FILE HISTORY

US 5,659,891

PATENT:	5,659,891
INVENTORS:	Hays, William D. Cameron, Dennis Roehr, Walter
TITLE:	Multicarrier techniques in bandlimited channels
APPLICATION NO:	US1995480718A
FILED:	07 JUN 1995
ISSUED:	19 AUG 1997
COMPILED:	13 JUN 2013

08/480718

Class	Subclass	ISSUE CLASSIFICATION
455	103	

5659891

UTILITY SERIAL NUMBER	PATENT DATE	PATENT NUMBER
08/480718	AUG 19 1997	5659891

SERIAL NUMBER	FILING DATE	CLASS	SUBCLASS	GROUP ART UNIT	
08/480,718	06/07/95	455	103	2611	L. NGUYEN

APPLICANTS: WILLIAM D. HAYS, JACKSON, MS; DENNIS CAMERON, JACKSON, MS; WALTER ROEHR, RESTON, VA.

CONTINUING DATA*******************
VERIFIED

None Lee

FOREIGN/PCT APPLICATIONS**********
VERIFIED

None Lee

FOREIGN FILING LICENSE GRANTED 11/30/95

Foreign priority claimed / 35 USC 119 conditions met / Verified and Acknowledged	AS FILED	STATE OR COUNTRY	SHEETS DRWGS.	TOTAL CLAIMS	INDEP. CLAIMS	FILING FEE RECEIVED	ATTORNEY'S DOCKET NO.
☐ yes ☑ no / ☐ yes ☑ no / Lee — Examiner's initials		MS	9	8	3	$860.00	03680.0143

ADDRESS: FINNEGAN HENDERSON FARABOW GARRETT & DUNNER
1300 I STREET NW
WASHINGTON DC 20005-3315

TITLE: MULTICARRIER TECHNIQUES IN BANDLIMITED CHANNELS

U.S. DEPT. OF COMM./ PAT. & TM—PTO-436L (Rev.12-94)

PARTS OF APPLICATION FILED SEPARATELY

Applications Examiner

NOTICE OF ALLOWANCE MAILED		CLAIMS ALLOWED	
2-4-97	LEE NGUYEN Assistant Examiner	Total Claims: 5	Print Claim: 1

ISSUE FEE			DRAWING		
Amount Due: $1,290.00	Date Paid: 5/1/97	Reinhard J. Eisenzopf 2-3-97 Reinhard J. Eisenzopf Supervisory Patent Examiner Group 200 Primary Examiner	Sheets Drwg.: 9	Figs. Drwg.: 11	Print Fig.: 1

ISSUE BATCH NUMBER: J12

Label Area

PREPARED FOR ISSUE

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Form PTO-436A
(Rev. 8/92)

(FACE)

5,659,891

MULTICARRIER TECHNIQUES IN BANDLIMITED CHANNELS

Transaction History

Date	Transaction Description
7/21/1995	Notice Mailed--Application Incomplete--Filing Date Assigned
8/9/1995	Request for Foreign Priority (Priority Papers May Be Included)
9/6/1995	Preliminary Amendment
10/3/1995	Information Disclosure Statement (IDS) Filed
10/3/1995	Information Disclosure Statement (IDS) Filed
11/9/1995	Miscellaneous Incoming Letter
11/13/1995	Application Is Now Complete
12/5/1995	Application Captured on Microfilm
12/18/1995	Case Docketed to Examiner in GAU
1/17/1996	Mail Miscellaneous Communication to Applicant
1/17/1996	Miscellaneous Communication to Applicant - No Action Count
2/5/1996	Non-Final Rejection
2/9/1996	Mail Non-Final Rejection
8/9/1996	Response after Non-Final Action
8/9/1996	Request for Extension of Time - Granted
8/21/1996	Date Forwarded to Examiner
10/28/1996	Final Rejection
10/29/1996	Mail Final Rejection (PTOL - 326)
1/21/1997	Amendment after Final Rejection
1/28/1997	Date Forwarded to Examiner
2/4/1997	Mail Notice of Allowance
2/4/1997	Notice of Allowance Data Verification Completed
2/4/1997	Mail Examiner's Amendment
2/4/1997	Examiner's Amendment Communication
3/3/1997	Mailroom Date of Drawing(s)
3/7/1997	Drawing(s) Matched to Application
3/7/1997	Drawing(s) Received at Publications
3/25/1997	Drawing(s) Processing Completed
4/3/1997	Mailroom Date of Drawing(s)
4/10/1997	Drawing(s) Matched to Application
4/10/1997	Drawing(s) Received at Publications
4/30/1997	Drawing(s) Processing Completed
5/1/1997	Issue Fee Payment Verified
7/14/1997	Issue Notification Mailed
8/19/1997	Recordation of Patent Grant Mailed

08/ 08/480718

PATENT APPLICATION

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APPROVED FOR LICENSE ☐

39526

INITIALS

CONTENTS

Date Entered or Counted			Date Received or Mailed
	1.	Application papers.	
	2.	LET RE-DEC	1/2/95
	3.	Dec Dir	9/21/95
	4.	Information Disclosure Statement	8-9-95
	5.	Pre Amdt A	9-6-95
	6.	Status Letter	Nov 9, 1995
	7.	Letter	1/7/96
	8.	Prior Art w/ref	10/3/95
2/5/96	9.	3 mos. Rej.	2-9-96 M.L.
	10.	Ext. of Time (3) / Amdt B	8/9/96
10/25/96	11.	Final Rej (3mths)	10-29-96
	12.	Amdt C	1/21/97
2/3/97	13.	Notice of Allow	2-4-97
3/7/97	14.		3/3/97
	15.	Notice of Drawing Requirement	3/25/97
4/10/97	16.	3 2	4/3/97
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STAPLE AREA

☆ U.S.G.P.O.: 1994 - 378-972

PATENT NUMBER	ORIGINAL CLASSIFICATION	
	CLASS	SUBCLASS
	455	103

APPLICATION SERIAL NUMBER

08/480,718

APPLICANT'S NAME (PLEASE PRINT)

HAYS et al.

IF REISSUE, ORIGINAL PATENT NUMBER

CROSS REFERENCE(S)

CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)			
455	45			
370	339	343		

INTERNATIONAL CLASSIFICATION

H	0	4	B		1/02

GROUP ART UNIT: 2611

ASSISTANT EXAMINER (PLEASE STAMP OR PRINT FULL NAME): LEE NGUYEN

PRIMARY EXAMINER (PLEASE STAMP OR PRINT FULL NAME): REINHARD J. EISENZOPF

PTO 270
(REV. 5-91)

ISSUE CLASSIFICATION SLIP

U.S. DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE

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POSITION		ID NO.	DATE
CLASSIFIER		8	7-13-95
EXAMINER		504	7-19-95
TYPIST		324	11/28/95
VERIFIER		230	12-1-95
CORPS CORR.			
SPEC. HAND	ll	428	11/9/95
FILE MAINT.	ll		7-20-95
DRAFTING			

INDEX OF CLAIMS

Claim Final	Claim Original	Date 1/1/96	Date 10/15/96	Date 2/1/97	Date	Date	Date	Date	Date
1	1	=	=	=					
2	2	=	=	=					
3	3	✓	=	=					
4	4	✓	=	=					
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SYMBOLS

- ✓ .... Rejected
- = ... Allowed
- \- (Through numberal) Canceled
- \+ .... Restricted
- N .... Non-elected
- I .... Interference
- A .... Appeal
- O .... Objected

Claim Final	Claim Original	Date	Date	Date	Date	Date	Date	Date	Date
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SEARCHED

Class	Sub.	Date	Exmr.
455	103 104 17 46 59 60 61 62 49.1	1/26/96	Lee
375	260	1/28/96	Lee
370	69.1 70 38 40	1/31/96	Lee
455	45	"	"
370	121	"	"
340	825.44	"	"
Update	Search	2/1/97	Lee

INTERFERENCE SEARCHED

Class	Sub.	Date	Exmr.
455	103, 45	2/1/97	Lee
370	339, 343		

SEARCH NOTES

	Date	Exmr.
Don Vo (375)	1/28/96	Lee
Chan Nguyen (370)	1/30/96	Lee
Ben Safourek (370, 455)	1/31/96	Lee
Faile (455)	1/31/96	Lee
Zimmerman (340)	1/31/96	Lee

(RIGHT OUTSIDE)

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  *              W E L C O M E   T O   T H E                    *
  *         U. S.   P A T E N T   T E X T   F I L E             *
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=> s multicarrier or multi-carrier

           110 MULTICARRIER
        188216 MULTI
        254738 CARRIER
           118 MULTI-CARRIER
                 (MULTI(W)CARRIER)
L1         198 MULTICARRIER OR MULTI-CARRIER
=> d l1 1-10

1.  5,563,909, Oct. 8, 1996, Radio communication system; Isao Nakazawa,
375/224; 342/196; 375/347 [IMAGE AVAILABLE]

2.  5,561,686, Oct. 1, 1996, Radio information communication system using
**multi**-**carrier** spread spectrum transmission system; Hiroshi
Kobayashi, et al., 375/200 [IMAGE AVAILABLE]

3.  5,559,830, Sep. 24, 1996, Equalization system for AM compatible
digital receiver; Mark J. Dapper, et al., 375/230, 232 [IMAGE AVAILABLE]

4.  5,557,612, Sep. 17, 1996, Method and apparatus for establishing
communication in a multi-tone data transmission system; John A. C.
Bingham, 370/71, 124 [IMAGE AVAILABLE]

5.  5,555,257, Sep. 10, 1996, Cellular/satellite communications system
with improved frequency re-use; Paul W. Dent, 370/95.1; 342/352; 379/58;
455/13.3, 54.1, 63 [IMAGE AVAILABLE]

6.  5,551,070, Aug. 27, 1996, Cartesian **multicarrier** feedback; Ulf
Skarby, et al., 455/126; 330/149; 375/261; 455/103, 119 [IMAGE AVAILABLE]

7.  5,550,812, Aug. 27, 1996, System for broadcasting and receiving
digital data, receiver and transmitter for use in such system; Norbert J.
L. Philips, 370/19, 69.1; 375/362; 455/182.2 [IMAGE AVAILABLE]

8.  5,548,813, Aug. 20, 1996, Phased array cellular base station and
associated methods for enhanced power efficiency; Philippe M. Charas, et
al., 455/33.2; 343/890; 455/53.1 [IMAGE AVAILABLE]

9.  5,548,671, Aug. 20, 1996, Programmable, differential wavelength
discriminator; Chi Wu, et al., 385/37, 45 [IMAGE AVAILABLE]

10.  5,548,582, Aug. 20, 1996, **Multicarrier** frequency hopping
communications system; Americo Brajal, et al., 370/18, 20, 23; 375/202
[IMAGE AVAILABLE]
=>
```

US PAT NO: 4,858,225 [IMAGE AVAILABLE] L3: 16 of 21

SUMMARY:

BSUM(8)

According . . . bandwidth B.sub.T while the remaining bandwidth B.sub.T -B.sub.x may be channelized into a multiplicity of narrow VBVCF channels suitable for **multicarrier** traffic with a varying number of different carriers. In its operation, each channel is subsequently routed to a defined downlink. . .

DETDESC:

DETD(10)

A . . . carrier, variable bit rate traffic in uplink plan 20 occupies a useful bandwidth B.sub.x 22 from f.sub.T1 to f.sub.x1 while **multicarrier** traffic occupies a bandwidth B.sub.T -B.sub.x from f.sub.x2 to f.sub.T2. In this example, **multicarrier** traffic is assigned to two connectivity paths 23 and 24 each containing traffic destined to the same downlink beam.

DETDESC:

DETD(11)

The . . . with the M-th channelization level of passband 32. Under these circumstances, the adjacent channel interference (ACI) between single carrier and **multicarrier** traffic is suppressed more than 39 dB. The center frequency of passband 32 is f.sub.RC =(f.sub.R3 +f.sub.R4)/2. It is referred. . .

DETDESC:

DETD(41)

If . . . according to the relationship f.sub.X1 -(f.sub.LO +B'.sub.X)=f.sub.R2. In this way, all single carrier traffic remains within passband 31 while all **multicarrier** traffic is within passband 32. Traffic within the bandwidth 32 emerges from port 47 of the paralleling circuit 46. Output. . .

CLAIMS:

CLMS(7)

7. . . . variable bandwidth variable center-frequency satellite communications system as recited in claim 6 wherein the filter banks of adjacent subchannels have **asymmetric** transmission amplitude characteristics at the edges thereof.

US PAT NO: 4,757,495 [IMAGE AVAILABLE] L3: 17 of 21

ABSTRACT:
The . . . quality, a requested data rate, or a value indicating the relative user weighting of speech quality and data rate. A **multi**-**carrier** multi-mode modulation scheme is employed for data transmission, with this scheme having the ability to fully utilize the remaining bandwidth,. . .

SUMMARY:

BSUM(26)

The first component is a **multi**-**carrier**, multi-mode, ensemble modem as disclosed in U.S. patent application Ser. No. 06-736,200 filed May 20, 1985 entitled "Ensemble Modem Structure. . .

DETDESC:

DETD(61)

The . . . Duplex protocol approach is that the full transmission capacity of the link is available at all times to respond to **asymmetric** data transmission requirements.

CLAIMS:

CLMS(33)

33. . . .
for data transmission, said evaluating means being operatively associated with the selecting means for said selecting of the data sub-band, and
multicarrier data transmitting means for transmitting data in the data sub-band on a plurality of carriers.

US PAT NO: 4,328,902 [IMAGE AVAILABLE] L3: 20 of 21

SUMMARY:

BSUM(4)

The Muller and Masser patents are examples of prior art interlocking carriers which have **asymmetrical** interlocking arrangements that are both difficult to fabricate and time consuming to assemble. The Cornelius patent requires that the carriers. . .

SUMMARY:

BSUM(5)

It . . . desirable and it is an object of this invention to provide carrier units which may be readily interlocked into a **multi**-**carrier** assembly.

US PAT NO: 3,898,566 [IMAGE AVAILABLE] L3: 21 of 21
TITLE: Method and apparatus for reducing distortion in **multicarrier** communication systems

SUMMARY:

BSUM(2)

The . . . patent application using harmonically related coherent carriers for transmitting a plurality of multiplexed signals such as television programs in a **multicarrier** communications system were deemed to be sufficiently great to outweigh the possible disadvantage of a theoretically predicted increase in crossmodulation.. . .

SUMMARY:

BSUM(9)

The present invention thus provides a method of reducing distortion such as crossmodulation between modulated carriers in a **multicarrier** communication system by establishing a coherent harmonic frequency relationship between the carriers, combining the carriers to transmit a signal which. . .

DETDESC:

DETD(11)

In . . . forms of both FIG. 1a and FIG. 1b are symmetrical about .pi. radians, no consideration has yet been given to **asymmetry** as must be done in more complex cases. However, it will be noted that in FIG. 1b the peak-to-peak excursion. . .

DETDESC:

DETD(41)
Again . . . and +9.73 for a peak-to-peak excursion of 21.63. The reduction factor in this case is 21.63/50 = 0.432 and the **asymmetry**

biasing is (11.90-9.73)/2 = 1.08.

CLAIMS:

CLMS(1)

What we claim is:

1. The method of reducing distortion in a **multicarrier** CATV cable communication system comprising the steps of:
a. establishing a harmonically related coherent frequency relationship between the carriers of. . .

CLAIMS:

CLMS(3)

3. The method of reducing distortion in a **multi**-**carrier** communication system in which a plurality of said carriers is individually modulated and then combined to form a vector sum. . .

CLAIMS:

CLMS(4)

4. The method of reducing distortion in a **multi**-**carrier** communication system in which a plurality of said carriers is individually modulated and then combined to form a vector sum. . .

CLAIMS:

CLMS(5)

5. The method of reducing distortion in a **multi**-**carrier** communication system in which a plurality of said carriers is individually modulated and then combined to form a vector sum. . .

CLAIMS:

CLMS(6)

6. In a **multi**-**carrier** communication system, the improvement comprising;
a. means to estalish a harmonically related coherent frequency relationship between the carriers of said. . .

CLAIMS:

CLMS(7)

7. In a **multi**-**carrier** CATV cable system, the improvement comprising:
a. means to establish a harmonically related coherent frequency relationship between the carriers of. . .

CLAIMS:

CLMS(8)

8. In a **multi**-**carrier** CATV cable system, the improvement comprising:
a. means to establish a harmonically related coherent frequency relationship between the carriers of. . .

CLAIMS:

CLMS(9)

9. In a **multi**-**carrier** CATV cable system, the improvement comprising:
a. means to establish a harmonically related coherent frequency relationship between the carriers of. . .

CLAIMS:

CLMS(28)

28. . . . the visual effect of triple beat and other second and third order distortion in the transmitted multiplexed signal in a **multi**-**carrier** cable television system having the same channel frequency bandwidth for each channel, said method comprising the steps of:
a. providing. . .
=>

=> d l3 1-21

1. 5,557,612, Sep. 17, 1996, Method and apparatus for establishing communication in a multi-tone data transmission system; John A. C. Bingham, 370/71, 124 [IMAGE AVAILABLE]

2. 5,550,812, Aug. 27, 1996, System for broadcasting and receiving digital data, receiver and transmitter for use in such system; Norbert J. L. Philips, 370/19, 69.1; 375/362; 455/182.2 [IMAGE AVAILABLE]

3. 5,519,731, May 21, 1996, ADSL compatible discrete multi-tone apparatus for mitigation of T1 noise; John M. Cioffi, 375/260; 348/388, 436; 370/6, 70; 375/240, 285, 296, 340, 346; 379/93 [IMAGE AVAILABLE]

4. 5,506,141, Apr. 9, 1996, Apertured cell carrier; Arye Weinreb, et al., 435/309.1; 422/101; 435/288.4, 307.1, 308.1 [IMAGE AVAILABLE]

5. 5,479,447, Dec. 26, 1995, Method and apparatus for adaptive, variable bandwidth, high-speed data transmission of a **multicarrier** signal over digital subscriber lines; Peter S. Chow, et al., 375/260; 370/118; 375/377 [IMAGE AVAILABLE]

6. 5,461,640, Oct. 24, 1995, Method and system for optimizing an equalizer in a data transmission system; Alan Gatherer, 375/231; 364/724.2 [IMAGE AVAILABLE]

7. 5,408,260, Apr. 18, 1995, Customer premises ADSL signal distribution arrangement; Ephraim Arnon, 348/6, 12; 455/5.1 [IMAGE AVAILABLE]

8. 5,400,322, Mar. 21, 1995, Updating of bit allocations in a **multicarrier** modulation transmission system; Ronald R. Hunt, et al., 370/19, 76, 121 [IMAGE AVAILABLE]

9. 5,329,249, Jul. 12, 1994, High efficiency RF power amplifier; Stephen C. Cripps, 330/302, 306 [IMAGE AVAILABLE]

10. 5,321,542, Jun. 14, 1994, Control method and apparatus for wireless data link; Richard F. Freitas, et al., 359/172, 113, 152; 370/84 [IMAGE AVAILABLE]

11. 5,317,596, May 31, 1994, Method and apparatus for echo cancellation with discrete multitone modulation; Minnie Ho, et al., 375/232; 370/32.1; 379/410, 411 [IMAGE AVAILABLE]

12. 5,310,674, May 10, 1994, Apertured cell carrier; Arye Weinreb, et al., 435/286.1; 422/101; 435/308.1, 309.1 [IMAGE AVAILABLE]

13. 5,272,081, Dec. 21, 1993, System and methods for cell selection; Arye Weinreb, et al., 435/240.1, 240.2, 240.21, 243, 261, 948 [IMAGE AVAILABLE]

14. 5,119,042, Jun. 2, 1992, Solid state power amplifier with dynamically adjusted operating point; David L. Crampton, et al., 330/295, 136, 284, 285; 455/116, 126, 127, 129 [IMAGE AVAILABLE]

15. 5,017,885, May 21, 1991, Optical amplifier with reduced nonlinearity; Adel A. M. Saleh, 359/337, 124, 181 [IMAGE AVAILABLE]

16. 4,858,225, Aug. 15, 1989, Variable bandwidth variable center-frequency multibeam satellite-switched router; Pietro deSantis, 370/95.3, 104.1 [IMAGE AVAILABLE]

17. 4,757,495, Jul. 12, 1988, Speech and data multiplexor optimized for use over impaired and bandwidth restricted analog channels; Dwight W. Decker, et al., 370/76, 69.1 [IMAGE AVAILABLE]

18. 4,742,576, May 3, 1988, Optical communication system employing coherent detection and method; Donald H. McMahon, 359/126, 168, 182, 183, 184, 190, 191 [IMAGE AVAILABLE]

19. 4,729,949, Mar. 8, 1988, System and methods for cell selection; Arye Weinreb, et al., 435/30; 209/38, 397; 210/222, 695; 356/38, 244; 422/101; 435/34, 173.9, 288.4, 288.7, 308.1; 436/63, 177 [IMAGE AVAILABLE]

20. 4,328,902, May 11, 1982, Beverage carrier; Thomas M. North, 220/23.4, 516 [IMAGE AVAILABLE]

21. 3,898,566, Aug. 5, 1975, Method and apparatus for reducing distortion in **multicarrier** communication systems; Israel Switzer, et al., 455/4.1; 370/69.1; 455/67.3 [IMAGE AVAILABLE]

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US005659891A

United States Patent [19]

Hays et al.

[11] Patent Number: 5,659,891

[45] Date of Patent: Aug. 19, 1997

[54] **MULTICARRIER TECHNIQUES IN BANDLIMITED CHANNELS**

[75] Inventors: **William D. Hays; Dennis Cameron**, both of Jackson, Miss.; **Walter Roehr**, Reston, Va.

[73] Assignee: **Mobile Telecommunication Technologies**, Jackson, Miss.

[21] Appl. No.: **480,718**

[22] Filed: **Jun. 7, 1995**

[51] **Int. Cl.**[6] **H04B 1/02**

[52] **U.S. Cl.** **455/103**; 455/45; 370/339; 370/343

[58] **Field of Search** 455/103, 104, 455/17, 46, 59, 60, 61, 62, 49.1, 45; 375/260; 370/69.1, 70, 38, 40, 121; 340/825.44

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,488,445	1/1970	Chang	370/69.1
3,914,554	10/1975	Seidel	179/15.55 R
4,244,047	1/1981	Perkins	370/69
5,163,181	11/1992	Koontz	455/103
5,343,499	8/1994	Jasper et al.	375/39
5,392,452	2/1995	Davis	455/38.1

OTHER PUBLICATIONS

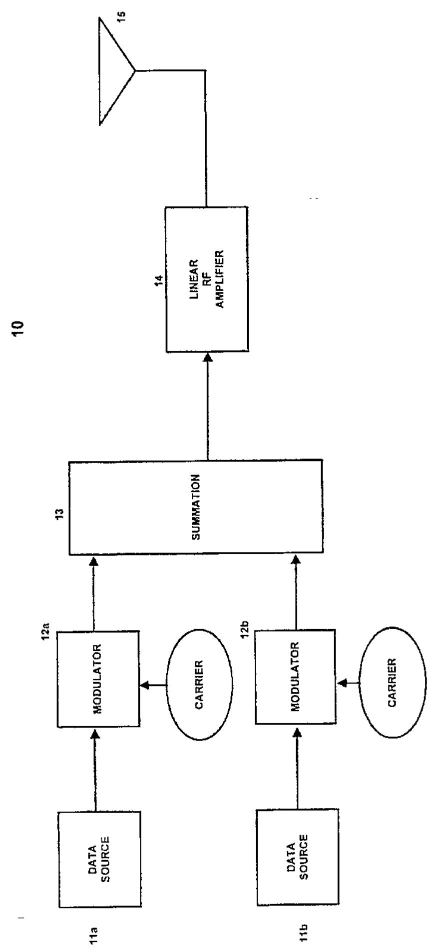
47 C.F.R. § 22.106 (1994).

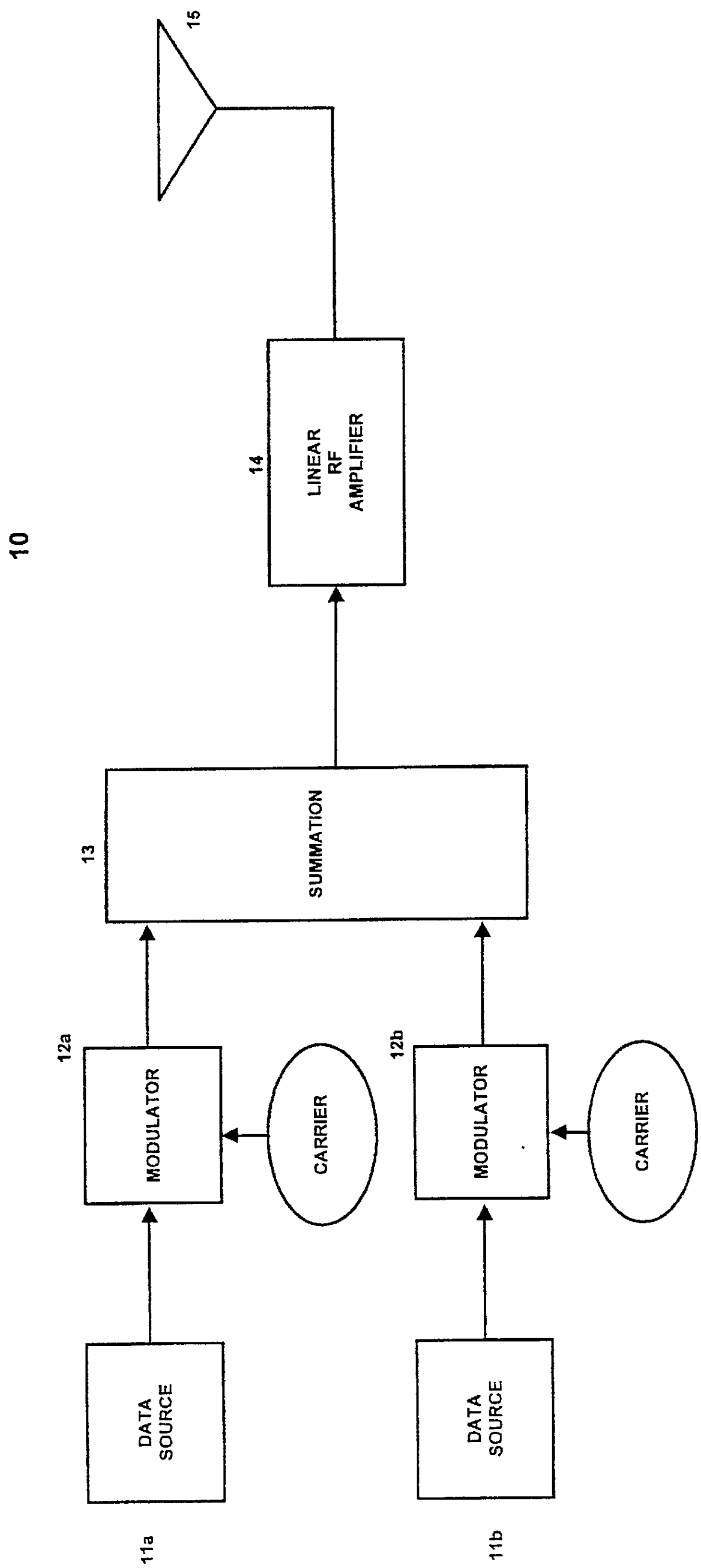
Primary Examiner—Reinhard J. Eisenzopf
Assistant Examiner—Lee Nguyen
Attorney, Agent, or Firm—Finnegan, Henderson, Farabow, Garrett and Dunner

[57] **ABSTRACT**

A method of multicarrier modulation using co-located transmitters to achieve higher transmission capacity for mobile paging and two-way digital communication in a manner consistent with FCC emission mask limits. Co-location of the transmitters obviates the need for stringent, symmetrical subchannel interference protection and provides for a wider range of operating parameters, including peak frequency deviation, bit rate, and carrier frequencies, to obtain optimal transmission performance.

5 Claims, 11 Drawing Sheets

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CARRIER
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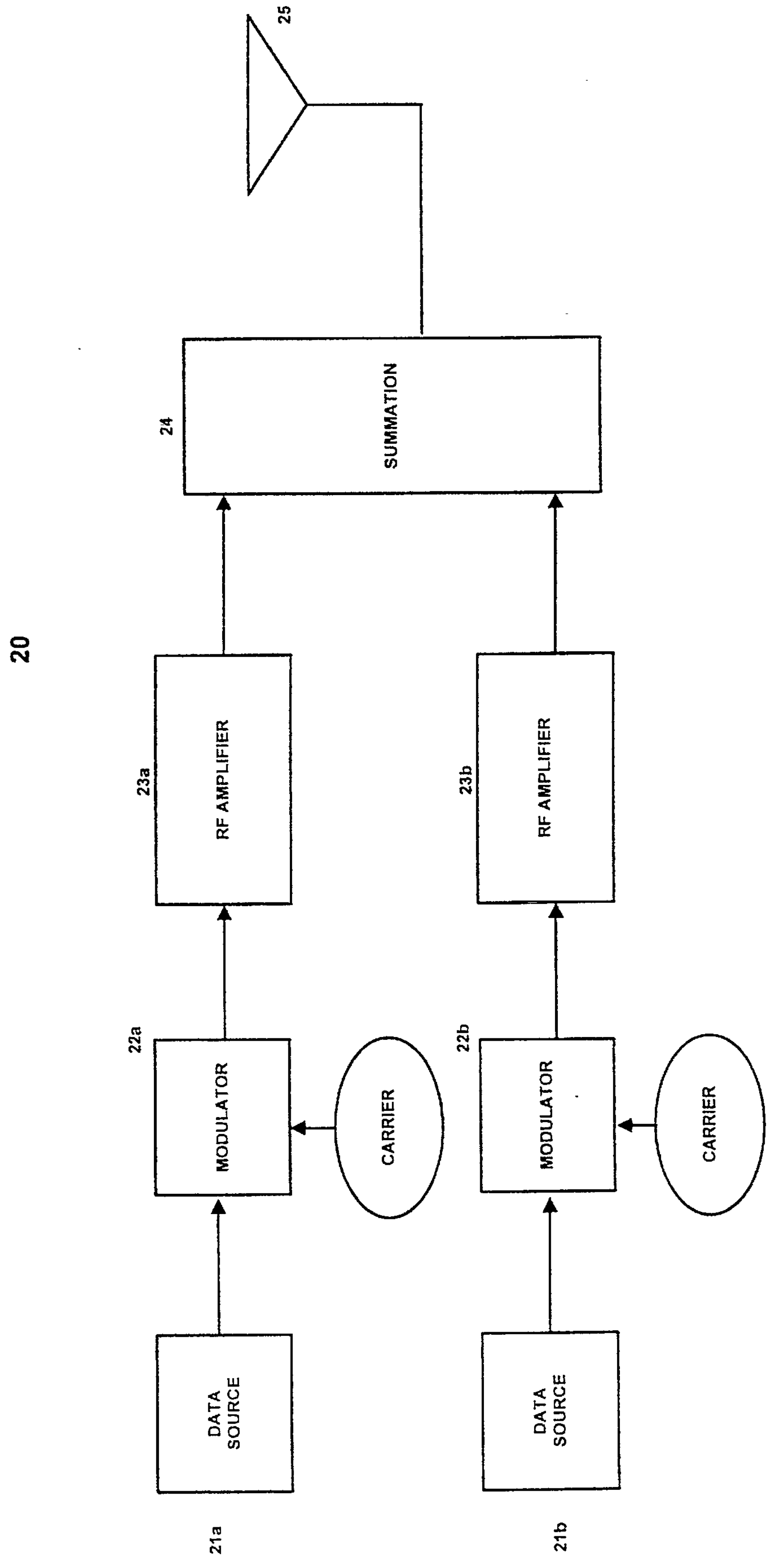
SOURCE
11b

FIGURE 1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MODULATOR
CARRIER
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RF AMPLIFIER
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SUMMATION
25

FIGURE 2

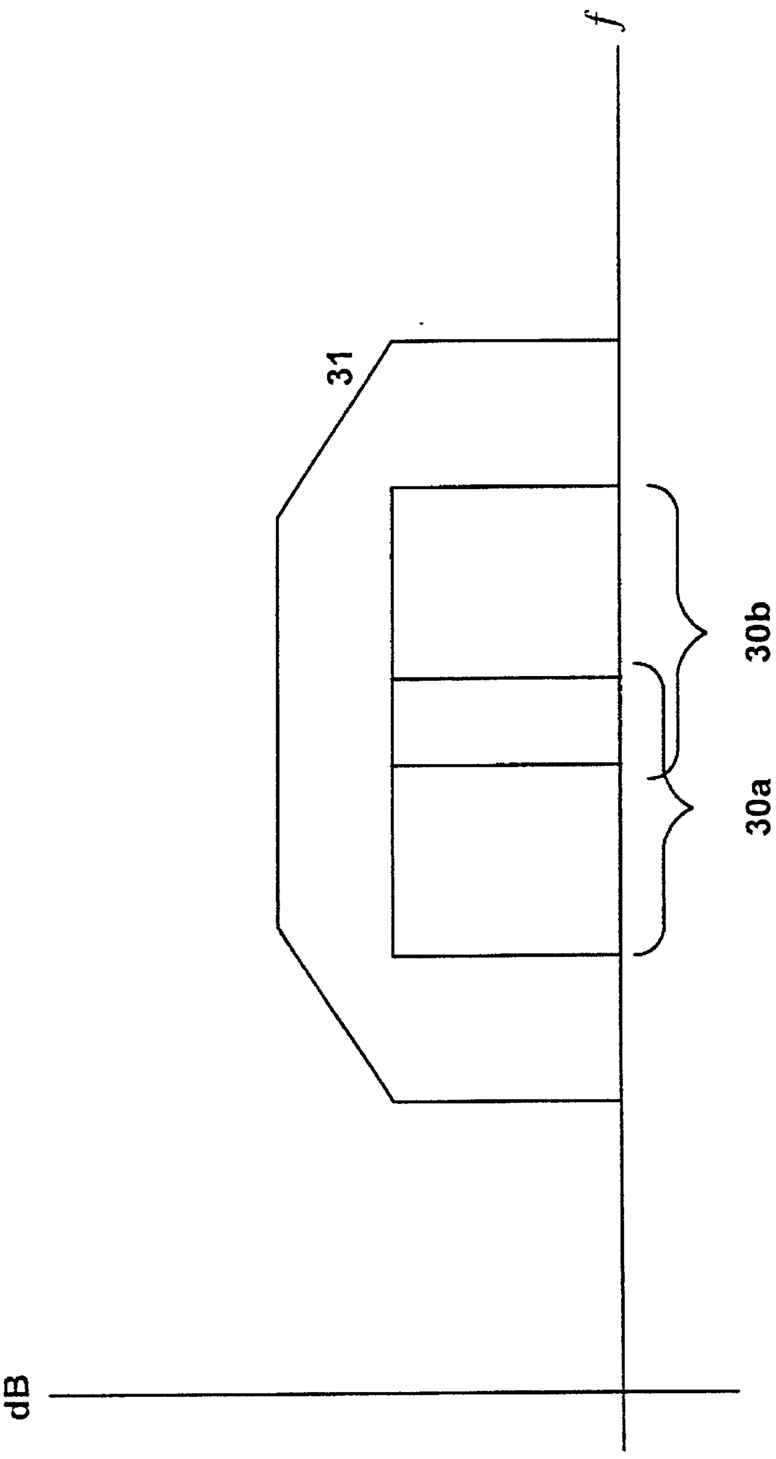


FIGURE 3A

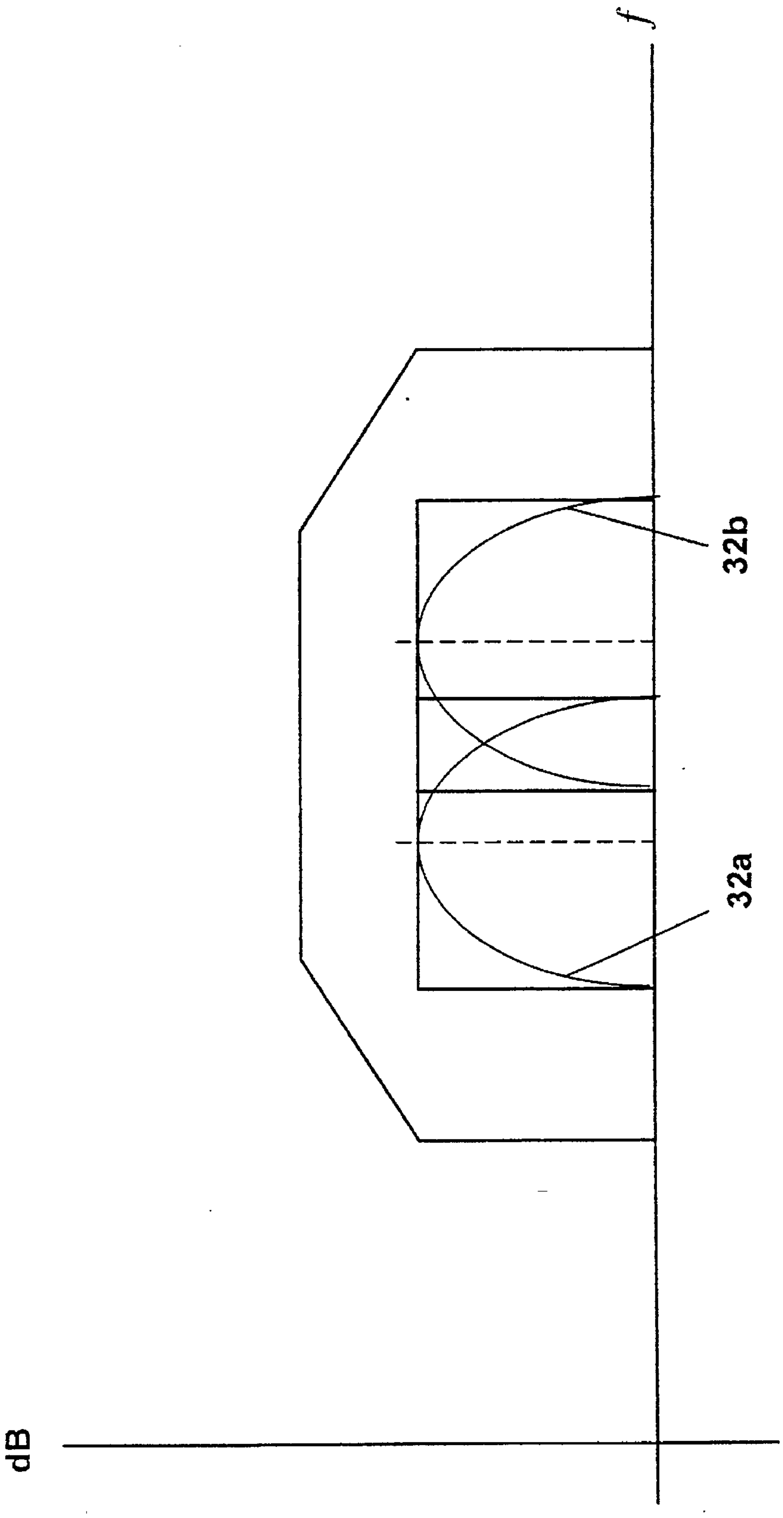
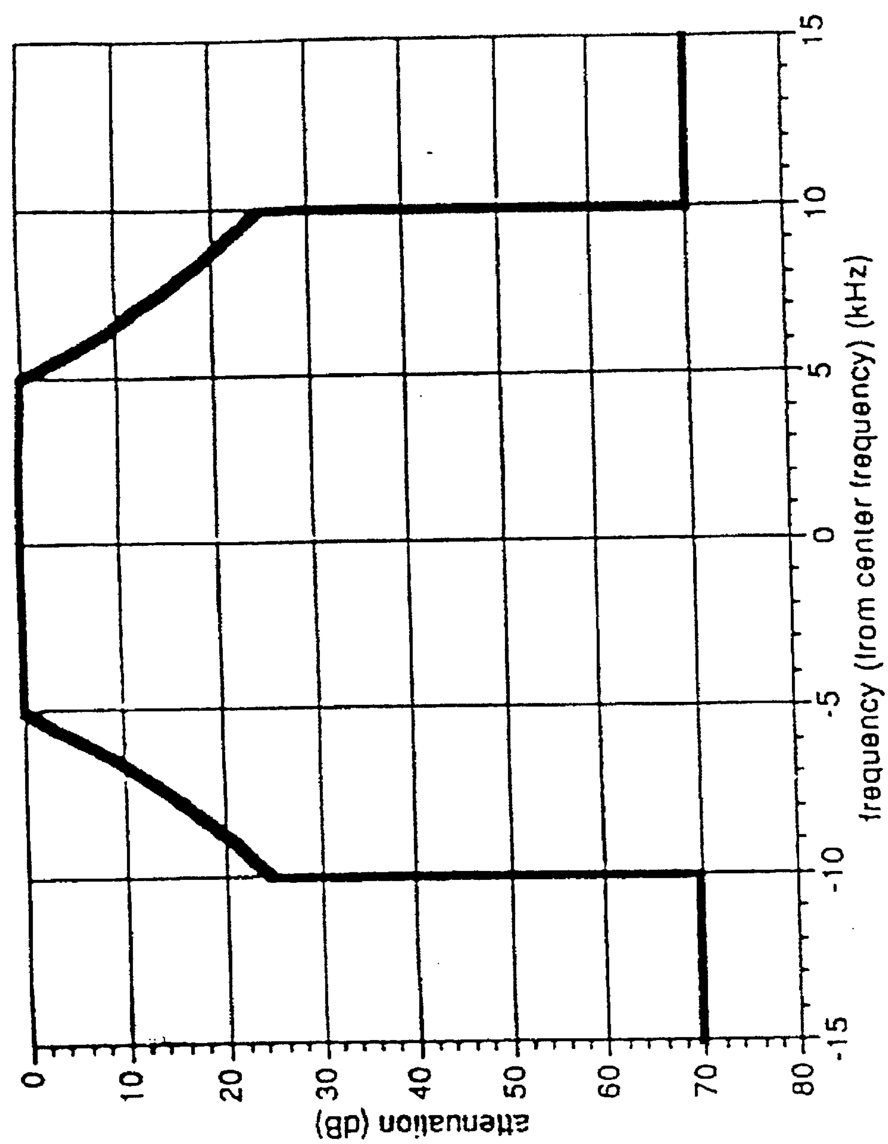


FIGURE 3B

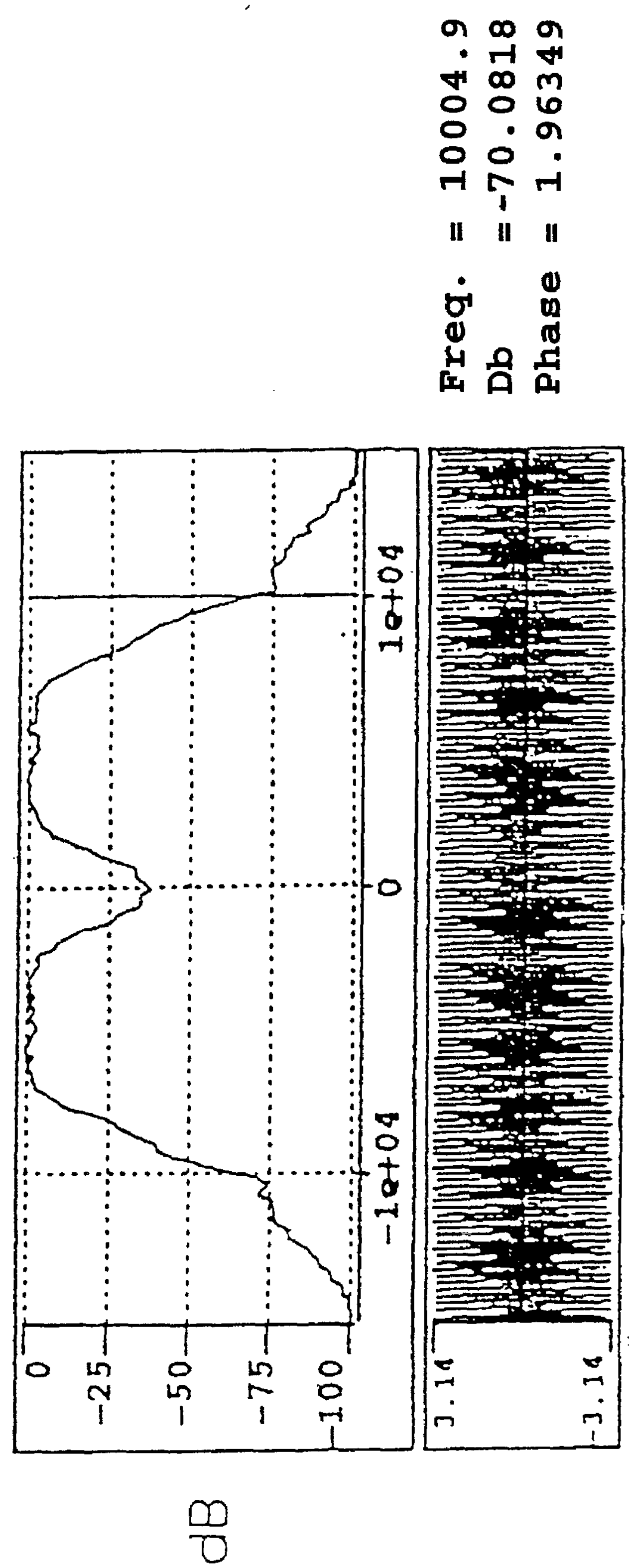


attenuation (dB)
0
10
20
30
40
50
60
70
80
frequency (from center frequency) (kHz)
-15
-10
-5
0
5
10
15

FIGURE 4

FIGURE 5A

2400 max deviation, 6k bps bit rate, 4590 Hz carrier



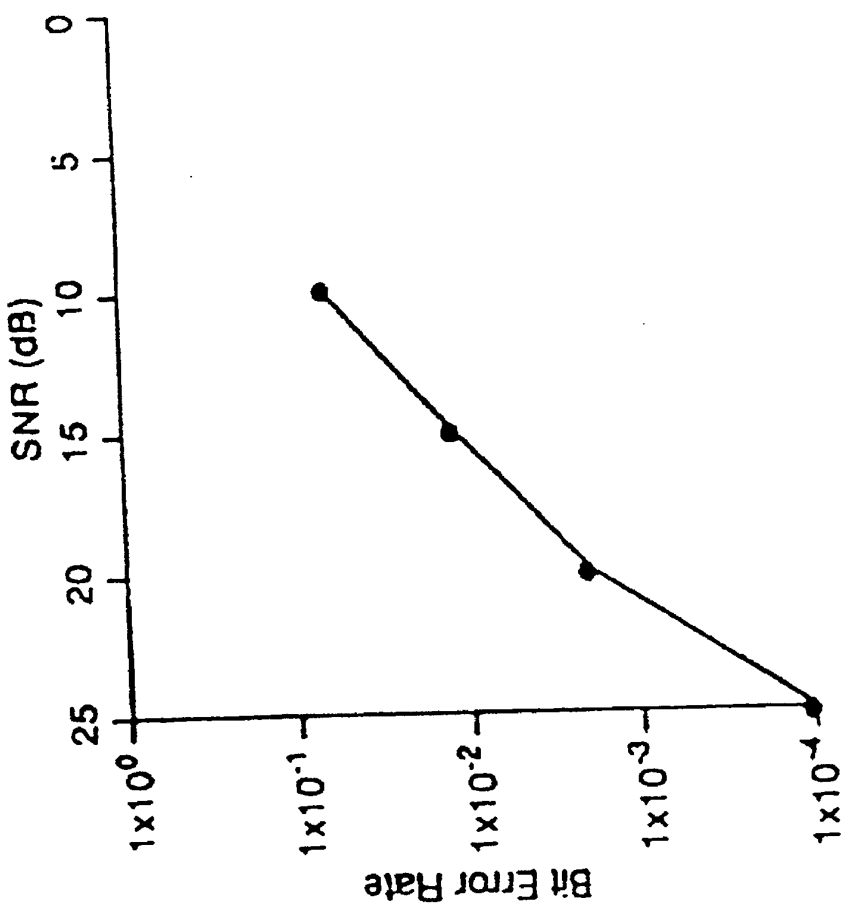
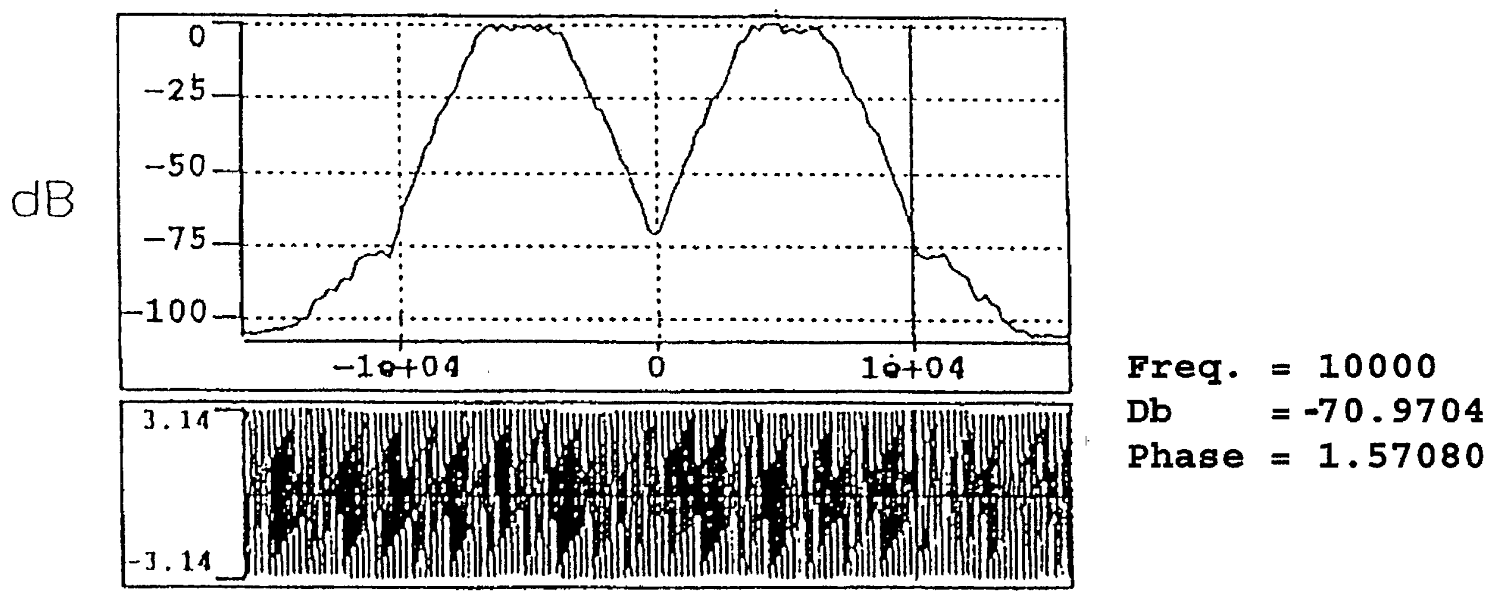

SNR (dB)
0
5
10
15
20
25
Bit Error Rate
1×10^{0}
1×10^{-1}
1×10^{-2}
1×10^{-3}
1×10^{-4}

FIGURE 5B

FIGURE 6A

1800 max deviation, 6.4k bps bit rate, 5150 Hz carrier



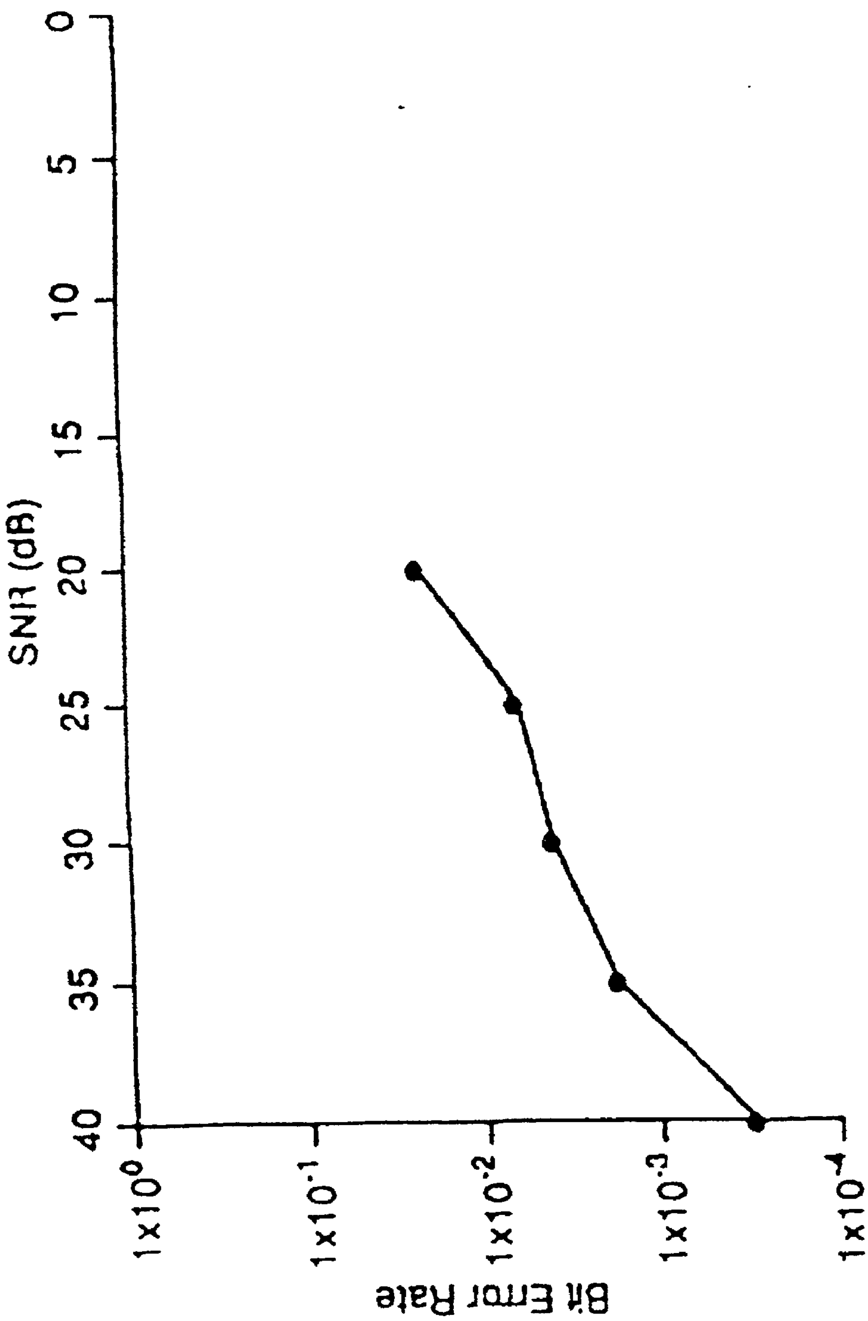
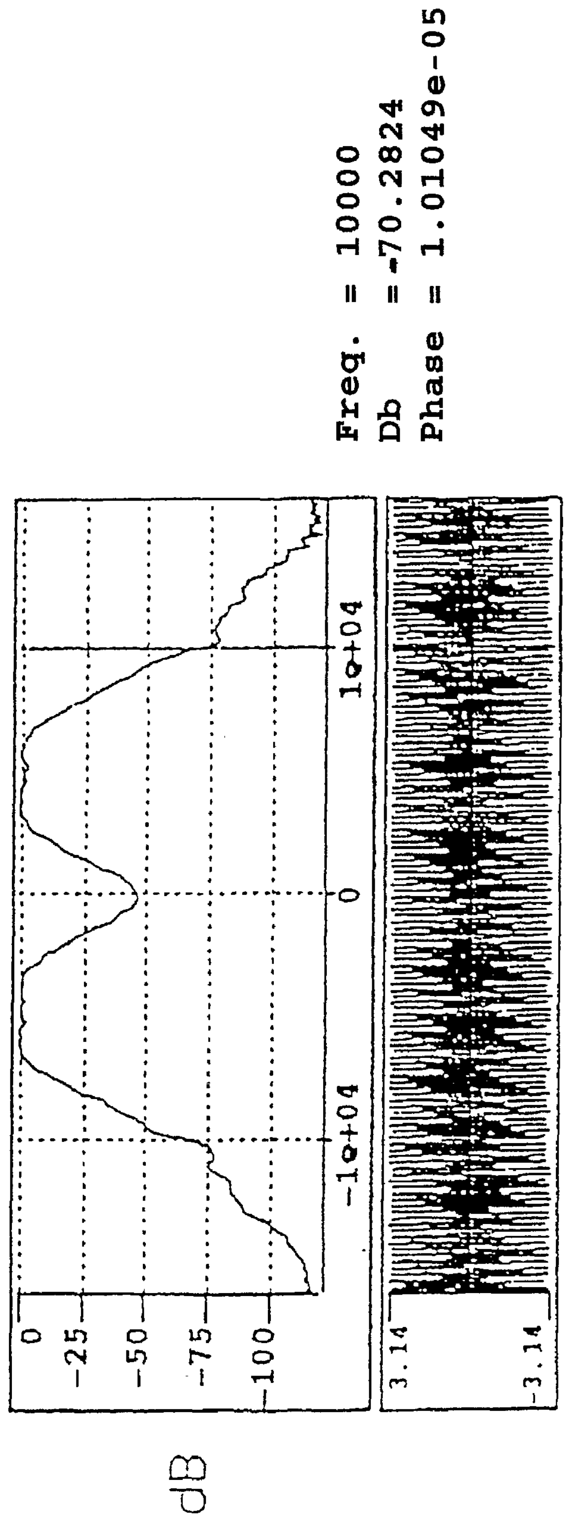

SNR (dB)
0
5
10
15
20
25
30
35
40
1×10^{0}
1×10^{-1}
1×10^{-2}
1×10^{-3}
1×10^{-4}
Bit Error Rate

FIGURE 6B

FIGURE 7A

2100 max deviation, 6.4k bps bit rate, 4750 Hz carrier



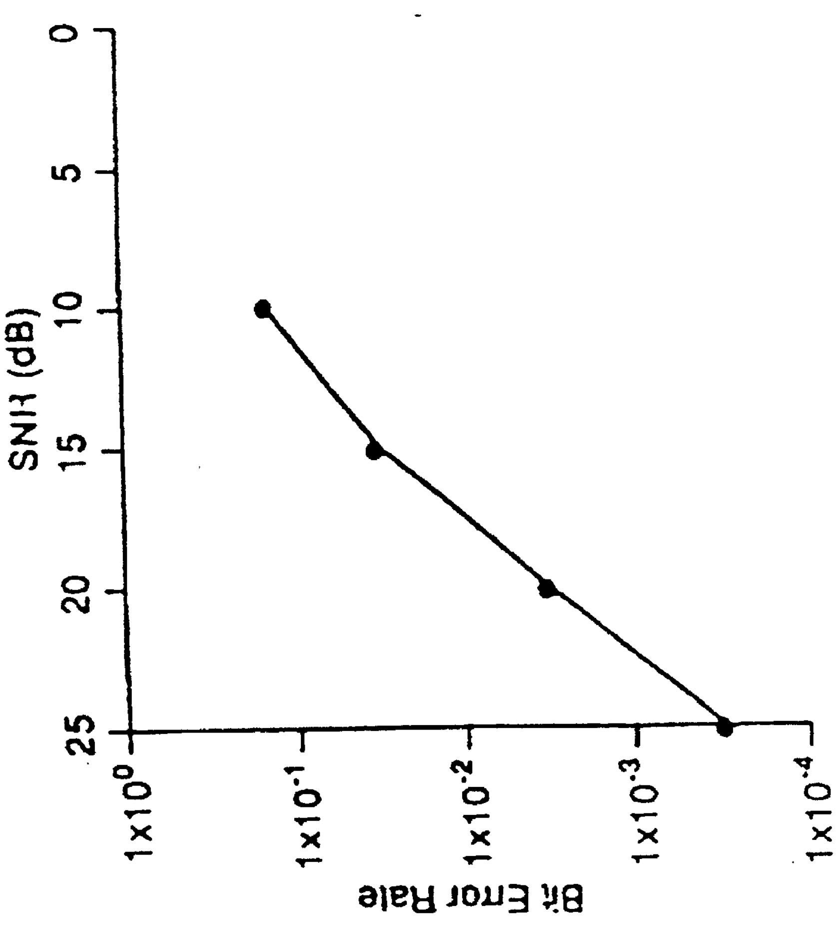

SNR (dB)
0
5
10
15
20
25
1x10^0
1x10^-1
1x10^-2
1x10^-3
1x10^-4
Bit Error Rate

FIGURE 7B

MULTICARRIER TECHNIQUES IN BANDLIMITED CHANNELS

FIELD OF THE INVENTION

The present invention relates generally to multicarrier modulation techniques, and more particularly, to a method for operating more than one carrier in a single mask-defined, bandlimited channel assigned to mobile paging use.

DISCUSSION OF RELATED ART

The rising popularity of mobile paging services has resulted in increased competition for air time on the limited number of radio-frequency channels allocated by the Federal Communications Commission (FCC) for mobile paging use. As demand begins to approach and even exceed the capacity of assigned channels to handle transmission traffic, delays in service and deterioration of transmission quality are becoming a major concern to mobile paging users and providers.

The ability of mobile paging providers to successfully address the problem of transmission saturation is limited by the finite range of air space dedicated to mobile paging use. Channels assigned by the FCC to radio paging providers typically have narrow bandwidths (e.g. 25 kHz) and are subject to stringent emission mask limitations.

One method that can be used to allow greater access to a particular channel is to increase the number of messages transmitted over the channel in a given period. This can be achieved, for example, by increasing the data rate of the transmission or by reducing the length of transmitted messages. U.S. Pat. No. 5,392,452 issued to Davis, for example, describes a high data rate transmission scheme for handling lengthy messages in a paging system. Systems employing techniques to increase transmission rates, however, are prone to higher error rates. In addition, high data rates tend to generate greater transmission interference.

Another approach to addressing the saturation problem is to increase the transmission capacity of the channel itself. Traditionally, mobile paging providers have operated only one transmission signal, or carrier, within an assigned channel. While this mode ensures simplicity of operation and compliance with FCC mask requirements, it does not provide the most efficient use of the limited frequency bandwidth available. Successful multicarrier modulation, however, is difficult to achieve without incurring unacceptable levels of interference.

The problem of interference is compounded when a receiver is attempting to acquire a signal from a distant transmitter while in close proximity to a transmitter operating on an adjacent .channel. In this environment, the receiver may experience difficulty in detecting the signal from the distant source due to interference from the signal transmitted on the adjacent channel from the closer source. This is known as the "near-far" problem. This problem can be avoided by co-locating the transmitters at essentially the same geographic location.

The FCC requires signals to be confined within emission limit masks in order to prevent interference caused by signals straying or spilling into adjacent channels. FCC masks typically require the power spectral density of a signal to be attenuated at least 70 dB at the band edge. Despite these stringent constraints, some carrier overlap can be expected, even when the maximum carrier spacing consistent with the FCC mask requirements is utilized. Such overlap can result in unacceptable interference of the carriers, making it difficult for the receivers to acquire the proper carrier.

Thus, a traditional multicarrier design would commonly require the same stringent protection levels between subchannels. Specifically, when more than one carrier is operating within a single channel, each carrier is traditionally confined to a submask defining a subchannel internal to the channel. The carriers are symmetrically located within the channel such that they are evenly spaced relative to each other and to the band edges of the primary mask defining the primary channel. Although such symmetry achieves maximum inter-carrier spacing and reduces the opportunity for interference among adjacent carriers, it often necessitates the need for sophisticated receiver and transmitter schemes.

SUMMARY OF THE INVENTION

It is an object of this invention to achieve higher capacity over a bandlimited channel for paging without the need for stringent subchannel interference protection. Additional objects, advantages, and features of the invention will be set forth in part in the description that follows, and in part will be obvious from the description, or may be learned by practice of the invention. The advantages of the invention will be realized and attained by means of the instrumentalities and combinations particularly pointed out in the written description and claims herein, as well as the appended drawings.

To achieve these and other objects, advantages, and features in accordance with the purpose of the invention, as embodied and broadly described herein, the invention provides a method of operating a plurality of paging carriers in a single mask-defined, bandlimited channel comprising the step of transmitting the carriers from the same location at center frequencies within the channel such that the frequency difference between the center frequency of the outer most carriers and the band edge of the mask defining said channel is more than half the frequency difference between the center frequencies of each adjacent carrier.

In another aspect, the invention provides a method of operating at least two paging carriers each in a corresponding subchannel of a single mask-defined, bandlimited channel comprising the step of transmitting the carriers from the same location with each carrier centrally located in a corresponding subchannel wherein the frequency difference between the center frequency of the outer most subchannels and the band edge of the mask defining said channel is more than half the frequency difference between the center frequencies of each adjacent carrier.

in another aspect, the invention provides a method of operating a plurality of carriers in a single mask-defined, bandlimited channel to achieve higher transmission capacity over the channel in a mobile paging system having a plurality of transmitters generating a plurality of modulated carriers over a single bandlimited channel and a plurality of mobile, independent receiving units capable of receiving one of said plurality of carriers. The method comprises the steps of co-locating the plurality of transmitters such that the plurality of carriers can be emanated from the same transmission source, and transmitting the carriers over a plurality of subchannels spaced asymmetrically within the mask defining the channel.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several embodiments of the invention and together with the description, serve to explain the principles of the invention. In the drawings,

FIG. 1 is a block diagram of a co-located multicarrier transmitter system in a linear amplifier configuration for using the present invention;

FIG. 2 is a block diagram of a co-located multicarrier transmitter system in a composite transmitter configuration for using the present invention;

FIG. 3A is a graph depicting two submasks defining two subchannels in a single, mask-defined bandlimited channel.

FIG. 3B is a graph depicting the power spectra of two carriers asymmetrically located within a single mask-defined, bandlimited channel.

FIG. 4 is a graph depicting an exemplary FCC emissions mask that requires the power spectral density to be attenuated at least 70 dB within 10 kHz from center frequency.

FIG. 5A is a graph depicting the power spectra of a system with peak deviation of 2400 Hz and data rate of 6000 bits per second (bps);

FIG. 5B is a graph depicting the performance of the system of FIG. 5A in terms of bit error rate versus the signal noise ratio (SNR);

FIG. 6A is a graph depicting the power spectra of a system with peak deviation of 1800 Hz and a data rate of 6400 bps;

FIG. 6B is a graph depicting the performance of the system of FIG. 6A in terms of bit error rate versus SNR;

FIG. 7A is a graph depicting the power spectra of a system with peak deviation of 2100 Hz and a data rate of 6400 bps; and

FIG. 7B is a graph depicting the performance of the system of FIG. 7A in terms of bit error rate versus SNR.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference will now be made in detail to the presently preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

Referring to FIG. **1**, a co-located multicarrier transmitter system in a linear amplifier configuration **10** comprises a first and second data source, **11***a* and **11***b*, a first and second modulator, **12***a* and **12***b*, a summation circuit **13**, a linear RF amplifier **14**, and an antenna **15**. The first and second data sources, **11***a* and **11***b*, generate a respective first and second digital bit stream which are provided to respective first and second modulators, **12***a* and **12***b*. Each modulator converts the incoming digital information into a representative modulated signal or carrier. The outputs of each modulator are then combined into a single output signal by summation circuit **13**, the output of which is fed into linear RF amplifier **14**. The combined output signal is then applied to antenna **15** for transmission in a bandlimited channel.

Alternatively, referring to FIG. **2**, a co-located multicarrier transmitter in a composite amplifier configuration **20** comprises a first and second data source, **21***a* and **21***b*, a first and second modulator, **22***a* and **22***b*, a first and second RF amplifier, **23***a* and **23***b*, a summation circuit **24**, and an antenna **25**. The first and second digital bit streams generated respectively by the first and second data sources, **21***a* and **21***b*, are provided to first and second modulators, **22***a* and **22***b*, respectively. Each modulator converts the incoming digital information into a representative modulated signal or carrier. The outputs of the first and second modulators are fed into first and second RF amplifiers, **23***a* and **23***b*, respectively. The outputs of the RF amplifiers are combined into a single output signal by summation circuit **24**, the output of which is applied to antenna **25** for transmission in a bandlimited channel.

Alternative embodiments of co-located transmitter systems are also possible. For example, the co-located transmitter configurations discussed above can be expanded to support more than two data sources and transmit more than two carriers in the bandlimited channel.

Because transmitter co-location does not give rise to the near-far problem to which the FCC mask requirements are directed, carrier spacings far closer than would ordinarily be allowed (e.g., 5 to 10 kHz) are achievable. Moreover, the carriers need not be symmetrically or evenly spaced within the mask defining the channel. That is, the frequency spacings between adjacent carriers, while symmetric to each other, can be smaller than the frequency spacings between the band edges of the mask and the nearest respective carrier. Indeed, carrier spacings may be irregular such that the carriers are asymmetrically located within the mask without incurring undue interference.

Referring to FIG. **3**A, two submasks defining two subchannels, **30***a* and **30***b*, are asymmetrically located within a single mask-defined, bandlimited channel **31**, resulting in some subchannel overlap. FIG. **3**B depicts two carriers, **32***a* and **32***b*, operating respectively over two asymmetrically-located subchannels, resulting in some carrier overlap. In accordance with this asymmetry, the frequency difference between the center frequency of each carrier and the nearest band edge of the mask is greater than half the frequency difference between the center frequencies of the two carriers.

The practical implication of transmitter co-location is that a greater range of operating parameters, including the peak frequency, deviation bit rate, and carrier frequencies, are available so that multicarrier modulation in a standard bandlimited channel can be obtained without the need for stringent subchannel interference protection. In accordance with the present invention, these and other parameters can be adjusted so that the carriers generated and transmitted according to the present invention will remain within the FCC emission limits while providing optimal transmission performance.

FIG. **4** shows a FCC emissions mask which requires the power spectral density to be attenuated at least 70 dB within 10 kHz from center frequency. Co-location of the transmitters allows for signals with a greater range of deviation and baud rates to be carried in the bandlimited channel than has been otherwise thought possible in view of FCC 70 dB cutoff requirements. The present invention will be further clarified by the following examples, which are intended to be purely exemplary of the invention.

FIG. **5**A is a spectra graph of a two-carrier system in which the following parameter values were selected: a peak frequency deviation of 2400 Hz, a bit rate of 6000 bps, premodulation filter cutoff frequency of 3000 Hz, and carrier frequencies set to within 4590 Hz of the center frequency. Using this operative parameter combination, the carriers remained within the FCC mask while providing an acceptable error-rate versus signal strength performance (FIG. **5**B).

Alternatively, FIG. **6**A is a spectra graph of a two-carrier system using a peak frequency deviation of 1800 Hz, a bit rate of 6400 bps, a premodulation filter cutoff frequency of 3200, and carrier frequencies set to within 5150 Hz of the center frequency. As depicted in FIG. 6B, this combination of operative parameters exhibited a higher bit error rate than the system of FIG. 5A.

FIG. 7A is a spectra graph of a two-carrier system using a peak frequency deviation of 2100 Hz, a bit rate of 6400 bps, a premodulation filter cutoff frequency of 3200, and carrier frequencies set to within 4750 Hz of the center frequency. As depicted in FIG. 7B, this combination gives significantly better performance than the system of FIG. 6A but performs slightly worse than the system of FIG. 5A.

Thus, according to the present invention, increased transmission capacity is achieved by operating more than one carrier in a standard bandlimited channel assigned for mobile paging use, such as in the Narrowband Personal Communications Service or the Part 22 Service. In the modulation technique of the present invention, carriers operating at different frequencies are fit within a single bandwidth allocation in a manner consistent with FCC mask requirements. This is achieved through the use of co-located transmitters and the selection of an optimal combination of operating parameters, including peak frequency deviation, bit rate, and carrier separation frequencies. Through the multicarrier modulation technique of the present invention, the normal transmission capacity of a standard channel can be increased without the need for stringent subchannel protection levels and complicated receiver and transmitter schemes.

The modulation technique of the present invention has particular application in metropolitan areas where the volume and concentration of transmission traffic is high and where the need for increased transmission capacity is acute. In addition, the modulation technique of the present invention may also be suited for use in areas where the incidence of unacceptable interference is high, such as international border regions. In that type of environment, transmissions from the respective bordering countries can be assigned to one of the carriers operating within the channel to reduce the risk of interference.

It will be apparent to those skilled in the art that various modification and variations can be made to present invention without departing from the spirit or scope of the invention. Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. Thus, it is intended that the specification and examples be considered

as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

What is claimed is:

1. A method of operating a plurality of paging carriers in a single mask-defined, bandlimited channel comprising the step of transmitting said carriers from the same location with said carriers having center frequencies within said channel such that the frequency difference between the center frequency of the outer most of said carriers and the band edge of the mask defining said channel is more than half the frequency difference between the center frequencies of each adjacent carrier.

2. The method of claim 1 wherein adjacent carriers overlap with each other.

3. A method of operating at least two paging carriers each in a corresponding subchannel of a single mask-defined, bandlimited channel comprising the step of transmitting said carriers from the same location with each carrier centrally located in said corresponding subchannel wherein the frequency difference between the center frequency of the outer most of said corresponding subchannels and the band edge of the mask defining said channel is more than half the frequency difference between the center frequencies of each adjacent carrier.

4. The method of claim 3 wherein adjacent subchannels overlap with each other.

5. In a paging system having a plurality of transmitters transmitting a plurality of modulated carriers over a single mask-defined, bandlimited channel and a plurality of mobile receiving units independently receiving one of said plurality of carriers, a method of operating said plurality of carriers in said channel to achieve higher transmission capacity comprising the steps of:

co-locating said plurality of transmitters such that said plurality of carriers can be emanated from the same transmission source; and

transmitting said plurality of carriers over a plurality of subchannels spaced within the mask defining said channel wherein the frequency difference between the center frequency of the outer most carriers and the band edge of said mask is greater than half the frequency difference between the center frequencies of each adjacent carrier.

* * * * *

PATENT APPLICATION SERIAL NO. 08/480718

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APPLICANT

WILLIAM D. HAYS, JACKSON, MS; DENNIS CAMERON, JACKSON, MS; WALTER ROEHR, RESTON, VA.

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ADDRESS

FINNEGAN HENDERSON FARABOW GARRETT &
DUNNER
1300 I STREET NW
WASHINGTON DC 20005-3315

TITLE

MULTICARRIER TECHNIQUES IN BANDLIMITED CHANNELS

This is to certify that annexed hereto is a true copy from the records of the United States Patent and Trademark Office of the application which is identified above.

By authority of the
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Date Certifying Officer

08/480718

FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, L. L. P.

1300 I STREET, N. W.

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MINATO-KU, TOKYO 105, JAPAN
TELEPHONE 011-813-3431-6943
FACSIMILE 011-813-3431-6945

WRITER'S DIRECT DIAL NUMBER:

(202) 408-4010

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BOX PATENT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231

Re: New U.S. Patent Application
Title: MULTICARRIER TECHNIQUES IN BANDLIMITED CHANNELS
Inventor: William D. Hays, Dennis Cameron and Walter Roehr

1-00, 2-00, 3-00

Sir:

We enclose the following papers for filing in the United States Patent and Trademark Office in connection with the above patent application.

1. Application - 14 pages, including Title Page, Abstract, 3 independent claims, and 8 claims total.

2. Drawings - 9 sheets of informal drawings.

3. A check for $730.00 representing a filing fee.

Please accord this application a serial number and filing date and return to the undersigned.

The Commissioner is hereby authorized to charge any additional filing fees due and any other fees due under 37 C.F.R. § 1.16 or § 1.17 during the pendency of this application to our Deposit Account No. 06-0916.

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW,
GARRETT & DUNNER

By: John M. Romary
Reg. No. 26,331

JMR/HAK:jfi
Enclosures

UNITED STATES PATENT APPLICATION

OF

WILLIAM D. HAYS

DENNIS CAMERON

AND

WALTER ROEHR

FOR

MULTICARRIER TECHNIQUES IN BANDLIMITED CHANNELS

9 08/480718 08/480,718

MULTICARRIER TECHNIQUES IN BANDLIMITED CHANNELS

Field Of The Invention

The present invention relates generally to multicarrier modulation techniques, and more particularly, to a method for operating more than one carrier in a single mask-defined, bandlimited channel assigned to mobile paging use.

Discussion Of Related Art

The rising popularity of mobile paging services has resulted in increased competition for air time on the limited number of radio-frequency channels allocated by the Federal Communications Commission (FCC) for mobile paging use. As demand begins to approach and even exceed the capacity of assigned channels to handle transmission traffic, delays in service and deterioration of transmission quality are becoming a major concern to mobile paging users and providers.

The ability of mobile paging providers to successfully address the problem of transmission saturation is limited by the finite range of air space dedicated to mobile paging use. Channels assigned by the FCC to radio paging providers typically have narrow bandwidths (e.g. 25 kHz) and are subject to stringent emission mask limitations.

One method that can be used to allow greater access to a particular channel is to increase the number of messages transmitted over the channel in a given period. This can be achieved, for example, by increasing the data rate of the transmission or by reducing the length of transmitted messages.

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U.S. Patent No. 5,392,452 issued to Davis, for example, describes a high data rate transmission scheme for handling lengthy messages in a paging system. Systems employing techniques to increase transmission rates, however, are prone to higher error rates. In addition, high data rates tend to generate greater transmission interference.

Another approach to addressing the saturation problem is to increase the transmission capacity of the channel itself. Traditionally, mobile paging providers have operated only one transmission signal, or carrier, within an assigned channel. While this mode ensures simplicity of operation and compliance with FCC mask requirements, it does not provide the most efficient use of the limited frequency bandwidth available. Successful multicarrier modulation, however, is difficult to achieve without incurring unacceptable levels of interference.

The problem of interference is compounded when a receiver is attempting to acquire a signal from a distant transmitter while in close proximity to a transmitter operating on an adjacent channel. In this environment, the receiver may experience difficulty in detecting the signal from the distant source due to interference from the signal transmitted on the adjacent channel from the closer source. This is known as the "near-far" problem. This problem can be avoided by co-locating the transmitters at essentially the same geographic location.

The FCC requires signals to be confined within emission limit masks in order to prevent interference caused by signals straying or spilling into adjacent channels. FCC masks typically require the power spectral density of a signal to be attenuated at least 70 dB at the band edge. A1 ~~Due to the limited bandwidth of a standard channel, however, some carrier overlap can be expected in multicarrier transmission~~, even when the maximum carrier spacing consistent with the FCC mask requirements is utilized.

INS A1

frequencies within the channel such that the frequency difference between the center frequency of the outer most carriers and the band edge of the mask defining said channel is more than half the frequency difference between the center frequencies of each adjacent carrier.

In another aspect, the invention provides a method of operating at least two paging carriers each in a corresponding subchannel of a single mask-defined, bandlimited channel comprising the step of transmitting the carriers from the same location with each carrier centrally located in a corresponding subchannel wherein the frequency difference between the center frequency of the outer most subchannels and the band edge of the mask defining said channel is more than half the frequency difference between the center frequencies of each adjacent carrier.

In another aspect, the invention provides a method of operating a plurality of carriers in a single mask-defined, bandlimited channel to achieve higher transmission capacity over the channel in a mobile paging system having a plurality of transmitters generating a plurality of modulated carriers over a single bandlimited channel and a plurality of mobile, independent receiving units capable of receiving one of said plurality of carriers. The method comprises the steps of co-locating the plurality of transmitters such that the plurality of carriers can be emanated from the same transmission source, and transmitting the carriers over a plurality of subchannels spaced asymmetrically within the mask defining the channel.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several embodiments of the invention and together with the description, serve to explain the principles of the invention. In the drawings,

Fig. 1 is a block diagram of a co-located multicarrier transmitter system in a linear amplifier configuration for using the present invention;

Fig. 2 is a block diagram of a co-located multicarrier transmitter system in a composite transmitter configuration for using the present invention;

Fig. 3A is a graph depicting two submasks defining two subchannels in a single mask-defined bandlimited channel.

Fig. 3B is a graph depicting the power spectra of two carriers asymmetrically located within a single mask-defined, bandlimited channel.

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Fig. 4 is a graph depicting A3 ~~the FCC emission limits mask for digital transmitters operating in the frequency bands 450.0 to 512.0 MHz and 929.0 to 932.0 MHz~~;

Fig. 5A is a graph depicting the power spectra of a system with peak deviation of 2400 Hz and data rate of 6000 bits per second (bps);

Fig. 5B is a graph depicting the performance of the system of Figure 5A in terms of bit error rate versus the signal noise ratio (SNR);

Alternatively, referring to Fig. 2, a co-located multicarrier transmitter in a composite amplifier configuration 20 comprises a first and second data source, 21a and 21b, a first and second modulator, 22a and 22b, a first and second RF amplifier, 23a and 23b, a summation circuit 24, and an antenna 25. The first and second digital bit streams generated respectively by the first and second data sources, 21a and 21b, are provided to first and second modulators, 22a and 22b, respectively. Each modulator converts the incoming digital information into a representative modulated signal or carrier. The outputs of the first and second modulators are fed into first and second RF amplifiers, 23a and 23b, respectively. The outputs of the RF amplifiers are combined into a single output signal by summation circuit 24, the output of which is applied to antenna 25 for transmission in a bandlimited channel.

Alternative embodiments of co-located transmitter systems are also possible. For example, the co-located transmitter configurations discussed above can be expanded to

Referring to Fig. 3A, two submasks defining two subchannels, 30a and 30b, are asymmetrically located within ~~a~~ single mask-defined, bandlimited channel 31, resulting in some subchannel overlap. Fig. 3B depicts two carriers, 32a and 32b, operating respectively over two asymmetrically-located subchannels, resulting in some carrier overlap. In accordance with this asymmetry, the frequency difference between the center frequency of each carrier and the nearest band edge of the mask is greater than ~~the~~ half the frequency difference between the center frequencies of the two carriers.

The practical implication of transmitter co-location is that a greater range of operating parameters, including the peak frequency, deviation bit rate, and carrier frequencies, are available so that multicarrier modulation in a standard bandlimited channel can be obtained without the need for stringent subchannel interference protection. In accordance with the present invention, these and other parameters can be adjusted so that the carriers generated and transmitted according to the present invention will remain within the FCC emission limits while providing optimal transmission performance.

Fig. 4 shows a FCC emissions mask which requires the power spectral density to be attenuated at least 70 dB within 10 kHz from center frequency. Co-location of the transmitters allows for signals with a greater range of deviation and baud rates to be carried in the bandlimited channel than has been otherwise thought possible in view of FCC 70 dB cutoff requirements. The present invention will be further clarified by the following examples, which are intended to be purely exemplary of the invention.

Fig. 5A is a spectra graph of a two-carrier system in which the following parameter values were selected: a peak frequency deviation of 2400 Hz, a bit rate of 6000 bps, premodulation filter cutoff frequency of 3000 Hz, and carrier frequencies set to within 4590 Hz of the center frequency. Using this operative parameter combination, the carriers remained within the FCC mask while providing an acceptable error-rate versus signal strength performance (Fig. 5B).

Alternatively, Fig. 6A is a spectra graph of a two-carrier system using a peak frequency deviation of 1800 Hz, a bit frequency deviation, bit rate, and carrier separation frequencies. Through the multicarrier modulation technique of the present invention, the normal transmission capacity of a standard channel can be increased without the need for stringent subchannel protection levels and complicated receiver and transmitter schemes.

The modulation technique of the present invention has particular application in metropolitan areas where the volume and concentration of transmission traffic is high and where the need for increased transmission capacity is acute. In addition, the modulation technique of the present invention ~~is also well~~ may also be suited for use in areas where the incidence of unacceptable interference is high, such as international border regions. In that type of environment, transmissions from the respective bordering countries can be assigned to one of the carriers operating within the channel to reduce the risk of interference.

It will be apparent to those skilled in the art that various modification and variations can be made to present invention without departing from the spirit or scope of the invention. Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. Thus, it is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

WHAT IS CLAIMED IS:

1. A method of operating a plurality of paging carriers in a single mask-defined, bandlimited channel comprising the step of transmitting said carriers from the same location with said carriers having center frequencies within said channel such that the frequency difference between the center frequency of the outer most of said carriers and the band edge of the mask defining said channel is more than half the frequency difference between the center frequencies of each adjacent carrier.

2. The method of claim 1 wherein adjacent carriers overlap with each other.

3. A method of operating at least two paging carriers each in a corresponding subchannel of a single mask-defined, bandlimited channel comprising the step of transmitting said carriers from the same location with each carrier centrally located in said corresponding subchannel wherein the frequency difference between the center frequency of the outer most of said corresponding subchannels and the band edge of the mask defining said channel is more than half the frequency difference between the center frequencies of each adjacent carrier.

4. The method of claim 3 wherein adjacent subchannels overlap with each other.

5. In a paging system having a plurality of transmitters transmitting a plurality of modulated carriers over a single mask-defined, bandlimited channel and a plurality of mobile receiving units independently receiving one of said plurality of carriers, a method of operating said plurality of carriers in said channel to achieve higher transmission capacity comprising the steps of

co-locating said plurality of transmitters such that said plurality of carriers can be emanated from the same transmission source; and

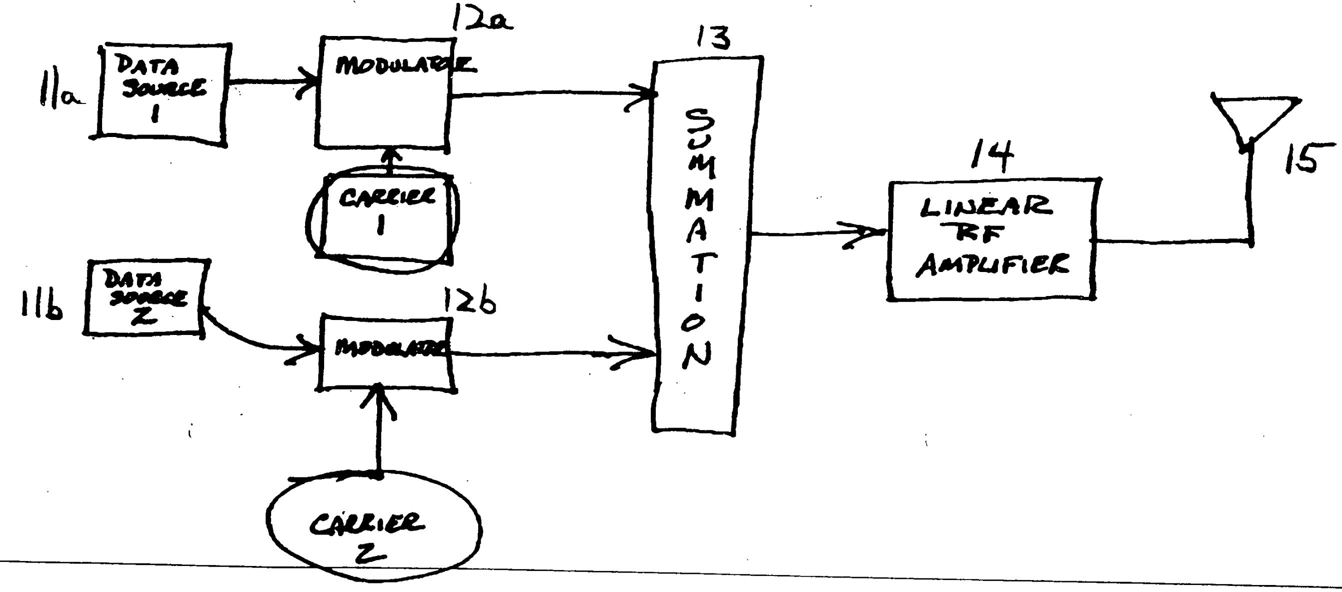
transmitting said plurality of carriers over a plurality of subchannels spaced asymmetrically within the mask defining said channel.

6. The method according to claim 5 wherein said transmitting step includes operating said plurality of carriers in a mask defining said bandlimited channel requiring at least

MULTI CARRIER TRANSMITTERS

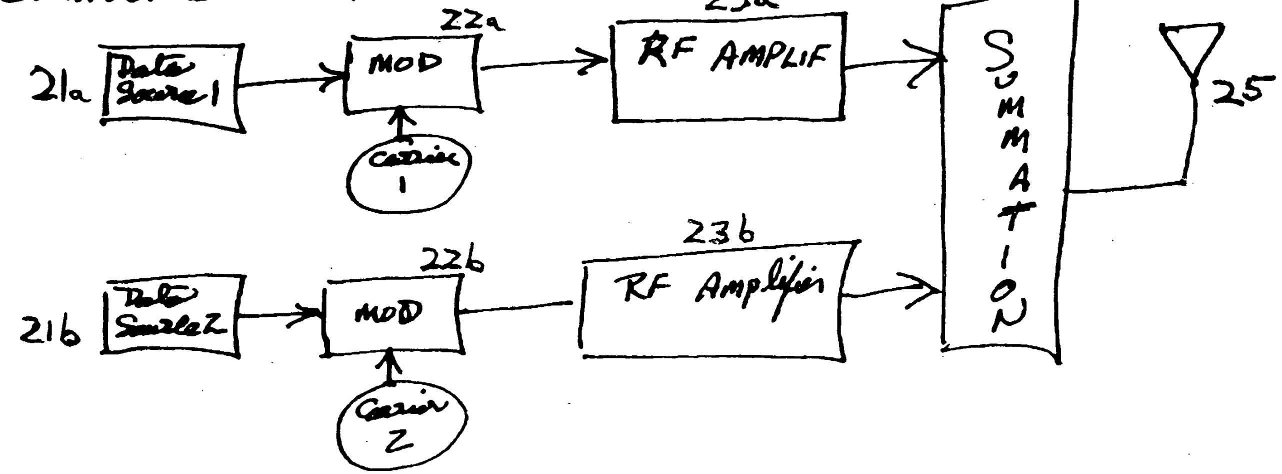
LINEAR AMPLIFIER TRANSMITTER 10

FIG 1



COMPOSITE TRANSMITTER

FIG 2



08/480718

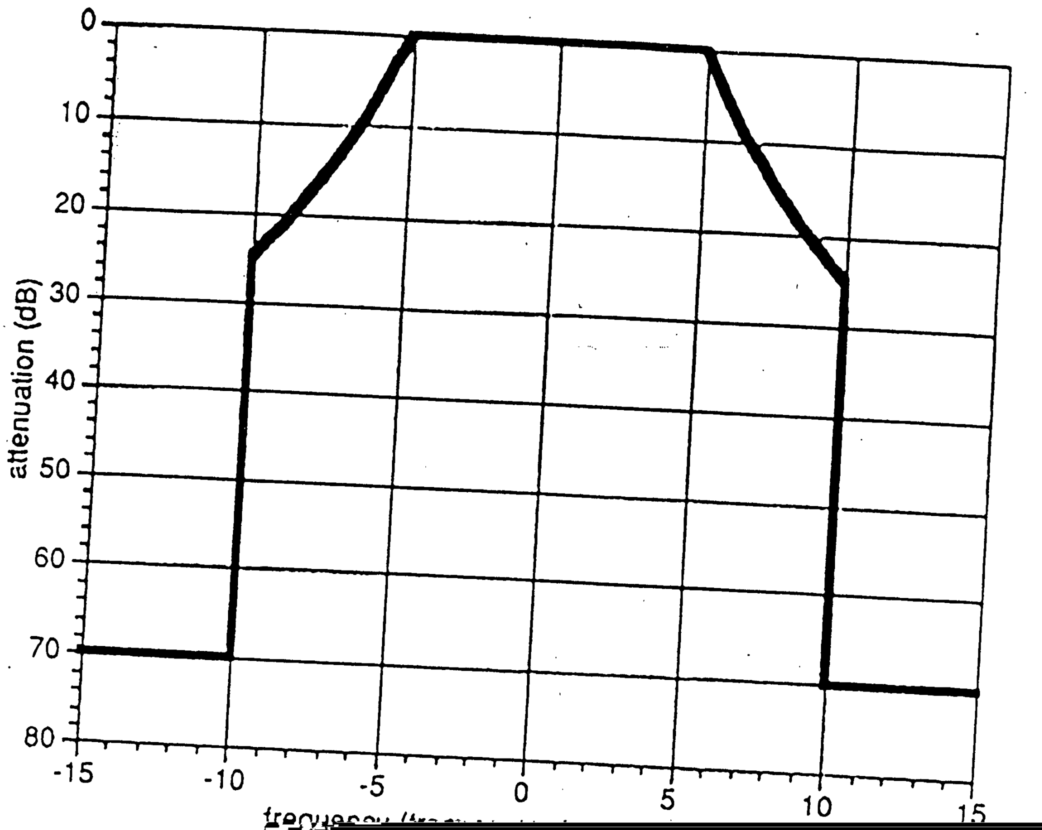


FIG 4

455/103

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AS ORIGINAL FILED

08/480718

FIG 1

08/480718

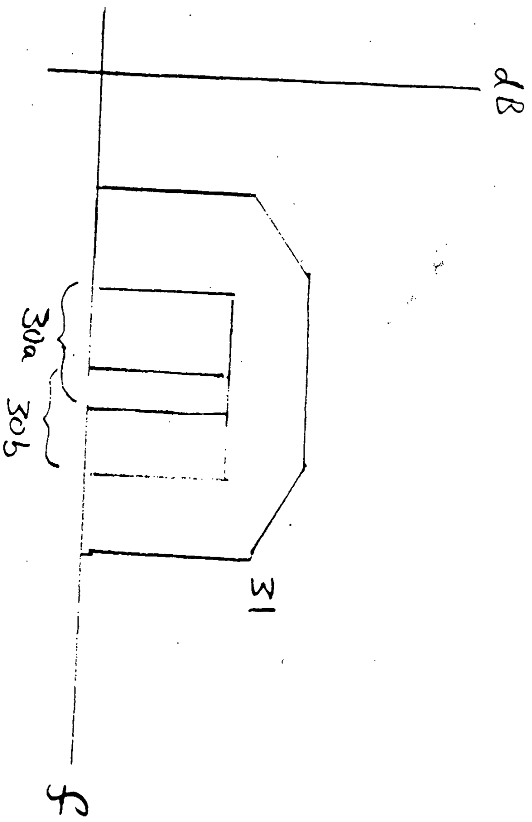


FIG 3A

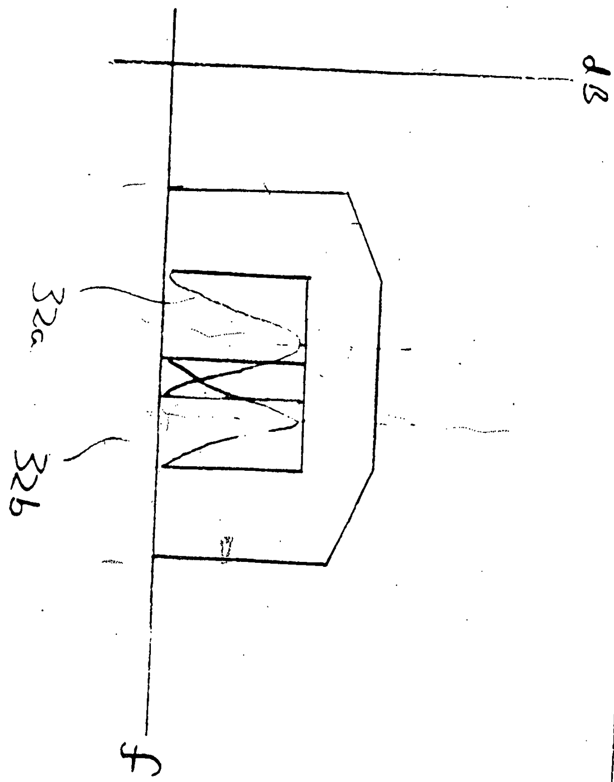
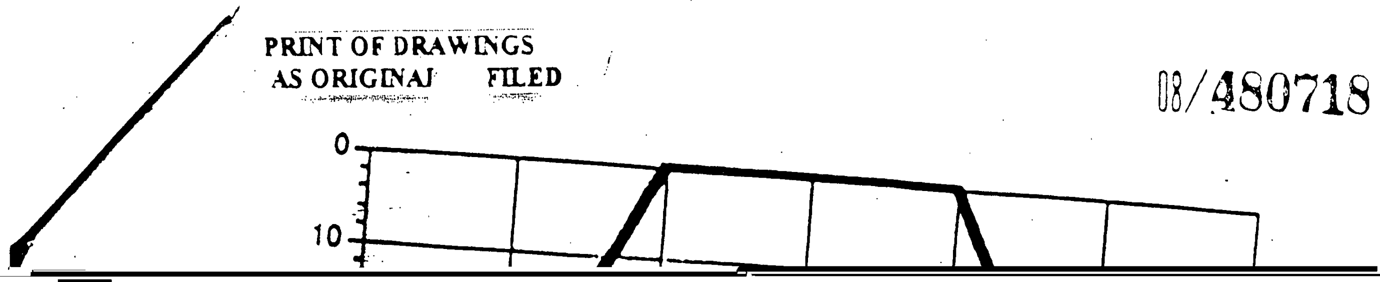


FIG 3B

PRINT OF DRAWINGS
AS ORIGINAL FILED

08/480718



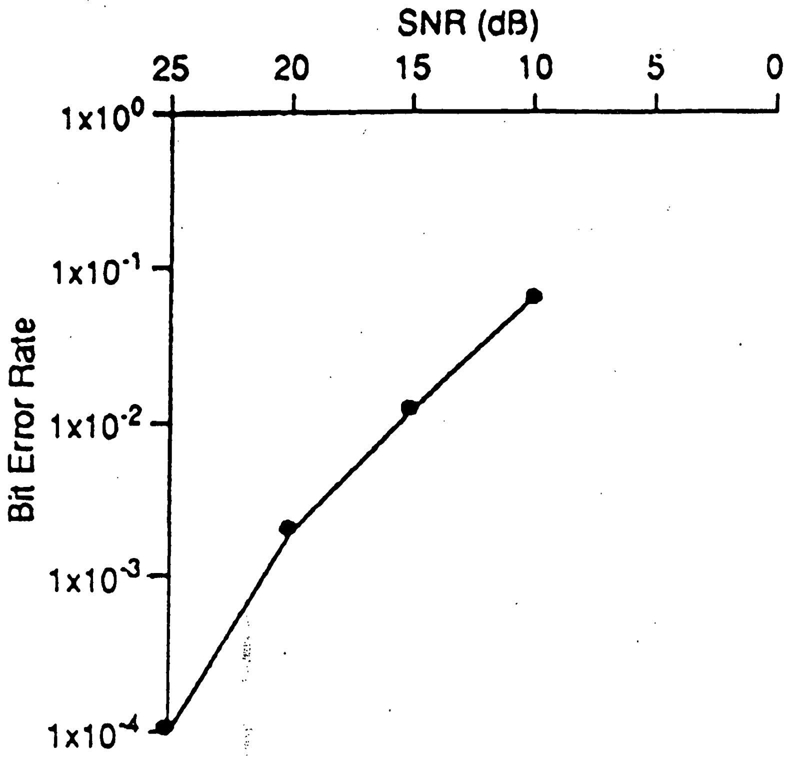

SNR (dB)
25
20
15
10
5
0
1x10^0
1x10^-1
1x10^-2
1x10^-3
1x10^-4
Bit Error Rate

FIG 5B

08/480718

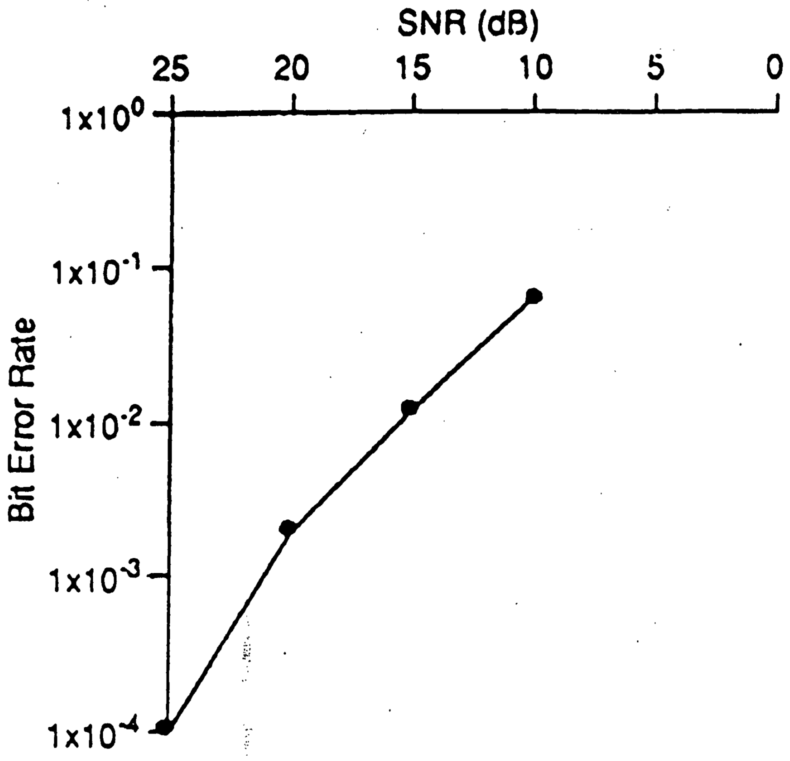


FIG 5B

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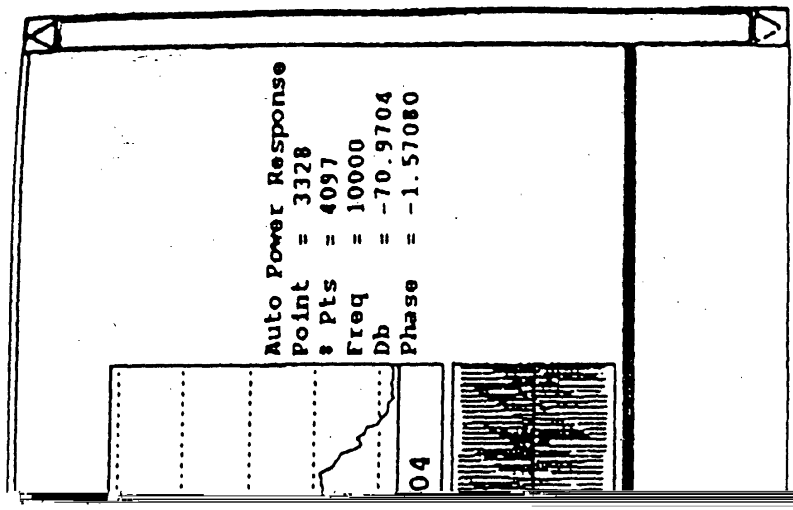
AS ORIGINAL FILED

16

08/480718



PRINT OF DRAWINGS

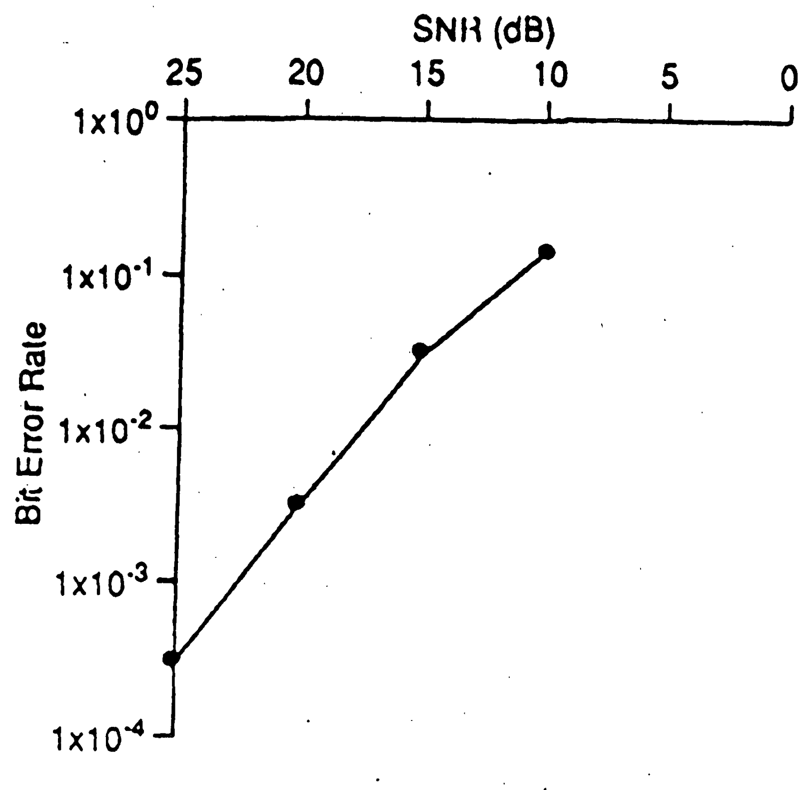


FIG 7B

BOX MISSII PARTS
Attorney Du.ket No.: 03680.0143
Serial No. 08/480,718

time under 37 C.F.R. § 1.136 not accounted for above, such an extension is requested and the fee should also be charged to our Deposit Account.

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, L.L.P.

By: Howard A. Kwon
Howard A. Kwon
Reg. No. 36,350

Dated: September 21, 1995

LAW OFFICES
FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, L.L.P.
1300 I STREET, N. W.
WASHINGTON, DC 20005
202-408-4000

FULL NAME OF THIRD INVENTOR Walter Roehr	INVENTOR'S SIGNATURE	DATE
RESIDENCE		COUNTRY OF CITIZENSHIP U.S.A.
POST OFFICE ADDRESS		

Attorney Docket No. 03680.0143

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that: my residence, post office address and citizenship are as stated below next to my name; I believe I am the original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled: MULTICARRIER TECHNIQUES IN BANDLIMITED CHANNELS the specification of which [ ] is attached and/or [X] was filed as United States Application Serial No. 08/480,718 on June 7, 1995 and was amended on September 6, 1995.

specification including the claims as amended by any amendment referred to above. I

I hereby appoint the following attorney and/or agent(s) to prosecute this application and

HENDERSON, FARABOW, GARRETT & DUNNER, Reg. No. 22,540; Douglas B. Henderson, Reg. No. 20,291;

3-00

FULL NAME OF THIRD INVENTOR Walter Roehr	INVENTOR'S SIGNATURE	DATE 11 Sept 95
RESIDENCE 11317 SOUTH SHORE RD		COUNTRY OF CITIZENSHIP U.S.A.
POST OFFICE ADDRESS RESTON VA 22090		

VA

130,00-105 AN

SEP 21 1995

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

APPLICATION NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
08/480,718	06/07/95	HAYS W	03680.0143

0212/0721

FINNEGAN HENDERSON FARABOW GARRETT &
DUNNER
1300 I STREET NW
WASHINGTON DC 20005-3315

OMB No. 0651-0011

INFORMATION DISCLOSURE CITATION (Use several sheets if necessary)	Atty. Docket No. 03680.0143	Serial No. 08/480,718
	Applicant William D. Hays et al.	
	Filing Date June 7, 1995	Group 2611 Unassigned

MAIL ROOM AUG 9 1995

ing 9.5 kHz: At least 103 $\log_{10}$ (f_d/3.9) decibels;

(iii) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 9.5 kHz up to and including 15 kHz: At least 157 $\log_{10}$ (f_d/5.3) decibels;

(iv) On any frequency removed from the center of the authorized bandwidth by a displacement frequency greater than 15 kHz: At least 50 plus 10 $\log_{10}$ (P) or 70 decibels, whichever is the lesser attenuation.

(4) For those transmitters that operate in the frequency bands 932–932.5/941–941.5 MHz with a bandwidth greater than 12.5 kHz,

(i) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5 kHz up to and including 10 kHz: At least 83 $\log_{10}$ (f_d/5) decibels;

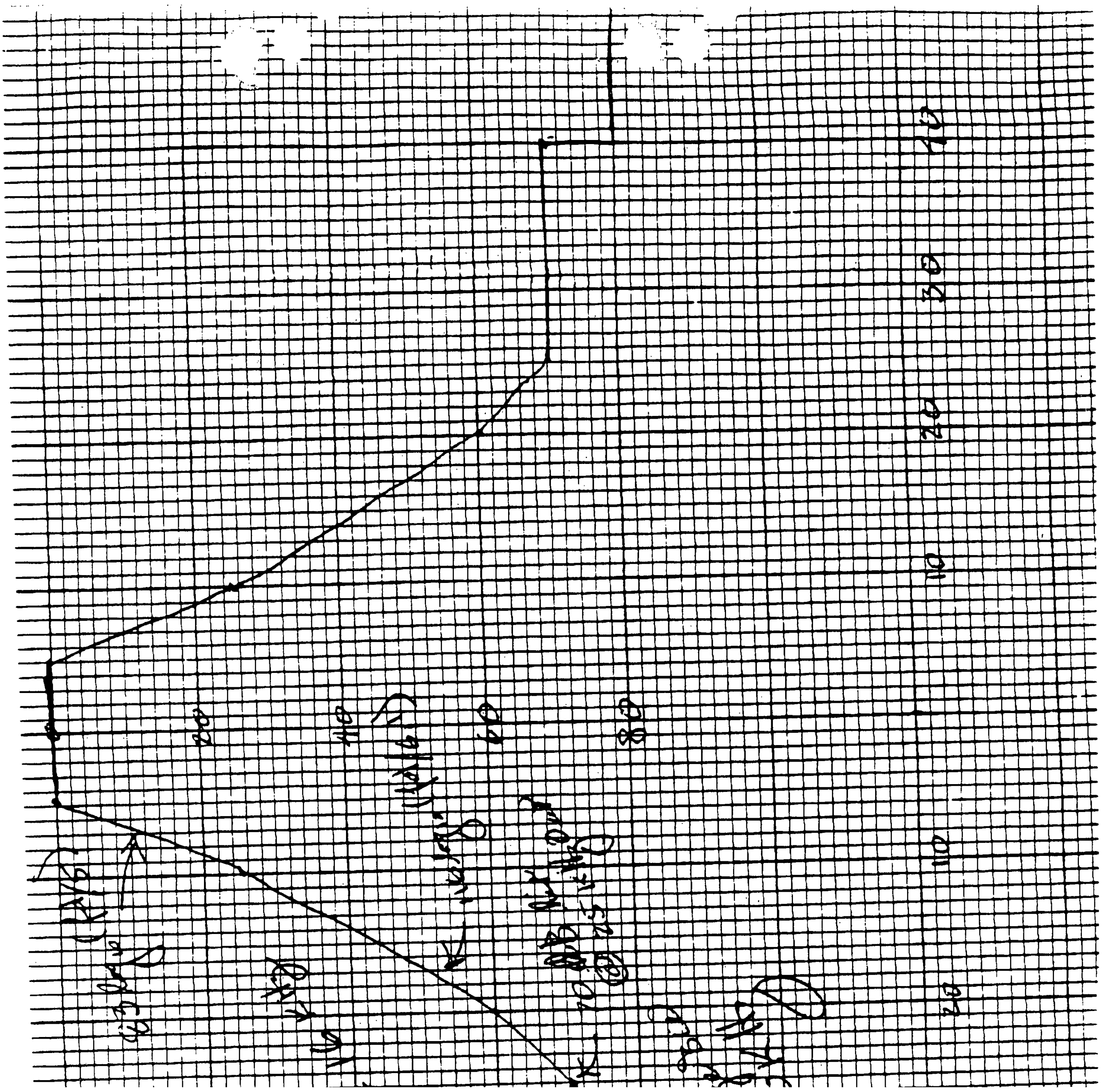
(ii) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 10 kHz up to and including 250 percent of the authorized band-

§ 22.108 Directional antennas.

(a) *Directional antennas required.* Rural radio stations, control stations, repeater stations, and dispatch stations shall use a directional antenna with the major lobe of radiation in the horizontal plane directed toward the receiving station or the passive reflector with which the station communicates. A multi- or omni-directional antenna may be authorized if necessary where a station communicates with more than one point.

(b) *Beam width required.* Stations required to use directional antennas shall meet the standards indicated below. Maximum beam width is for the major lobe of radiation at the half power points. Suppression is the minimum attenuation required for any secondary lobe signal and is referenced to the maximum signal in the main lobe.

Frequency range	Maximum beam width (degrees)	Suppression (dB)



03C0
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PATENT
Attorney Docket No. 03680.0143-00

MAIL ROOM
SEP 6 1995
52
PAT. & TRADEMARK OFF.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE #5

Pre Amdnt A
12-14-95
M.L.

In re Application of:	)	
William D. Hays et al.	)	
Serial No.: 08/480,718	)	Group Art Unit: Unassigned
Filed: June 7, 1995	)	Examiner: Unassigned
For: MULTICARRIER TECHNIQUES IN BANDLIMITED CHANNELS	)	

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

PRELIMINARY AMENDMENT

line 14, after "receiver" insert --and transmitter--.

which occurrence

N.E Page 4, line 22, after "receiving" insert --at least--.

Page 5, lines 18-20, change "the FCC emission limits mask for digital transmitters operating in the frequency bands 450.0 to 512.0 MHz and 929.0 to 932.0 MHz" to --an exemplary FCC

A3 emissions mask that requires the power spectral density to be attenuated at least 70 dB within 10 kHz from center frequency--.

Page 8, line 13, after "frequency" insert --deviation--.

Page 10, line 5, after "receiver" insert --and transmitter--; and

line 10, change "is also well" to --may also be--.

IN THE CLAIMS:

which occurrence

N.E Claim 5, line 5, after "receiving" insert --at least--.

REMARKS

The specification has been amended to provide more clarity to the Discussion of Related Art, to conform the Brief Description of the Drawings for Fig. 4 to the language used in the body of the specification, and to correct a number of minor matters in a manner fully consistent with the application as filed. Applicants thus submit that these amendments do not

Accordingly, Applicants respectfully request that the Examiner enter the amendments forthwith.

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW,
GARRETT & DUNNER, L.L.P.

By: Howard A. Kwon
Howard A. Kwon
Reg. No. 36,350

Dated: September 6, 1995

LAW OFFICES
FINNEGAN, HENDERSON
FARABOW, GARRETT
& DUNNER
1300 I STREET, N. W.
WASHINGTON, DC 20005
1-202-408-4000

Transaction History Date 1995-10-03
Date information retrieved from USPTO Patent Application Information Retrieval (PAIR) system records at www.uspto.gov

2611
121

0360 / 10-6-95

#8
TLR 1/19/96
I.D.S. w/ref

MAIL ROOM
OCT 3 1995
PAT. & TRADEMARK OFF.

PATENT
Attorney Docket No.: 03680/0143

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	
William D. Hays et al.	
Serial No.: 08/480,718	Group Art Unit: Unassigned
Filed: June 7, 1995	Examiner: Unassigned
For: MULTICARRIER TECHNIQUES IN BANDLIMITED CHANNELS	

RECEIVED
JAN -3 AM 7:05
GROUP 260

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

INFORMATION DISCLOSURE STATEMENT UNDER 37 C.F.R. § 1.97(b)

Pursuant to 37 C.F.R. §§ 1.56 and 1.97(b), Applicants bring to the attention of the Examiner the document listed on the attached PTO 1449 and referenced in the above-identified

MAIL ROOM
OCT 9 1995
PAT. & TRADEMARK OFF.

OMB No. 0651-0011

INFORMATION DISCLOSURE CITATION (Use several sheets if necessary)	Atty. Docket No. 03680.0143	Serial No. 08/480,718
	Applicant William D. Hays et al.	
	Filing Date June 7, 1995	Group Unassigned 2611

U.S. PATENT DOCUMENTS

*Examiner Initial		Document Number	Date	Name	Class	Sub Class	Filing Date If Appropriate
[illegible]		5,392,452	02/21/95	Davis	455	38.1	[illegible]

FOREIGN PATENT DOCUMENTS

		Document Number	Date	Country	Class	Sub Class	Translation Yes	Translation No

2601

12-8-95 2611 Tech 1/3/96

030

PATENT
Attorney Docket No. 03680.0143

MAIL ROOM
NOV 9 1995
52
PAT. & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:)
)
William D. Hays et al.)
) #6
[illegible]) Group Art Unit: Unassigned

[illegible]

UNITED STATES DEPARTMENT OF COMMERCE

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
08/480,718	06/07/95	HAYS W	03680.0143

26M1/0117

FINNEGAN HENDERSON FARABOW GARRETT &
DUNNER
1300 I STREET NW
WASHINGTON DC 20005-3315

EXAMINER	
NGUYEN, L	
ART UNIT	PAPER NUMBER
2611	7

DATE MAILED: 01/17/96

UNITED STATES DEPARTMENT OF COMMERCE

SERIAL NUMBER	FILING DATE	FIRST NAMED INVENTOR		ATTORNEY DOCKET NO.
08/480,718	06/07/95	HAYS	W	03680.0143

EXAMINER	
NGUYEN, L	
ART UNIT	**PAPER NUMBER**
2611	9

26M2/0209

FINNEGAN HENDERSON FARABOW GARRETT &
DUNNER
1300 I STREET NW
WASHINGTON DC 20005-3315

DATE MAILED: 02/09/96

This is a communication from the examiner in charge of your application.
COMMISSIONER OF PATENTS AND TRADEMARKS

for the examiner to consider the applicability of potential 35 U.S.C. § 102(f) or (g) prior art under 35 U.S.C. § 103.

3. Claims 5-7 are rejected under 35 U.S.C. § 103 as being unpatentable over the prior art admitted by Applicant in view of Chang (U.S. Patent 3,488,445).

As to claim 5, pages 1-3 of the admitted prior art teaches system of the admitted prior art with as modified by Chang in order to approach the theoretical maximum data rate (col. 2, lines 3-7 of Chang).

[redacted]

5. Claims 3-4 would be allowable if rewritten or amended to [redacted]

6. Claim 8 is objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent [redacted]

Seidel (U.S. Patent 3,914,554) teaches communication system employing spectrum folding.

Jasper et al. (U.S. Patent 5,343,499) teach quadrature amplitude modulation synchronization method.

Koontz (U.S. Patent 5,163,181) teaches multiple RF signal amplification method and apparatus.

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Lee Nguyen whose telephone number is (703) 308-5249. The examiner can normally be reached on Monday-Friday from 8:00 AM to 5:30 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Reinhard Eisenzopf, can be reached on (703) 305-4711. The fax phone number for this Group is (703) 305-9508.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the Group receptionist whose telephone number is (703) 305-4700.

Lee Nguyen Lee
February 1, 1996

Reinhard J. Eisenzopf 2-5-96
Supervisory Patent Examiner
Group 260

TO SEPARATE, HOLD TOP AND BOTTOM EDGES, SNAP–APART AND DISCARD CARBON

FORM PTO-892 (REV. 2-92) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	SERIAL NO.	GROUP ART UNIT	ATTACHMENT TO PAPER NUMBER
NOTICE OF REFERENCES CITED	08/480,718		9
	APPLICANT(S): Hays et al.		

U.S. PATENT DOCUMENTS

*		DOCUMENT NO.	DATE	NAME	CLASS	SUB-CLASS	FILING DATE IF APPROPRIATE
	A	4244047	1/6/81	Perkins	370	69	3/20/79
	B	3488445	1/6/70	Chang	370	69.1	11/14/66
	C	3914554	10/21/75	Seidel	179	15.55 R	5/18/73
	D	5343499	8/30/94	Jasper et al.	375	39	1/9/92
	E	5163181	11/10/92	Koontz	455	103	10/21/88
	F						
	G						
	H						
	I						
	J						
	K						

FOREIGN PATENT DOCUMENTS

SUB- PERTINENT

Gro. /117 #10/B TLR 8/21 Amd+F Ext(3

PATENT

Attorney Docket No.: 03680.0143

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	
William D. HAYS et al.	
Serial No.: 08/480,718	Group Art Unit: 2611
Filed: June 7, 1995	Examiner: L. Nguyen
For: MULTICARRIER TECHNIQUES IN BANDLIMITED CHANNELS	

8-22-96

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

AMENDMENT

In response to the Office Action dated February 9, 1996, the period of response having been extended for three months by the filing of a request for extension and fee payment filed concurrently herewith, please amend the application as follows:

IN THE SPECIFICATION:

Page 8, line 9, after "than" delete --the--.

IN THE CLAIMS:

Please amend claim 3 as follows:

Claim 3, line 6, after "said" insert --corresponding--.

LAW OFFICES
FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, L.L.P.
1300 I STREET, N. W.
WASHINGTON, DC 20005
202-408-4000

070 WJ 08/14/96 08480718

Attorney Docket No.: 03680.0143
Serial No.: 08/480,718

REMARKS

Specification

A minor editorial change has been made to the specification.

Claims

The Examiner has rejected claims 3-7 and objects to claim 8 insofar as it depends from claim 5. At the outset, Applicants acknowledge with appreciation the Examiner's indication that claims 1-4 and 8 are directed to allowable

Claims 5-7 are rejected under 35 U.S.C. § 103 in view of Chang and the admitted prior art. Applicants respectfully traverse the Examiner's obviousness rejections of these claims. Applicants submit that the claimed invention would not have been obvious to one of ordinary skill in the art based on the prior art of record.

Chang discloses a point-to-point wire line data transmission system that simultaneously transmits and simultaneously receives a plurality of multiplexed band-limited data signals over a line 49 using mutually orthogonal signaling channels. The Examiner believes that one of ordinary skill in the art would have arrived at Applicants' claimed "paging system" method in view of Chang's point-to-point wire line system and the admitted prior art. In reaching that determination, the Examiner expressly relies on Chang's disclosure of shaping the spectra of adjacent channels by virtue of their orthogonality so that they can overlap without producing interchannel interference. Applicants submit that Chang falls well short of the Applicants' claimed method.

LAW OFFICES
FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, L.L.P.
1300 I STREET, N. W.
WASHINGTON, DC 20005
202-408-4000

Unlike the method disclosed by Chang, the multicarrier paging system modulation technique claimed by Applicants requires "a plurality of mobile receiving units independently receiving one of said plurality of carriers." Thus, Applicants' method does not involve the simultaneous receipt of multiplexed orthogonal carriers over a simple transmission line, as disclosed by Chang. Rather, in Applicants' claimed method, a plurality of carriers are broadcasted over a plurality of individual subchannels spaced asymmetrically within a bandlimited channel. As described in Applicants' specification, the frequency spacings between adjacent carriers are smaller than the even channel. Similarly, no odd channel is overlapped with another odd channel. The even and odd channels are instead

Accordingly, Applicants submit that the method of claim 5 would not have been obvious to one or ordinary skill in the art in view of the prior art of record. In addition, dependent claims 6 and 7 are allowable at least by virtue of their dependency on claim 5.

In view of the foregoing amendments and remarks, Applicants respectfully request the reconsideration and reexamination of this application and the timely allowance of the pending claims.

If any fees are due in connection with the filing of this Amendment, please charge those fees to Deposit Account No. 06-0916.

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW,
GARRETT & DUNNER, L.L.P.

By: Howard A. Kwon
Howard A. Kwon
Reg. No. 36,350

Dated: August 9, 1996

LAW OFFICES
FINNEGAN, HENDERSON,
FARABOW, GARRETT
& DUNNER, L.L.P.
1300 I STREET, N. W.
WASHINGTON, DC 20005
202-408-4000

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

APPLICATION NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
08/480,718	06/07/95	HAYS	W 03580.0143

26M2/1029
FINNEGAN HENDERSON FARABOW GARRETT &
DUNNER
1300 I STREET NW
WASHINGTON DC 20005-3315

EXAMINER	
NGUYEN, L	
ART UNIT	**PAPER NUMBER**
2611	11

DATE MAILED: 10/29/96

This is a communication from the examiner in charge of your application.
COMMISSIONER OF PATENTS AND TRADEMARKS

OFFICE ACTION SUMMARY

☑ Responsive to communication(s) filed on 8/9/96.

☑ This action is **FINAL**.

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

A shortened statutory period for response to this action is set to expire 03 month(s), or thirty days, whichever is longer, from the mailing date of this communication. Failure to respond within the period for response will cause the application to become abandoned. (35 U.S.C. § 133). Extensions of time may be obtained under the provisions of 37 CFR [redacted]

☑ Claim(s) 1-7 and 9 is/are pending in the application.

Of the above, claim(s) ______ is/are withdrawn from consideration.

☑ Claim(s) 1-4 and 9 is/are allowed.

[redacted]

☐ Claim(s) ______ is/are rejected.

[redacted]

☐ Claims ______ are subject to restriction or election requirement.

Application Papers

☐ See the attached Notice of Draftsperson's Patent Drawing Review, PTO-948.

☐ The drawing(s) filed on ______ is/are objected to by the Examiner.

☐ The proposed drawing correction, filed on ______ is ☐ approved ☐ disapproved.

☐ The specification is objected to by the Examiner.

☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. § 119

☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d).

☐ All ☐ Some* ☐ None of the CERTIFIED copies of the priority documents have been

Part III DETAILED ACTION

Claim Rejections - 35 USC ° 103

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

> A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.
>
> Subject matter developed by another person, which qualifies as prior art only under subsection (f) or (g) of section 102 of this title, shall not preclude patentability under this section where the subject matter and the claimed invention were, at the time the invention was made, owned by the same person or subject to an obligation of assignment to the same person.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103, the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 C.F.R. 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of potential 35 U.S.C. 102(f) or (g) prior art under 35 U.S.C. 103.

2. Claims 5-7 are rejected under 35 U.S.C. 103 as being unpatentable over pages 2-3 of the prior art admitted by Applicant in view of Chang (U.S. Patent 3,488,445).

channel. The limitation of "a plurality of mobile receiving units independently receiving one of said plurality of carriers" has been addressed by the examiner in the previous paragraph. Second, regarding the argument of transmitting a plurality of carriers over a plurality of subchannels that are asymmetrically located within the mask defining a channel, Chang shows in figs. 4-5 that non-obviousness by attacking references individually where, as here, the rejections are based on combinations of references.

Therefore, from the responses stated above the examiner believes that the rejection of claim 5 is still proper.

5. THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 C.F.R. ° 1.136(a).

A SHORTENED STATUTORY PERIOD FOR RESPONSE TO THIS FINAL ACTION IS SET TO EXPIRE THREE MONTHS FROM THE DATE OF THIS ACTION. IN THE EVENT A FIRST RESPONSE IS FILED WITHIN TWO MONTHS OF THE MAILING DATE OF THIS FINAL ACTION AND THE ADVISORY ACTION IS NOT MAILED UNTIL AFTER THE END OF THE THREE-MONTH SHORTENED STATUTORY PERIOD, THEN THE SHORTENED STATUTORY PERIOD WILL EXPIRE ON THE DATE THE ADVISORY ACTION IS MAILED, AND ANY EXTENSION FEE PURSUANT TO 37 C.F.R. ° 1.136(a) WILL BE CALCULATED FROM THE MAILING DATE OF THE ADVISORY ACTION. IN NO EVENT WILL THE STATUTORY PERIOD FOR RESPONSE EXPIRE LATER THAN SIX MONTHS FROM THE DATE OF THIS FINAL ACTION.

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Lee Nguyen whose telephone number is (703) 308-5249. The examiner can

[redacted]

receptionist whose telephone number is (703) 305-4700

[redacted]

The drawings submitted with this application were declared informal by the applicant. Accordingly they have not been reviewed by a draftsperson at this time. When formal drawings are submitted, the draftsperson will perform a review.

Direct any inquires concerning drawing review to the Drawing Review Branch (703) 305-8404.

SUBSTITUTE PTO-948

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1/28/97
(NE)
entered

Corres. and Mail
BOX AF

MAIL ROOM
JAN 21 1997

BOX AF
RESPONSE UNDER 37 C.F.R.§ 1.116
EXPEDITED PROCEDURE
EXAMINING GROUP 2611

PATENT
Attorney Docket No. 03680-0143

[redacted]

Attorney Docket No.: 03680.0143
Serial No.: 08/480,718

REMARKS

The Examiner has rejected claims 5-7 under 35 U.S.C. § 103 as obvious over the prior art admitted by Applicants in view of Chang. The Examiner has allowed claims 1-4 and 9.

To advance prosecution of this application, Applicants cancel rejected claims 5-7, thereby placing the application in condition for allowance upon entry of this amendment. Allowance of this application is requested.

If any fees are due in connection with the filing of

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

SERIAL NUMBER	FILING DATE	FIRST NAMED APPLICANT	ATTORNEY DOCKET NO.
08/480,718	06/07/95	HAYS W	03

26M2/0204
FINNEGAN HENDERSON FARABOW GARRETT &
DUNNER
1300 I STREET NW
WASHINGTON DC 20005-3315

EXAMINER	
NGUYEN, L	
ART UNIT	**PAPER NUMBER**
2611	13

DATE MAILED: 02/04/97

NOTICE OF ALLOWABILITY

PART I.

1. ☑ This communication is responsive to Amendment filed 1/21/97.
2. ☑ All the 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 And Issue Fee Due or other appropriate communication will be sent in due course.
3. ☑ The allowed claims are 1-4 and 9.
4. ☐ The drawings filed on ______ are acceptable.
5. ☐ Acknowledgment is made of the claim for priority under 35 U.S.C. 119. The certified copy has [_] been received. [_] not been received. [_] been filed in parent application Serial No. ______, filed on ______.
6. ☐ Note the attached Examiner's Amendment.
7. ☐ Note the attached Examiner Interview Summary Record, PTOL-413.

[redacted]

9. ☐ Note the attached NOTICE OF REFERENCES CITED, PTO-892.
10. ☐ Note the attached INFORMATION DISCLOSURE CITATION, PTO-1449.

PART II.

A SHORTENED STATUTORY PERIOD FOR RESPONSE to comply with the requirements noted below is set to EXPIRE THREE MONTHS FROM THE "DATE MAILED" indicated on this form. Failure to timely comply will result in the ABANDONMENT of this application. Extensions of time may be obtained under the provisions of 37 CFR 1.136(a).

1. ☐ Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL APPLICATION, PTO-152, which discloses that the oath or declaration is deficient. A SUBSTITUTE OATH OR DECLARATION IS REQUIRED.
2. ☑ APPLICANT MUST MAKE THE DRAWING CHANGES INDICATED BELOW IN THE MANNER SET FORTH ON THE REVERSE SIDE OF THIS PAPER.
   a. ☑ Drawing informalities are indicated on the NOTICE RE PATENT DRAWINGS, PTO-948, attached hereto or to Paper No. 5. CORRECTION IS REQUIRED.
   b. ☐ The proposed drawing correction filed on ______ has been approved by the examiner. CORRECTION IS REQUIRED.
   c. ☐ Approved drawing corrections are described by the examiner in the attached EXAMINER'S AMENDMENT. CORRECTION IS REQUIRED.
   d. ☑ Formal drawings are now REQUIRED.

Any response to this letter should include in the upper right hand corner, the following information from the NOTICE OF ALLOWANCE AND ISSUE FEE DUE: ISSUE BATCH NUMBER, DATE OF THE NOTICE OF ALLOWANCE, AND SERIAL NUMBER.

Attachments:

- _ Examiner's Amendment
- _ Examiner Interview Summary Record, PTOL-413
- _ Reasons for Allowance
- _ Notice of References Cited, PTO-892
- _ Information Disclosure Citation, PTO-1449
- _ Notice of Informal Application, PTO-152
- _ Notice re Patent Drawings, PTO-948
- _ Listing of Bonded Draftsmen
- _ Other

UNITED STATES DEPARTMENT OF COMMERCE
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Address: Box ISSUE FEE
ASSISTANT COMMISSIONER FOR PATENTS
WASHINGTON, D.C. 20231

NOTICE OF ALLOWANCE AND ISSUE FEE DUE

26M2/0204

FINNEGAN HENDERSON FARABOW GARRETT &

1300 I STREET NW
WASHINGTON DC 20005-3315

APPLICATION NO.	FILING DATE	TOTAL CLAIMS	EXAMINER AND GROUP ART UNIT		DATE MAILED
08/480,718	06/07/95	005	NGUYEN, L	2611	02/04/97
First Named Applicant	HAYS,		WILLIAM D.		

TITLE OF INVENTION MULTICARRIER TECHNIQUES IN BANDLIMITED CHANNELS

ATTY'S DOCKET NO.	CLASS-SUBCLASS	BATCH NO.	APPLN. TYPE	SMALL ENTITY	FEE DUE	DATE DUE
2 03680.0143	455-103.000	J12	UTILITY	NO	$1290.00	05/05/97

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

THE ISSUE FEE 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.

HOW TO RESPOND 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 changed, pay twice the amount of the FEE DUE shown and notify the Patent and Trademark Office of the change in status, or

If the SMALL ENTITY is shown as NO:

A. Pay FEE DUE shown above, or

MAIL ROOM
MAR 3 1997
PAT. & TRADEMARK OFF.

OAM #14 AO B

PATENT
Attorney Docket No.: 03680.0143

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	
William D. HAYS et al.	Group Art Unit: 2611
Serial No.: 08/480,718	Examiner: L. Nguyen
Filed: June 7, 1995	NOTICE OF ALLOWANCE DATED: February 4, 1997
For: MULTICARRIER TECHNIQUES IN BANDLIMITED CHANNELS	Batch No.: J12

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

SUBMISSION OF FORMAL DRAWINGS

Subject to the approval of the Examiner, please replace the informal drawings with the formal drawings filed herewith. If the formal drawings for any reason are not in full compliance with the pertinent statutes and regulations, please so advise the undersigned.

If any fees are due in connection with the submission of these formal drawings, please charge those fees to Deposit Account No. 06-0916.

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW,
GARRETT & DUNNER, L.L.P.

By: Howard A. Kwon
Howard A. Kwon
Reg. No. 36,350

LAW OFFICES
FINNEGAN, HENDERSON,
FARABOW, GARRETT
& DUNNER, L.L.P.
1300 I STREET, N. W.
WASHINGTON, D. C. 20005
202-408-4000

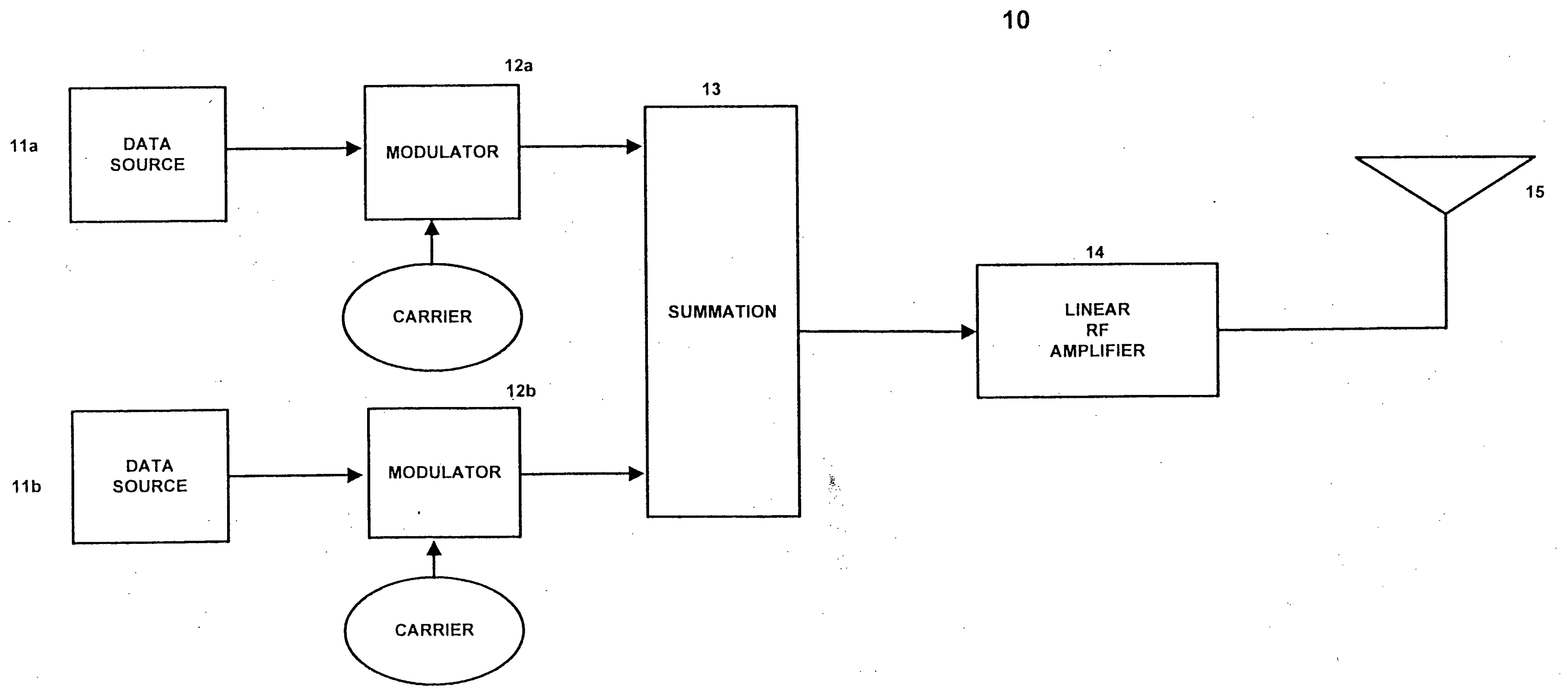
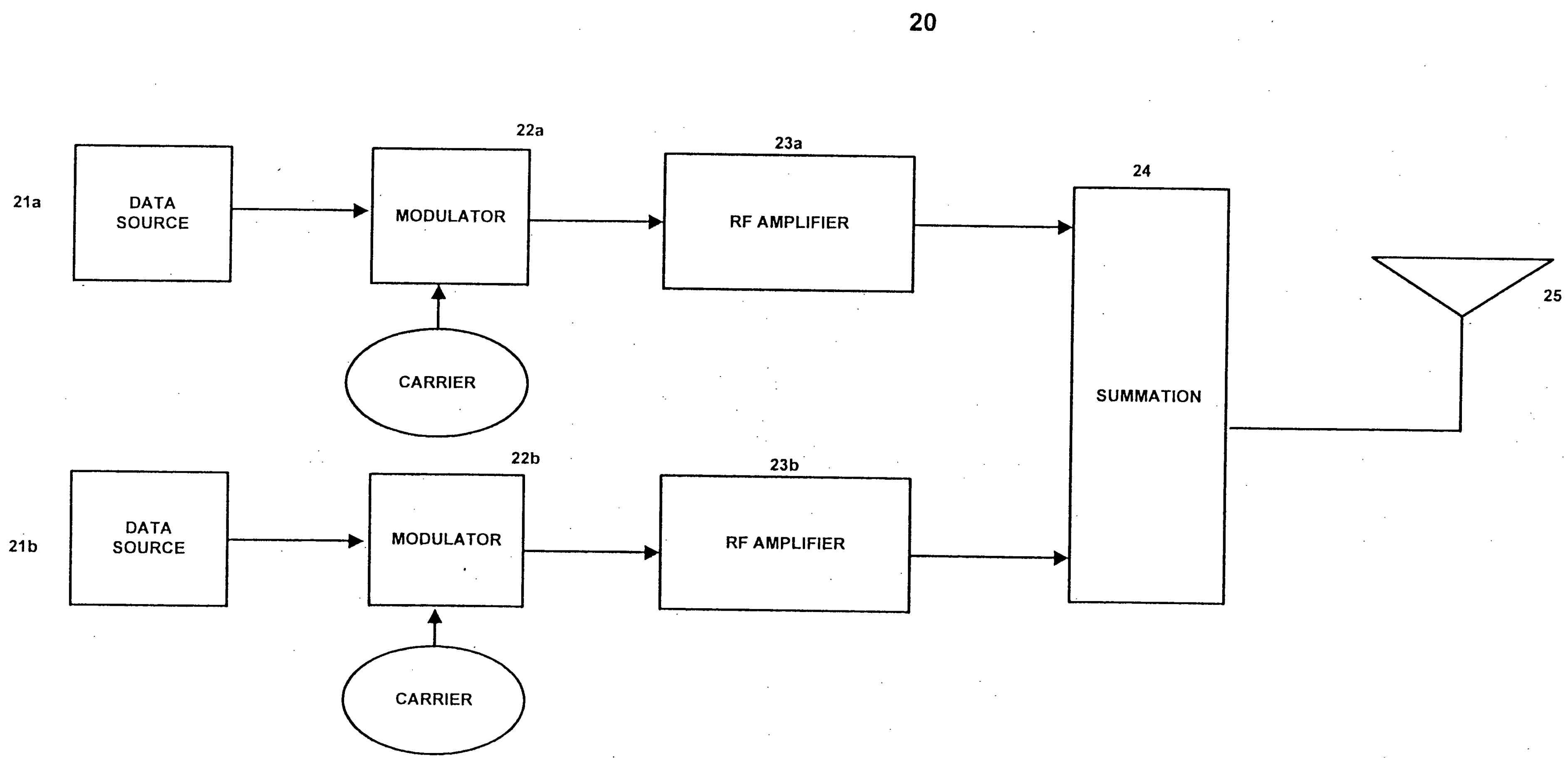


FIGURE 1

5659891

4807 RE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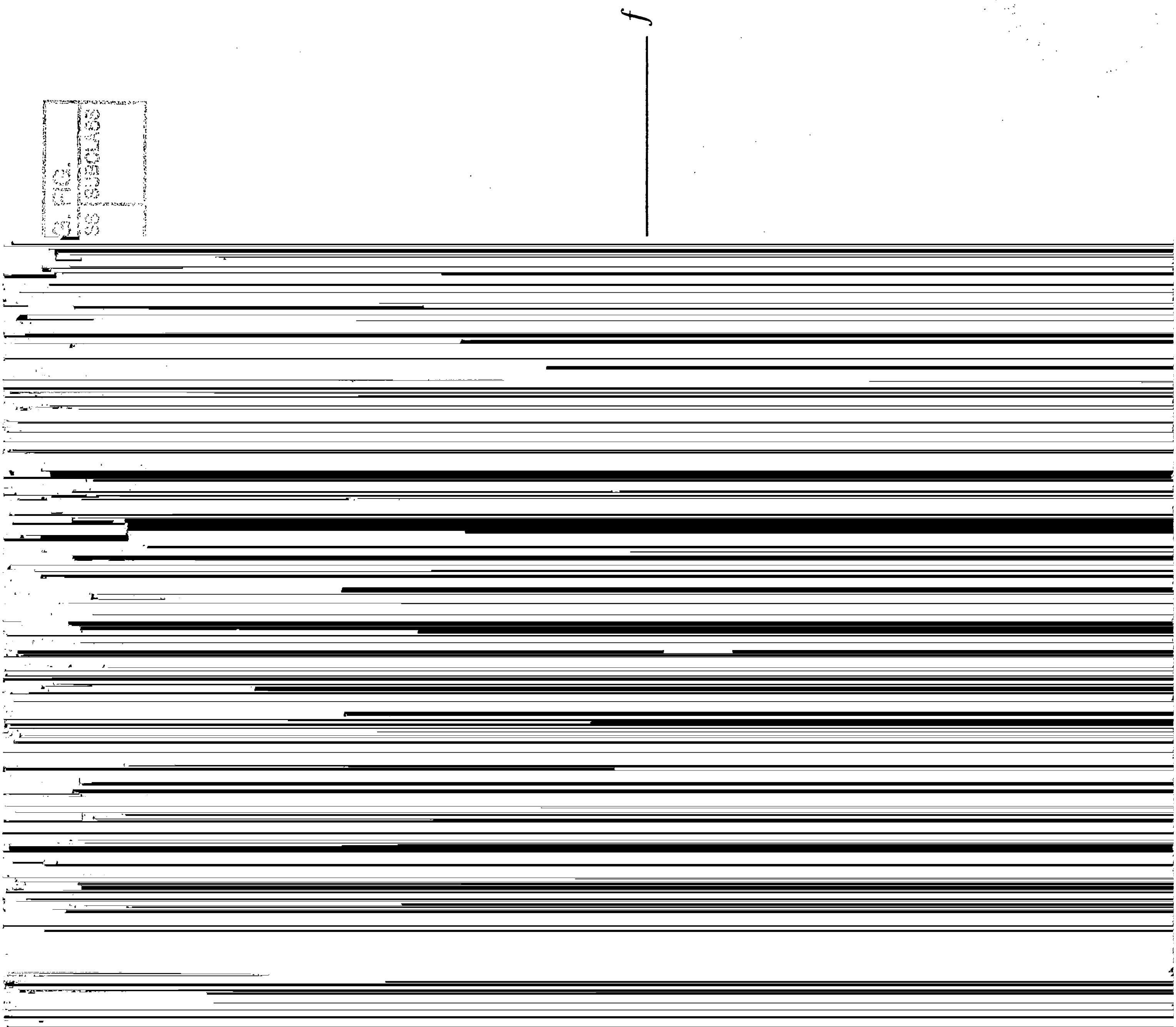
21a
DATA SOURCE
22a
MODULATOR
CARRIER
23a
RF AMPLIFIER
21b
DATA SOURCE
22b
MODULATOR
CARRIER
23b
RF AMPLIFIER
24
SUMMATION
25

FIGURE 2



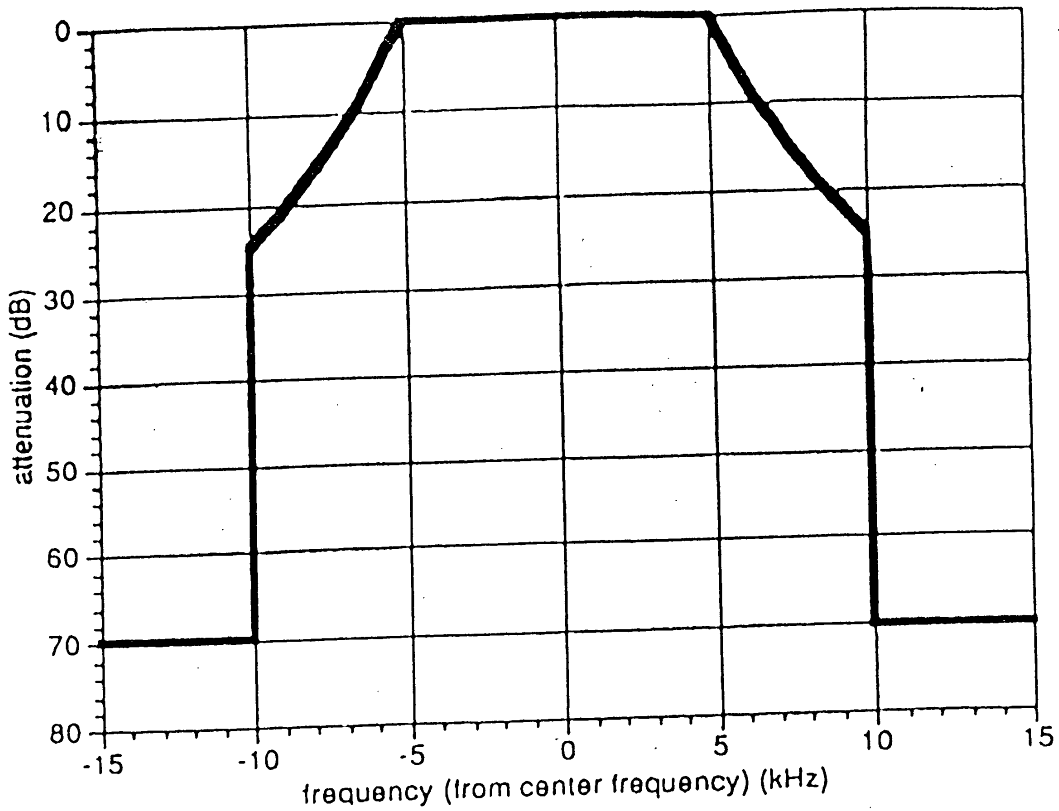
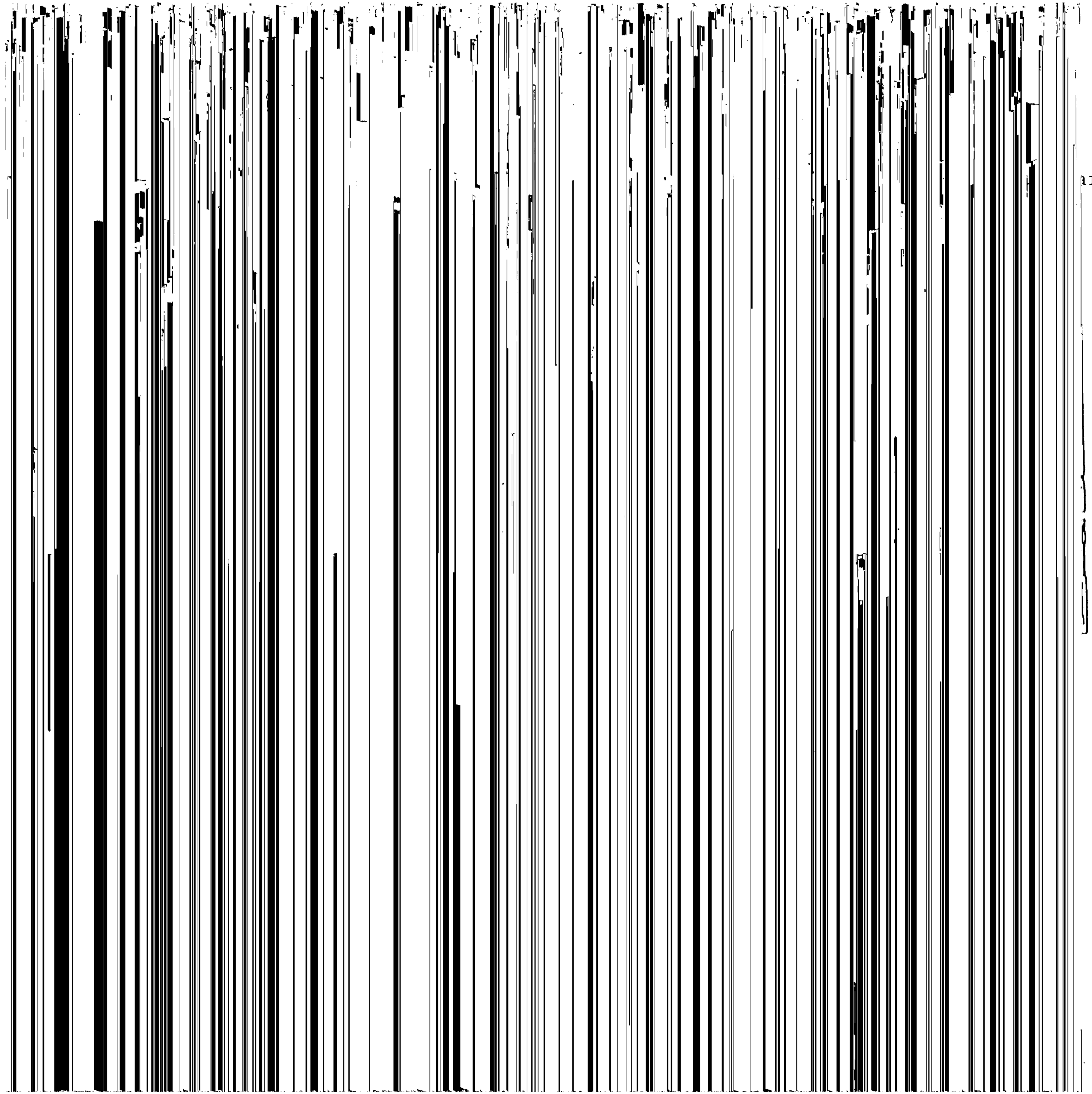

attenuation (dB)
0
10
20
30
40
50
60
70
80
-15
-10
-5
0
5
10
15
frequency (from center frequency) (kHz)

FIGURE 4


arrier
Freq = 10004.9
Db = -70.0818
Phase = 1.96349

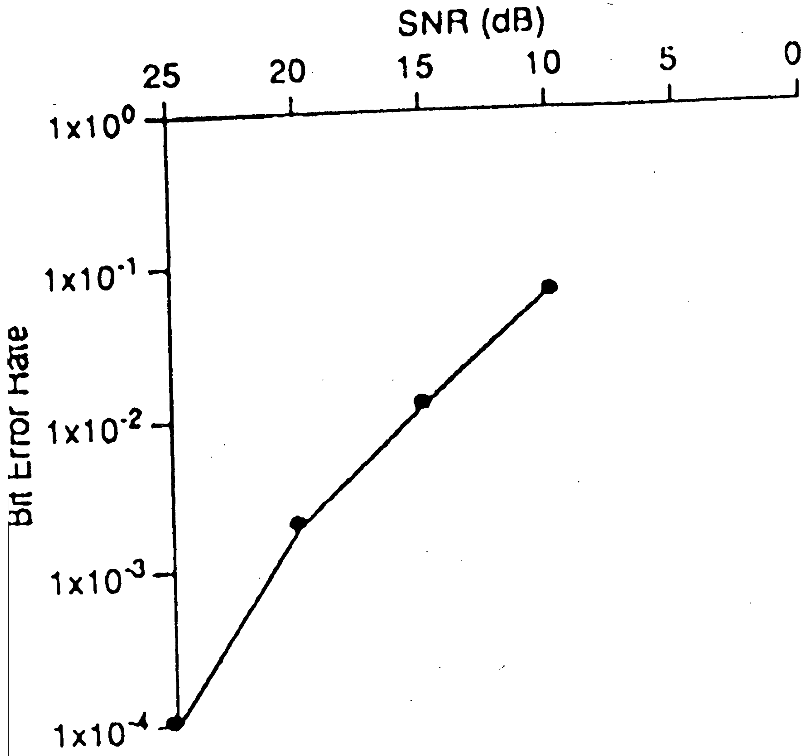
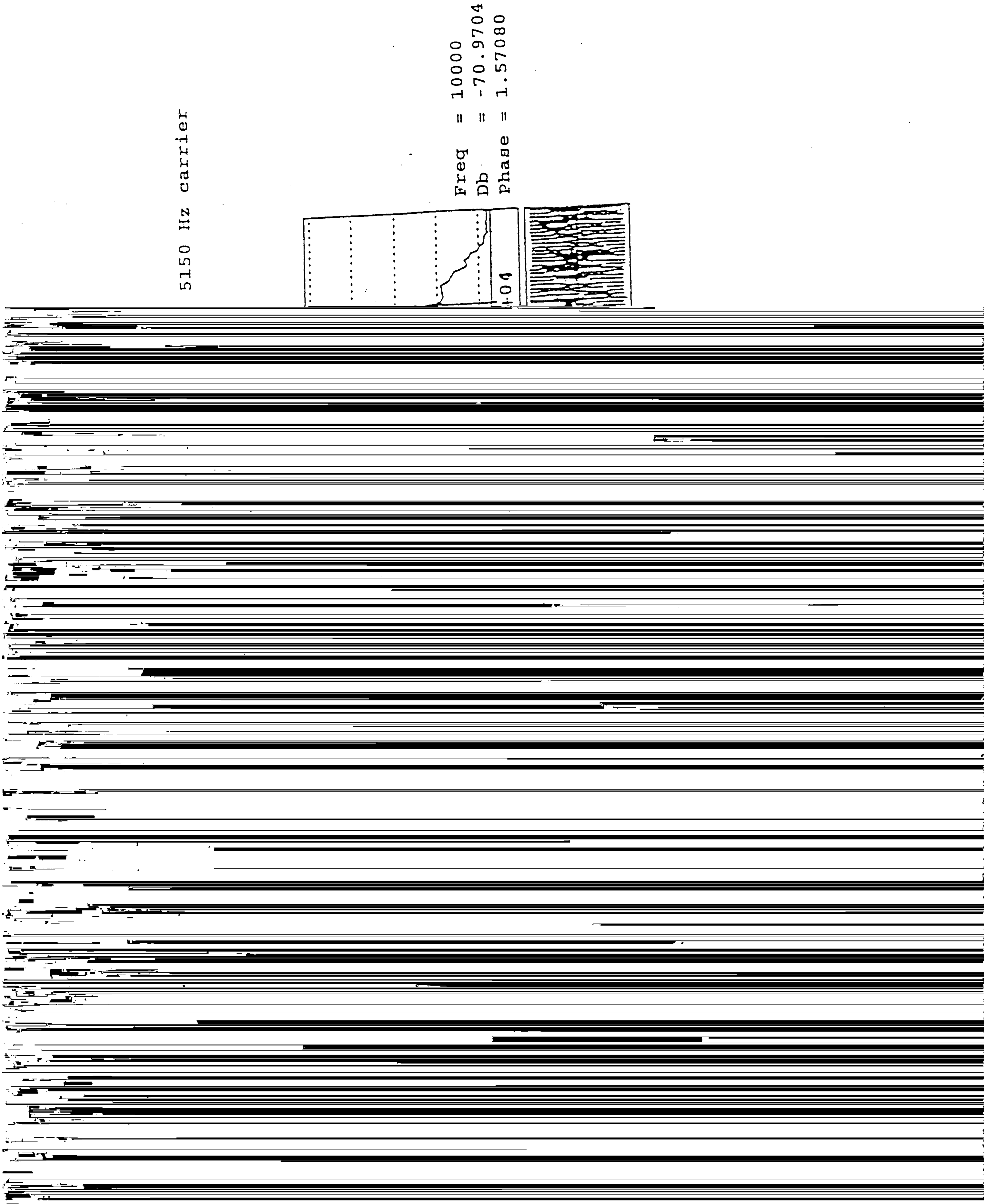
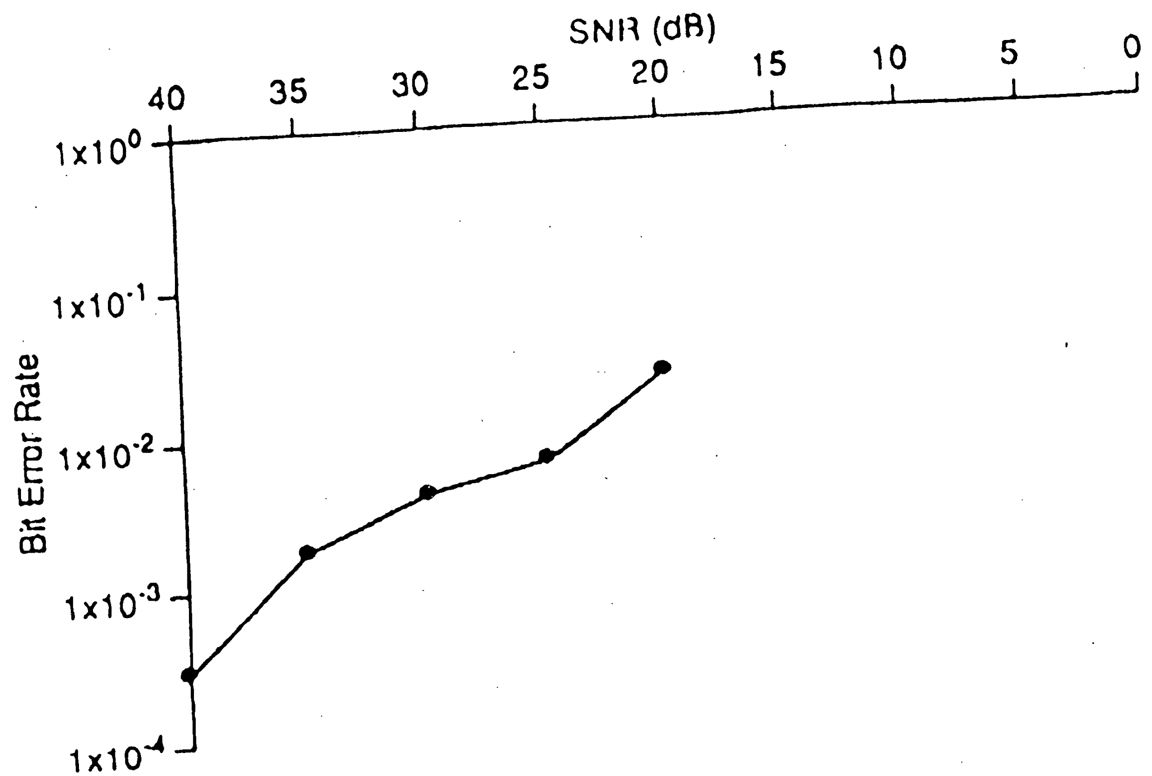

SNR (dB)
25
20
15
10
5
0
1x10⁰
1x10⁻¹
1x10⁻²
1x10⁻³
1x10⁻⁴
Bit Error Rate

FIGURE 5B

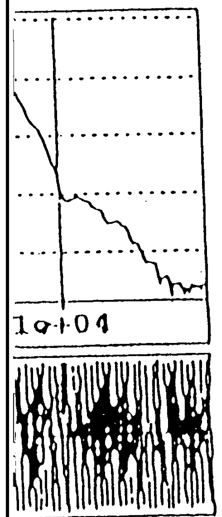

5150 Hz carrier
Freq = 10000
Db = -70.9704
Phase = 1.57080
.04



SNR (dB)
40
35
30
25
20
15
10
5
0
Bit Error Rate
1x10^0
1x10^-1
1x10^-2
1x10^-3
1x10^-4

FIGURE 6B

e, 4750 Hz carrier



Freq = 10000
Db = -70.2824
Phase = 1.01049e-05

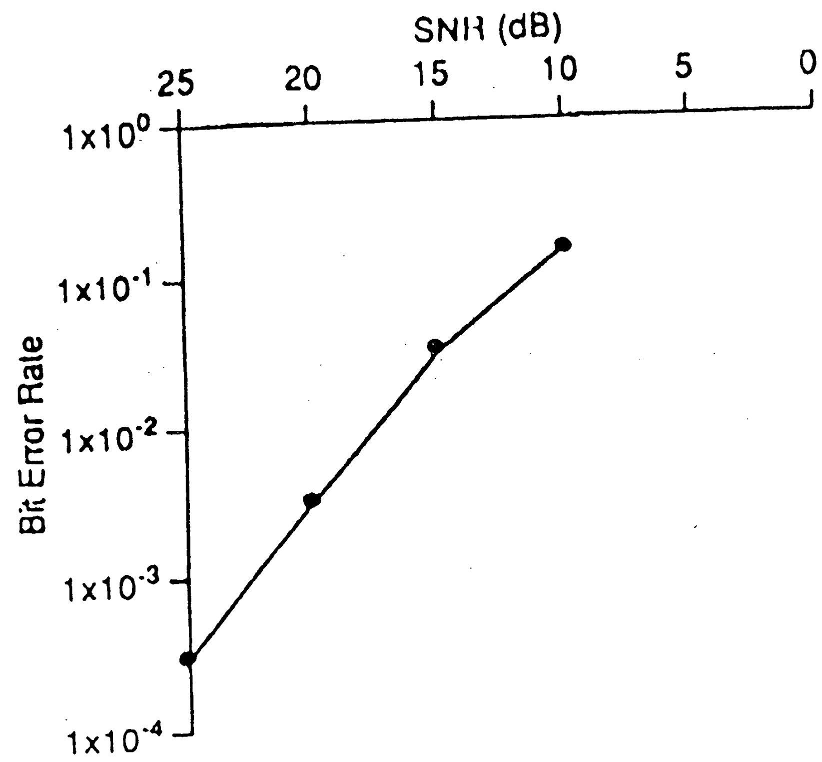

SNR (dB)
25
20
15
10
5
0
1x10^0
1x10^-1
1x10^-2
1x10^-3
1x10^-4
Bit Error Rate

FIGURE 7B

Form PTO 948 (Rev. 10-94) U.S. DEPARTMENT OF COMMERCE - Patent and Trademark Office Application No. 08/480718

NOTICE OF DRAFTSPERSON'S PATENT DRAWING REVIEW

PTO Draftpersons review all originally filed drawings regardless of whether they are designated as formal or informal. Additionally, patent Examiners will review the drawings for compliance with the regulations. Direct telephone inquiries concerning this review to the Drawing Review Branch, 703-305-8404.

The drawings filed (insert date) 3/3/97, are
A. ✓ not objected to by the Draftsperson under 37 CFR 1.84 or 1.152.
B. ✓ objected to by the Draftsperson under 37 CFR 1.84 or 1.152 as indicated below. The Examiner will require submission of new, corrected

___ View and enlarged view not labled separatly or properly.
Fig(s)____________
Sectional views. 37 CFR 1.84 (h) 3
Hatching not indicated for sectional portions of an object

#16 Am

(1) Am

PATENT
Attorney Docket No.: 03680.0143

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:)
)

If any fees are due in connection with the submission of these formal drawings, please charge those fees to Deposit Account No. 06-0916.

Respectfully submitted,

FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, L.L.P.

By: ______________________
Howard A. Kwon
Reg. No. 36,350

Dated: April 3, 1997
Enclosures: Figures - 5A, 6A, 7A

LAW OFFICES
FINNEGAN, HENDERSON, FARABOW, GARRETT & DUNNER, L.L.P.
1300 I STREET, N.W.
WASHINGTON, DC 20005
202-408-4000

FIGURE 6A

ation, 6.4k bps bit rate, 5150 Hz carrier

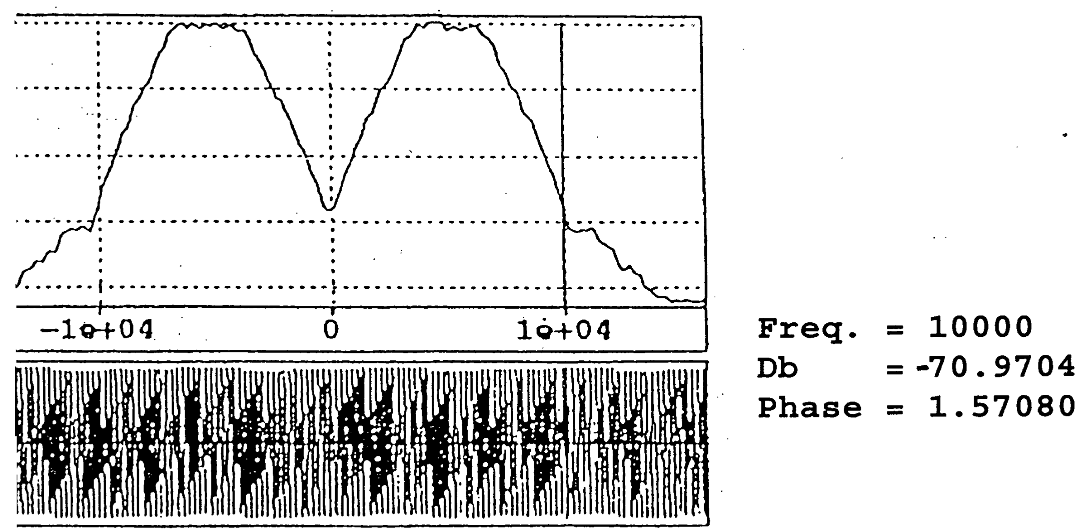
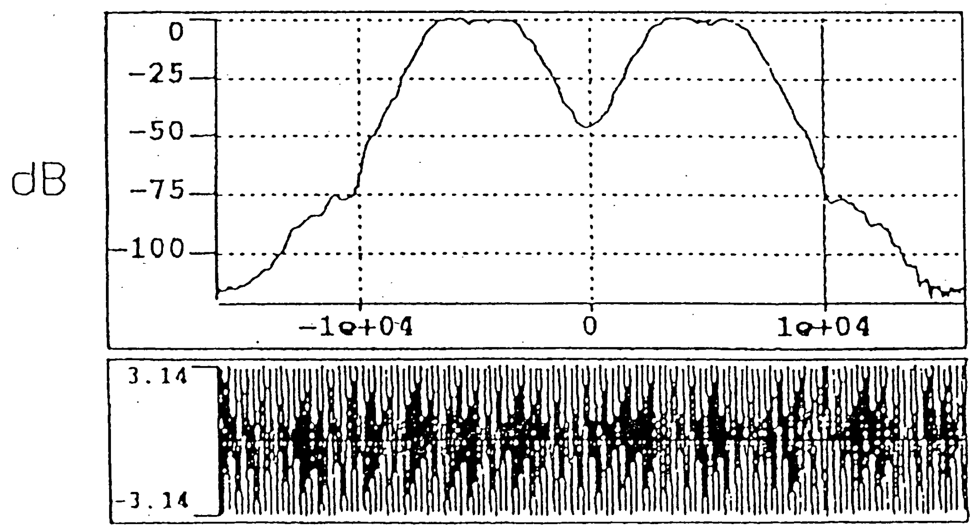


FIGURE 7A

2100 max deviation, 6.4k bps bit rate, 4750 Hz carrier



Freq. = 10000
Db = -70.2824
Phase = 1.01049e-05

10

MAILING INSTRUCTIONS: This form should be u[illegible] transmitting the ISSUE FEE. Blocks 2 through 6 sholud be [illegible]eted where appropriate. All futher correspondence including the issue Fee Receipt, the Patent, advance [illegible] and notification of maintenance fees will be mailed to ad[illegible]sses entered in Block 1 unless you direct otherwise, by: (a) specifyinga new correspondence address in Block 3 below; or (b) providing the PTO with a separate "FEE ADDRESS" for maintenance fee notifications with the payment of issue Fee or thereafter. **See reverse for Certificate of Mailing, below.**

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.

Thomson Innovation Patent Export, 2013-06-13 10:59:11 -0500

Table of Contents

Family 1/1

1 record(s) per family

Record 1/1 US5659891A Multicarrier techniques in bandlimited channels

Publication Number: US5659891A 19970819

Title: Multicarrier techniques in bandlimited channels

Title - DWPI: Paging carrier operating method for mobile paging service has frequency difference between centre frequem
is more than half frequency difference between centre frequencies of each adjacent carrier

Priority Number: US1995480718A

Priority Date: 1995-06-07

Application Number: US1995480718A

Application Date: 1995-06-07

Publication Date: 1997-08-19

IPC Class Table:

IPC	Section	Class	Subclass	Class Group	Subgroup
H04L002726	H	H04	H04L	H04L0027	H04L002726

IPC Class Table - DWPI:

IPC - DWPI	Section - DWPI	Class - DWPI	Subclass - DWPI	Cl DWPI	Subgroup - DWPI
H04B000102	H	H04	H04B	H04B0001	H04B000102

Assignee/Applicant: Mobile Telecommunication Q

JP F Terms:

JP FI Codes:

Assignee - Original: Mobile Telecommunication Technologies

Any CPC Table:

Type	Invention	Additional	Version	Office
Current	H04L 27/2601	-	20130101	EP

ECLA: H04L002726M

Abstract:

A method of multicarrier modulation using co-located transmitters to achieve higher transmission capacity for mobile paging and two-way digital communication in a manner consistent with FCC emission mask limits. Co-location of the transmitters obviates the need for stringent, symmetrical subchannel interference protection and provides for a wider range of operating parameters, including peak frequency deviation, bit rate, and carrier frequencies, to obtain optimal transmission performance.

Language of Publication: EN

INPADOC Legal Status Table:

Gazette Date	Code	INPADOC Legal Status Impact
2009-07-30	SULP	+
Description: SURCHARGE FOR LATE PAYMENT		
2009-07-30	FPAY	+
Description: FEE PAYMENT		
2009-02-23	REMI	-
Description: MAINTENANCE FEE REMINDER MAILED		
2007-03-14	AS	-
Description: ASSIGNMENT NEWCASTLE PARTNERS, L.P., TEXAS SECURITY AGREEMENT; ASSIGNORS:BELL INDUSTRIES, INC.; BELL INDUSTRIES, INC.; REEL/FRAME:019009/0529 2007-03-12		
2007-01-31	AS	-
Description: ASSIGNMENT WELLS FARGO FOOTHILL, INC., AS AGENT, CALIFORNIA PATENT SECURITY AGREEMENT; ASSIGNORS:BELL INDUSTRIES, INC., A CALIFORNIA CORPORATION; BELL INDUSTRIES, INC., A MINNESOTA CORPORATION; REEL/FRAME:018826/0503 2007-01-31		
2007-01-24	AS	-
Description: ASSIGNMENT SKYTEL CORP., VIRGINIA MERGER; ASSIGNOR:SKYTEL COMMUNICATIONS, INC.; REEL/FRAME:018797/0318 2004-12-31		
2005-02-22	FPAY	+
Description: FEE PAYMENT		

2004-08-23	AS	-
Description: ASSIGNMENT SKYTEL COMMUNICATIONS, INC., VIRGINIA CHANGE OF NAME; ASSIGNOR:MOBILE TELECOMMUNICATIONS TECHNOLOGIES CORP.; REEL/FRAME:015074/0648 1998-05-21		
2001-03-13	REMI	-
Description: MAINTENANCE FEE REMINDER MAILED		
2001-02-16	FPAY	+
Description: FEE PAYMENT		
1995-09-21	AS	-
Description: ASSIGNMENT MOBILE TELECOMMUNICATIONS TECHNOLOGIES, MISSISSIPP ASSIGNMENT OF ASSIGNORS INTEREST; ASSIGNORS:HAYS, WILLIAM D.; CAMERON, DENNIS; ROEHR, WALTER; REEL/FRAME:007721/0991; SIGNING DATES FROM 19950911 TO 19950920		

Post-Issuance (US):

Reassignment (US) Table:

Assignee	Assignor	Date Signed	Reel/Frame	Date
NEWCASTLE PARTNERS L.P.,DALLAS,TX,US	BELL INDUSTRIES, INC.	2007-03-12	019009/0529	2007-03-14
	BELL INDUSTRIES, INC.	2007-03-12		
Conveyance: SECURITY AGREEMENT				
Correspondent: RANDY M. FRIEDBERG, ESQ. OLSHAN GRUNDMAN FROME ROSENSZWEIG ET AL PARK AVENUE TOWER 65 EAST 55TH STREET NEW YORK, NY 10022				
WELLS FARGO FOOTHILL INC. AS AGENT,SANTA MONICA,CA,US	BELL INDUSTRIES, INC., A CALIFORNIA CORPORATION	2007-01-31	018826/0503	2007-01-31
	BELL INDUSTRIES, INC., A MINNESOTA CORPORATION	2007-01-31		
Conveyance: PATENT SECURITY AGREEMENT				
Correspondent: PAUL HASTINGS JANOFSKY & WALKER LLP 515 SOUTH FLOWER STREET, 25TH FLOOR LOS ANGELES, CA 90071				
SKYTEL CORP.,ASHBURN,VA,US	SKYTEL COMMUNICATIONS, INC.	2004-12-31	018797/0318	2007-01-24

Conveyance: MERGER (SEE DOCUMENT FOR DETAILS).				
Correspondent: EDEN STRIGHT 1515 COURTHOUSE ROAD, SUITE 500 ARLINGTON, VA 22201-2909				
SKYTEL COMMUNICATIONS INC.,ASHBURN,VA,US	MOBILE TELECOMMUNICATIONS TECHNOLOGIES CORP.	1998-05-21	015074/0648	2004-08-23
Conveyance: CHANGE OF NAME (SEE DOCUMENT FOR DETAILS).				
Correspondent: MICHAEL A. WRENN 9854/003 1133 19TH STREET NW WASHINGTON, D.C. 20036				
MOBILE TELECOMMUNICATIONS TECHNOLOGIES,JACKSON, MS,US	HAYS, WILLIAM D.	1995-09-20	007721/0991	1995-09-21
	CAMERON, DENNIS	1995-09-18		
	ROEHR, WALTER	1995-09-11		
Conveyance: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS).				
Correspondent: HOWARD A. KWON FINNEGAN, HENDERSON ET AL. 1300 I STREET WASHINGTON, D.C. 20005-3315				

Maintenance Status (US):

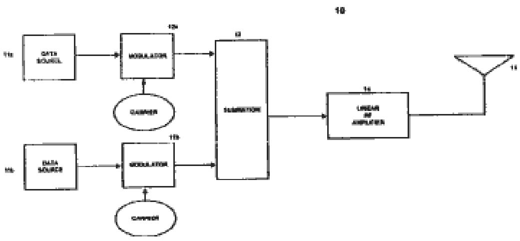
Litigation (US): 2013-04-02 2013 Mobile Telecommunications Technologies, LLC Apple, Inc. E.D. Texas 2:13cv00258

Opposition (EP):

License (EP):

EPO Procedural Status:

Front Page Drawing:



USPTO Maintenance Report

Patent Bibliographic Data					06/13/2013 11:53 AM
Patent Number:	5659891		Application Number:	08480718	
Issue Date:	08/19/1997		Filing Date:	06/07/1995	
Title:	MULTICARRIER TECHNIQUES IN BANDLIMITED CHANNELS				
Status:	4th, 8th and 12th year fees paid			Entity:	LARGE
Window Opens:	N/A	Surcharge Date:	N/A	Expiration:	N/A
Fee Amt Due:	Window not open	Surchg Amt Due:	Window not open	Total Amt Due:	Window not open
Fee Code:					
Surcharge Fee Code:					
Most recent events (up to 7):	07/30/2009 07/30/2009 02/23/2009 02/22/2005 03/13/2001 02/20/2001 02/16/2001	11.5 yr surcharge- late pmt w/in 6 mo, Large Entity. Payment of Maintenance Fee, 12th Year, Large Entity. Maintenance Fee Reminder Mailed. Payment of Maintenance Fee, 8th Year, Large Entity. Maintenance Fee Reminder Mailed. Payor Number Assigned. Payment of Maintenance Fee, 4th Year, Large Entity. --- End of Maintenance History ---			
Address for fee purposes:	COMPUTER PACKAGES, INC. 414 HUNGERFORD DRIVE ROCKVILLE MD 20850				