements for optical switch and shown in Figure 5. There are two basic technologies; (i) Bulk Optic Devices and (ii) Guided Wave Devices.

A bulk optic switch element, shown in Figure 5(a), uses mechanical or physical reorientation of the optical path to achieve the switching of the incoming optical signals between output ports. An example of this type of switch is presented below for a single input switchable between two outputs. Other

switch configurations using this as a basic building block facilitate 2x2 and 2x4 switches.

A guided wave device switch element, shown in Figure 5(b), uses the electro-optic effect to change the optical propagation characteristics of switch waveguides through the application of electric fields. An example of this device type is the Mach Zender Interferometer (MZI) shown in Figure 5(b). This type of switch can be extended from a simple 2x2 to a non-blocking 8x8 switch matrix.

Claims

1. A communications system comprising: a base centre having one or more radio transceivers for providing a number of radio frequency (RF) communications links; a plurality of fixed radio ports through which RF signals can be transmitted and received over the air; a fibre optic network for interconnecting the RF transceivers and the fixed radio ports, and for carrying the RF signals by means of optical signals; a plurality of radio/optical interfaces by which RF signals can be modulated onto and demodulated from one or more optical signals, which interfaces are between the RF transceivers and the fibre optic network, and between the fibre optic network and the fixed radio ports.

2. A communications system comprising: a base centre having one or more radio transceivers for providing a number of radio frequency (RF) communications links; a plurality of fixed radio ports through which RF signals can be transmitted and received over the air; a fibre optic network for interconnecting the RF transceivers and the fixed radio ports, and for carrying the RF signals by means of optical signals; a plurality of radio/optical interfaces by which RF signals can be modulated onto and demodulated from one or more optical signals, which interfaces are between the RF transceivers and the fibre optic network, and between the fibre optic network and the fixed radio ports; and a matrix switch for selectively interconnecting the transceivers and the radio ports through the fibre optic network.

3. A communications system as claimed in claim 2 wherein the RF links are frequency division multiplexed.

4. A communications system as claimed in claim 2 wherein the RF links are time division multiplexed.

5. A communications system as claimed in claim 2, 3 or 4, wherein there is means for combining RF signals to or from one or more of the RF ports.

6. A communications system as claimed in any one of claims 2 to 5 wherein the matrix switch is for switching optical signals and between the op-

tical matrix switch and the one or more RF transceivers there are one or more RF/optical interfaces.

7. A communications system as claimed in any of claims 2 to 5 wherein the matrix switch is for switching RF signals, and between the RF matrix switch and the fibre optic network there are one or more RF/optical interfaces. 5

8. A communications system as claimed in any preceding claim wherein there is multiplexing/demultiplexing of the optical signals in the fibre optic network. 10

9. A communications system as claimed in any preceding claim wherein the fibre optic network incorporates wavelength routing of optical signals. 15

10. A communication system as described in any preceding claim which call handover is between radio ports is controlled in the base centre through switching the radio transceiver from one radio port to another radio port by the matrix switch. 20

11. A communication system as claimed in any preceding claim which diversity operation is provided by combining or switching between two or more radio points in the matrix switching. 25

12. A communication system as claimed in any preceding claim which dynamic channel allocation is controlled in the base centre. 30

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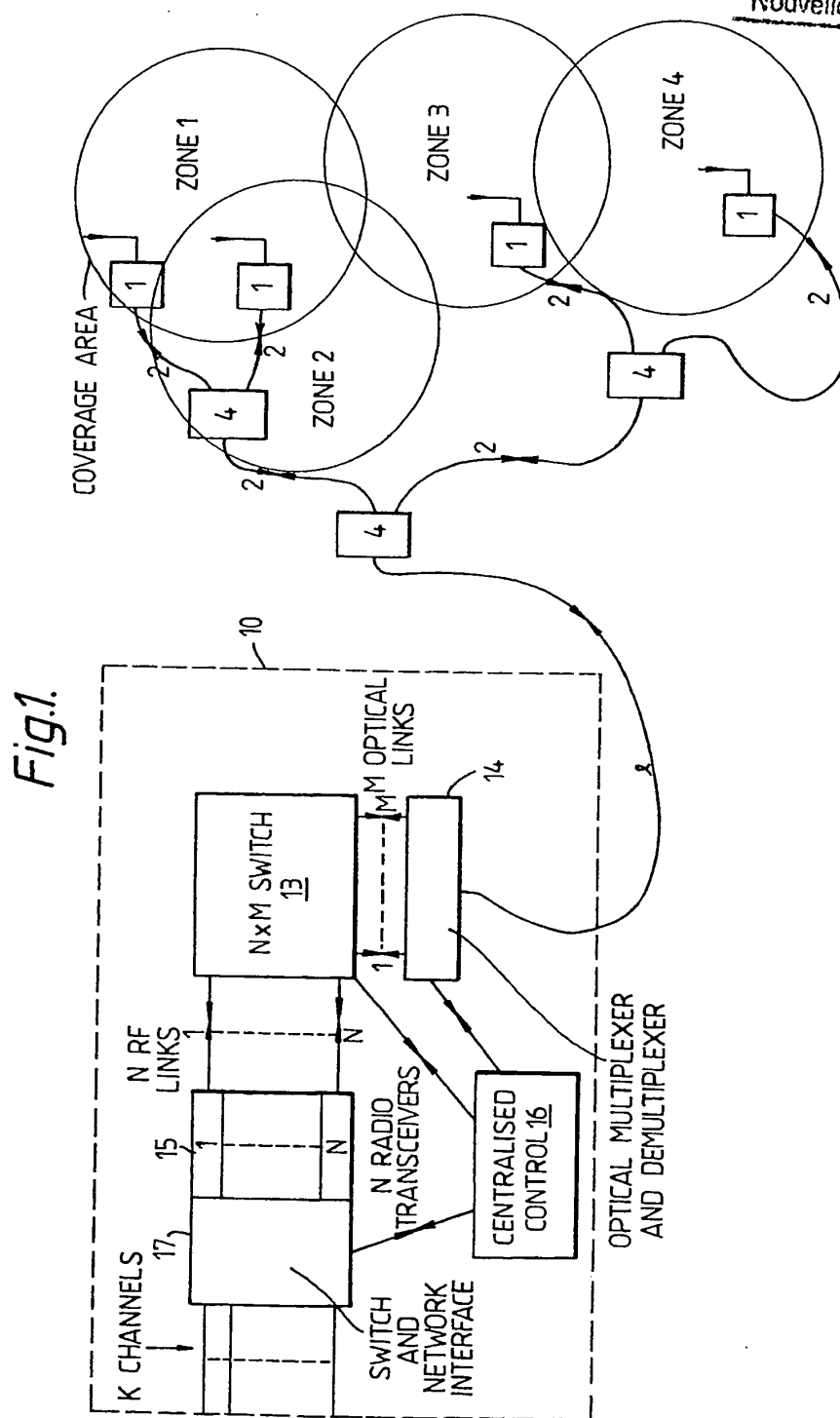
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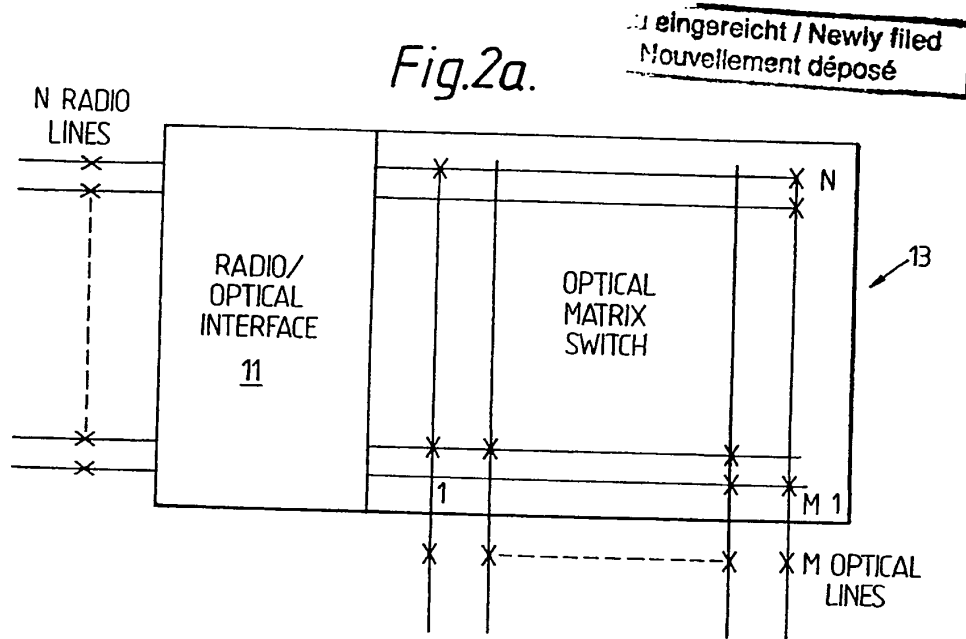
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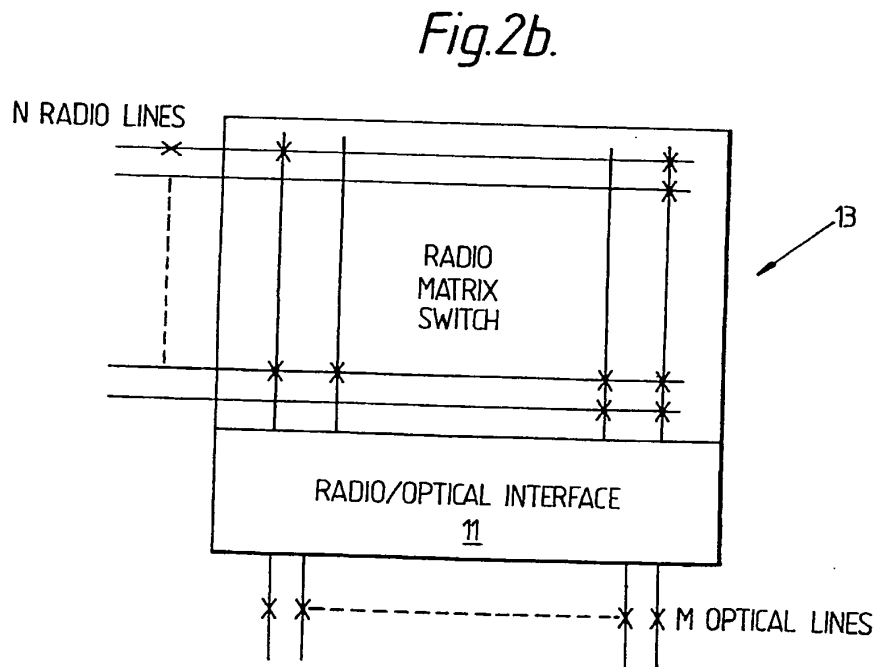
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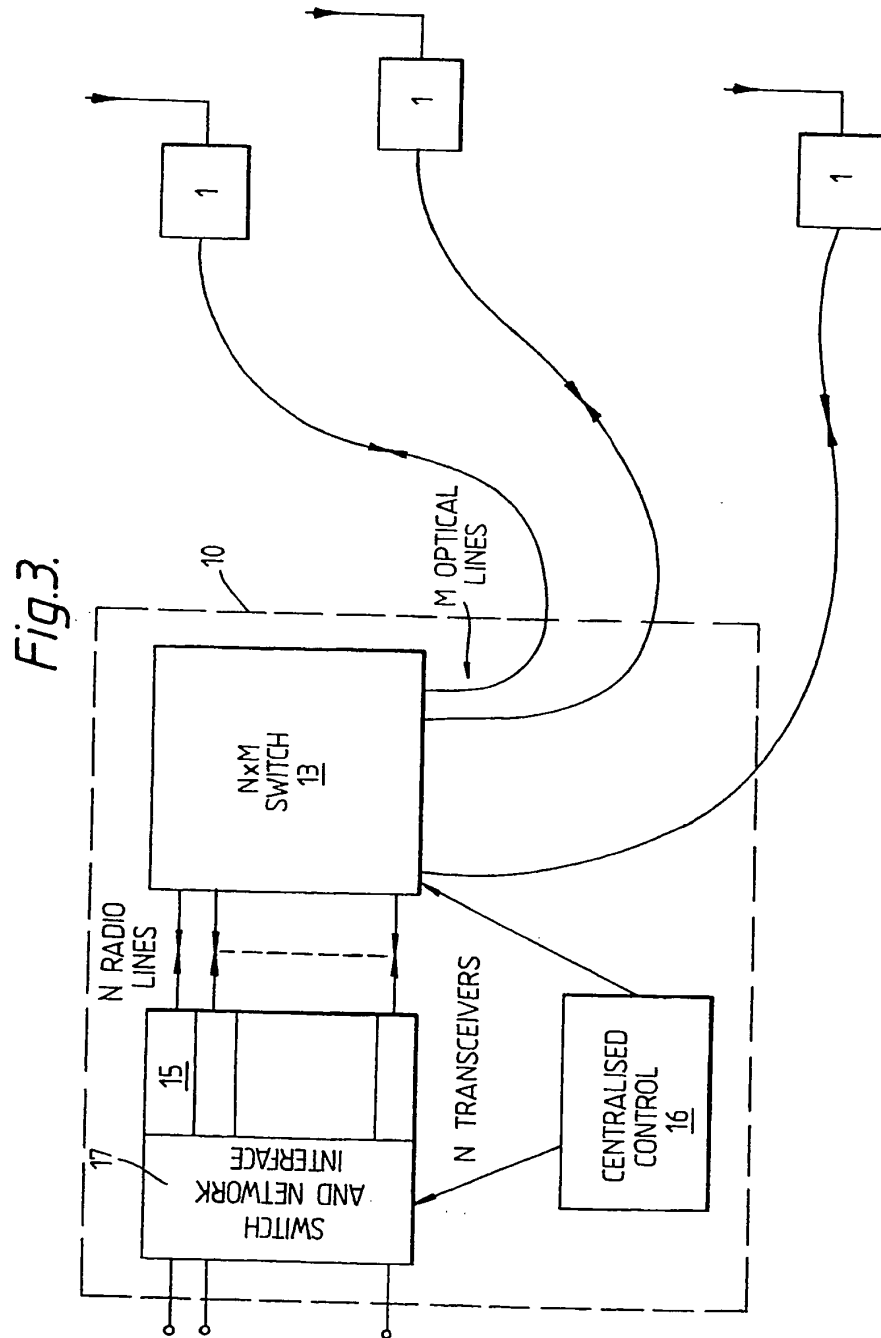




* DENOTES CONNECTION OF A COLUMN TO A ROW THUS COLUMN M IS SHOWN CONNECTED TO ROWS 1, $N-1$ AND N

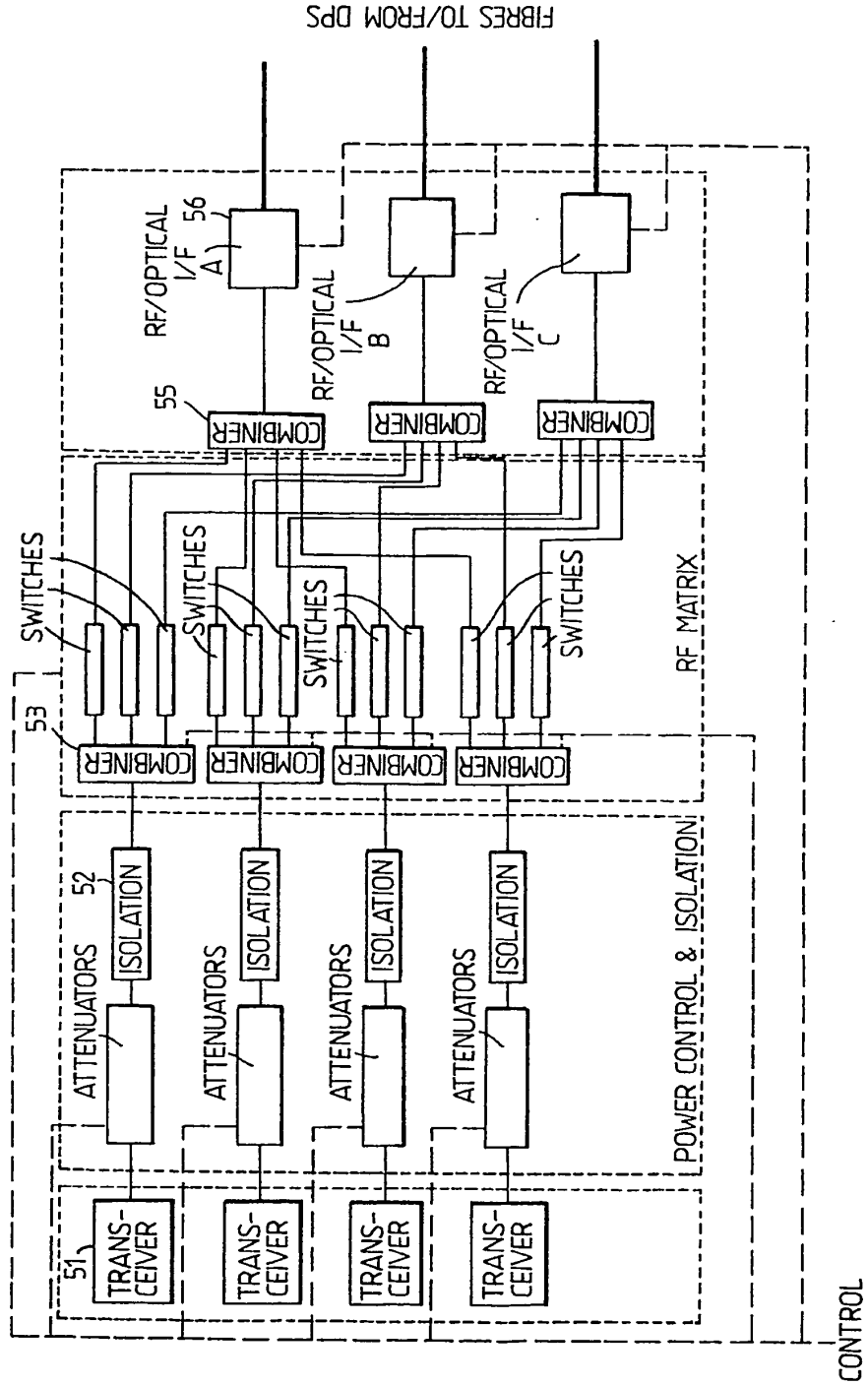


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Fig.4.



Neu eingereicht / Newly filed
Nouvellement déposé

Fig.5a.

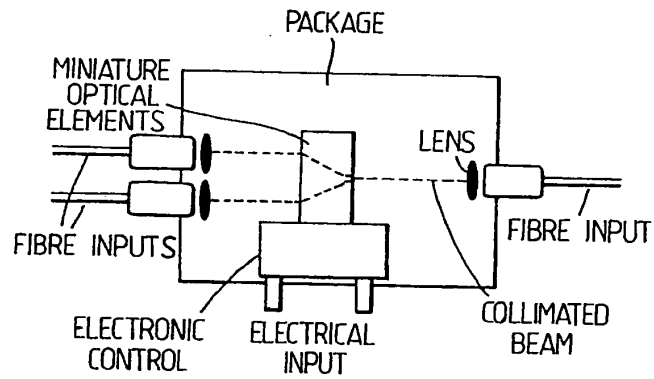
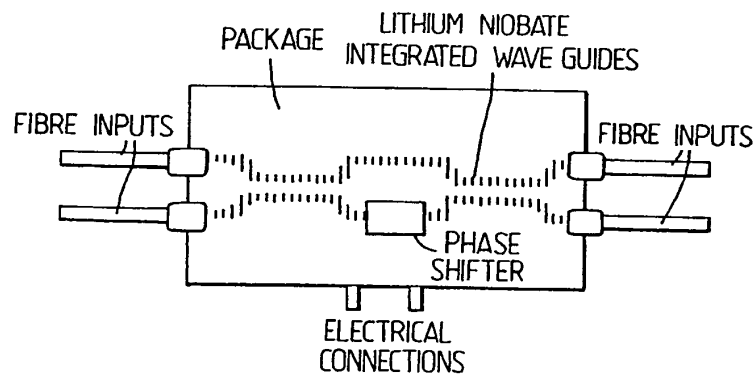


Fig.5b.





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 89 31 1656

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	PROCEEDINGS OF THE IEEE, vol. 75, no. 4, April 1987, pages 436-477, IEEE, New York, US; D.C. COX: "Universal digital portable radio communications" * Page 441, right-hand column, paragraph IV; page 452, right-hand column, paragraph e, lines 1-15; page 456, right-hand column, lines 19-25; page 457, right-hand column, paragraph 3 - page 459, right-hand column, paragraph c; page 465, left-hand column, paragraph c - right-hand column, paragraph 7 *	1-5,11-12	H 04 Q 7/04 H 04 B 7/26 H 04 M 1/72
A	GB-A-2 138 652 (STD. TELEPHONES AND CABLES) * Page 1, lines 1-54; page 1, line 76 - page 2, line 10; page 2, lines 28-62; page 2, line 98 - page 3, line 35 *	1,2,4	
A	EP-A-0 233 963 (ANT) * Page 6, lines 13-31; page 6, line 49 - page 7, line 5; page 7, line 42 - page 12, line 11 *	2-4,7,10,12	TECHNICAL FIELDS SEARCHED (Int. Cl.5) H 04 B H 04 M H 04 Q
A	DE-A-3 135 231 (S.E.L.) * Page 5, line 18 - page 6, line 15; page 7, lines 1-13; page 8, line 1 - page 9, line 20 *	1,2,5,8	
A	EP-A-0 156 336 (S.E.L.) * Page 2, line 12 - page 4, line 27 *	1,2,4,10	
A	PATENT ABSTRACTS OF JAPAN, vol. 5, no. 15 (E-43)[687], 29th January 1981, page 87 E 43; & JP-A-55 143 854 (NIPPON DENSHIN DENWA KOSHA) 10-11-1980	1,2,5,11	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 08-02-1990	Examiner GERLING J.C.J.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 01.83 (P0401)

Requested Patent: EP0468688A2

65138

Title:

METHOD AND APPARATUS FOR PROVIDING WIRELESS COMMUNICATIONS
BETWEEN REMOTE LOCATIONS ;

Abstracted Patent: EP0468688 ;

Publication Date: 1992-01-29 ;

Inventor(s): RUSSELL JESSE EUGENE (US); ZYSMAN GEORGE ISAAC (US) ;

Applicant(s): AMERICAN TELEPHONE TELEGRAPH (US) ;

Application Number: EP19910306479 19910717 ;

Priority Number(s): US19900557873 19900725 ;

IPC Classification: H04B7/26 ;

Equivalents: CA2041705, DE69116949D, DE69116949T, JP4234233

ABSTRACT:

A wireless telecommunication system includes a microwave link between a main base station (100) and a remote reception and radiation site (106) capable of communicating with a plurality of telephone subscriber stations (107, 108). At the main base station (100), radio frequency signals intended for the telephone subscriber stations are modulated on a microwave frequency carrier signal prior to their transmission, via a microwave antenna (112), to the remote site. At the remote site (106), the frequencies of the microwave signals, received at a microwave antenna (114), are reduced prior to modulating such frequency-reduced signals on a radio frequency carrier signal and radiating, via a radio frequency antenna (115), the modulated radio signals out of the site. All radio signals received at the remote site from telephone subscriber stations are modulated on a microwave carrier signal prior to their transmission, via a microwave antenna (114), to the main base station (100). At the main base station (100), the frequencies of the incoming microwave signals are reduced prior to modulating such frequency-reduced signals on a radio frequency carrier signal and coupling the modulated radio signals to a receiver.



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⑤④ **Method and apparatus for providing wireless communications between remote locations.**

⑤⑦ A wireless telecommunication system includes a microwave link between a main base station (100) and a remote reception and radiation site (106) capable of communicating with a plurality of telephone subscriber stations (107, 108). At the main base station (100), radio frequency signals intended for the telephone subscriber stations are modulated on a microwave frequency carrier signal prior to their transmission, via a microwave antenna (112), to the remote site. At the remote site (106), the frequencies of the microwave signals, received at a microwave antenna (114), are reduced prior to modulating such frequency-reduced signals on a radio frequency carrier signal and radiating, via a radio frequency antenna (115), the modulated radio signals out of the site. All radio signals received at the remote site from telephone subscriber stations are modulated on a microwave carrier signal prior to their transmission, via a microwave antenna (114), to the main base station (100). At the main base station (100), the frequencies of the incoming microwave signals are reduced prior to modulating such frequency-reduced signals on a radio frequency carrier signal and coupling the modulated radio signals to a receiver.

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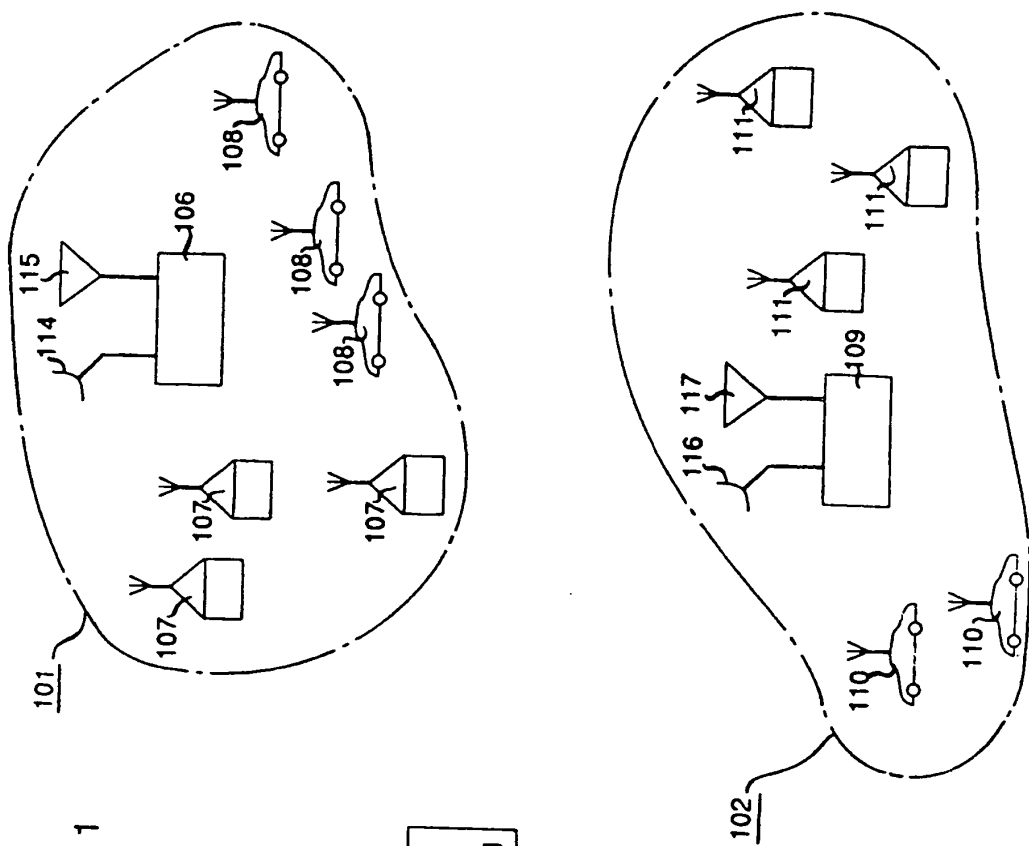


FIG. 1

Technical Field

The present invention generally relates to wireless communications systems and, more particularly, to techniques for providing wireless telecommunications between a main base station and a remote location which includes, for example, a mobile radio reception and radiation cellular site.

Background of the Invention

In high capacity cellular mobile radiotelephone systems, a plurality of base stations, also referred to as cell sites, are arranged so that each cell site covers a respective geographical area called a cell. Typically, each such cell site contains a radio transmitter-receiver and is directly wired to a mobile telephone switching office (MTSO) which in turn is part of a regional or nationwide network of telephone switching offices. One example of such cell site is the AT&T Series I cell sites (Model 1 and Model 2 architecture) used in the family of AUTOPLEX® cellular telecommunications systems which are commercially available from the American Telephone and Telegraph Company of New York, N.Y. Because of increased demands for more radio channels resulting from a growing cellular customers base, cellular telephone service providers often desire to expand their networks to service an increasing number of subscriber stations within a geographical location.

Various solutions to meet the foregoing need have suggested placing cell site antennas geographically very close to the potential locations of mobile or portable subscriber stations and carrying signals between the cell site and its remote antennas over either coaxial transmission lines or an optical fiber cable network interconnecting the cell site and its antennas. One such microcellular communication system includes optical fiber connections between a cellular base station and a plurality of radio frequency antennas. Such optical fiber links operate satisfactorily for their intended purposes for which they were originally designed. However, due to rapid growth of cellular customer demands combined with the requirements of quickly, reliably and cost-effectively providing cellular service to customers either on a permanent basis or on a temporary one, such as for example in case of emergencies, there exists a need for a more flexible, lower-cost and more easily and quickly expandable communication system than now exists with commercially available equipments.

Summary of the Invention

The foregoing need is met in an embodiment of the invention wherein a method for providing wireless communications between a main base station of a type capable of being connected to a telephone net-

work and at least one remote reception and radiation site of a type capable of communicating with a plurality of telephone subscriber stations over predetermined radio frequencies comprises the steps of reducing the frequency of radio signals which are intended for the telephone subscriber stations to a lower frequency range, amplifying the frequency-reduced signals, modulating the amplified signals on a microwave frequency carrier signal, amplifying the microwave frequency modulated signals, and coupling the amplified microwave signals to a microwave antenna for transmission to the remote reception and radiation site.

In accordance with another embodiment, a method for receiving wireless communications signals at the main base station from the remote reception and radiation site comprises the steps of receiving at the microwave antenna of the main base station incoming microwave signals, amplifying the received microwave signals, reducing the frequency of the amplified signals to a substantially lower frequency range which includes the subscriber stations predetermined radio frequencies, amplifying the frequency-reduced signals, modulating the amplified frequency-reduced signals on a radio frequency carrier signal to generate radio frequency signals, and coupling the generated radio frequency signals to a receiver within the main base station.

In accordance with a further embodiment, a method for transmitting from the reception and radiation site a plurality of radio telecommunications signals having predetermined radio frequencies and intended for a plurality of telephone subscriber stations comprises the steps of receiving at the site incoming microwave signals, reducing the frequencies of the received microwave signals to substantially lower frequencies thereby generating intermediate signals, modulating the intermediate signals on a carrier signal having a frequency selected from the predetermined radio frequencies, and coupling the modulated radio signals to a radio frequency antenna.

In accordance with a still further embodiment, a method for processing at the reception and radiation site a plurality of radio telecommunications signals having predetermined radio frequencies comprises the steps of receiving at the site incoming radio signals, reducing the frequencies of the received radio signals to lower frequencies to generate intermediate signals, modulating the intermediate signals on a microwave frequency carrier signal, and coupling the modulated microwave signals to a microwave frequency antenna.

In one illustrative embodiment of the invention, transmitting apparatus at the main base station comprise a frequency downconverter for reducing the frequency of cellular radio signals intended for a mobile subscriber station, and a modulator for modulating the

frequency-reduced signals on a microwave carrier for transmission to a remote mobile radio reception and

communication link 103, to a telephone switching office 104 for example a mobile telephone switching

tional block diagram form, only certain portions of the main base station 100 useful in the understanding of one embodiment of the invention. The main base station 100 comprises a transmitter portion and a receiver portion. Communication signals between the MTSO 104 and the various telephone subscriber stations 107, 108, 110 and 111, shown in FIG. 1, are derived from, as well as detected at radio channel units within the main base station 100 of which one such radio channel unit 200 is illustratively shown. In the transmitter portion of the main base station 100, radio signals to be transmitted to distant telephone subscriber stations are present on output lead 201 of radio channel unit 200. In the receiver portion of the main base station 100, radio signals received from distant telephone subscriber stations are present on input lead 212 of radio channel unit 200. Typically, the transmission radio signals present on lead 201 have frequencies that differ from those of reception radio signals present on lead 212. In connection with cellular mobile telephone communications, a typical transmission radio frequency for outgoing signals on lead 201 is of the order of 870 MHz, while a typical reception radio frequency for incoming signals on lead 212 is of the order of 825 MHz. In accordance with one aspect of the invention, the frequency of the outgoing signals present on lead 201 is reduced by a frequency downconverter 202 to a frequency range of the order of the frequency band of the remote site, e.g., 106, to which such outgoing signals are intended. For purpose of illustration only, in connection with the foregoing example, the 870 MHz frequency of the outgoing radio signals may be reduced by the downconverter 202 to about 2 MHz. Next, in such case, the 2 MHz frequency-reduced signals are amplified via amplifier 203 and applied to a modulator 204 adapted to modulate the frequency-reduced signals on a microwave frequency carrier signal. The frequency of the latter may be selected from any of the normally used microwave frequency bands, e.g., the 18 GHz band. The output signals of the modulator 204 are preferably coupled to a microwave amplifier 205 prior to coupling to the microwave antenna 112 via a microwave duplexer 206. Given desired frequency ranges and bands, the downconverter 202, the amplifiers 203 and 205, the modulator 204 and the duplexer 206 can be selected from any commercially available circuits meeting desired frequency and amplification parameters.

As shown in FIG. 2, the receiver portion of the main base station 100 includes a microwave amplifier 207 coupled to the duplexer 206 and adapted to amplify incoming microwave signals received at the antenna 112. In accordance with another aspect of the invention, a frequency downconverter circuit 208 has an input coupled to the output of amplifier 207 so that the frequency of the incoming microwave signals received at the antenna 112 is substantially reduced

to a frequency range of the order of the frequency band of a remote site, e.g., 106 or 109, from which the incoming microwave signals originate. Referring to the above-mentioned example, the output signals of the downconverter 208 may have a frequency of the order of 2 MHz. Such substantially reduced frequency signals are next amplified via amplifier 209 and applied to a modulator 210 adapted to modulate them on a radio frequency carrier signal. It may be desirable to connect a second amplifier circuit (not shown) to the output of the modulator 210 if the amplitudes of the modulated radio frequency signals, as generated by the modulator 210 and present on the lead 212, are of insufficient magnitudes for further processing by the radio channel unit 200.

Although the embodiment of FIG. 2 was described with reference to a single microwave antenna 112 and an associated duplexer 206, separate transmission and reception microwave antennas can readily be substituted for the antenna 112 thus eliminating the need for duplexer 206.

Referring now to FIG. 3, there is shown, in functional block diagram form, various circuit elements included in the remote reception and radiation site 106. As mentioned in connection with the description of the arrangement shown in FIG. 1, the microwave antenna 114 is adapted to receive and transmit microwave signals, respectively, from and to the main base station. A duplexer circuit 301, such as for example a microwave circulator of commercially available type, is connected to the antenna 114 so that the site 106 comprises two portions, namely a microwave receive/radio transmit portion 302, and a radio receive/microwave transmit portion 303 both coupled to the antenna 114. In accordance with an illustrative embodiment, the portion 302 includes a frequency downconverter 304, having an input terminal coupled to one output of the duplexer 301, for substantially reducing the frequency of the microwave signals received at the antenna 114 and generating intermediate signals, present on downconverter output lead 305. These intermediate signals are connected to a modulator circuit 306 for modulating them on a carrier radio signal having a predetermined frequency selected from the frequency band used for radio transmission of signals intended for the subscriber telephone stations served by the site 106. An amplifier circuit 307, preferably a linear amplifier, and a duplexer 308 are connected between the output of the modulator circuit 306 and the radio antenna 115. Shown in FIG. 3, are two filter circuits 309 and 310 that may be optimally inserted in the circuit of the portion 302 depending upon the frequency bands desired, respectively, for the intermediate signals and for the modulated radio signals.

As shown in FIG. 3, the other portion of the reception and radiation site 106, i.e., the radio receive/microwave transmit portion 303, includes a

frequency downconverter 311 for reducing the frequency of radio signals received at the radio antenna 115, and for generating second intermediate signals on lead 312. A modulator circuit 313 is coupled to the downconverter 311 for modulating the intermediate signals present on lead 312 on a microwave frequency carrier signal. The modulated signals are coupled to the microwave antenna 114 via an amplifier 314 and the duplexer 301. Also shown in FIG. 3, are filter circuits 315, 316 and 317 that may be optionally inserted in the circuit of portion 303 depending upon the respective frequency bands desired at various points along this circuit.

The above embodiment of FIG. 3 was described with reference to a single antenna 114 and an associated duplexer 301 for implementing both the reception and transmission of microwave signals. Also, a single radio antenna 115, in association with a duplexer 308, is shown to implement both the transmission and reception of radio signal. Clearly, a transmit antenna and a receive antenna can readily be substituted for each of the antennas 114 and 115 thus rendering unnecessary their associated duplexers 301 and 308.

Although the present invention has been described in connection with particular embodiments thereof, additional embodiments, modifications and applications which will be apparent to those skilled in the art are included within the spirit and scope of the invention.

Claims

1. A method for providing wireless communications between a main base station (100) of a type capable of being connected to a telephone network (104) and at least one remote reception and radiation site (106) of a type capable of communicating with a plurality of telephone subscriber stations (107,108) over predetermined radio frequencies, CHARACTERISED BY reducing the frequency of radio signals which are intended for the telephone subscriber stations to a lower frequency range, amplifying the frequency-reduced signals, modulating the amplified signals on a microwave frequency carrier signal, amplifying the microwave frequency modulated signals, and coupling the amplified microwave signals to a microwave antenna (112) for transmission to the remote reception and radiation site.
2. A method as claimed in claim 1 wherein the frequency reducing step comprises the step of reducing the frequency of the radio signals to a frequency range of the order of the frequency band of the remote reception and radiation site.
3. A method for receiving wireless communications signals at a main base station (100) of a type capable of being connected to a telephone network (104) from at least one remote reception and radiation site (106) of a type capable of communicating with a plurality of telephone subscriber stations (107,108) over predetermined radio frequencies, CHARACTERISED BY receiving at a microwave antenna (112) of the main base station incoming microwave signals, amplifying the received microwave signals, reducing the frequency of the amplified signals to a substantially lower frequency range which comprises the subscriber stations predetermined radio frequencies, amplifying the frequency-reduced signals, modulating the amplified frequency-reduced signals on a radio frequency carrier signal to generate radio frequency signals, and coupling the generated radio frequency signals to receiving means (200) within the main base station.
4. A method for transmitting from a reception and radiation site (106) a plurality of radio telecommunications signals having predetermined radio frequencies and intended for a plurality of telephone subscriber stations (107,108), CHARACTERISED BY receiving at the site incoming microwave signals, reducing the frequencies of the received microwave signals to substantially lower frequencies thereby generating intermediate signals, modulating the intermediate signals on a carrier signal having a frequency selected from the predetermined radio frequencies, and coupling the modulated radio signals to a radio frequency antenna (115).
5. A method as claimed in claim 4 wherein the frequency reducing step comprises the step of generating the intermediate signals having frequencies in a frequency range of the order of the frequency band of the telephone subscriber stations.
6. A method for processing at a reception and radiation site (106) a plurality of radio telecommunications signals having predetermined radio frequencies, comprising the steps of receiving at the site incoming radio signals, reducing the frequencies of the received radio signals to lower frequencies to generate intermediate signals, modulating the intermediate signals on a microwave frequency carrier signal, and coupling the modulated microwave signals to a microwave frequency antenna (114).
7. Apparatus for providing wireless communications between a main base station (100) of a type capable of being connected to a telephone network

- (104) and at least one remote reception and radiation site (106) of a type capable of communicating with a plurality of telephone subscriber stations (107,108) CHARACTERISED IN THAT the apparatus comprises means (202) for reducing the frequency of radio signals intended for the telephone subscriber stations to a lower frequency range, means (203) for amplifying the frequency-reduced signals, means (204) for modulating the amplified signals on a microwave frequency carrier signal, means (205) for amplifying the microwave frequency modulated signals, and means (206) for coupling the amplified microwave signal to a microwave antenna (112) for transmission to the remote reception and radiation site.
8. Apparatus as claimed in claim 7 wherein the lower frequency range is of the order of the frequency band of the remote reception and radiation site.
9. Apparatus for receiving wireless communications at a main base station (100) of a type capable of being connected to a telephone network (104) from at least one remote reception and radiation site (106) of a type capable of communicating with a plurality of telephone subscriber stations (107,108), CHARACTERISED IN THAT the apparatus comprises means (112) for receiving at the main base station incoming microwave signals, means (207) for amplifying the received microwave signals, means (208) for reducing the frequency of the amplified signals to a substantially lower frequency range, means (209) for amplifying the frequency-reduced signals, and means (210) for modulating the amplified frequency-reduced signals on a radio frequency carrier signal thereby generating radio frequency signals.
10. Apparatus as claimed in claim 9 wherein the substantially lower frequency range is of the order of the frequency band of the telephone subscriber stations.
11. A reception and radiation site (106) CHARACTERISED BY a first antenna (115) for transmitting radio signals having frequencies in a first range of frequencies, a second antenna (114) for receiving microwave signals having frequencies in a second range of frequencies that are substantially higher than the frequencies in the first range of frequencies, means (304) coupled to the second antenna for substantially reducing the frequencies of the received microwave signals thereby generating intermediate signals, means (306) coupled to the frequency reducing means
- for modifying the intermediate signals on a radio frequency carrier signal, and means (308) for coupling the modulated radio signals to the first antenna.
12. A reception and radiation site (106) CHARACTERISED BY a first antenna (115) for receiving radio signals having frequencies in a first range of frequencies, a second antenna (114) for transmitting microwave signals having frequencies in a second range of frequencies that are substantially higher than the frequencies in the first range of frequencies, means (311) coupled to the first antenna for reducing the frequencies of the received radio signals thereby generating intermediate signals, means (313) coupled to the frequency reducing means for modulating the intermediate signals on a microwave frequency carrier signal, and means (301) for coupling the modulated microwave signals to the second antenna.
13. A mobile radio reception and radiation cellular site (106) CHARACTERISED BY a first antenna (115) for transmitting mobile radio signals having frequencies in a first range of frequencies, a second antenna (114) for receiving microwave signals having frequencies in a second range of frequencies that are substantially higher than the frequencies in the first range of frequencies, means (304) coupled to the second antenna for substantially reducing the frequencies of the received microwave signals thereby generating intermediate signals, means (306) coupled to the frequency reducing means for modulating the intermediate signals on a radio frequency carrier signal, and means (308) for coupling the modulated radio signals to the first antenna.
14. A mobile radio reception and radiation cellular site (106) CHARACTERISED BY a first antenna (115) for receiving mobile radio signals having frequencies in a first range of frequencies, a second antenna (114) for transmitting microwave signals having frequencies in a second range of frequencies that are substantially higher than the frequencies in the first range of frequencies, means (311) coupled to the first antenna for reducing the frequencies of the received mobile radio signals thereby generating intermediate signals, means (313) coupled to the frequency reducing means for modulating the intermediate signals on a microwave frequency carrier signal, and means (301) for coupling the modulated microwave signals to the second antenna.

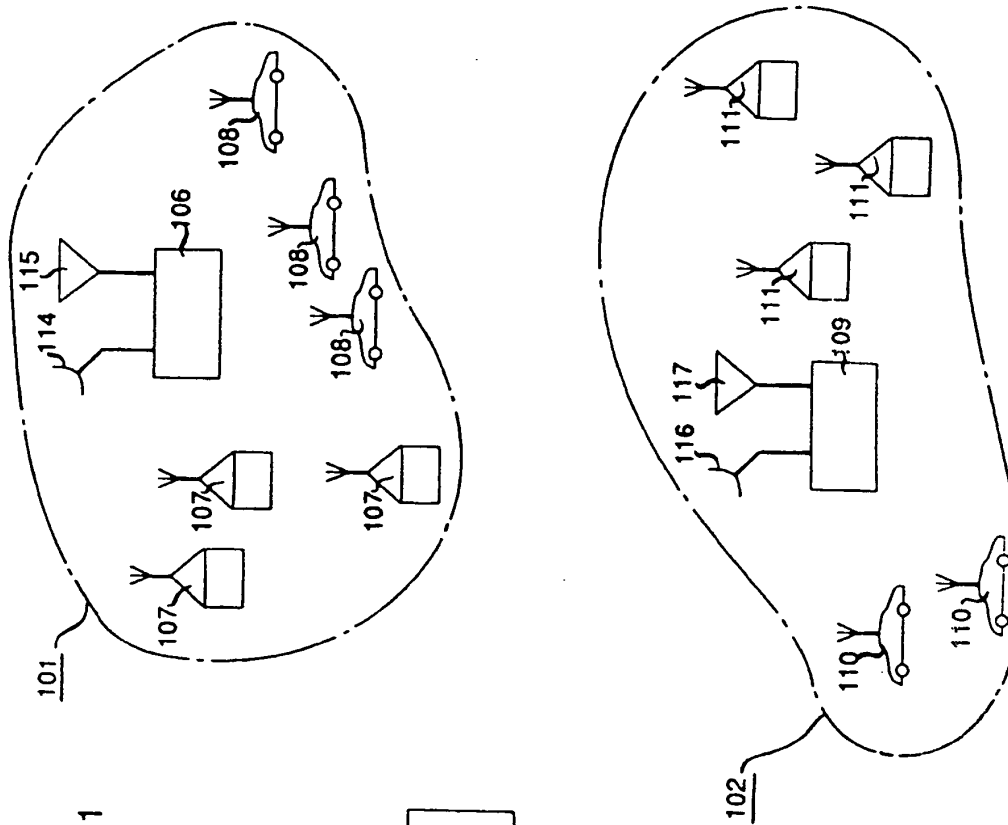
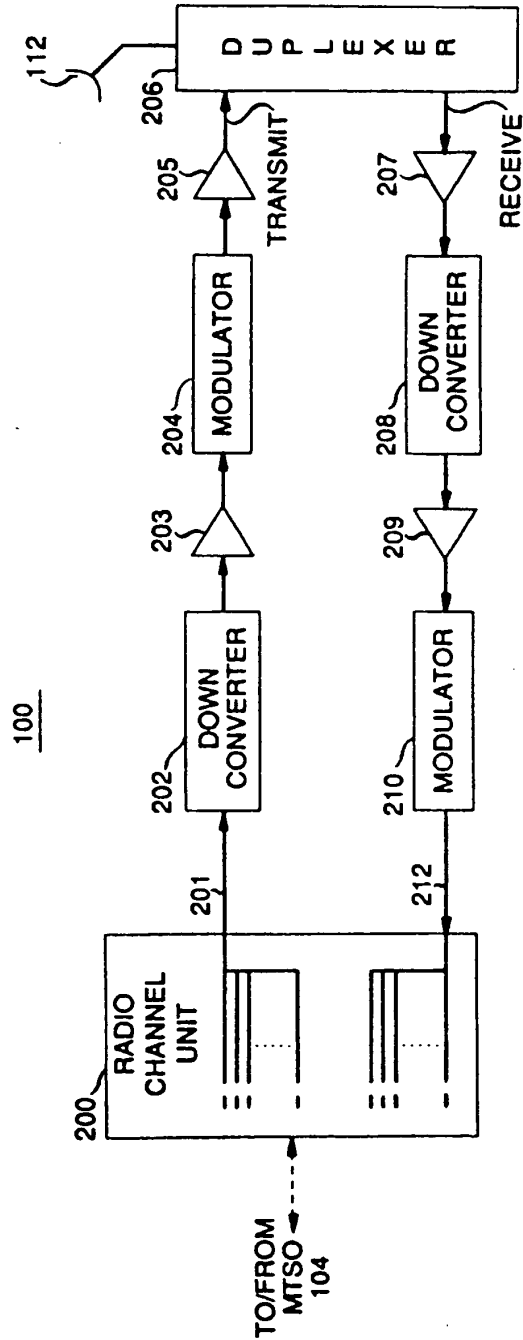
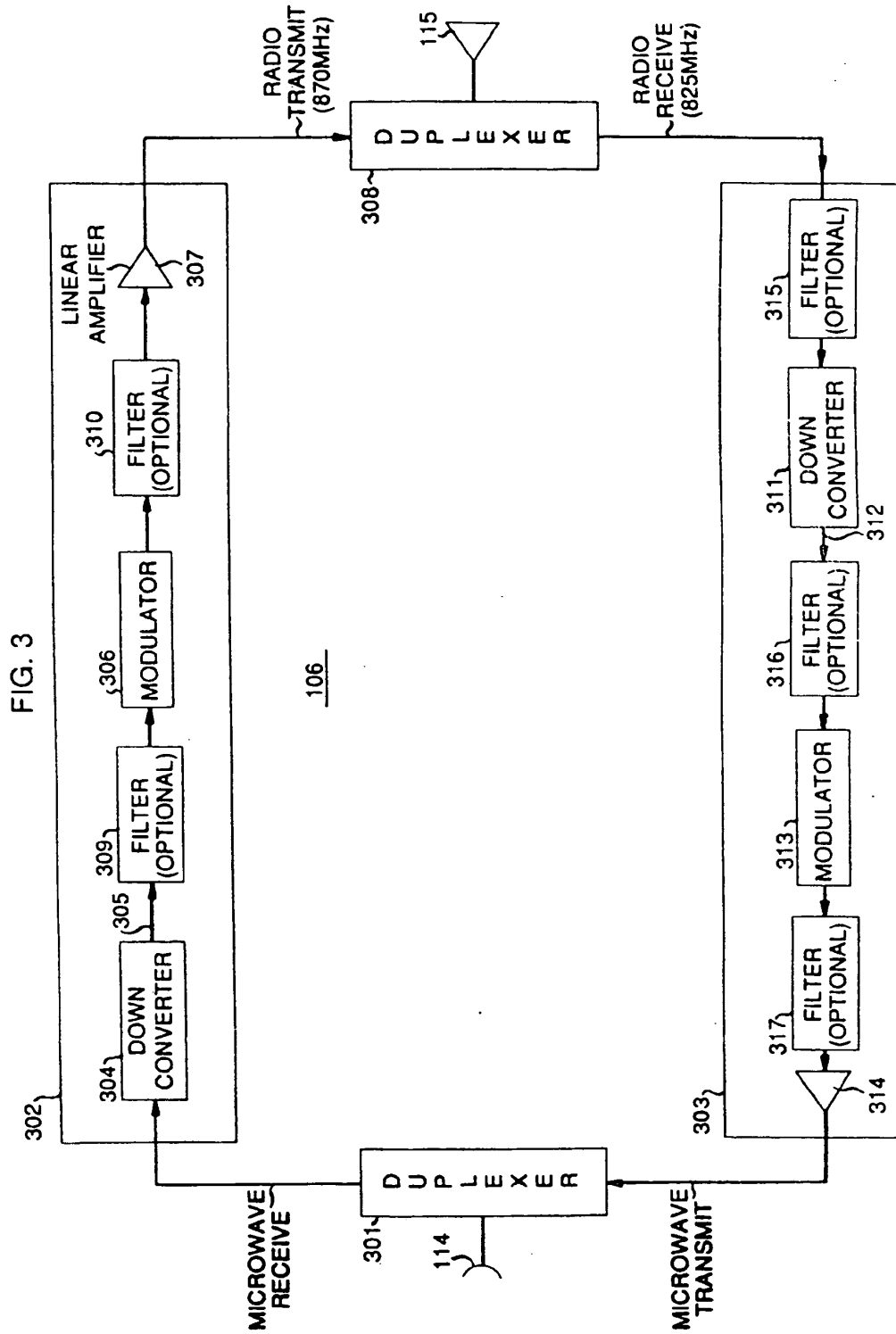


FIG. 1

FIG. 2





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PROCEDE ET APPAREILS POUR LES RADIOCOMMUNICATIONS ET/OU LES RADIO SIGNALISATIONS EN MILIEUX CLOS

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 Publication date: 1977-10-21
 Inventor:
 Applicant: SINA SPA (IT)
 Classification:
 - international: H04B7/26
 - european: H04B5/00L
 Application number: FR19770008522 19770322
 Priority number(s): IT19760009381 19760322

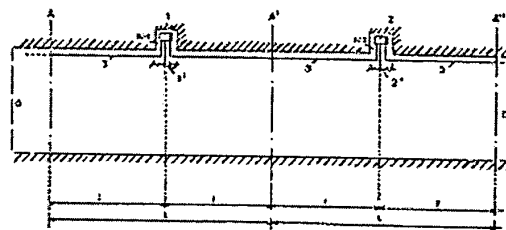
Also published as:

DE 2712498 (A1)
 CH61 5306 (A5)
 IT107 0376 (B)

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Abstract of FR2345865

The process consists in emitting the radio signals into the medium in such a manner that said medium operates, for said signals, in the manner of a waveguide. The apparatus comprises a plurality of radio repeaters (1, 2) placed at a distance from one another and linked to one another and to one or more external radio repeaters by means of a simple telephone cable (3). Each radio repeater is equipped with a radiative element (1', 2'). The process and the apparatus are especially utilised for transmission in railway and road tunnels and in underpasses.



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**DEMANDE
DE BREVET D'INVENTION**

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N° 77 08522

(54) Procédé et appareils pour les radiocommunications et/ou les radiosignalisations en milieux clos.

(51) Classification Internationale (Int. Cl.7). H 04 B 7/26.

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(71) Déposant : Sociétés dites : S.I.N.A. S.P.A. et I.M.A.R.T. S.R.L., résident en Italie.

(72) Invention de :

(73) Titulaire : *Idem* (71)

(74) Mandataire : Germain, Maureau et Millet, Conseils en brevets, 4, rue d'Amsterdam, 75009 Paris.

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Il n'y a aucun doute que l'on a assisté, au cours de ces dernières années, à l'augmentation du nombre des services publics et privés assurés par des opérateurs et/ou des unités fixes et/ou mobiles constamment reliés entre eux et/ou à des centrales opérationnelles par signaux radio de fréquences déterminées, par exemple de fréquences radiophoniques.

A titre d'exemple, citons les services des forces de l'ordre, des corps de police et de surveillance publics et privés, les services d'assistance à la circulation et à la santé publique, les services de transports publics urbains, les services de mise en place et d'assistance pour les installations de production et de transport de l'énergie électrique et pour les installations industrielles en général, les services de surveillance de la circulation routière, autoroutière, par chemin de fer, etc...

On observe de même que de plus en plus les communications et les appareils radio remplacent des installations qui auparavant faisaient appel à différentes techniques et destinées par exemple à la gestion, au contrôle, à la réglementation et à la signalisation à distance des installations électriques, ferroviaires, routières, hydrauliques et permettent d'assurer à distance les opérations, les vérifications et les contrôles nécessaires par l'intermédiaire d'impulsions radio émises par les centres opérationnels et/ou les appareils récepteurs-émetteurs de ces mêmes unités sous contrôle, fixes et mobiles et l'affichage sur les tableaux de commande installés à la centrale opérationnelle non seulement de l'état des installations, mais également des opérations effectuées et de toute autre information nécessaire ; et ce, toujours par l'intermédiaire de signaux radio.

Dans les pays dont les caractéristiques orographiques sont assez complexes, comme en Italie, ou encore dans les villes, où se développe sans cesse le phénomène de l'urbanisation souterraine, avec des routes et des voies de chemin de fer construites dans le sous-sol, la "couverture" de ce que l'on appelle les "zones d'ombre" pose de nombreux problèmes car les liaisons radio sont empêchées par les difficultés auxquelles se heurte la propagation des ondes électromagnétiques, tout particulièrement dans les tunnels où, en général, les liaisons radio entre deux véhicules ou entre un poste fixe et un véhicule sont coupées lorsque le véhicule se trouve à l'intérieur du tunnel ; il s'agit là d'un inconvénient qui de manière générale se produit toujours dans des milieux fermés, se

développant essentiellement dans le sens de la longueur, même si ceux-ci débouchent sur l'extérieur.

On sait que cela arrive même si la liaison radio passe par l'intermédiaire d'une station relais normale, car en effet, 5 les ondes électromagnétiques, qu'elles soient émises par la radio relais ou par le véhicule, ne sont pas en mesure de traverser les barrières ferromagnétiques ou conductrices d'une certaine densité, ni d'ailleurs les terrains de couverture et la structure même de l'ouvrage souterrain qui constituent de véritables obstacles à la 10 propagation des ondes radio.

On connaît les procédés et les appareils mis au point à ce jour pour pallier ces inconvénients ; ils comportent néanmoins des limitations non négligeables à l'efficacité et à la fiabilité des services indiqués plus haut, qualités qui pourtant ne devraient 15 pas faire défaut lorsque les objectifs à atteindre sont la sécurité et la continuité du service.

Les systèmes émetteurs-récepteurs en tunnel et en milieux souterrains, ou de toutes manières fermés, se développant essentiellement dans le sens de la longueur, débouchant aux extrémités sur 20 l'extérieur, ont été, jusqu'à ce jour, réalisés suivant deux techniques principales : ceux de la première génération qui utilisent des antennes à rayonnement aux entrées des tunnels, ne sont applicables qu'en cas de développement longitudinal limité, compte tenu de l'atténuation considérable des signaux ; ceux de la deuxième 25 génération, tels que le système AEG Telefunken, qui combinent les antennes directionnelles installées à l'extérieur du tunnel et les câbles coaxiaux "fendus", à rayonnement, installés tout le long de l'ouvrage souterrain, équipent actuellement un certain nombre de réseaux de métro et de lignes express, par exemple à Hambourg, 30 Munich et Sao Paulo, ainsi que des tunnels automobiles dans de grandes villes, comme à Francfort, permettant les communications en semi-duplex entre les véhicules et les centres opérationnels avec des résultats satisfaisants.

Ce deuxième système ne comporte pas d'inconvénients rédhibitoires, si ce n'est le coût élevé et la vulnérabilité intrinsèque 35 de l'élément essentiel, c'est-à-dire du câble coaxial "fendu" qui, monté tout le long du tunnel, risque d'être détruit en cas de sinistre (surtout en cas d'incendie) enlevant ainsi toute possibilité de communiquer avec l'extérieur dans des situations justement où il est 40 plus que jamais nécessaire de pouvoir disposer d'un tel service.

L'objet de la présente invention est constitué par une combinaison d'appareils et de techniques, déjà connus individuellement, mais utilisés selon une méthode et avec un équipement de conception originale permettant de dépasser les limites indiquées plus haut, le coût de la réalisation restant réduit.

On n'ignore pas en effet que le comportement des liaisons radio en milieu fermé est différent de celui en ambiance libre. Dans l'espace, les ondes ne s'atténuent pas, mais se dispersent en fonction du carré de la distance.

En milieu fermé, au contraire, la fréquence radio est en partie absorbée par les parois (placées à une distance déterminée de la source), et en partie réfléchi. La partie réfléchi agit à nouveau sur les parois, avec un résultat identique ; et ainsi de suite jusqu'à absorption totale de l'émission. Cet effet de réflexion-absorption entraîne l'atténuation rapide du phénomène électromagnétique, en fonction de la distance séparant les parois, de la nature et de la forme de celles-ci ainsi que de la fréquence des ondes radio utilisées.

Dans la suite, pour abréger, nous désignerons par le terme "tunnel" tout milieu fermé, se développant essentiellement dans le sens longitudinal, d'une longueur même importante, ouvert sur l'extérieur aux deux extrémités, dites "entrées".

Une observation s'impose ici : du point de vue géométrique, un tunnel peut être considéré comme un espace délimité par six surfaces opposées, dont quatre placées à des distances déterminées (les parois latérales, la voûte et le sol) et deux à une distance infinie (les entrées). Suivant une approche originale, les déposants ont voulu étudier de manière concrète, en procédant à des expériences et à des essais, la possibilité d'assimiler le tunnel à une ligne de transmission de fréquence radio, sans rayonnement, c'est-à-dire à un "guide d'onde" par rapport à la propagation des ondes électromagnétiques. Elles sont ainsi arrivées au résultat surprenant que toutes les lois théoriques régissant la propagation d'ondes électromagnétiques dans les guides d'onde sont en partie applicables aux tunnels.

On n'ignore pas qu'il est possible d'irradier des fréquences radio à l'intérieur d'un conduit si l'on respecte les conditions suivantes :

1) la fréquence minimale pouvant être propagée est fonction des caractéristiques géométriques de la section du conduit ainsi que

du système d'excitation ;

- 2) le système d'excitation doit être choisi parmi les systèmes possibles en fonction du type du conduit ;
- 3) la surface interne du conduit doit être uniforme, exempte d'aspérités, se rapprochant le plus possible des caractéristiques d'un miroir, d'une conductibilité électrique élevée.

Ainsi, par exemple, dans le cas d'un tunnel d'autoroute standard, la première condition est respectée si la fréquence est supérieure à 60 MHz ; la deuxième peut être obtenue facilement ; la troisième, au contraire, n'est pas remplie pour des raisons évidentes ayant trait aux caractéristiques de construction de l'ouvrage, dont les parois sont en général de béton, à coefficients de rugosité élevés et à haut pouvoir absorbant ; on se heurte par conséquent au phénomène de l'atténuation. Néanmoins, des essais approfondis ont fait apparaître que l'atténuation, tout en étant importante, n'exclut pas l'utilisation du tunnel en tant que guide d'onde.

En prenant toujours l'exemple d'un tunnel d'autoroute standard, l'atténuation spécifique moyenne est d'environ 0,15 dB/m à 160 MHz assurant ainsi une "couverture" moyenne suffisante, sur environ 900 mètres, à partir du point d'excitation, en amont et en aval dudit système d'excitation.

Ces considérations et ces essais sont à la base de la présente invention qui est fondée sur l'idée d'utiliser des relais placés à l'intérieur du tunnel et permettant d'étendre, toujours à l'intérieur de celui-ci, la zone de couverture des relais extérieurs.

En ce qui concerne le procédé, celui-ci est fondé sur la combinaison des données ci-dessous ;

- 1) un système d'excitation radioélectrique placé à l'intérieur d'un guide d'onde entraîne la propagation des ondes radio dans les deux directions opposées ; il en découle qu'un élément rayonnant placé à l'intérieur d'un tunnel fournit une couverture radio interne d'une longueur double par rapport à celle qu'il serait possible d'obtenir avec un élément rayonnant placé à l'entrée dudit tunnel.

- 2) Une information peut être transmise à un ou plusieurs relais intérieurs par l'intermédiaire d'un câble téléphonique relié à un relais extérieur, ou, de manière plus générale, à la source de l'information.

- 3 - L'atténuation caractéristique du tunnel étant élevée, il y a

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Lieu d'utiliser un relais à deux voies et d'alimenter, à partir de ce même relais, un deuxième élément rayonnant placé sous l'arcade voisine dudit tunnel si l'ouvrage, ainsi que cela se produit souvent, est constitué de deux tunnels côte à côte (chemins de fer, routes, etc...)

La perte de répartition dans ce cas est de 3 dB (réduction de 20 mètres environ seulement de chaque côté de la zone de couverture de chaque élément dans le cas d'un tunnel d'autoroute standard à 160 MHz, mais en cas d'arcade double la zone couverte par un seul relais est doublée.

Il en résulte qu'un relais placé sous un tunnel d'autoroute standard à double arcade est en mesure de fournir une zone globale de couverture d'environ $900 \times 4 = 3.600$ m à 160 MHz.

4) L'atténuation plus importante des tunnels aux fréquences plus basses est compensée par l'atténuation caractéristique moindre d'un câble coaxial traditionnel par rapport au tunnel lui-même ; ainsi, en éloignant l'élément ou les éléments rayonnants du relais en utilisant un câble coaxial simple, il est possible d'étendre encore davantage la zone couverte par un relais.

5) Si la longueur d'un tunnel est nettement supérieure aux possibilités de couverture d'un relais unique, relié à un ou plusieurs éléments rayonnants par un simple câble coaxial, on peut utiliser deux ou plusieurs relais reliés entre eux par un simple câble téléphonique.

6) L'utilisation sur des fréquences toujours plus hautes (par exemple 400 - 470 MHz) assure une couverture bien supérieure à celle que l'on pourrait obtenir avec un seul relais à 160 MHz pour un tunnel d'autoroute standard.

Le procédé objet de la présente invention ainsi que l'équipement correspondant offrent de nombreux avantages par rapport à l'état actuel de la technique ; on peut les résumer ainsi :

- a) utilisation du tunnel comme guide d'onde, avec excitation à l'intérieur du tunnel ;
- b) liaison entre un relais extérieur et un ou plusieurs relais placés à l'intérieur du tunnel par simple câble téléphonique ;
- c) exploitation de l'atténuation élevée du tunnel pour la réduction de la perte de répartition à deux voies et couvrir avec un relais unique, dans l'hypothèse de deux tunnels côte à côte, les deux arcades voisines ;

- d) utilisation du taux nettement inférieur de perte du câble coaxial par rapport à celui du tunnel pour étendre la zone de couverture de chaque relais à l'intérieur du tunnel, plusieurs éléments rayonnants étant reliés entre eux et alimentés par câble coaxial par chaque relais ;
- e) coût de l'installation nettement inférieur par rapport à celui d'une installation de liaison radio réalisée avec le système du câble "fendu" ;
- f) vulnérabilité réduite en cas d'incendie, explosion, sabotage ou endommagement, car il est possible de concentrer en un seul endroit, que l'on choisira le plus à l'abri possible, tous les appareils ;
- g) risque statistique de pannes réduit si les événements ci-dessus venaient à se produire car l'élément rayonnant est placé en un ou plusieurs endroits du tunnel mais pas sur toute sa longueur ;
- h) risque statistique de panne totale réduit dans le cas de plusieurs éléments rayonnants et/ou relais à l'intérieur du tunnel ; l'endommagement éventuel d'un seul élément rayonnant et/ou relais ne ferait que réduire, pour ce qui a trait à la zone correspondante, la zone totale de couverture radio.

A titre d'exemple non limitatif, la figure 1 schématise l'une des dispositions possibles d'une installation fonctionnant suivant le procédé conforme à la présente invention.

- Elle représente, en coupe horizontale, un tunnel (G - G') d'une longueur par hypothèse indéfinie, où la partie (L = 2I) représente la longueur de la zone de couverture radio que l'on peut obtenir avec un seul relais (la valeur (I) correspondant au rapport existant entre la puissance disponible du relais, exprimée en dB, et le facteur d'atténuation, exprimé en dB/m qui, pour une fréquence donnée, est fonction des caractéristiques de construction du tunnel). A l'intérieur de ce tunnel (G - G') sont installés deux relais (1, 2), à côté de leur élément rayonnant (1' - 2'), chacun permettant de recevoir et d'émettre des ondes radio respectivement dans les parties du tunnel comprises entre les sections (A - A') et (A' - A''). Les relais intérieurs (1 - 2) reçoivent l'information du ou des relais installés à l'extérieur du tunnel (qui, pour simplifier, ne sont pas représentés) par l'intermédiaire d'un câble téléphonique (3) qui assure également la liaison entre les relais intérieurs.

Bien évidemment, si la longueur du tunnel était inférieure

ou égale à (L) (1800 m environ dans le cas de tunnels d'autoroute avec revêtement de béton et de section standard, pour une fréquence de 160 MHz) un seul relais, installé à l'intérieur du tunnel, est suffisant pour assurer la réception et l'émission sur toute la longueur de l'ouvrage souterrain.

La figure 2, toujours à titre d'exemple non limitatif, montre comment, sans changer le nombre ni les prestations des relais devant être installés à l'intérieur du tunnel, la longueur de la zone de couverture radio pouvant être obtenue avec un seul relais (11) peut être étendue, dans une certaine mesure, en éloignant du relais (11) les éléments rayonnants (11' - 11'') en utilisant un simple câble coaxial (4).

La longueur de la zone de couverture radio (L') pouvant ainsi être obtenue peut être égale à $4I'$ où (I'), à prestations égales du relais, est nettement inférieure à (I), en raison des atténuations dans le câble coaxial, mais presque toujours supérieure à $1/2$ si l'on considère que le facteur d'atténuation du câble est faible par rapport à celui caractéristique du tunnel, surtout si le revêtement est en maçonnerie, ce qui est normalement le cas.

Ainsi, par exemple, pour les tunnels d'autoroutes de sections standard, dont la fréquence est de 160 MHz et le facteur d'atténuation caractéristique du tunnel de 0,15 dB/m, la longueur maximale pouvant être desservie par un seul relais, en utilisant un simple câble coaxial RG8/U (atténuation caractéristique à 160 MHz : 0,08 dB/m), peut dépasser les 1.800 m indiqués plus haut et atteindre 2.000 - 2.200 m.

Les figures 1 et 2 montrent également comment les relais radio doivent être installés à l'intérieur du tunnel, dans des niches (N1 - N2- N11) respectivement, séparés et à l'abri de la circulation, du public, etc...

La figure 3 montre, toujours à titre d'exemple non limitatif, un tronçon de tunnel à deux arcades ($G_1 - G'_1$) - ($G_2 - G'_2$) d'une longueur $2L$ et l'une des dispositions possibles d'une installation fonctionnant suivant la méthode conforme à la présente invention en cas de deux tunnels côte à côte dont la longueur serait supérieure à $2L$ disposant bien entendu de passages de service ("by pass") permettant de passer d'une arcade à l'autre : les relais (21 - 22) sont convenablement placés dans les passages de service (P21 - P22) et, grâce aux éléments rayonnants

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(21' - 21" - 21^m - 21) (22' - 22" - 22^m - 22) alimentés par les câbles coaxiaux (4), ils permettent de recevoir et d'émettre dans les deux tronçons des arcades ($G_1 - G'_1$) et ($G_2 - G'_2$) du tunnel. L'information est fournie aux relais par un câble téléphonique (3) qui les relie entre eux et au ou aux relais extérieurs (non représentés). La longueur de la zone de couverture radio (L'') ainsi obtenue, pour chaque arcade et pour chaque relais, est égale à $4 I''$, où $I'' - I'$ env.

Dans la pratique, les détails d'exécution peuvent de toutes manières varier dans la forme, les dimensions, la disposition des éléments, la nature des matériaux sans toutefois sortir du cadre des idées de solution adoptées.

REVENDEICATIONS

- 1 - Procédé pour les radiocommunications et/ou les radiosignalisations en milieux fermés, se développant essentiellement en longueur et débouchant sur l'extérieur par les deux extrémités, même souterrains, en particulier tunnels, même de longueur importante, caractérisé par le fait qu'il consiste à assimiler lesdits milieux à un guide d'onde qui, correctement excité à l'intérieur, entraîne la propagation des ondes électromagnétiques grâce à l'utilisation d'un ou plusieurs relais et des éléments rayonnants correspondants et par le fait que ces relais sont reliés entre eux et à un ou plusieurs relais extérieurs par simple câble téléphonique.
- 2 - Procédé selon la Revendication précédente caractérisé par le fait que pour étendre la zone de couverture de chaque relais intérieur sont utilisés deux ou plusieurs éléments rayonnants, convenablement éloignés de chaque relais intérieur grâce à un câble coaxial dont le facteur d'atténuation caractéristique est nettement inférieur à celui du tunnel lui-même et par le fait qu'en cas de deux tunnels côte à côte les deux ou plusieurs éléments rayonnants sont placés un ou plusieurs par arcade de manière à couvrir, avec un seul relais, des tronçons d'égale longueur des deux tunnels côte à côte.
- 3 - Equipement pour les radiocommunications et/ou les radiosignalisations en milieux fermés se développant essentiellement en longueur et débouchant sur l'extérieur par les deux extrémités, même souterrain, en particulier tunnels, même de longueur importante, agencé pour la mise en oeuvre du procédé selon les Revendications ci-dessus, caractérisé par le fait qu'il comprend un ou plusieurs relais installés à des distances dépendant de la puissance disponible dudit ou desdits relais, de la fréquence adoptée ainsi que des caractéristiques géométriques et de construction du milieu ou tunnel, le ou les relais intérieurs étant reliés à un ou plusieurs relais extérieurs par simple câble téléphonique.
- 4 - Equipement selon la Revendication 3, caractérisé par le fait que les éléments rayonnants du ou des relais montés à l'intérieur du tunnel sont convenablement écartés du ou des relais grâce à un câble coaxial et par le fait que dans l'hypothèse de deux tunnels côte à côte les éléments rayonnants du ou des relais intérieurs sont convenablement éloignés desdits appareils grâce à des câbles coaxiaux, chaque câble coaxial pouvant porter même plusieurs

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éléments, permettant ainsi, à chaque relais, de couvrir des tronçons des deux tunnels.

5 - Equipement selon l'une quelconque des Revendications 3 et 4, caractérisé par le fait que les relais intérieurs sont reliés entre eux au moyen d'un simple câble téléphonique.

6 - Equipement selon l'une quelconque des Revendications 3 à 5, caractérisé par le fait que les émetteurs-récepteurs intérieurs sont installés dans des niches et/ou logés dans les passages de service des tunnels.

PL.1-3

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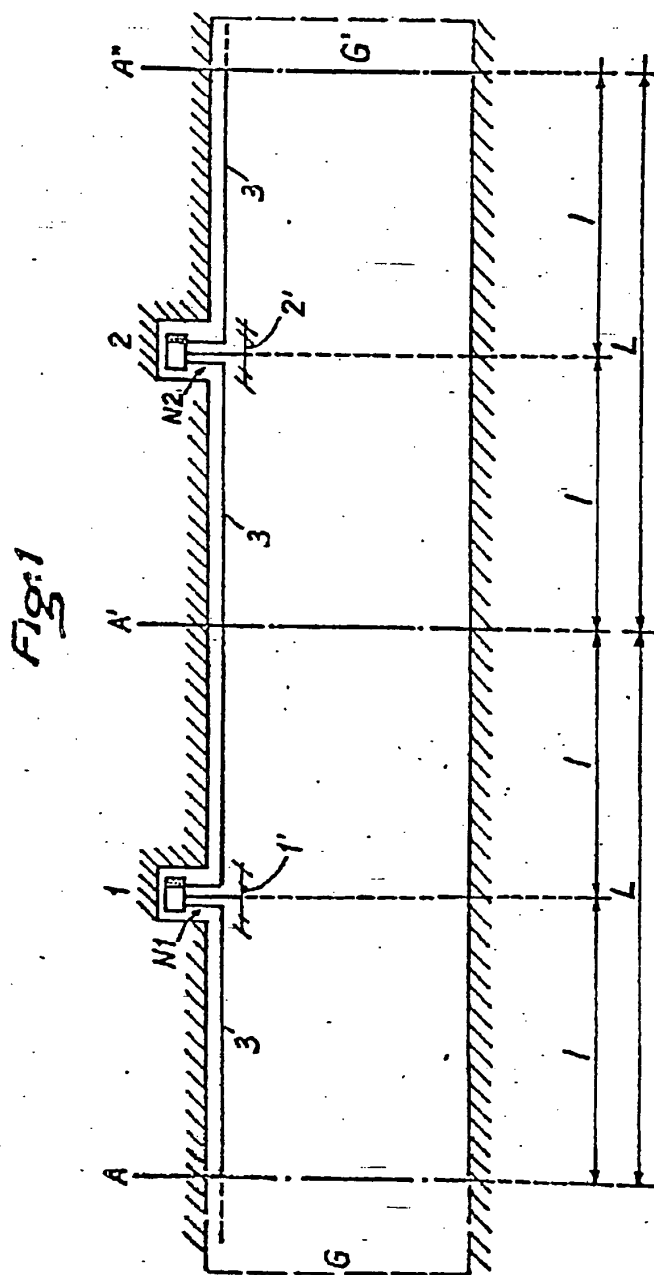
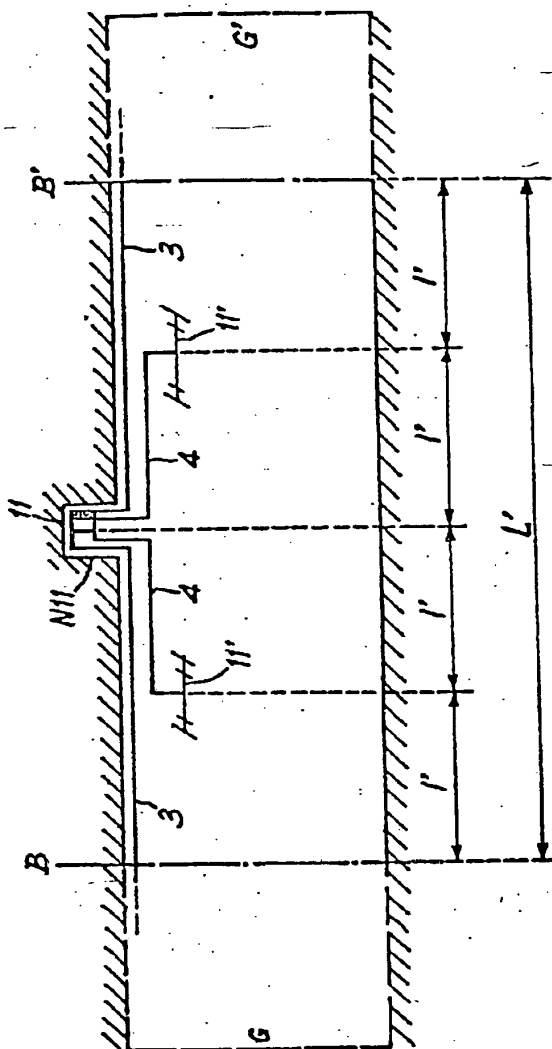


Fig. 1

PL.11-3

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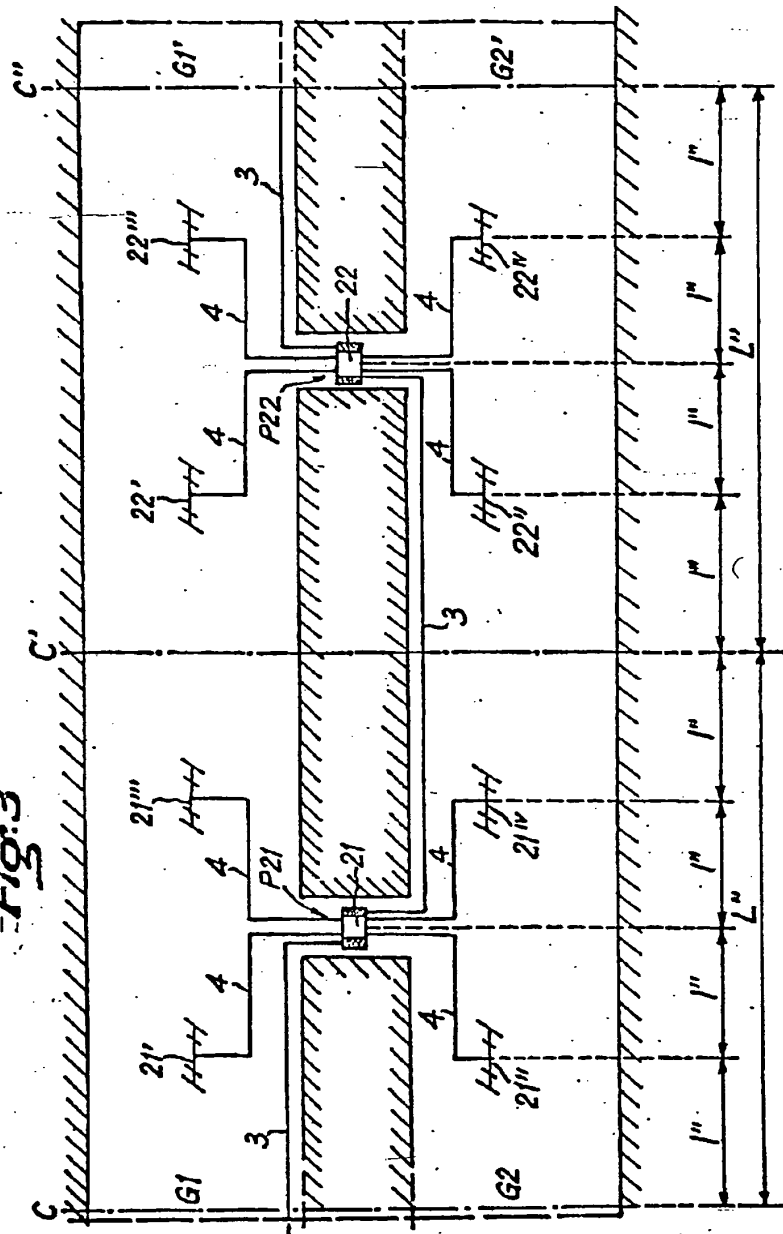
Fig: 2



PL.III-3

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Fig. 3





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DATE MAILED: 09/29/2005

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/414,907	04/16/2003	Donald R. Bauman	100.453US01	6313

TITLE OF INVENTION: SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN DISTRIBUTED DIGITAL COMMUNICATIONS

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APPLN. TYPE	SMALL ENTITY	ISSUE FEE	PUBLICATION FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	\$1400	\$300	\$1700	12/29/2005

EXAMINER	ART UNIT	CLASS-SU BCLASS
VO, NGUYEN THANH	2685	455-522000

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 enclosed:

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

4b. Payment of Fee(s):

- ☐ A check in the amount of the fee(s) is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☐ The Director is hereby authorized by charge the required fee(s), 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).

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

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/414,907	04/16/2003	Donald R. Bauman	100.453US01	6313

34206 7590 09/29/2005
FOGG AND ASSOCIATES, LLC
P.O. BOX 581339
MINNEAPOLIS, MN 55458-1339

EXAMINER

VO, NGUYEN THANH

ART UNIT	PAPER NUMBER
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2685

DATE MAILED: 09/29/2005

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 470 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 470 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 (703) 305-8283.

Notice of Allowability	Application No.	Applicant(s)	
	10/414,907	BAUMAN ET AL.	
	Examiner	Art Unit	
	Nguyen T. Vo	2685	

-- 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 _____.
2. ☒ The allowed claim(s) is/are 1-22.
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)

- | | |
|---|--|
| <ol style="list-style-type: none"> 1. ☒ Notice of References Cited (PTO-892) 2. ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948) 3. ☒ Information Disclosure Statements (PTO-1449 or PTO/SB/08),
Paper No./Mail Date _____ 4. ☐ Examiner's Comment Regarding Requirement for Deposit
of Biological Material | <ol style="list-style-type: none"> 5. ☐ Notice of Informal Patent Application (PTO-152) 6. ☐ Interview Summary (PTO-413),
Paper No./Mail Date _____ 7. ☐ Examiner's Amendment/Comment 8. ☒ Examiner's Statement of Reasons for Allowance 9. ☐ Other _____ |
|---|--|

Nguyen T. Vo
9-17-2005

**NGUYEN T. VO
PRIMARY EXAMINER**

REASONS FOR ALLOWANCE

1. The following is an examiner's statement of reasons for allowance: regarding independent claims 1, 7, 10, 13, 14, 18, 21 and 22, it is believed that Naidu (6,580,905) is closest prior art with respect to the claimed invention. Naidu discloses a system and method for controlling the gain of signals transported over transmission media in a distributed antenna network. The system includes a plurality of remote antenna units where each remote antenna unit includes a signal level comparator for comparing the level of the signals received by the respective antenna unit with a predetermined reference level, and a gain controller for reducing the gain of the remote antenna unit when the signal level comparator determines that the level of the received signal exceeds said predetermined reference level. See column 2 line 46 to column 3 line 8. Naidu, however, fails to disclose or render obvious comparing at least one of the plurality of signal levels from an antenna with a dynamic range fair share threshold; and attenuating each of the at least one of the compared signal levels that is greater than the dynamic range fair share threshold with a gain factor that is determined in response to a remaining portion of the total system dynamic range after attenuation of other signal levels of the plurality of signal levels, as specified in the claims.

None of other prior art cures the above deficiencies in Naidu.

In addition, application No. 10/308,854 (Publication No. US 2004/0203339 A1) has one common inventor with the present application. The above publication, however, fails to disclose or render obvious comparing at least one of the plurality of signal levels from an antenna with a dynamic range fair share threshold; and

attenuating each of the at least one of the compared signal levels that is greater than the dynamic range fair share threshold with a gain factor that is determined in response to a remaining portion of the total system dynamic range after attenuation of other signal levels of the plurality of signal levels, as specified in the claims.

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."

2. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Nguyen T. Vo whose telephone number is (571) 272-7901. The examiner can normally be reached on Monday-Friday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Edward Urban can be reached on (571)272-7899. 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).

Application/Control Number: 10/414,907
Art Unit: 2685

Page 4

Nguyen Vo

Nguyen Vo
9-17-2005

NGUYEN T. VO
PRIMARY EXAMINER



Approved for use through 07/31/2006. OMB 0651-0031

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Substitute for form 1449A/PTO

(Use as many sheets as necessary)

Sheet

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of

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Attorney Docket Number

100.453US01

U.S. PATENT DOCUMENTS

FOREIGN PATENT DOCUMENTS

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. *Applicant's unique citation designation number (optional). *See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. *Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). *For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. *Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. *Applicant is to place a check mark here if English language Translation is attached.

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If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Notice of References Cited	Application/Control No. 10/414,907	Applicant(s)/Patent Under Reexamination BAUMAN ET AL.	
	Examiner Nguyen T. Vo	Art Unit 2685	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-6,580,905	06-2003	Naidu et al.	455/522
*	B	US-6,128,470	10-2000	Naidu et al.	455/16
*	C	US-6,308,085	10-2001	Shoki, Hiroki	455/562.1
*	D	US-2004/0203339	10-2004	Bauman, Donald R.	455/007
	E	US-			
	F	US-			
	G	US-			
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FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
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NON-PATENT DOCUMENTS

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

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

Issue Classification 	Application/Control No.	Applicant(s)/Patent under Reexamination	
	10/414,907	BAUMAN ET AL.	
	Examiner	Art Unit	
	Nguyen T. Vo	2685	

ISSUE CLASSIFICATION									
ORIGINAL				CROSS REFERENCE(S)					
CLASS		SUBCLASS		CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
455		522		455	562.1	127.2	249.1	250.1	
INTERNATIONAL CLASSIFICATION									
H	0	4	B						
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				 (Assistant Examiner) (Date)  NGUYEN T. VO PRIMARY EXAMINER (Primary Examiner) (Date) Total Claims Allowed: 22 O.G. Print Claim(s) 1 O.G. Print Fig. 10					

☒ Claims renumbered in the same order as presented by applicant										☐ CPA		☐ T.D.		☐ R.1.47	
Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
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Part of Paper No. 09172005

Index of Claims 	Application/Control No.		Applicant(s)/Patent under Reexamination	
	10/414,907		BAUMAN ET AL.	
	Examiner		Art Unit	
	Nguyen T. Vo		2685	

✓ Rejected	- (Through numeral) Cancelled	N Non-Elected	A Appeal
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Claim		Date			
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Search Notes 	Application/Control No. 10/414,907 Examiner Nguyen T. Vo	Applicant(s)/Patent under Reexamination BAUMAN ET AL. Art Unit 2685
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SEARCHED			
Class	Subclass	Date	Examiner
455	522	9/15/2005	NVO
	561		
	562.1		
	127.2		
	127.3		
	232.1		
	234.1		
	245.2		
	249.1		
	250.1		
375	345		

INTERFERENCE SEARCHED			
Class	Subclass	Date	Examiner
PGPUB Text Search - See Interference Search Printout		9/17/2005	NVO

SEARCH NOTES (INCLUDING SEARCH STRATEGY)		
	DATE	EXMR
EAST - See Search History Printout	9/15/2005	NVO
Interference Search Printout	9/17/2005	NVO



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Bib Data Sheet

CONFIRMATION NO. 6313

SERIAL NUMBER 10/414,907	FILING DATE 04/16/2003 RULE	CLASS 435	GROUP ART UNIT 2685	ATTORNEY DOCKET NO. 100.453US01
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APPLICANTS

Donald R. Bauman, Waseca, MN;
 Philip M. Wala, Waseca, MN;
 Jerry Edward Toms, Shakopee, MN;

** CONTINUING DATA *****
 This appln claims benefit of 60/430,435 12/03/2002 *yes n/a*

** FOREIGN APPLICATIONS ***** *none n/a*

IF REQUIRED, FOREIGN FILING LICENSE GRANTED
 ** 06/11/2003

Foreign Priority claimed ☐ yes ☒ no 35 USC 119 (a-d) conditions met ☐ yes ☒ no ☐ Met after Allowance Verified and Acknowledged Examiner's Signature <i>[Signature]</i> Initials <i>[Initials]</i>	STATE OR COUNTRY MN	SHEETS DRAWING 11	TOTAL CLAIMS 22	INDEPENDENT CLAIMS 8
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ADDRESS
 34206
 FOGG AND ASSOCIATES, LLC
 P.O. BOX 581339
 MINNEAPOLIS , MN
 55458-1339

TITLE
 Small signal threshold and proportional gain distributed digital communications

FILING FEE RECEIVED 1206	FEES: Authority has been given in Paper No. _____ to charge/credit DEPOSIT ACCOUNT No. _____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue)
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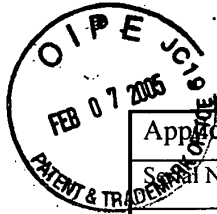
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L2	66086	(remain\$3 residue).clm.	US-PGPUB	OR	ON	2005/09/17 10:11
L3	43	1 and 2	US-PGPUB	OR	ON	2005/09/17 10:11
L4	19845	"455"/\$.ccls.	US-PGPUB	OR	ON	2005/09/17 10:12
L5	14	3 and 4	US-PGPUB	OR	ON	2005/09/17 10:12

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
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L2	1779106	distribut\$3	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 07:43
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L4	904663	threshold (predetermin\$3 adj2 (level value))	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 07:43
L5	2946142	remain\$3 residue	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 07:45
L6	11892	3 same 4 same 5	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 07:46
L7	5220	1 near3 2	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 07:46
L8	18	6 and 7	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 07:49
L9	164362	3 same 4	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 07:50
L10	285	7 and 9	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 07:50
L11	267	10 not 8	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 08:42
L12	147	1 same 6	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 08:42

Search History 9/15/05 8:46:50 AM Page 1

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L14	89977	"455"/\$.ccls.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 08:43
L15	36	13 and 14	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 08:45
L16	3749902	total range	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 08:45
L17	24318	3 same 4 same 16	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 08:46
L18	417	1 same 17	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 08:46
L19	386	18 not 10	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 08:46
L20	118	14 and 19	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2005/09/15 08:46

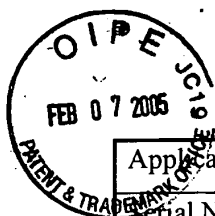


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Applicant(s)	Bauman	TRANSMITTAL FORM UNDER 37 CFR 1.8 (LARGE ENTITY)
Serial No.	10/414,907	
Filing Date	4/16/03	
Examiner Name	Unknown	
Group Art Unit	Unknown	
Confirmation No.	6313	
Attorney Docket No.	100.453US01	
Title: SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN DISTRIBUTED DIGITAL COMMUNICATIONS		

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

Enclosures					
The following documents are enclosed:					
☒ An Information Disclosure Statement (1 pg.); Form 1449 (1 pg.); and a copy of the International Search Report (5 pgs.).					
☒ A return postcard.					
Please charge any additional fees or credit any overpayments to Deposit Account No. 502432.					
CUSTOMER NO. 34206					
Submitted By					
Name	David M. Fogg	Reg. No.	35,138	Telephone	(612) 332-4720
Signature				Date	February 3, 2005
Attorneys for Applicant Fogg and Associates, LLC P.O. Box 581339 Minneapolis, MN 55458-1339 T: 612-332-4720 F: 612-332-4731					
Certificate of Mailing					
I certify that this correspondence, and the documents identified above, are being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450 on February 3, 2005.					
Name	Lisa D. Gentry	Signature			



Applicant(s)	Bauman	INFORMATION DISCLOSURE STATEMENT
Serial No.	10/414,907	
Filing Date	4/16/03	
Examiner Name	Unknown	
Group Art Unit	Unknown	
Confirmation No.	6313	
Attorney Docket No.	100.453US01	
Title: SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN DISTRIBUTED DIGITAL COMMUNICATIONS		

Commissioner for Patents
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In compliance with 37 C.F.R. §§ 1.56 and 1.97, *et seq.*, the enclosed materials are brought to the attention of the Examiner for consideration in connection with the above-identified Application. Applicant respectfully requests that this Information Disclosure Statement be entered and the references listed on the attached Form 1449 be considered by the Examiner and made of record. Pursuant to MPEP §609, Applicant further requests that the Examiner initial next to each reference on the Form 1449 to indicate that the listed references have been considered. Applicant further requests that a copy of the initialed Form 1449 be returned with the next official communication.

All but one of these references were recently cited in a communication in a counterpart foreign application. A copy of the International Search report is enclosed herewith. The reference not cited in the International Search Report is US Publication No. 2003/0162516.

Because as an Office Action has not yet been issued in this application, it is believed that no fee is due. However, the Commission for Patents is hereby authorized to charge any fees deemed necessary or credit any overpayment to Deposit Account No. 502432.

The Examiner is invited to contact the Applicant's Representative at the below-listed telephone number if they are any questions regarding this communication.

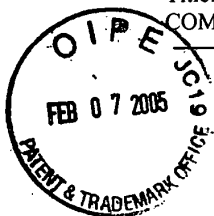
INFORMATION DISCLOSURE STATEMENT

PAGE 2

Serial No. 10/414,907

Attorney Docket No. 100.453US01

Title: SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN DISTRIBUTED DIGITAL COMMUNICATIONS



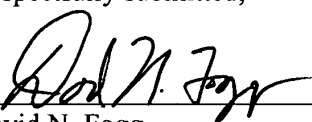
CERTIFICATION UNDER 37 CFR 1.97(e)(1)

The undersigned attorney hereby certifies that all but US Publication No. 2003/0162516 was cited in a communication from a foreign patent office in a counterpart foreign application as indicated above, not more than three months prior to the mailing date of this Information Disclosure Statement.

If the Examiner has any questions or concerns regarding this application, please contact the undersigned at the number listed below.

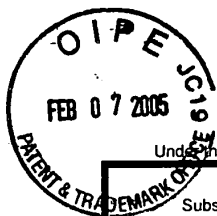
Respectfully submitted,

Date: February 3, 2005



David N. Fogg
Reg. No. 35,138

Attorneys for Applicant
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Minneapolis, MN 55458-1339
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PTO/SB/08a (08-03)

Approved for use through 07/31/2006. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Use as many sheets as necessary)				Complete if Known	
				Application Number	10/414,907
				Filing Date	4/16/2003
				First Named Inventor	Bauman et al.
				Art Unit	Unknown
				Examiner Name	Unknown
Sheet	1	of	1	Attorney Docket Number	100.453US01

U.S. PATENT DOCUMENTS					
Examiner Initials*	Cite No. ¹	Document Number	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
		Number - Kind Code ² (if known)			
		US- 2001/0031014	10-18-2001	Subramanian et al.	
		US- 2003/0133182	07-17-2003	Ng et al.	
		US-2003/0162516	08-28-2003	Solum	
		US- 5,774,085	06-30-1998	Yanagimoto et al.	
		US- 6,643,498	11-04-2003	Miyajima	
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		Country Code ³ - Number ⁴ - Kind Code ⁵ (if known)				
		NONE				

Examiner Signature		Date Considered	
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This collection of information is required by 37 CFR 1.97 and 1.98. 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 2 hours 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, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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EX-1002

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0109



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APPLICATION NUMBER	PATENT NUMBER	GROUP ART UNIT	FILE WRAPPER LOCATION
10/414,907		2685	0120

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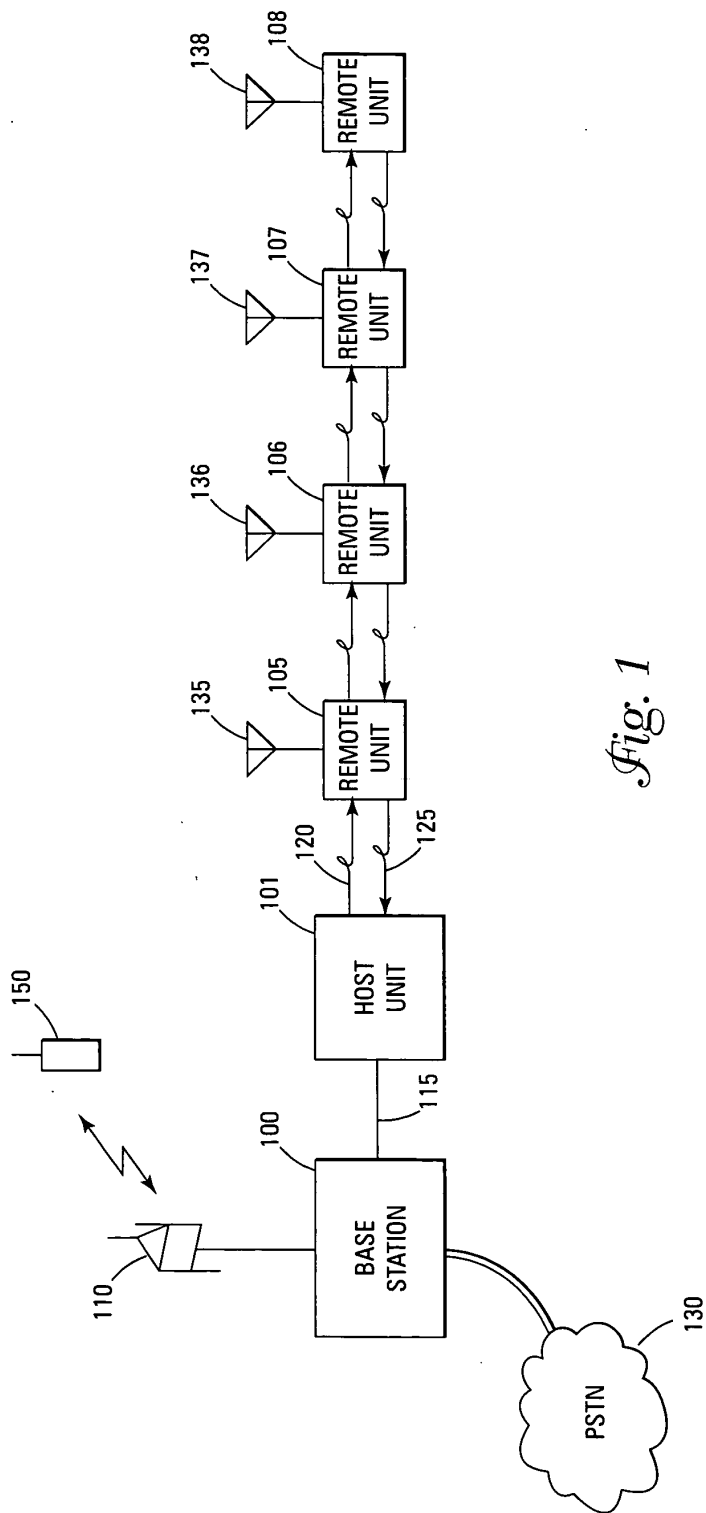
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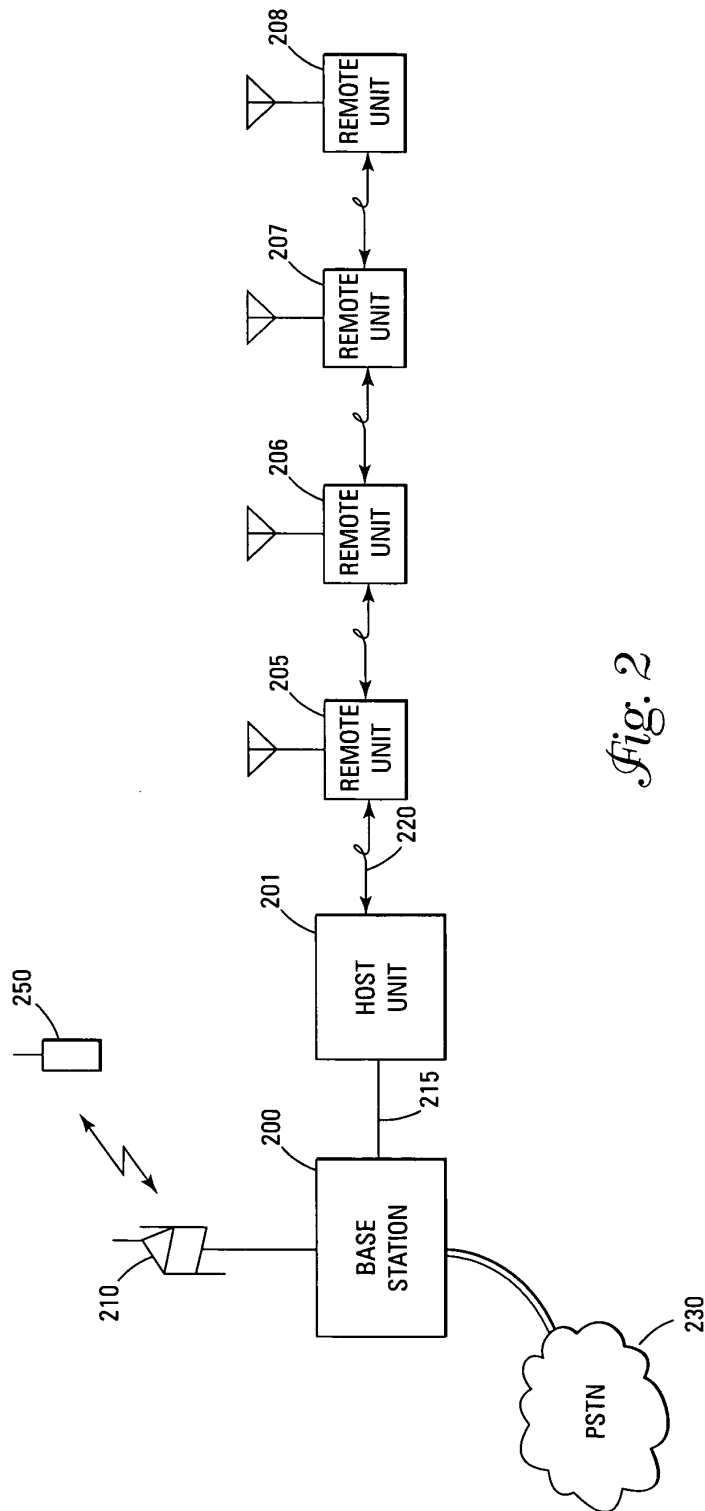
Donald R. Bauman et al.
SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN DISTRIBUTED DIGITAL
COMMUNICATIONS
Atty Docket No. 100.453US01 Serial No. 10/414,907

1/11

*Fig. 1*



2/11



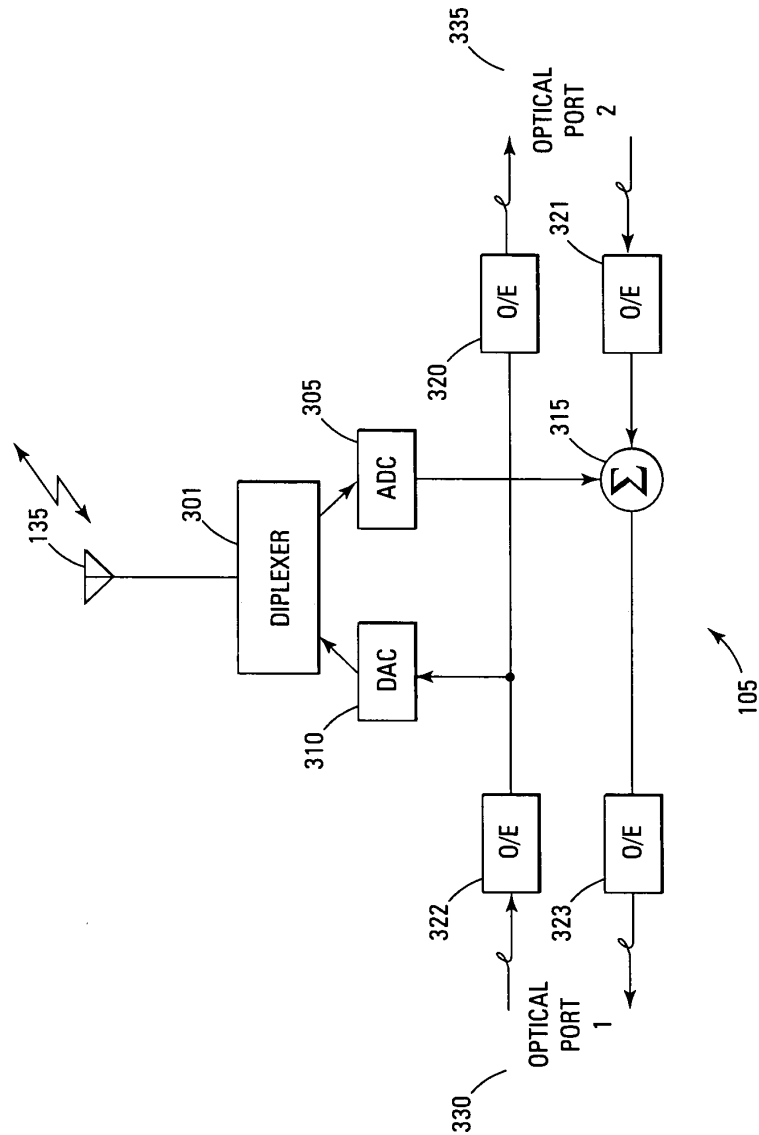


Fig. 3

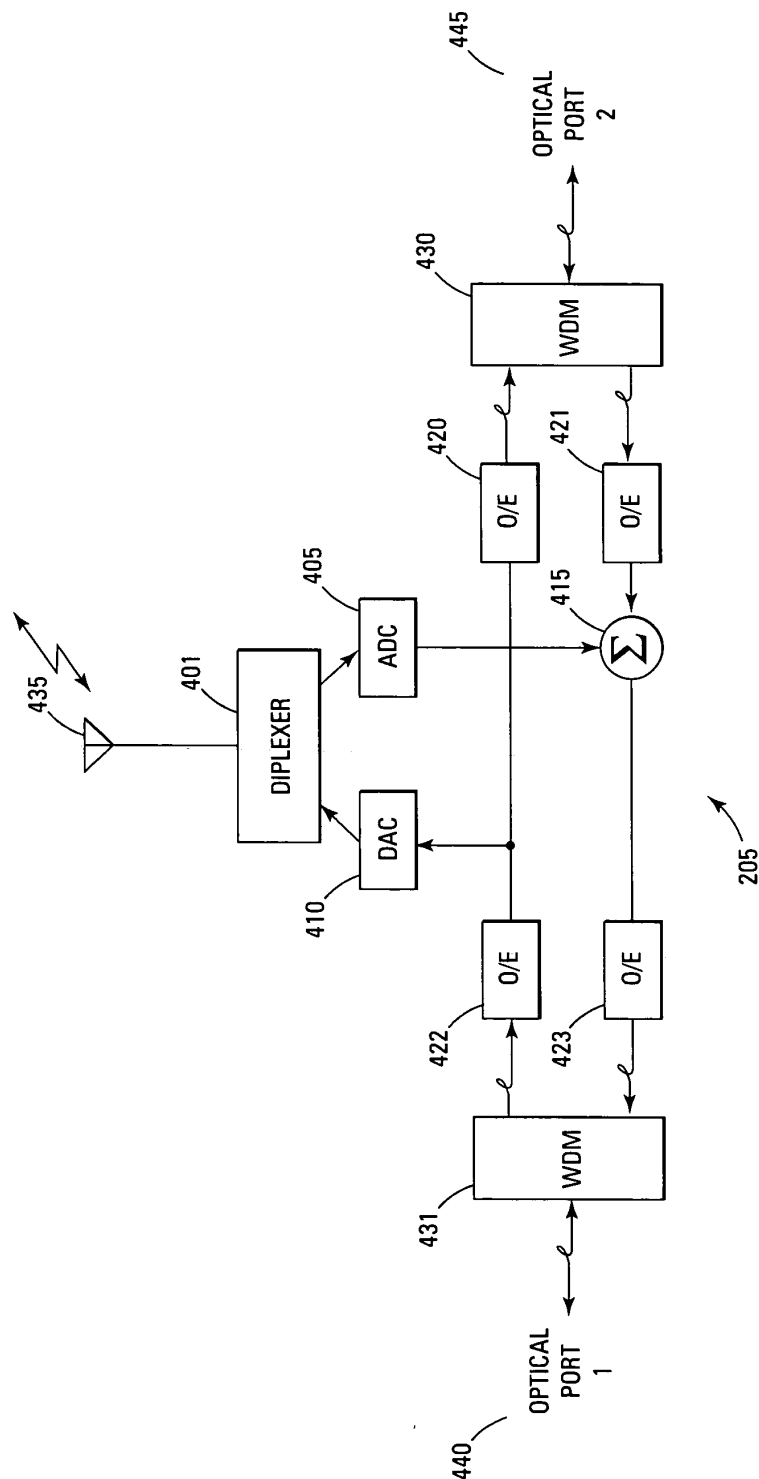


Fig. 4



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Atty Docket No. 100.453US01 Serial No. 10/414,907

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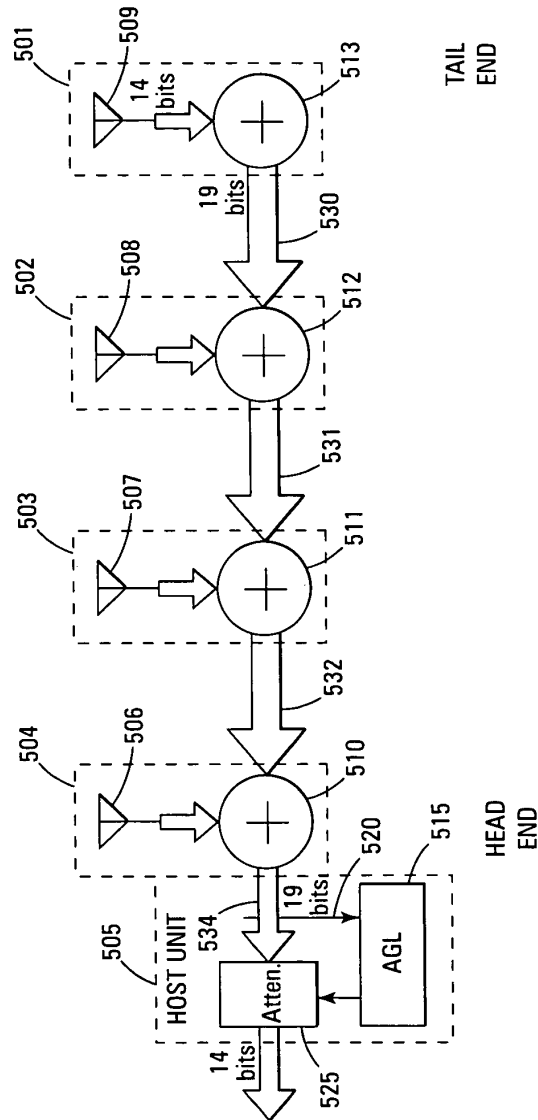


Fig. 5

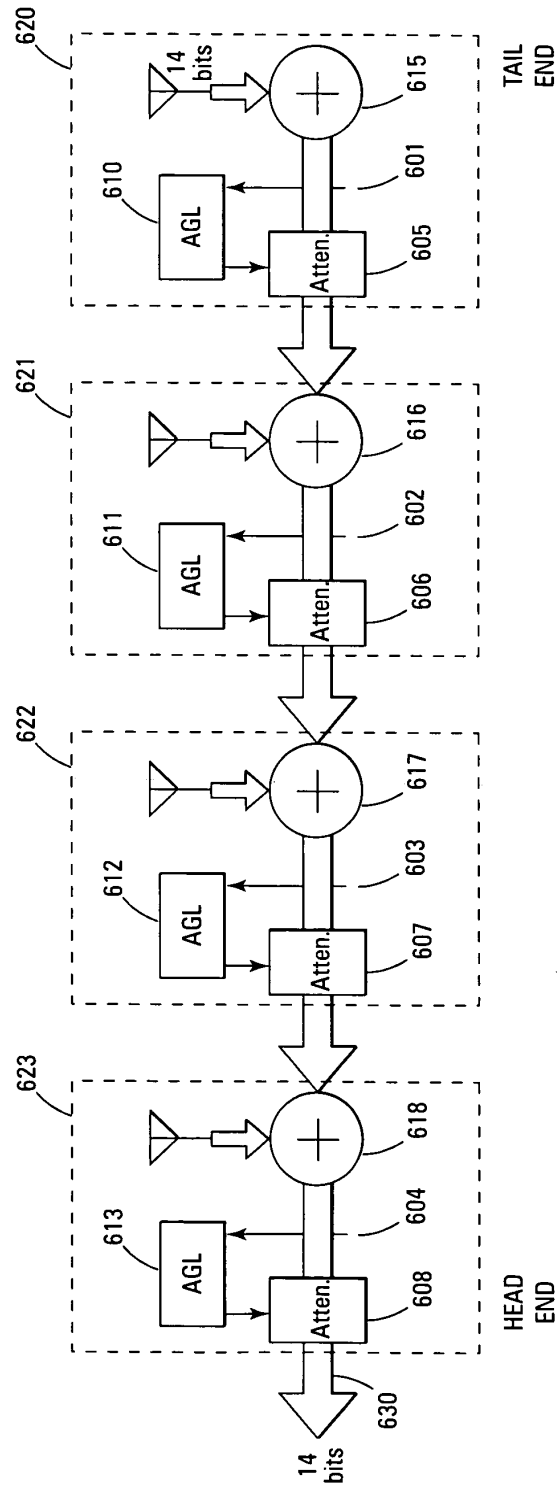


Fig. 6



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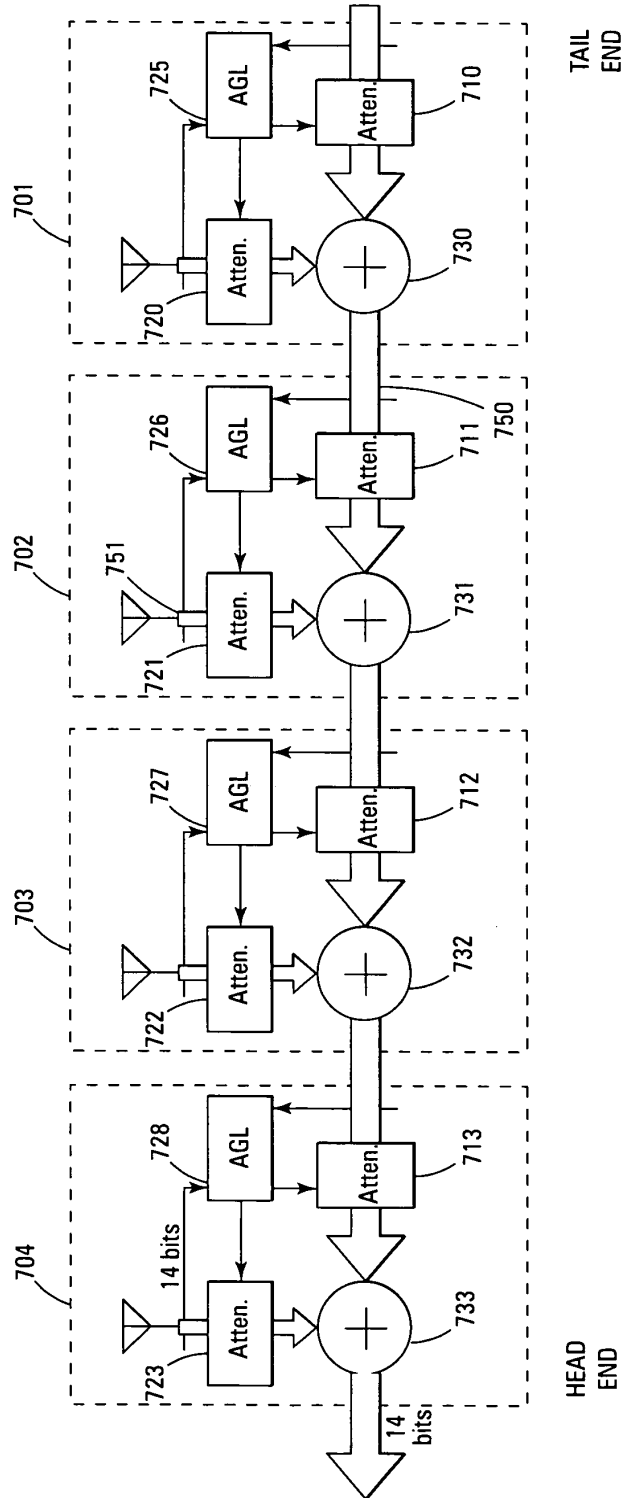


Fig. 7

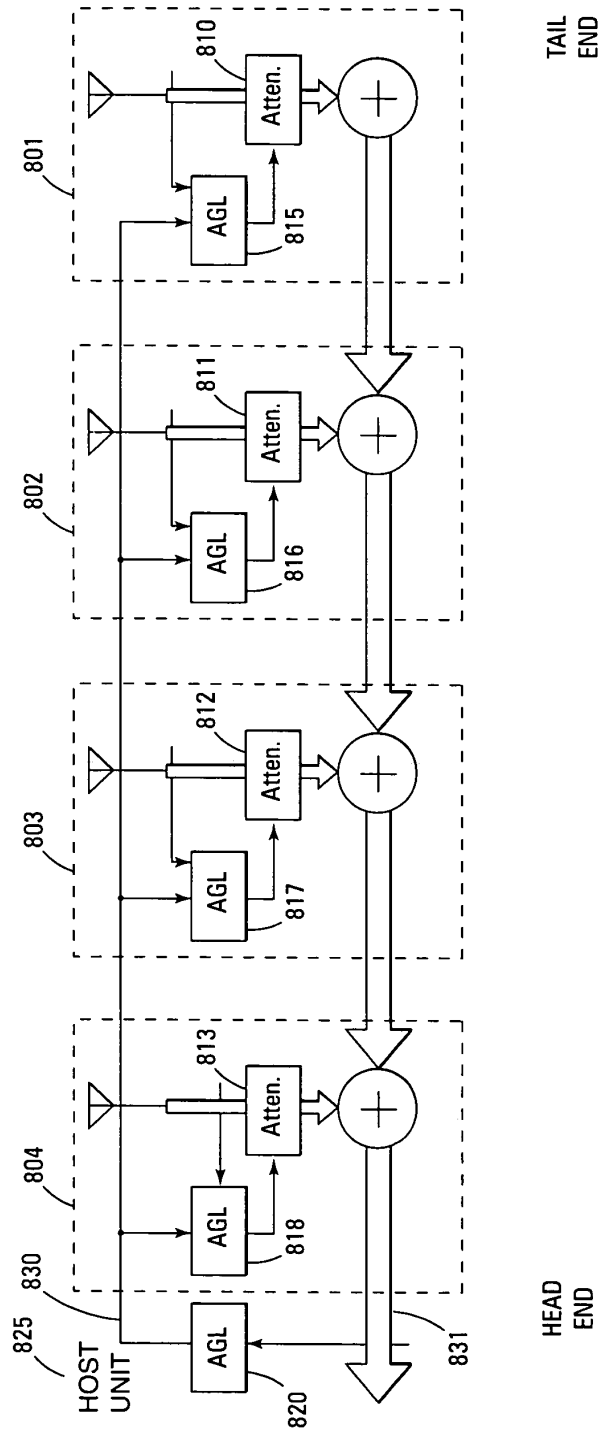


Fig. 8

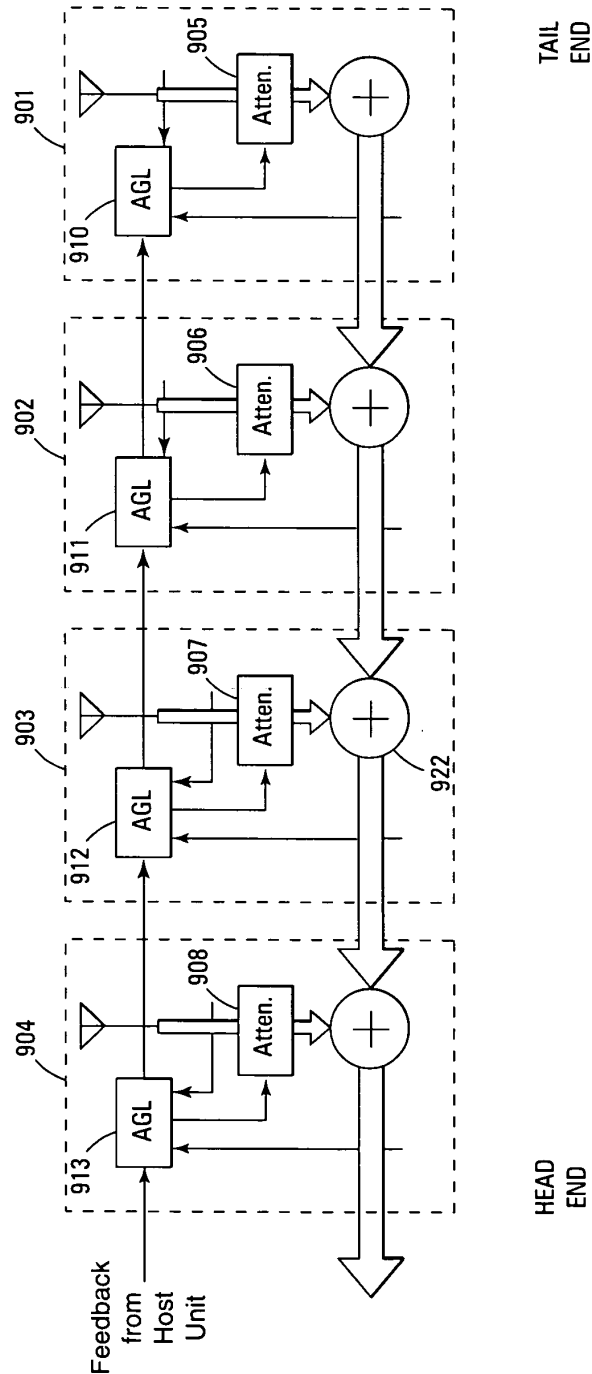


Fig. 9

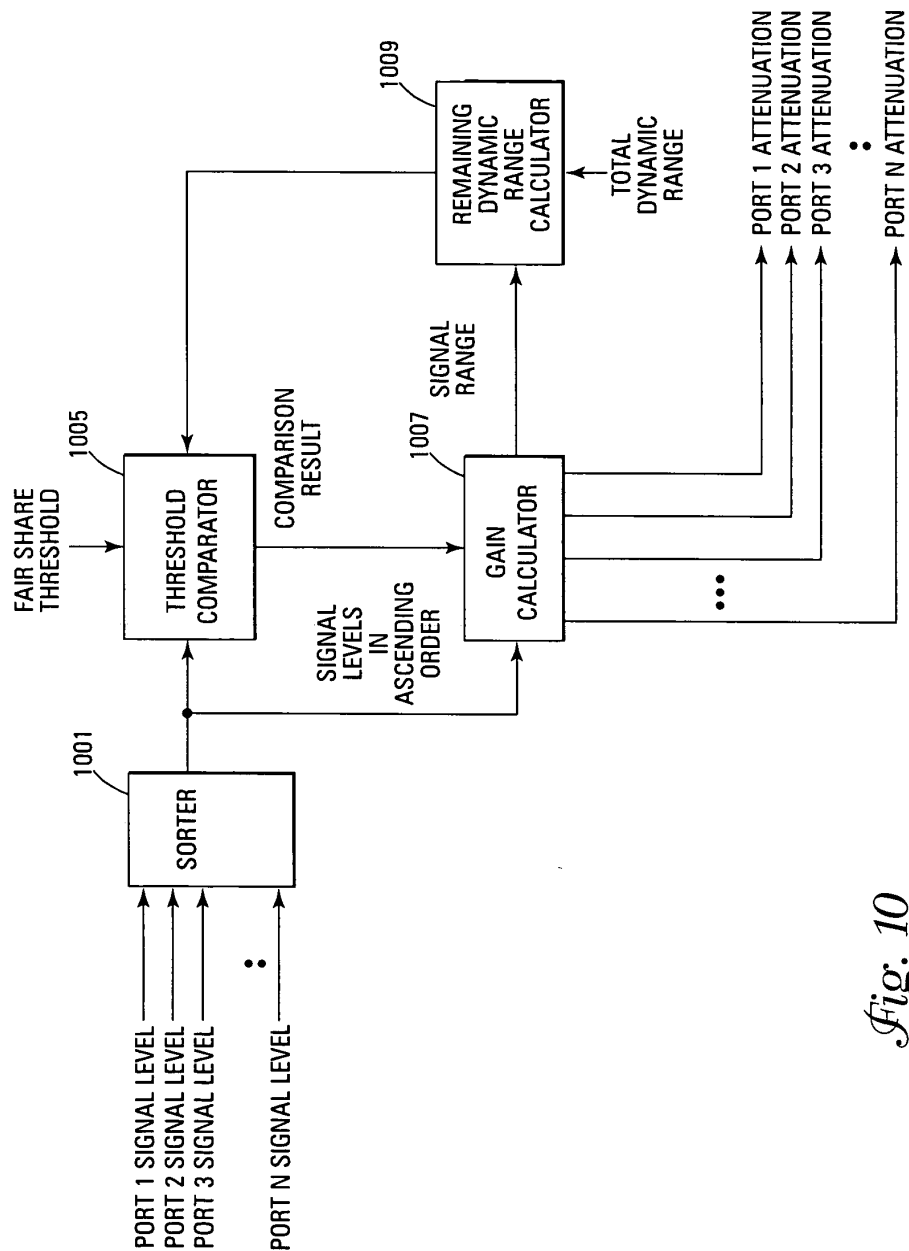


Fig. 10



11/11

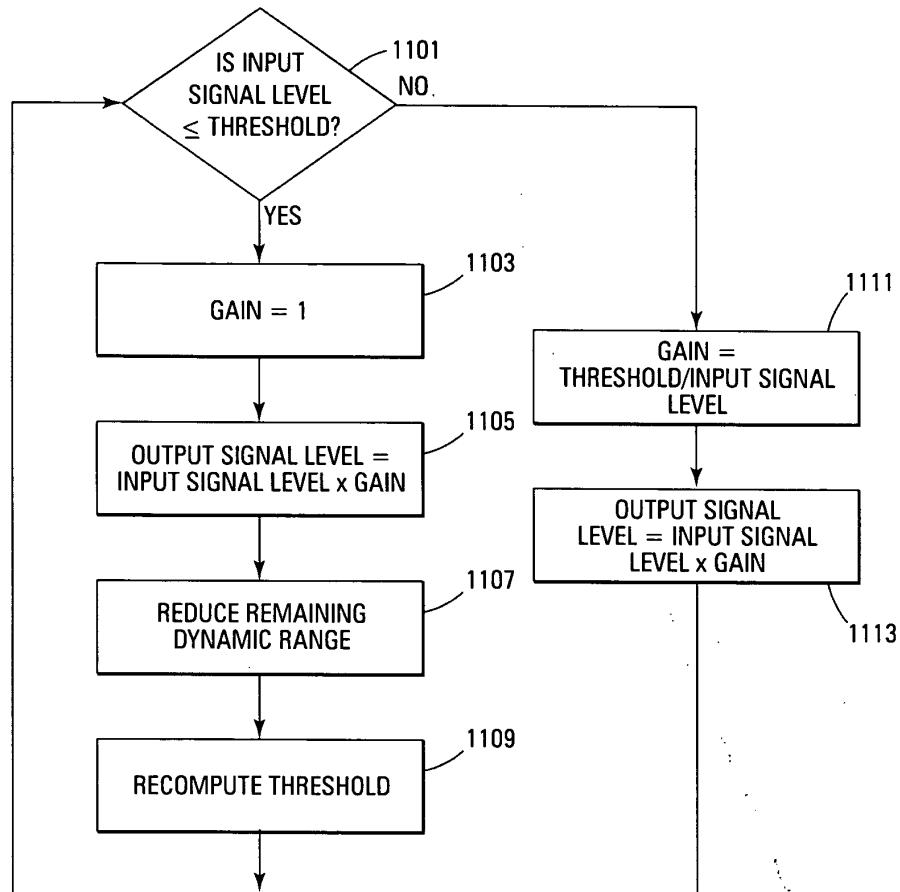


Fig. 11



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APPLICATION NUMBER	FILING/RECEIPT DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NUMBER
10/414,907	04/16/2003	Donald R. Bauman	100.453US01

CONFIRMATION NO. 6313

Fogg and Associates, LLC
 P.O. Box 581339
 Minneapolis, MN 55458-1339

FORMALITIES LETTER



OC000000010238925

Date Mailed: 06/11/2003

NOTICE TO FILE CORRECTED APPLICATION PAPERS

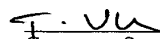
Filing Date Granted

An application number and filing date have been accorded to this application. The application is informal since it does not comply with the regulations for the reason(s) indicated below. Applicant is given TWO MONTHS from the date of this Notice within which to correct the informalities indicated below. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

The required item(s) identified below must be timely submitted to avoid abandonment:

- Replacement drawings in compliance with 37 CFR 1.84 and 37 CFR 1.121 are required. The drawings submitted are not acceptable because:
 - The drawings must be made on paper that has a white background (see 37 CFR 1.84 (e)). For example, drawings on graph paper, lined paper, or paper that has a non-white background are not acceptable. See Figure(s) 5, 6, 7, 8, 9, 10.

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Applicant: Donald R. Bauman et al.

Packet No.: 100.453US01

Title: SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN DISTRIBUTED DIGITAL COMMUNICATIONS

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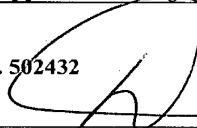
- ☒ Utility Patent Application: Specification (25 pgs. which includes 22 claims and 1 pg. Abstract).
☒ 11 Sheets of Informal Drawings.
☒ A signed Combined Declaration and Power of Attorney (2 pgs.).
☒ An Assignment of the invention to ADC Telecommunications, Inc. and Recordation Form Cover Sheet (5 pgs.).
☒ A check in the amount of \$1246 to cover the filing fee as calculated below (\$1206) and the \$40.00 Assignment Recordation Fee.
☒ A return postcard.

The filing fee has been calculated below as follows:

APPLICATION FILING FEE					
	Number of Claims Filed (1)	Claims Included in Basic Filing Fee (2)	Number of Extra Claims (1-2)	Cost per Extra Claim	Fee Required
Total Claims	22	- 20 =	2	x \$ 18 =	\$ 36
Independent Claims	8	- 3 =	5	x \$ 84 =	\$ 420
One or More Multiple Dependent Claims Presented?					\$ 0
Enter Basic Filing Fee (Utility Patent-Large Entity)					\$ 750
Total Application Filing Fee					\$ 1,206

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By: 
Name: David N. Fogg
Reg. No.: 35,138
Telephone: 612-332-4720
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Date of Deposit: April 16, 2003

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(LARGE ENTITY TRANSMITTAL UNDER 37 C.F.R. 1.10)

**SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN
DISTRIBUTED DIGITAL COMMUNICATIONS**

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application is related to, and claims the benefit of the filing date of, US Provisional Patent Application No. 60/430,435, filed on December 3, 2002.

TECHNICAL FIELD

[0002] The present invention relates generally to communications and particularly to gain control of signals in a distributed antenna system.

BACKGROUND

[0003] Various types of wireless communication systems have become prevalent around the world. For example, cellular communication systems cover most major metropolitan areas as well as major highways through remote areas. Cellular systems permit individuals with cellular handsets to communicate with base stations that are connected to the public switched telephone network (PSTN) or some other communication network.

[0004] As with any communication system, cellular systems can leave coverage "holes" where the signal from the base stations cannot reach. The holes can be in tunnels, valleys, city streets between tall buildings, or any other location where a radio frequency (RF) signal is blocked.

[0005] Placing additional base stations where these coverage holes are located is not always an option. Base stations tend to be very expensive due not only to the cost of the equipment but also because of land acquisition costs. Additionally, large base station antennas may not fit within an area either physically or aesthetically.

[0006] One solution to hole coverage is to use smaller distributed antennas where coverage is needed but a base station is not warranted or desired. There are problems, however, with using a distributed antenna system.

[0007] Any system has a certain dynamic range over which signals are processed. For a system that has only one antenna port, the entire dynamic range is available to the single port signal. When the system has multiple antenna ports, as in the distributed antenna system, the same dynamic range is shared amongst the aggregate signal from all the ports. This reduces the dynamic range available for each port when multiple ports are simultaneously active. One problem with distributed antennas on a single signal path is that the aggregate signal along the signal path may exceed the system's allowable dynamic range. There is a resulting need in the art for adequately controlling the aggregate signal in a single path distributed antenna system.

SUMMARY

[0008] The embodiments of the present invention encompass a method for proportional gain distribution in a system comprising a plurality of distributed antennas. A sampling function senses a signal level at each of the plurality of distributed antennas. Each of the plurality of signal levels are compared with a dynamic range fair share threshold. Each signal level that is greater than the dynamic range fair share threshold is attenuated with a gain factor that is determined in response to a remaining portion of the total system dynamic range after attenuation of other signal levels. Each signal level that is less than or equal to the dynamic range fair share threshold are attenuated with a unity gain factor.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Figure 1 shows a block diagram of one embodiment of a distributed digital antenna system of the present invention.

[0010] Figure 2 shows a block diagram of another embodiment of a distributed digital antenna system of the present invention.

[0011] Figure 3 shows a block diagram of one embodiment of a remote unit in accordance with the system of Figure 1.

[0012] Figure 4 shows a block diagram of one embodiment of a remote unit in accordance with the system of Figure 2.

[0013] Figure 5 shows a block diagram of one embodiment of a system having distributed summation and gain control with head end common attenuation.

[0014] Figure 6 shows a block diagram of one embodiment of a system having distributed summation and gain control with localized common attenuation.

[0015] Figure 7 shows a block diagram of one embodiment of a system having distributed summation and gain control with localized input attenuation.

[0016] Figure 8 shows a block diagram of one embodiment of a system having distributed summation and gain control with head end common attenuation.

[0017] Figure 9 shows a block diagram of one embodiment of a system having distributed summation and gain control with head end common attenuation.

[0018] Figure 10 shows a block diagram of one embodiment of a method for fair and balanced gain control in a distributed summation and gain control system of the present invention.

[0019] Figure 11 shows a flowchart of one embodiment of the fair and balanced attenuation method of the present invention.

DETAILED DESCRIPTION

[0020] By distributing signal attenuation and control of the attenuation, the embodiments of the present invention retain the original system dynamic range. A signal level threshold prevents small but valid signals from being attenuated to the point of being useless while the unused dynamic range is redistributed to signals that require the additional dynamic range.

[0021] The embodiments of the present invention refer to fiber optics as a communications medium between remote units and the host unit. However, the communications medium connecting the remote units to the host unit can take any

form including a laser through an air interface, an RF signal over coaxial cable, or an RF signal through an air interface.

[0022] Figure 1 illustrates a block diagram of one embodiment of a distributed digital antenna system of the present invention. The system has a base station (100) that communicates over an RF link using an antenna (110). The base station communicates over the RF link using any appropriate air interface standard. For example, the air interface standard comprises one of Advanced Mobile Phone System (AMPS), code division multiple access (CDMA), time division multiple access (TDMA), Global System for Mobile communications (GSM), or any other appropriate air interface standard.

[0023] The RF link is made up of a forward link over which the base station (100) transmits to a subscriber unit (150). The subscriber unit (150) transmits back to the base station (100) over a reverse link. The subscriber unit (150) is either a mobile station or a fixed station such as in a wireless local loop system.

[0024] The base station (100) has the transmitters and receivers that enable the subscriber unit (150) to communicate with the public switched telephone network (PSTN) (130). In one embodiment, the base station links the subscriber unit (150) to other subscriber units that are communicating with other base stations. In one embodiment, the base station (100) is connected to the PSTN through a mobile switching center that handles the switching of calls with multiple base stations.

[0025] A host unit (101) is connected to the base station (100) through an RF link (115). In one embodiment, this link (115) is a coaxial cable. Other embodiments use other types of connections such as an air interface or an optical fiber carrying digital RF signals. U.S. Patent Application Serial No. 09/619,431, assigned to ADC Telecommunications, Inc. and incorporated herein by reference, discloses digital RF signals.

[0026] The host unit (101) is responsible for converting the RF signal from the base station (100) to an optical signal for transmission over an optical medium. The host unit (101) also converts a received optical signal to an RF signal for transmission to the base station (100). In other embodiments, the host unit (101) performs additional functions.

[0027] One or more remote units (105 – 108) are connected to the host unit (101) through an optical medium, such as fiber optic lines (120 and 125), in a daisy-chain arrangement. The remote units (105 – 108) are placed in locations that require additional signal coverage due to a lack of coverage by the base station (100). The remote units (105 – 108) communicate with subscriber units in a particular remote unit's coverage area over an RF link provided by the remote unit antennas (135 – 138).

[0028] For purposes of illustration, four remote units (105 – 108) are shown. However, alternate embodiments use other quantities of remote units. If only a small geographic area requires coverage, as few as one remote unit (105) is used. If a highway in a remote area requires additional coverage, more than four remote units are typically used.

[0029] The embodiment of Figure 1 uses a separate fiber optic line for each direction of communication. Each fiber carries a different wavelength. For example, the fiber optic line (120) from the host unit (101) to the remote units (105 – 108) carries a wavelength of λ_1 . The fiber optic line (125) from the remote units (105 – 108) to the host unit (101) carries a wavelength of λ_2 . In alternate embodiments, each fiber carries the same wavelength.

[0030] The fiber optic line (120) from the host unit (101) to the remote units (105 – 108) carries the digital optical signal for transmission by the remote units (105 – 108). The fiber optic line (125) from the remote units (105 – 108) carries a digital optical signal comprising the sum of the received signals from each of the remote units (105 – 108). The generation of this summation signal from the remote units is discussed subsequently.

[0031] Figure 2 illustrates a block diagram of another embodiment of a distributed digital antenna system of the present invention. This system is similar to the embodiment of Figure 1 except that the remote units (205 – 208) are connected to the host unit (201) over a single optical medium (220).

[0032] The system of Figure 2 has a base station (200) that communicates over an RF link using an antenna (210). The base station can communicate over the RF link using any air interface standard. For example, the air interface standard may be

code division multiple access (CDMA), time division multiple access (TDMA), or Global System for Mobile communications (GSM).

[0033] The RF link is made up of a forward link over which the base station (200) transmits to a subscriber unit (250). The subscriber unit (250) transmits back to the base station (200) over a reverse link. The subscriber unit (250) may be a mobile station or a fixed station such as in a wireless local loop system.

[0034] The base station (200) has the transmitters and receivers that enable the subscriber unit (250) to communicate with the public switched telephone network (PSTN) (230). The base station may also link the subscriber unit (250) to other subscriber units that are communicating with other base stations. In one embodiment, the base station (200) is connected to the PSTN through a mobile switching center that handles the switching of calls with multiple base stations.

[0035] A host unit (201) is connected to the base station (200) through an RF link (215). In one embodiment, this link (215) is a coaxial cable. Other embodiments use other types of connections such as an air interface or an optical fiber carrying digital RF signals.

[0036] The host unit (201) is responsible for converting the RF signal from the base station (200) to a digital optical signal for transmission over an optical medium. The host unit (201) also converts a received optical signal to an RF signal for transmission to the base station (200). In other embodiments, the host unit (201) performs additional functions.

[0037] One or more remote units (205 – 208) are connected to the host unit (201) through an optical medium, such as a fiber optic line (220), that is connected in a daisy-chain arrangement. The remote units (205 – 208) are placed in locations that require additional signal coverage due to a lack of coverage by the base station (200).

[0038] For purposes of illustration, four remote units (205 – 208) are shown. However, alternate embodiments use other quantities of remote units depending on the application.

[0039] The embodiment of Figure 2 uses a single fiber optic line (220) for communication both to and from the remote units (205 – 208). This is accomplished by the single fiber (220) carrying multiple wavelengths. For example, the fiber optic line (220) uses a wavelength of λ_1 for the digital signal from the host unit to the

remote units (205 – 208). The fiber optic line (220) also carries a digital summation signal with a wavelength of λ_2 . This digital summation signal is the sum of the received signals from the remote units (205 – 208). The generation of this summation signal from the remote units is discussed subsequently.

[0040] Figure 3 illustrates a block diagram of one embodiment of a remote unit (105) of Figure 1. Each of the remote units (105 – 108) of the embodiment of Figure 1 are substantially identical in functional composition.

[0041] The remote unit (105) transmits and receives RF communication signals over the antenna (135). Both the receive and transmit circuitry is connected to the antenna (135) through a diplexer (301). Alternate embodiments use other quantities of antennas. For example, one embodiment uses three antennas to cover three different sectors of an area. In other embodiments, diversity antennas are used.

[0042] An analog signal that is received on the antenna (135) is split off by the diplexer (301) to an analog-to-digital converter (305). The analog-to-digital converter (305) digitizes the received analog signal by periodically sampling the signal. The sampling generates a digital representation of the received analog signal. In one embodiment, the digital signal comprises 14 bit samples of the received analog signal.

[0043] The digitized received signal is input to a summer (315) to be added to the digitized signals from the preceding remote units in the daisy-chain. The input of the summer (315), therefore, is coupled to an output of a previous remote unit. The output of the summer (315) is a summation signal that is coupled to either the input of a subsequent remote unit or to the host unit. The host unit thus receives a summation signal that represents the sum of all the signals received by the remote units (105 – 108) of the system.

[0044] A digital signal from the host unit is coupled to a digital-to-analog converter (310). The digital-to-analog converter (310) takes the digital representation of an analog signal and converts it to the analog signal for transmission by the antenna (135).

[0045] Optical-to-Electrical converters (320 – 323) are located at the optical ports (330 and 335) of the remote unit (105). Each optical port (330 and 335) has an input and an output that are each coupled to an Optical-to-Electrical converter (320 – 323).

[0046] Since the remote unit (105) operates with electrical signals that are represented by the optical signals coming in through the optical ports (330 and 335), the Optical-to-Electrical converters (320 – 323) are responsible for converting the optical signals to electrical signals for processing by the remote unit (105). Received electrical signals are converted from electrical to an optical representation for transmission over the optical fiber.

[0047] Figure 4 illustrates a block diagram of one embodiment of a remote unit (205) of Figure 2. Each of the remote units (205 – 208) of the embodiment of Figure 1 is substantially identical in functional composition.

[0048] The remote unit (205) transmits and receives RF communication signals over the antenna (435). Both the receive and transmit circuitry are connected to the antenna (435) through a diplexer (401). Alternate embodiments use other quantities of antennas. For example, one embodiment uses three antennas to cover three different sectors of an area. In other embodiments, diversity antennas are used.

[0049] An analog signal that is received on the antenna (435) is split off by the diplexer (401) to an analog-to-digital converter (405). The analog-to-digital converter (405) digitizes the received analog signal by periodically sampling the signal. The sampling generates a digital representation of the received analog signal. In one embodiment, the digital signal comprises 14 bit samples of the received analog signal.

[0050] The digitized received signal is input to a summer (415) to be added to the digitized signals from the preceding remote units in the daisy-chain. The host unit thus receives a summation signal that represents the sum of all the signals received by the remote units (205 – 208) of the system.

[0051] A digital signal from the host unit is coupled to a digital-to-analog converter (410). The digital-to-analog converter (410) takes the digital representation of an analog signal and converts it to the analog signal for transmission by the antenna (435).

[0052] Optical-to-Electrical converters (420 – 423) are located at the optical ports (440 and 445) of the remote unit (205). Each optical port (440 and 445) has an input and an output that are each coupled to an Optical-to-Electrical converter (420 – 423).

[0053] Since the remote unit (205) operates with electrical signals that are represented by the optical signals coming in through the optical ports (440 and 445), the Optical-to-Electrical converters (420 – 423) are responsible for converting the optical signals to electrical signals for processing by the remote unit (205). Received electrical signals are converted from electrical to an optical representation for transmission over the optical fiber.

[0054] A wavelength division multiplexer (WDM) (430 and 431) is located at each optical port (440 and 445). The WDMs (430 and 431) perform the optical processing necessary to combine several optical signals having several wavelengths. The WDMs (430 and 431) also perform the optical demultiplexing necessary to split the multiple wavelengths of a single fiber to their own signal paths.

[0055] In the above-described embodiments, if one antenna port uses up all of the system's dynamic range, none is available for the other antenna ports and the aggregate dynamic range needs to be increased. The amount of additional dynamic range required (in dB) is expressed as $20\log N$, where N is the number of antenna ports. The quantity of additional bits required in a frame in order to express the aggregate signal is expressed as $\log_2 N$.

[0056] As an example of one embodiment of operation, the dynamic range for 14 bits is 84 dB. To accommodate the aggregate dynamic range for 32 antenna ports, an additional 30 dB and 5 bits are required. In this case, the analog-to-digital resolution for each port still remains at 14 bits but the summation of all the antenna port signals is represented by 19 bits.

[0057] In order to keep the original dynamic range and output signal levels, the distributed attenuation of the embodiments of the present invention use attenuators at antenna port inputs, outputs, or both. The distributed control may use a head-end based controller with feedback to each antenna port, local controllers at each antenna port, or distributed control with distributed feedback.

[0058] The various embodiments of the present invention use automatic gain limiting (AGL) as a gain control function. Alternate embodiments use automatic gain control (AGC) as a gain control function. AGL is active only when the signal exceeds some maximum value. AGC continuously controls attenuation.

[0059] The embodiments of the present invention employ different methods of attenuation. These methods include stepped attenuation, continuous attenuation, and fair and balanced attenuation.

[0060] Stepped attenuation is used when the summation of all of the antenna ports exceeds the maximum threshold. In one embodiment, this threshold is unity. In this case, the attenuator provides attenuation in discrete increments. For example, 6 dB increments can be accomplished in a binary number by bit shifting in the direction of a smaller value. One shift equals 6 dB, two shifts equals 12 dB, and three shifts equals 18 dB. This can be continued for as much attenuation as required. For 32 antenna ports, five shifts of 6 dB accommodates 30 dB of attenuation.

[0061] Continuous attenuation is continuous in value. The attenuation need not be in fixed steps but the attenuation could be accomplished with exactly as much as needed. In other words, the attenuation could be proportional to the excess aggregate signal level. If the aggregate signal is 2.3 dB above the maximum, the attenuator introduces exactly 2.3 dB of attenuation.

[0062] This method of attenuation is accomplished by multiplying the aggregate value by the appropriate attenuation factor. In one embodiment, the attenuation factor is between 0, for infinite attenuation, and 1 for no attenuation.

[0063] Applying the attenuation to the aggregate signal means that all of the signals are treated the same. The smallest signals suffer the most. In fact, very small signals may be attenuated to a level below the least significant bit. At this point, such signals cease to exist.

[0064] A block diagram of the fair and balanced attenuation method is illustrated in Figure 10. This method attenuates the smallest signals the least and the largest signals are attenuated the most. Some of the very small signals may not receive any attenuation. An additional benefit is that no portion of the dynamic range goes unused since it is progressively allocated to the larger signals. In one embodiment, the functions of Figure 10 are accomplished in the digital domain.

[0065] Referring to Figure 10, in order to perform the fair and balanced attenuation method, each individual antenna port input is sensed with a sampling function that is well known in the art to determine each input signal level. The signal levels are applied to the sorter (1001).

[0066] The sorter (1001) sorts the antenna port signals, designated x_j , in ascending order according to their level. In this case, $j = 1$ is the smallest and $j = N$ is the largest, where N is the number of antenna ports. The sorted signals are input to a threshold comparator (1005) and a gain calculator (1007). A "fair share" threshold is also input to the threshold comparator. The dynamic range fair share threshold, K , is calculated as $K = T/(n - j)$ where the total available system dynamic range is unity and is designated as T . In alternate embodiments, other appropriate threshold calculations are used.

[0067] The fair share threshold is dynamically redefined in order to divide any remaining dynamic range among the remaining signals. The total remaining system dynamic range is calculated by a remaining dynamic range calculator (1009) that is also input to the threshold comparator (1005). The remaining dynamic range calculator (1009) uses the signal range input from the gain calculator (1007) and the total dynamic range that is assumed to be unity in this embodiment. The total remaining dynamic range is expressed as $T = T - y_i$ where y_i is the output signal from the antenna port. Alternate embodiments use other total dynamic ranges.

[0068] The gain calculator generates a gain, G_j , from the threshold comparison results in order to progressively generate gain factors for Port 1 – Port N in ascending order. The process of Figure 10 can be expressed as:

if $x_j \leq K$, then	Input signal, x_j , is less than fair share
do for $j=1$ to N	
$G_j = 1$	
$y_j = G_j * x_j$	
$T = T - y_j$	
$K = T/(N-j)$	
end do	
else	Remaining input signals are more than fair share
$G_j = K/x_j$	Gain is inverse to signal level input
$y_j = G_j * x_j$	Reduce level proportionally
end if	

[0069] The fair and balanced attenuation embodiment of Figure 10 is illustrated in the following example using continuous attenuation:

Index j	Input x_j	Fair Share K	Gain G_j	Output y_j	Remaining Dynamic Range T	Number of Remaining Signals
					1	4
1	0.1	0.25	1	0.1	0.9	3
2	0.3	0.3	1	0.3	0.5	2
3	0.4	0.3	0.75	0.3	0.3	1
4	0.5	0.3	0.6	0.3	0	0

[0070] It can be seen in the table that the smallest signal (e.g., $x_j = 0.1$) remains unchanged. It has been attenuated with a unity gain factor. The next smallest signal (e.g., $x_j = 0.3$) takes advantage of the dynamic range that is not used by the first signal. This signal is also attenuated with a unity gain factor.

[0071] The next largest signal (e.g., $x_j = 0.4$) is attenuated by a gain factor of 0.75. The largest signal (e.g., $x_j = 0.5$) is attenuated the most by a gain factor of 0.6.

[0072] The process of Figure 10 can also be applied to a stepped attenuation embodiment. The following table illustrates such an embodiment. It should be noted that the 6 dB steps are for illustration purposes only and the present invention is not limited to any one attenuation increment.

Index j	Input X_j	Fair Share K	Gain G_j	Output Y_j	Remaining Dynamic Range T	Number of Remaining Signals
					1	4
1	0.1	0.25	1	0.1	0.9	3
2	0.3	0.3	1	0.3	0.6	2
3	0.4	0.3	0.5	0.2	0.4	1
4	0.5	0.3	0.5	0.25	0.15	0

[0073] This table shows that the smallest signal remains unchanged since it is attenuated with a unity gain factor. The next smallest signal takes advantage of the dynamic range not used by the first signal. This signal also is attenuated with a unity gain factor.

[0074] The next largest signal is attenuated by a gain factor of 0.5. This is a 6 dB step. Similarly, the largest signal is attenuated by a gain factor of 0.5. In this embodiment, a portion (e.g., 0.15) of the dynamic range is not used.

[0075] The following embodiments discuss certain transport path and aggregate signal levels (e.g., 14 bits). This is for illustration purposes only. The present invention is not limited to any one transport path size or aggregate signal level.

[0076] Figure 11 illustrates a flowchart of one embodiment of the fair and balanced attenuation method of the present invention. The method begins with determining if the input signal level is less than or equal to the threshold, K (1101).

[0077] If they are not equal, the gain is determined to be the threshold divided by the input signal level (1111). The output signal level is then equal to the input signal level times the gain (1113).

[0078] If the input signal level is less than or equal to the threshold (1101), the gain is set equal to one (1103). The output signal level is then computed to be the input signal level times the gain (1105). The remaining dynamic range is then reduced by the computed output signal level (1107). The threshold is also recomputed as the remaining dynamic range divided by the number of ports remaining (1109).

[0079] Figure 5 illustrates a block diagram of one embodiment of a system having distributed summation with head end common attenuation and gain control. For purposes of clarity, a functional equivalent of the above-described remote unit, in this and subsequent embodiments, is illustrated as an antenna (509) with a summation symbol (513).

[0080] The embodiment of Figure 5 includes the four remote units (501 – 504) and the host unit (505) as described previously. Each remote unit (501 – 504) has an antenna (506 – 509) that receives RF signals that are digitized and summed (510 – 513) with any previous remote unit signals.

[0081] The summations (510 – 513) and transport path (530 – 532) to each remote unit should have sufficient dynamic range to deliver the aggregate dynamic range. For example, in one embodiment the full dynamic range is 19 bits for 32 antenna ports. This embodiment assumes that all of the remote units are substantially identical.

[0082] In the embodiment of Figure 5, the host unit (505), located at the head end, performs the AGL (515) and attenuation (525) functions. The AGL sampling function (515) samples (520) the aggregate signal (534) from the last remote unit (504) before the host unit (505). This signal requires 19 bits for a dynamic range of 114 dB. Other embodiments have other bit quantities to represent different dynamic ranges.

[0083] If the AGL function (515) determines that the aggregate signal (531) is greater than the maximum allowable dynamic range, the AGL function (515) instructs the attenuation function (525) to attenuate the signal. The attenuation function (525) may use the stepped attenuation, the continuous attenuation, or other attenuation approaches.

[0084] In the example illustrated in Figure 5 where the aggregate signal is 19 bits, the attenuation function attenuates the signal to 14 bits. Thus, the signal from the host unit (505) to a base station will be within the allowable dynamic range.

[0085] Figure 6 illustrates a block diagram of one embodiment of a system having distributed summation and gain control with localized common attenuation. This embodiment uses a standard transport path (601 – 604) (e.g., 14 bits) by applying localized attenuation to its aggregate signal.

[0086] Each remote unit (620 – 623) attenuates its common output level so that the maximum level is not exceeded. The aggregate of all summations (615 – 618) and attenuations (605 – 608) results in a head end aggregate signal (630) that does not exceed the maximum level.

[0087] The AGL function (610 – 613) of each remote unit (620 – 623) samples the signal level output (601 – 604) from the respective summation (615 – 618). If the signal level is greater than the allowable dynamic range, the AGL function (610 – 613) instructs its respective attenuation function (605 – 608) to attenuate that particular signal.

[0088] Figure 7 illustrates a block diagram of one embodiment of a system having distributed summation and gain control with localized input attenuation. In this embodiment, each of the remote units (701 – 704) uses an AGL function (725 – 728) to control attenuation functions (710 – 713 and 720 – 723) on the summation (730 – 733) inputs.

[0089] The input signals that are attenuated in this embodiment include both the antenna port and the downstream port. For example, in one remote unit (702) the AGL function (726) samples the downstream signal path (750) and the antenna port input (751). If the dynamic range of either input is greater than the allowable maximum, the AGL function (726) instructs the attenuation function (711 and/or 721) of the appropriate input to attenuate that particular signal.

[0090] The fair and balanced attenuation method can be employed in the embodiment of Figure 7 as illustrated in Figures 10 and 11. However, this embodiment is not limited to any one attenuation method.

[0091] Figure 8 illustrates a block diagram of one embodiment of a system having distributed summation and gain control with head end controlled, distributed attenuation. This embodiment uses an AGL function (820) at the host unit (825) to provide feedback (830) to the remote units (801 – 804).

[0092] Each remote unit (801 – 804) has an attenuation function (810 – 813) at the antenna port to provide appropriate attenuation to the input signal. An AGL function (815 – 818) samples the antenna port's received signal in order to provide individual attenuation instructions to the attenuation functions (810 – 813).

[0093] The embodiment of Figure 8 additionally uses an AGL function (820) at the host unit (825) to sample the final aggregate signal (831). The host unit's AGL function (820) provides a head end feedback attenuation signal (830) to the remote units' AGL functions (815 – 818) to use in conjunction with the sampled input communication signal levels. This feedback signal (830) may take the form of one or more bits in the data being transmitted along the optical medium to the remote units (801 – 804) from the host unit (825).

[0094] For the case of continuous attenuation, the feedback attenuation signal is an attenuation factor that is comprised of a value between 0 and 1. For example, an unattenuated aggregate of 2 would be represented by an attenuation factor of 0.5. The attenuation factor is not applied directly to the individual remote units' attenuation functions (810 – 813). Instead, if a port signal is more than 0.5 of the total dynamic range, the remote units' AGL function (815 – 818) instructs the appropriate attenuation function (810 – 813) to apply a 0.5 attenuation factor to the port input. If the signal is equal to or less than 0.5, attenuation is not applied.

[0095] Since some of the signals may not be attenuated, the resulting aggregate signal may still be slightly too high. In this case, the AGL function (820) at the host unit (825) adjusts its feedback attenuation factor to whatever value is needed (e.g., 0.4). This value is dynamic and is lowered until the desired aggregate signal level is achieved.

[0096] Using the continuous attenuation method, the host unit's AGL function (820) samples the final aggregate signal (831) from the remote unit (804) nearest the head end. If the level of the final aggregate signal (831) is too large, the host unit (825) provides a feedback attenuation factor that starts at one and slews down toward zero. When the final aggregate signal level is within bounds (i.e., less than the maximum dynamic range), the host unit holds this attenuation factor.

[0097] If the final aggregate signal level later decreases sufficiently, the host unit (825) slowly raises the attenuation factor back toward one. All of the remote units (801 – 804) apply attenuation only to their own ports according to the fair and balanced attenuation method discussed previously. This means that the applied attenuation depends on the respective antenna port's input level as well as the feedback factor (830).

[0098] Using the stepped attenuation method, the host unit (825) samples the final aggregate signal (831) from the remote unit (804) nearest the head end. If the final aggregate signal (831) is too large, the host unit (825) provides a feedback attenuation signal that is an attenuation number that starts at 0 and increments towards 6. This is assuming 6 dB steps. Other embodiments use other increments.

[0099] When the final aggregate signal level is less than or equal to 0 dB (unity gain), the host unit's AGL function (820) holds this number. If the final aggregate signal level decreases to a predetermined level (e.g., -12 dB), the host unit decrements the number back towards 0. The decrementing occurs after a delay due to system end-to-end response.

[00100] In one embodiment, all of the remote units (801 – 804) apply attenuation to their own ports according to the fair and balanced attenuation method discussed previously. This means that the applied attenuation depends on the respective antenna port's input level as well as the feedback number.

[00101] The following table illustrates one example of the stepped fair attenuation as applied to the embodiment of Figure 8:

Step Number	Max Possible Attenuation	Actual Applied Attenuation				
		Port Signal Level				
		>-6dB	>-12dB	>-18dB	>-24dB	>-30dB
0	0 dB	0	0	0	0	0
1	6 dB	-6	0	0	0	0
2	12 dB	-12	-6	0	0	0
3	18 dB	-18	-12	-6	0	0
4	24 dB	-24	-18	-12	-6	0
5	30 dB	-30	-24	-18	-12	-6

[00102] It can be seen in the table that a remote unit's attenuation only affects its port signals. There is a 12 dB window between the decision to increase attenuation and the decision to decrease attenuation. If all ports have the same signal level, a step increment affects them all and causes 6 dB more attenuation in both the individual and aggregate signal levels. But if some of the signals are of different levels, only the largest signals are attenuated by 6 dB. This results in an aggregate additional level attenuation that is less than 6 dB.

[00103] Figure 9 illustrates a block diagram of one embodiment of a system having distributed summation and gain control. This embodiment puts the attenuation decision making with the individual remote units (901 – 904) while still providing the feedback of the attenuation factor.

[00104] In this embodiment, the final aggregate signal is sampled and a feedback attenuation factor is passed toward the tail end of the system. The feedback can be accomplished by embedding the attenuation factor in a data frame that is transmitted over the communication medium to the remote units. The data frame format and use is well known in the art and not discussed further. In other embodiments, dedicated bits or a continuous value are used for the feedback.

[00105] Similarly, the AGL function (910 – 913) of each remote unit (901 – 904) also samples the aggregate signal at the output of the summation (920 – 923) for that particular unit. The sampling AGL function then passes an attenuation factor to the preceding remote unit's AGL function (910 – 913) in a data frame.

[00106] As an example, the AGL function (913) of the head end remote unit (904) samples the final aggregate signal level and generates an attenuation factor. This factor is fed back in the direction of the tail end to the next remote unit (903) in the daisy-chain. This remote unit (903) samples the signal level out of the summation (922) at that unit and generates an attenuation factor based on that level. This factor is fed back to the next remote unit (902) in the daisy-chain.

[00107] Every remote units' (901 – 904) AGL function (910 – 913) has two attenuation factors: the one from its local evaluation of its antenna port (i.e., the local attenuation signal) and the one from the upstream unit (i.e., towards the head end). The AGL function (910 – 913) applies the more severe factor of the two to its port attenuation and passes this factor on toward the tail end.

[00108] In this embodiment, the host unit generates the highest attenuation factor because its aggregate signal is the largest. Because of the feedback, all remote units use this factor to apply attenuation. Since all of the remote units also sample their own antenna port, they will apply no attenuation or little attenuation to sufficiently small signals. The remote units will also apply large attenuation to large signals.

[00109] If there is a break in the feedback path, the aggregate sampling at each remote unit prevents any unit's aggregate signal from overflowing. Furthermore, all units from the tail end to the point of the break will perform fair sharing of the aggregate signals amongst themselves. Similarly, all units from the break to the head end will perform fair sharing of the aggregate signals amongst themselves. However, the tail end group is favored over the head end group.

[00110] Numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

What is claimed is:

1. A method for gain distribution in a system comprising a plurality of distributed antennas and a total system dynamic range, the method comprising:
sensing a signal level at each of the plurality of distributed antennas;
comparing at least one of the plurality of signal levels with a dynamic range fair share threshold; and
attenuating each of the at least one of the compared signal levels that is greater than the dynamic range fair share threshold with a gain factor that is determined in response to a remaining portion of the total system dynamic range after attenuation of other signal levels of the plurality of signal levels.
2. The method of claim 1 wherein the dynamic range fair share threshold is initially determined by an inverse of a quantity of the plurality of distributed antennas.
3. The method of claim 1 and further including:
sorting the sensed signal levels in an ascending order prior to comparing; and
updating the total system dynamic range, after attenuation of each signal level, by allocating unused total system dynamic range to subsequently attenuated signal levels.
4. The method of claim 1 and further including attenuating with unity gain signal levels that are less than or equal to the dynamic range fair share threshold.
5. The method of claim 1 wherein if the signal level is greater than the dynamic range fair share threshold, the gain factor applied to a first signal level is inversely proportional to the first signal level.
6. The method of claim 5 wherein the gain factor is substantially equal to K/x_j where K is an inverse of a quantity of the plurality of distributed antennas and x_j is the first signal level.

7. A method for gain distribution in a distributed antenna system having a total dynamic range, the method comprising:

- sorting a plurality of signal levels from the distributed antenna system;
- comparing each of the sorted signal levels with a dynamic range fair share threshold;

- if a first signal level is less than or equal to the dynamic range fair share threshold, applying a unity gain factor to the first signal level and dividing remaining total dynamic range between remaining signal levels of the plurality of signal levels;
- and

- if the first signal level is greater than the dynamic range fair share threshold, applying a gain factor that is inversely proportional to the first signal level.

8. The method of claim 7 wherein the gain factor that is substantially equal to the inverse of the first signal level is equal to a quantity of distributed antennas in the distributed antenna system divided by the first signal level.

9. The method of claim 7 wherein the plurality of signal levels are sorted in ascending order.

10. A method for gain distribution in a distributed antenna system having a system dynamic range, the method comprising:

- sorting, in ascending order, a plurality of signal levels from the distributed antenna system;

- comparing a first signal level of the plurality of sorted signal levels with a dynamic range fair share threshold;

- if the first signal level is less than or equal to the dynamic range fair share threshold, applying a unity gain factor to the first signal level;

- if the unity gain factor has been applied to the first signal level, updating the dynamic range fair share threshold to allocate remaining system dynamic range between remaining signal levels; and

if the first signal level is greater than the dynamic range fair share threshold, applying a first gain factor that is substantially equal to the dynamic range fair share threshold divided by the first signal level.

11. The method of claim 10 and further including applying a second gain factor to a second signal level if the second signal level is greater than the dynamic range fair share threshold, the second gain factor being substantially equal to the dynamic range fair share threshold divided by the second signal level.

12. The method of claim 10 and further including if the unity gain factor has been applied to the first signal level, updating the system dynamic range by decreasing the remaining system dynamic range by the first signal level to which the gain factor has been applied.

13. A method for gain distribution in a distributed antenna system having a system dynamic range, the method comprising:

sensing a signal level for each of a plurality of received signals from the distributed antenna system;

sorting, in ascending order, the plurality of signal levels;

comparing a first signal level of the plurality of sorted signal levels with a dynamic range fair share threshold;

if the first signal level is less than or equal to the dynamic range fair share threshold, applying a unity gain factor to the first signal level;

if the unity gain factor has been applied to the first signal level, updating the dynamic range fair share threshold to allocate remaining system dynamic range between remaining signal levels; and

if the first signal level is greater than the dynamic range fair share threshold, applying a first gain factor that is substantially equal to the dynamic range fair share threshold divided by the first signal level.

14. A distributed antenna system having gain distribution and a total dynamic range, the system comprising:

a plurality of distributed antennas that receive signals each having a signal level;

a sorter that sorts the received signals according to each signal level;

a threshold comparator, coupled to the sorter, that generates comparison results in response to a comparison between a sorted signal and a dynamic range fair share threshold that is updated with a remaining system dynamic range;

a remaining dynamic range calculator that generates the remaining system dynamic range by decreasing the total dynamic range by each attenuated signal level;

and

a gain calculator, coupled to the sorter, the threshold comparator, and the remaining dynamic range calculator, that progressively generates gain factors in response to the comparison results.

15. The distributed antenna system of claim 14 wherein the distributed antennas are coupled through distributed summers over a communication medium.

16. The distributed antenna system of claim 15 wherein the communication medium is an optical medium.

17. The distributed antenna system of claim 14 wherein the sorter sorts the received signals in ascending order in response to each signal level.

18. A distributed antenna system having gain distribution and a total dynamic range, the system comprising:

a plurality of distributed antennas that receive signals each having a signal level;

a signal level sampling function that senses each signal level;

a sorter that sorts the received signals in ascending order according to each signal level;

a threshold comparator, coupled to the sorter, that generates a comparison result in response to a comparison between a sorted signal and a dynamic range fair share threshold that is updated with a remaining system dynamic range;

a remaining dynamic range calculator that generates the remaining system dynamic range by decreasing the total dynamic range by each attenuated signal level;

a gain calculator, coupled to the sorter, the threshold comparator, and the remaining dynamic range calculator, that progressively generates a gain factor for each received signal in ascending order in response to each comparison result; and

a plurality of attenuators, each attenuator coupled to a received signal, for attenuating each received signal in response to its gain factor.

19. The system of claim 18 wherein the gain calculator generates a gain factor of unity for a received signal if its signal level is less than or equal to the dynamic range fair share threshold.

20. The system of claim 18 wherein the gain factors are generated in discrete increments.

21. A distributed antenna system having gain distribution and a total dynamic range, the system comprising:

a plurality of distributed antennas that receive analog signals each having a signal level represented in a digital form;

an analog to digital converter that converts the analog signals to digital signals;

a sorter that sorts the digital signals according to each signal level;

a threshold comparator, coupled to the sorter, that generates a comparison result in response to a comparison between a sorted signal and a dynamic range fair share threshold that is updated with a remaining system dynamic range;

a remaining dynamic range calculator that generates the remaining system dynamic range by decreasing the total dynamic range by each attenuated signal level; and

a gain calculator, coupled to the sorter, the threshold comparator, and the remaining dynamic range calculator, that progressively generates gain factors in response to the comparison results.

22. A method for gain distribution in a distributed antenna system having a system dynamic range, the distributed antenna system being coupled by an optical network, the method comprising:

- receiving a plurality of analog signals;

- converting each analog signal to a digital signal having a signal level expressed in a digital format;

- sorting, in ascending order, the plurality of digital signals according to their signal levels;

- comparing a first digital signal level of the plurality of digital signals with a dynamic range fair share threshold;

- if the first digital signal level is less than or equal to the dynamic range fair share threshold, applying a unity gain factor to the first digital signal level;

- if the unity gain factor has been applied to the first digital signal level, updating the dynamic range fair share threshold to allocate remaining system dynamic range between remaining digital signals; and

- if the first digital signal level is greater than the dynamic range fair share threshold, applying a first gain factor that is substantially equal to the dynamic range fair share threshold divided by the first digital signal level.

ABSTRACT

A method for signal gain adjustment in a multi-port, digital distributed antenna system uses a sorter to sort received signals in ascending order according to their signal levels. A threshold comparator generates a dynamic range fair threshold that is updated as any remaining system dynamic range is distributed amongst the remaining signals. Any received signal that is less than or equal to the threshold is attenuated with a unity gain factor. A signal that is greater than the threshold is attenuated with a gain factor that is inversely proportional to the signal level.

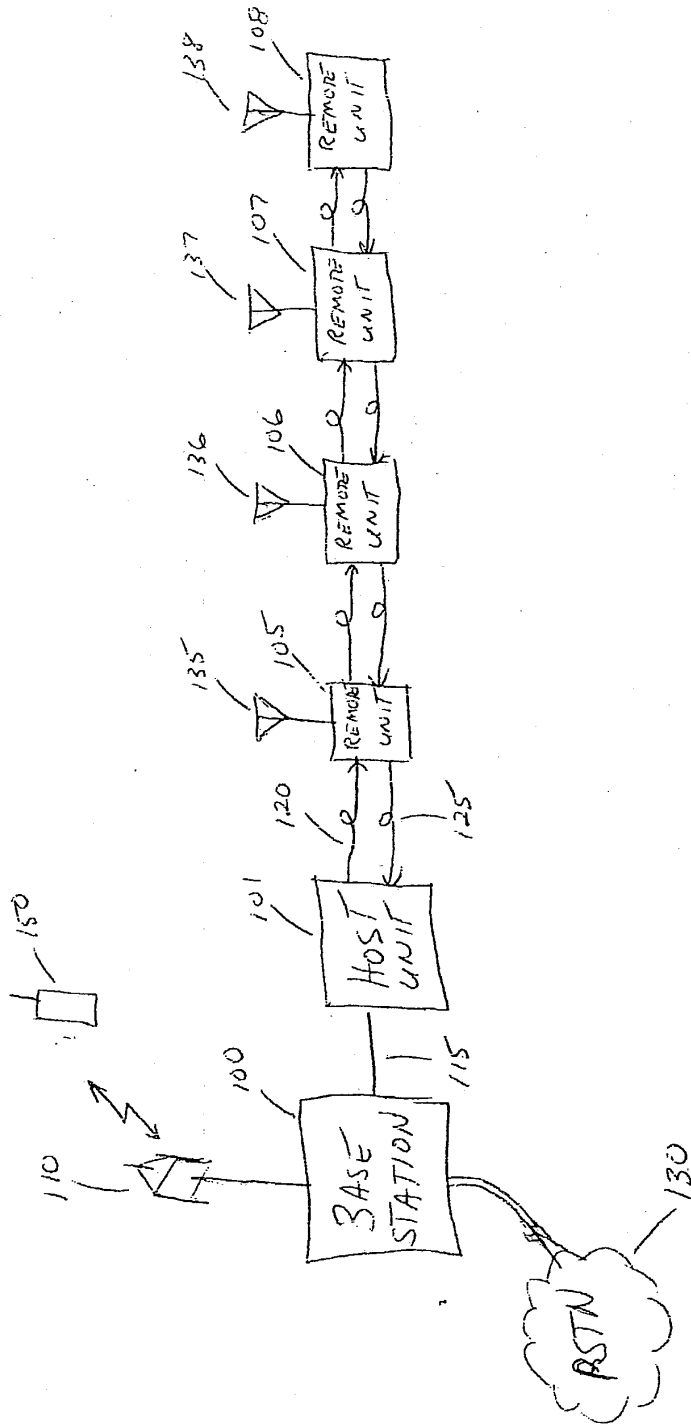


FIG. 1

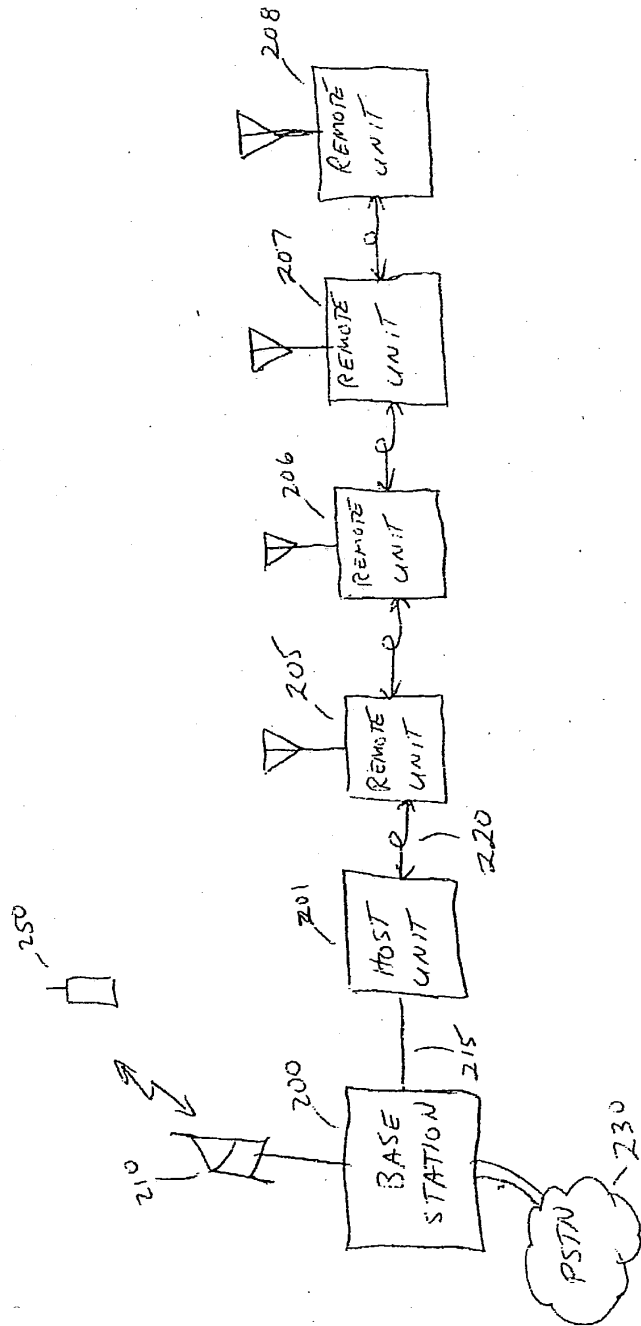
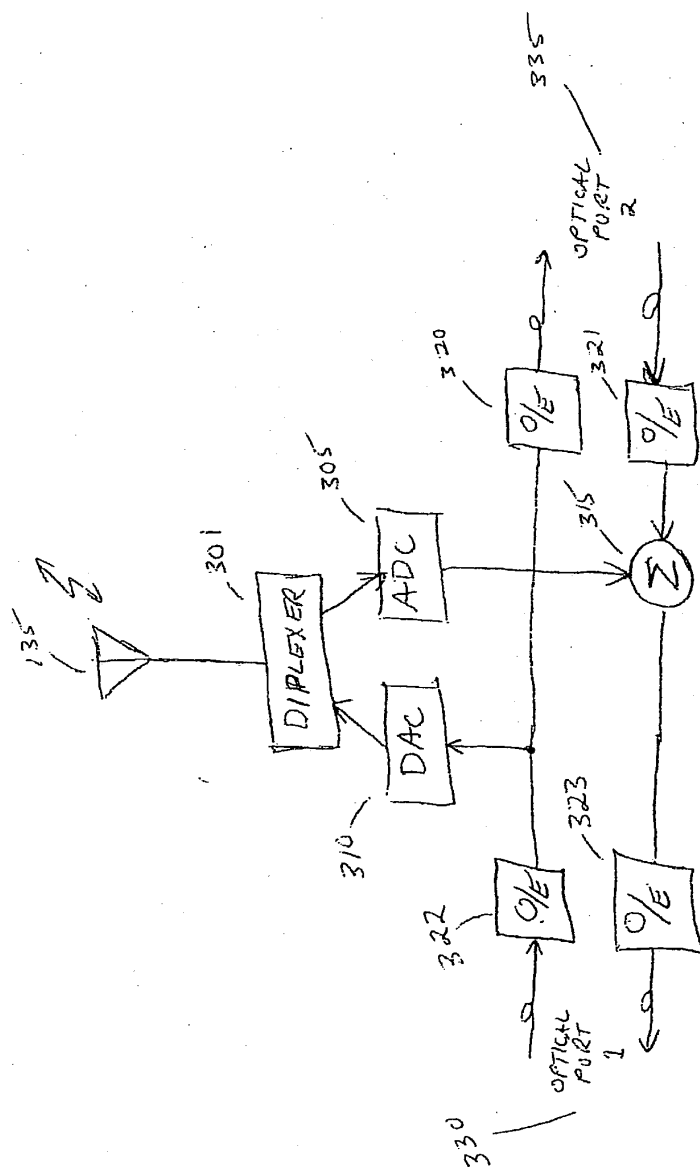
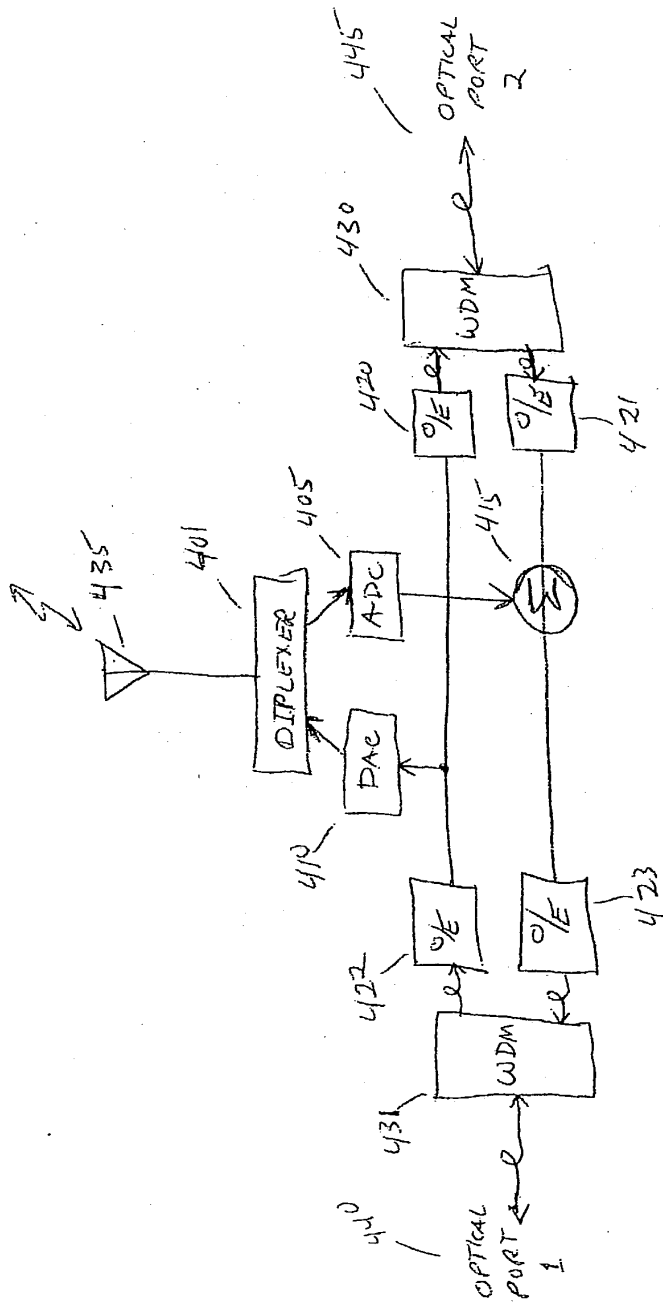


FIG. 2



105
—
FIG. 3



205

FIG. 4

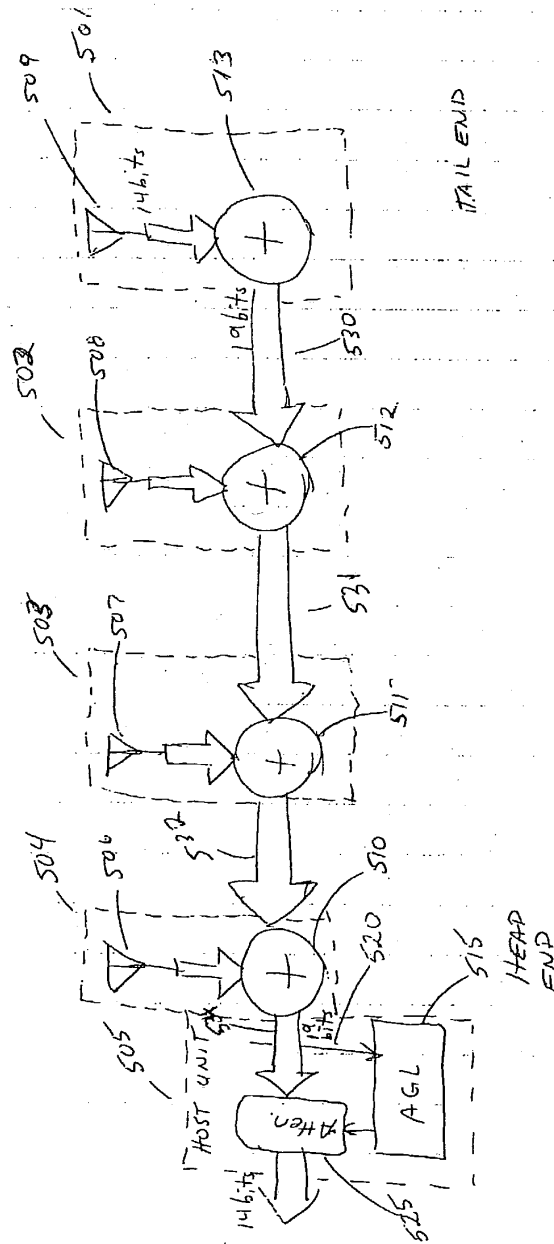
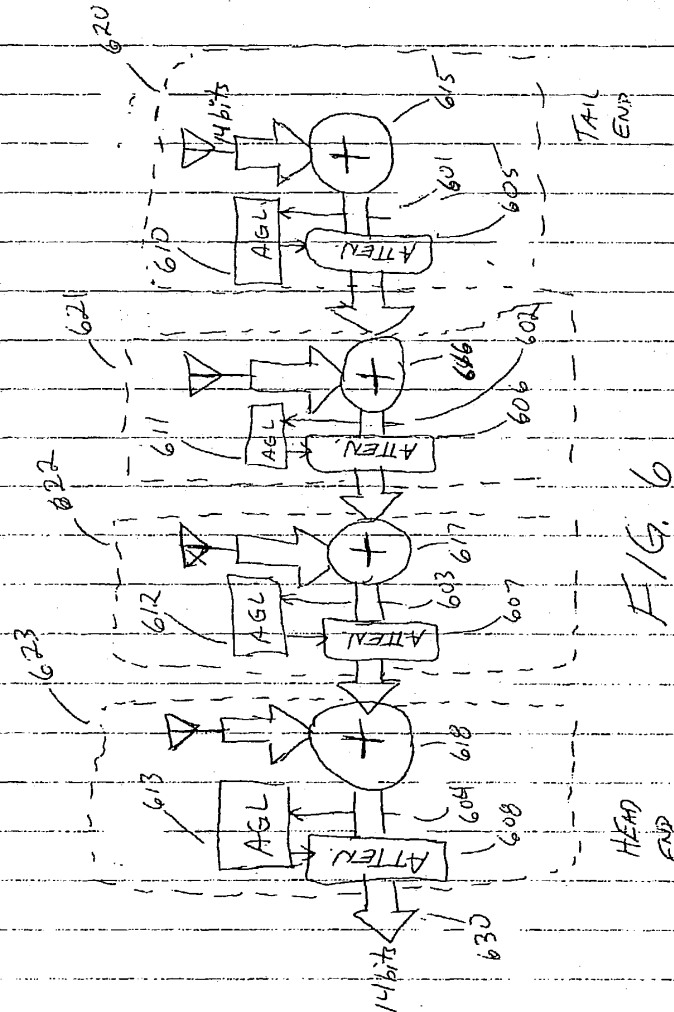


FIG. 5



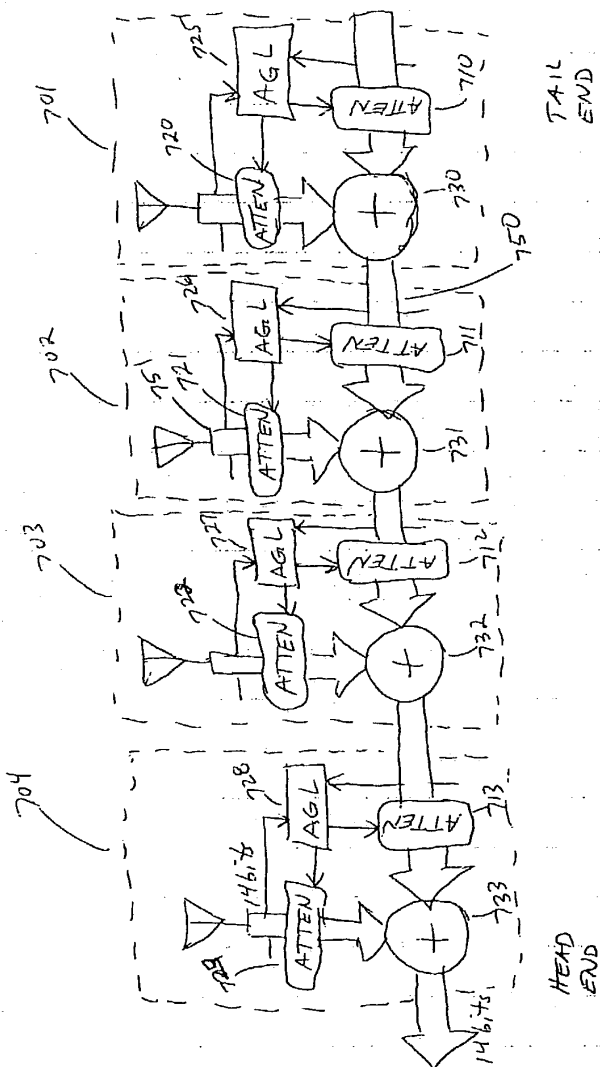


FIG. 7

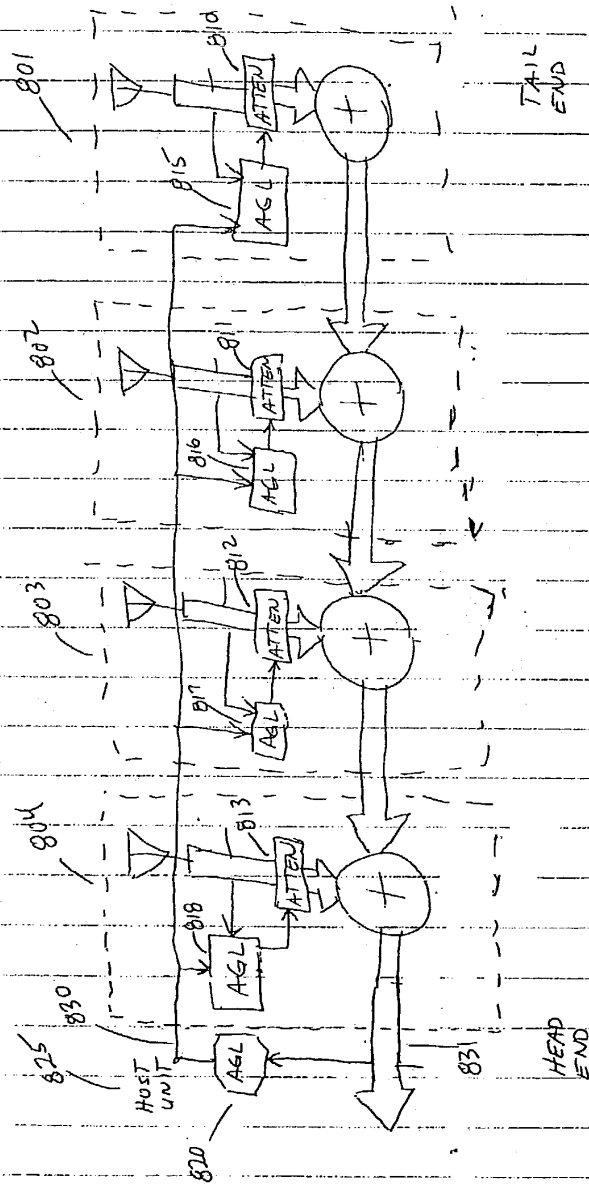


FIG. 8

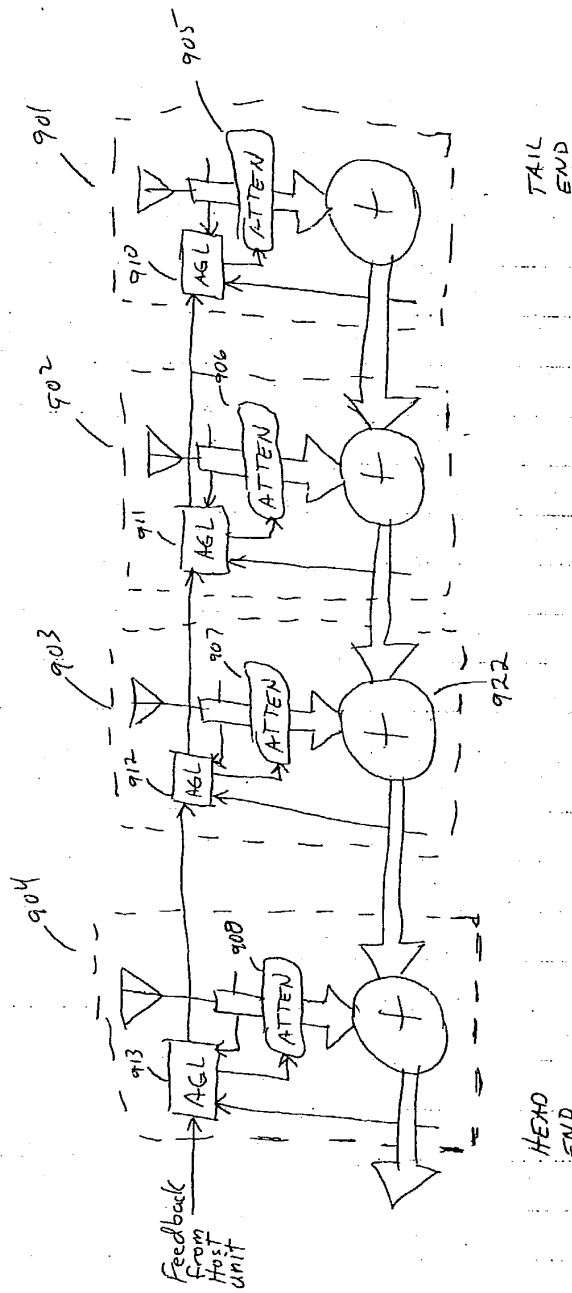


Fig 6

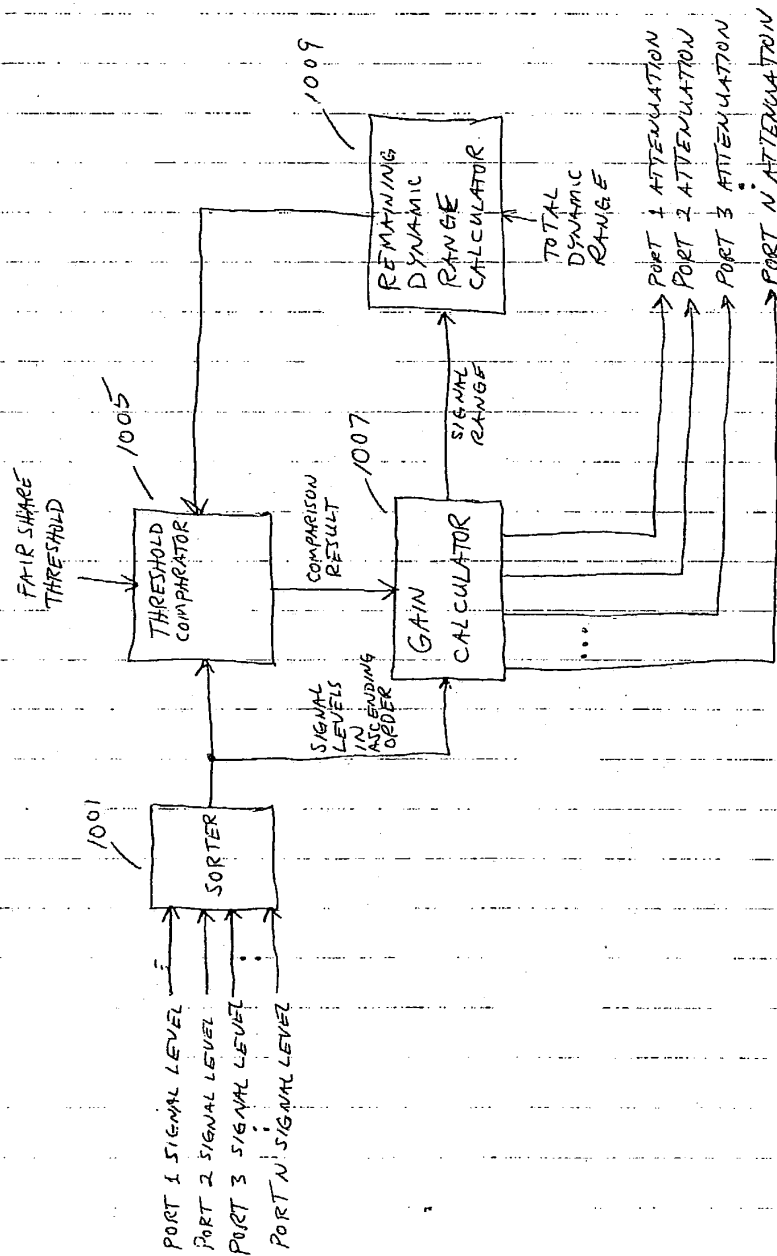


FIG. 10

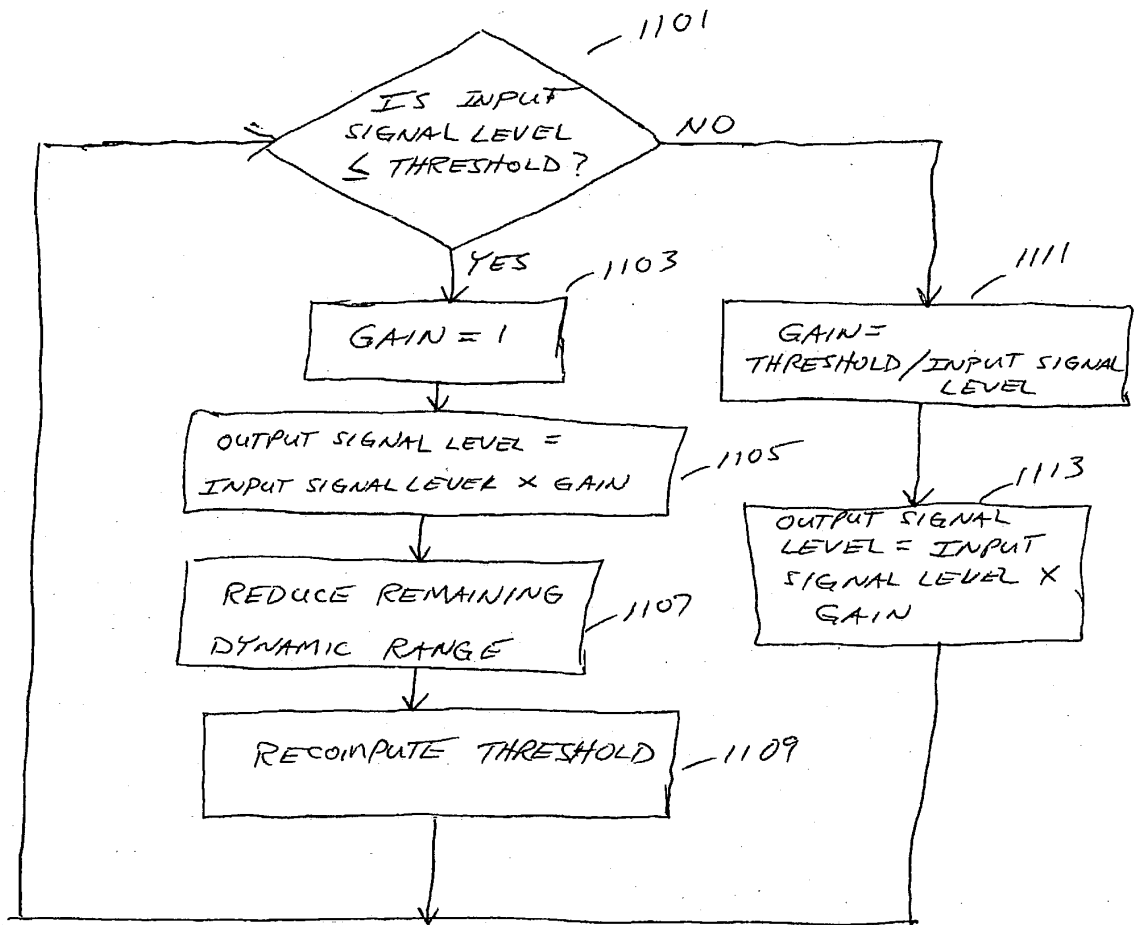


FIG. 11

1141490/ 2072202

United States Patent Application
COMBINED DECLARATION AND POWER OF ATTORNEY

As below named inventors, We declare that:

Our residence, post office address and citizenship are as stated below next to our names.

We believe that we are the original, first and joint inventors of the subject matter which is claimed and for which a patent is sought on the invention entitled: **SMALL SIGNAL THRESHOLD AND PROPORTIONAL GAIN DISTRIBUTED DIGITAL COMMUNICATIONS**; the specification of which is filed herewith.

We have reviewed and understand the contents of the above-identified specification, including the claims.

We acknowledge the duty to disclose information that is material to patentability as defined in 37 C.F.R. § 1.56.

We claim foreign priority benefits under 35 U.S.C. § 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on the basis of which priority is claimed.

Prior Foreign Application Number(s)	Country	Foreign Filing Date (MM/DD/YYYY)	Priority Not Claimed	Certified Copy Attached

As named inventors, we appoint the registered practitioners

at Customer Number

34206


34206
PATENT TRADEMARK OFFICE

to prosecute this application and to transact all business in the United States Patent and Trademark Office connected herewith, with full right of substitution.

Please direct all correspondence in this case to:

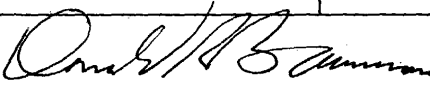
Fogg and Associates, LLC
P.O. Box 581339, Minneapolis, MN 55458-1339
Telephone No. (612) 332-4720
Fax (612) 677-3553

Attorney Docket No. 100.453US01
Filed Herewith
Page 1 of 2



We declare that all statements made herein are of our own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

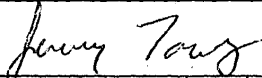
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Inventor's Signature						Date	4-7-03
Residence: City:	Shakopee	State	MN	Country	US	Citizenship	US
Post Office Address	244 Hickory Lane						
City	Shakopee	State	MN	Zip	55379	Country	US

Attorney Docket No. 100.453US01
 Filed Herewith
 Page 2 of 2

PATENT APPLICATION SERIAL NO. _____

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE
FEE RECORD SHEET

04/18/2003 NMEKONEN 00000025 10414907

01 FC:1001	750.00 OP
02 FC:1201	420.00 OP
03 FC:1202	36.00 OP

PTO-1556
(5/87)

PATENT APPLICATION FEE DETERMINATION RECORD
Effective January 1, 2003

Application or Docket Number

100-4532501

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)
TOTAL CLAIMS	22	
FOR	NUMBER FILED	NUMBER EXTRA
TOTAL CHARGEABLE CLAIMS	22 minus 20 = *	2
INDEPENDENT CLAIMS	8 minus 3 = *	5
MULTIPLE DEPENDENT CLAIM PRESENT ☐		

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

CLAIMS AS AMENDED - PART II

	(Column 1)	(Column 2)	(Column 3)
AMENDMENT A	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA
Total	*	Minus	**
Independent	*	Minus	***
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM ☐			

	(Column 1)	(Column 2)	(Column 3)
AMENDMENT B	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA
Total	*	Minus	**
Independent	*	Minus	***
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM ☐			

	(Column 1)	(Column 2)	(Column 3)
AMENDMENT C	CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA
Total	*	Minus	**
Independent	*	Minus	***
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM ☐			

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

SMALL ENTITY TYPE ☐ OR

OTHER THAN SMALL ENTITY

RATE	FEE
BASIC FEE	375.00
X\$ 9=	
X42=	
+140=	
TOTAL	

RATE	FEE
BASIC FEE	750.00
X\$18=	
X84=	
+280=	
TOTAL	1240

SMALL ENTITY OR

OTHER THAN SMALL ENTITY

RATE	ADDITIONAL FEE
X\$ 9=	
X42=	
+140=	
TOTAL	

RATE	ADDITIONAL FEE
X\$18=	
X84=	
+280=	
TOTAL	

RATE	ADDITIONAL FEE
X\$ 9=	
X42=	
+140=	
TOTAL	

RATE	ADDITIONAL FEE
X\$18=	
X84=	
+280=	
TOTAL	

RATE	ADDITIONAL FEE
X\$ 9=	
X42=	
+140=	
TOTAL	

RATE	ADDITIONAL FEE
X\$18=	
X84=	
+280=	
TOTAL	