No.	Date	Item
1	10/27/00	AM Auction 32 Mutually Exclusive Applicants Subject to Auction
2	12/6/00	CFA, EH: Crows or Swans? Why pay extra for analog?
3	8/7/00	NAB TechCheck, NAB Ad Hoc Group Urges FCC to Eliminate Field Proofs for Certain AM Arrays
4	7/25/00	Forfeiture Order, WRHC, Coral Gables, FL
5	5/2/00	6:22 PM MOM email
6	5/2/00	7:22 PM MOM email
7	3/28/00	Engineering Check Sheet, Category D
8	3/28/00	Office Memo re Local Channel AM Station Apps
9	3/27/00	Office Memo re New AM Technical Box Clarification
10	3/8/00	CDE Memo re prop MOM conditions
11	3/1/00	AFCCE DA 99-2605
12	2/29/00	CDE Memo re NAB Industry Meeting on MOM
13	2000	MININEC Development Historical Note
14	2000	IEEE Newsletter, Feature Article, Electromagnetic Surface Waves
15	2000	Electromagnetic Waves and Radiating Systems, Edward C. Jordan

AM 1
2000

PUBLIC NOTICE

FEDERAL COMMUNICATIONS COMMISSION
445 12th STREET, S.W.
WASHINGTON, D.C. 20554

News Media Information: (202) 418-0500
Fax-On-Demand: (202) 418-2830
Internet: http://www.fcc.gov
ftp.fcc.gov

DA 00-2416
October 27, 2000

AM Auction No. 32 Mutually Exclusive Applicants Subject to Auction

Settlement Period for Groups which Include a Major Modification Applicant

Filing Period for Section 307(b) Submissions

Report No. AUC-00-32-E (Auction No. 32)

On November 19, 1999, the Mass Media Bureau and the Wireless Telecommunications Bureau (collectively the "Bureaus") announced a five-day period, from January 24, 2000 to January 28, 2000, for the filing of applications for new AM stations and major modifications to authorized AM stations.[1] The filing window was subsequently extended to February 1, 2000.[2] By this Public Notice, the Bureaus provide, as Attachment A, a list of all applications received during the filing window, as extended, that are mutually exclusive with other applications submitted in the filing window.[3] Since the applications

[1] *AM Auction Filing Window and Application Freeze; Notice and Filing Requirements Regarding January 24 – 28, 2000 Window for Certain AM Construction Permits; Notice Regarding Freeze on the Acceptance of AM Minor Change Construction Permits from December 24, 1999 to January 21, 2000, Public Notice*, 14 FCC Rcd 19490 (1999) ("*November 19, 1999, Public Notice*"). Since any mutually exclusive application filed during the window would be subject to the Commission's auction procedures, *see* note 4 *infra*, applicants were required to file electronically a FCC Form 175. They also were required to file Section I and the Section III-A Tech Box of FCC Form 301, Application for Construction Permit. These sections permitted the staff to determine mutual exclusivities between applicants.

[2] *AM Auction Filing Window and Application Freeze Extended to February 1, 2000, Public Notice*, 15 FCC Rcd 1910 (2000). A Remedial Filing Window from July 31, to August 4, 2000 was established for certain specified entities. *See AM Auction Remedial Filing Window, Notice and Filing Requirements Regarding July 31-August 4, 2000 Remedial Filing Window for AM Auction, Public Notice*, DA 00-1582 (July 14, 2000).

[3] In determining mutual exclusivity among the AM applications, the staff employed technical standards consistent with the Commission proceeding undertaken to revitalize and improve the AM service. *See Review of the Technical Assignment Criteria for the AM Broadcast Service*, 6 FCC Rcd 6273 (1991), *recon granted in part and*

listed in Attachment A are mutually exclusive with at least one other proposal, they are subject to the Commission's competitive bidding procedures.[4] By this Public Notice, the Bureaus announce a settlement period for certain specified groups of mutually exclusive AM applicants and a period for filing 47 U.S.C. § 307(b) supplementary information, if relevant; the deadline for both is **December 29, 2000**.

Anti-Collusion Rule. The prohibition of collusion set forth in 47 C.F.R. § 1.2105(c) becomes effective upon the filing of FCC Form 175, Application to Participate in an FCC Auction, and applies to all broadcast service auctions. *See* 47 C.F.R. § 73.5002(d). However, in certain circumstances, the Commission will allow a limited opportunity to settle, or otherwise resolve mutual exclusivities by means of engineering solutions, following the filing of the FCC Form 175 applications.[5] Specifically, mutually exclusive groups listed in Attachment A consisting of either (1) major modification AM applications that are mutually exclusive with each other; or (2) major modification and new station AM applications that are mutually exclusive with each other, may submit settlement agreements or technical solutions to the Commission during the period which commences with the release of this public notice and ends December 29, 2000. The Commission will proceed to auction any competing mutually exclusive applications that are not resolved by the parties. Mutually exclusive groups consisting of only new station applications will be resolved through auction procedures.[6]

Applicants who are permitted to resolve their mutual exclusivities through settlement, described *supra*, must ensure that their settlement agreements comply with the provisions of 47 U.S.C. § 311(c) and pertinent requirements of 47 C.F.R. § 73.3525, including, *inter alia*, reimbursement restrictions.[7] In the interest of expediting new service to the public, conserving agency resources, and preserving the efficacy of the anti-collusion rules in general, only *universal* settlements will be considered.[8] To facilitate processing, applicants who intend to settle should promptly notify the staff in writing that a pre-auction settlement is forthcoming. The prevailing party in the universal settlement proposal must submit the agreements and affidavits required by 47 C.F.R. § 73.3525.[9] The staff will request a complete FCC Form 301, Application for Construction Permit for Commercial Broadcast Station, from the prevailing party upon approval of the settlement submission.

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denied in part, 8 FCC Rcd 3250 (1993). The staff also applied the following rule sections: 47 C.F.R. §§ 73.37, 73.182, 73.183(b)(1).

[4] *See* 47 U.S.C. § 309(j); 47 C.F.R. § 73.5000(a); *see generally, First Report and Order, Implementation of Section 309(j) of the Communications Act -- Competitive Bidding for Commercial Broadcast and Instructional Television Fixed Service Licenses*, 13 FCC Rcd 15920 (1998) ("*Broadcast First Report and Order*"). In addition, Attachment A includes six applications inadvertently listed on *AM Auction No. 32 Non-Mutually Exclusive Applications, Public Notice* DA 00-2142 (September 22, 2000).

[5] *See* Broadcast First Report and Order, 13 FCC Rcd at 15927, 15980-81.

[6] *Id*; see also Orion Communications Limited v. FCC, 213 F.3d 761 (D.C. Cir. 2000).

[7] *See* 47 C.F.R. § 73.3525.

[8] On reconsideration of the *Broadcast First Report and Order*, the Commission expressly declined to adopt wide-ranging exceptions to the anti-collusion rule and liberally allow settlement submissions in the broadcast auction context. *Implementation of Section 309(j) of the Communications Act -- Competitive Bidding for Commercial Broadcast and Instructional Television Fixed Service Licenses*, 14 FCC Rcd 8724. 8755-8756 (1999).

[9] *See* "When and Where to File," *infra*.

Applicants who are permitted to resolve their mutual exclusivities by means of engineering solutions, described *supra*, may do so by submitting Section I and the Tech Box of Section III-A of FCC Form 301 (May 1999 version). The staff will request a complete Form 301 upon confirmation that the engineering submission does, in fact, resolve the specific mutual exclusivity. Technical amendments submitted by applicants to resolve their mutual exclusivities must be minor, as defined by the applicable rules of the AM service, and must not create new mutual exclusivity or application conflict. *See* 47 C.F.R. § 73.3572. Consistent with the *Broadcast First Report and Order* and 47 C.F.R. § 73.5002, such engineering submissions must resolve the mutual exclusivities for the entire group.

307(b) Determination. In the *Broadcast First Report and Order*, the Commission determined that its competitive bidding authority should be harmonized with its statutory duty under 47 U.S.C. § 307(b) to effect an equitable distribution of radio stations throughout the United States. Therefore, the Commission directed the staff to undertake a traditional Section 307(b) analysis prior to conducting an auction for mutually exclusive AM applications proposing to serve different communities. *See Broadcast First Report and Order*, 13 FCC Rcd at 15964. Accordingly, for those mutually exclusive groups listed in Attachment A proposing to serve different communities, a 307(b) analysis is required.

In order to evaluate the Section 307(b) considerations, the staff requires submission of additional information. Specifically, where the mutually exclusive group consists of proposals to serve different communities, each applicant within the group must submit by December 29, 2000, an amendment containing supplemental information including the following: (1) the area and population within the proposed 2 mV/m and 0.5 mV/m contours; (2) the number of stations licensed to the proposed community of license; (3) the number of stations providing protected service to the proposed community of license; (4) the population (according to the latest Census data) of the proposed community of license; (5) a description of the civic, cultural, religious, social and commercial attributes of the proposed community of license; and (6) any other information determined relevant.[10] *See, e.g. Elijah Broadcasting Corporation*, 2 FCC Rcd 4468, 4480-4481 (ALJ Stirmer, 1987); *Radio Greenbrier, Inc.*, 80 FCC 2d 125, 126-135 (ALJ Lozner, 1979). The staff will dismiss, without further processing, the previously filed FCC Form 175 application and technical submission of any applicant that fails to file an amendment addressing the Section 307(b) criteria by December 29, 2000. *See* 47 C.F.R. § 73.3568(a)(1). Submitted Section 307(b) data must be based on the technical proposal as specified in the AM Auction filing window application. Mutually exclusive AM applicants may not change the technical proposal specified in the AM Auction filing window application, except as provided, *supra*. *See Broadcast First Report and Order*, 13 FCC Rcd at 15976. If a mutually exclusive group which is eligible to submit engineering solutions or settlements does not do so by December 29, 2000, and the applications in that group propose to serve different communities of license, each applicant within the group must submit an amendment addressing the Section 307(b) criteria by December 29, 2000.

When and Where to File: An original and four copies of all engineering proposals to resolve mutual exclusivity, settlement agreements, and Section 307(b) submissions must be filed **on or before December 29, 2000**, with the Commission's Secretary, Magalie Roman Salas, Office of the Secretary, Federal Communications Commission, 445 Twelfth Street, S.W. Room TW-A325, Washington, D.C. 20054. In addition, it is requested that a courtesy copy of all such filings be delivered to James

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[10] The Commission's service priorities when making a Section 307(b) determination are: (1) first full-time aural service; (2) second full-time aural service; (3) first local service, and (4) other public interest matters. *Second Report and Order, FM Channel Policies/Procedures*, 90 FCC 2d 88, 90-93 (1982); *recon. denied*, 56 RR 2d 448 (1984). Priorities (2) and (3) are given equal weight. These priorities were first applied in Section 307(b) determinations in the AM context by the Review Board in *Alessandro Broadcasting Co.*, 56 RR 2d 1568 (Rev. Bd. 1984).

Crutchfield, Audio Services Division, Mass Media Bureau, Federal Communications Commission, 445 12th Street, S.W., Room 2-B450, Washington, D.C. 20554.

The staff will withhold further action on the mutually exclusive AM applications listed in Attachment A, pending submission of settlement agreements or engineering proposals to resolve mutual exclusivity and Section 307(b) supplementary information. For additional information, contact Lisa Scanlan or Ed DeLaHunt of the Audio Services Division at (202) 418-2700.

The Form 175 is available for review electronically via the Internet.[11] In the browser location field, enter *http://wtbwww15.fcc.gov* and then click **175 Review**. Netscape Communicator 4.73 is recommended. However, Netscape Communicator 4.5, 4.51, 4.61, 4.7, or 4.72 (Internet web browser software) can also be used. **Note:** To download Netscape Communicator 4.73 free of charge, access the Netscape download site at: *http://home.netscape.com/download/*.

For technical assistance contact the FCC Technical Support Hotline at (202) 414-1250 (V) or (202) 414-1255 (TTY). The FCC Technical Support is generally available from 7 a.m. to 10 p.m. EST, Monday though Friday, 8 a.m. to 7 p.m. EST, Saturday, and 12 p.m. to 6 p.m. EST, Sunday. *All calls to the FCC Technical Support Hotline are recorded.*

This Public Notice contains the following Attachment:

Attachment A: AM Mutually Exclusive Applicants Subject to Auction

[11] The mutually exclusive applicants' FCC Form 301 Section I and the Section III-A Tech Box submissions filed during the AM Auction filing window are available for review in the Commission's Reference Information Center.

ATTACHMENT A
AM Mutually Exclusive Applicants Subject to Auction

The mutually exclusive AM application groups listed in this attachment encompass three categories. Processing treatment will reflect the particular category type. Specifically:

Category I: Mutually exclusive AM application groups which include at least one AM major modification applicant and are therefore entitled to settle or otherwise resolve mutual exclusivities by means of engineering solutions. If such an application group does not file a settlement agreement or engineering solution by the established deadline and the applications in that group propose to serve different communities of license, each applicant within the group must submit an amendment addressing the Section 307(b) criteria by December 29, 2000. These application groups will proceed to auction if they do not file a settlement agreement or engineering solution by the established deadline and the Section 307(b) determination is not dispositive.

Category II: Mutually exclusive AM application groups ineligible for settlement, but for which a Section 307(b) showing is required. If the Section 307(b) determination is not dispositive, these mutually exclusive AM application groups will proceed to auction.

Category III: Mutually exclusive AM application groups ineligible for settlement and for which no Section 307(b) showing is required. These groups need submit nothing at this time and will proceed to auction.

Call	Company Name	Location	Freq	MX Grp	Category
WSFN	MarMac Communications, L.L.C.	Brunswick, GA	570	AM01	I
New	Palmetto Radio Group, Inc.	Garden City, GA	570	AM01	I
New	Ronald W. Matheny dba Murphy Broadcasting System	Dock Junction, GA	570	AM01	I
New	Escanaba License Corp.	Houghton, MI	640	AM02	I
New	Jeffrey N. Eustis	Manistique, MI	650	AM02	I
WMBE	Maszka Pacer Radio, Inc.	Chilton, WI	650	AM02	I
New	Canandaigua Broadcasting, Inc.	Canandaigua, NY	650	AM03	II
New	Palmetto Radio Group, Inc.	Mooers, NY	650	AM03	II
New	Green Valley Broadcasters, Inc.	Sahuarita, AZ	670	AM04	II
New	KEMP COMMUNICATIONS, INC	Las Vegas, NV	670	AM04	II
New	Nelson Multimedia, Inc.	Las Vegas, NV	670	AM04	II
New	Guardian Communications, Inc.	Bosque Farms, NM	700	AM05	II
New	McCook Radio Group, L.L.C.	McCook, NE	700	AM05	II
New	The Watch, Inc.	Wylie, TX	700	AM05	II
New	Fargo Moorhead Radio City, L.L.C.	Fargo, ND	740	AM06	II
New	Jeffrey G. Dress	Fargo, ND	740	AM06	II
New	Pamplin Broadcasting-Washington, Inc.	Redmond, WA	740	AM06	II
New	Pamplin Broadcasting-Washington, Inc.	Hoquiam, WA	730	AM06	II
New	Pamplin Broadcasting-Washington, Inc.	Opportunity, WA	740	AM06	II
New	Kidd Communications	Fallon, NV	750	AM07	II
New	Sierra Broadcasters, LLC	Independence, CA	750	AM07	II
New	KM Communications, Inc.	South Hill, NY	750	AM08	II
New	Manchester Radio Partners	Manchester, NH	750	AM08	II
New	Romar Communications Inc.	Lansing, NY	750	AM08	II
New	Jeffrey B. Bate	Winchester, NV	790	AM09	I
New	Las Vegas Broadcasters Partnership	Las Vegas, NV	760	AM09	I
KTBA	Western Indian Ministries, Inc.	Tuba City, AZ	760	AM09	I

Call	Company Name	Location	Freq	MX Grp	Category
WKLN	Chesapeake-Portsmouth Broadcasting Corporation	Yulee, FL	770	AM10	I
New	Palmetto Radio Group, Inc.	Nassau Village-Ratliff, FL	770	AM10	I
New	Timothy C. Cutforth	Burns, WY	780	AM11	II
New	Timothy C. Cutforth	Pueblo, CO	780	AM11	II
New	MBC Grand Broadcasting, Inc.	Palisade, CO	810	AM12	II
New	Palmetto Radio Group, Inc.	Taylorsville-Bennion, UT	820	AM12	II
New	Elgin FM Limited Partnership	McGregor, TX	840	AM13	I
KJON	Monroe-Stephens Broadcasting, Inc.	Carrollton, TX	850	AM13	I
New	American Community Oriented Radio Network, Inc.	Bunnell, FL	830	AM14	II
New	Dale Hendrix	Norcross, GA	830	AM14	II
New	Frank McCoy	Sandy Springs, GA	830	AM14	II
New	Garner Ministries, Inc.	Bremen, GA	830	AM14	II
New	Jeffrey N. Eustis	Dunwoody, GA	830	AM14	II
New	The MacDonald Broadcasting Company	Charleston, SC	830	AM14	II
New	The MacDonald Broadcasting Company	Orange Park, FL	830	AM14	II
New	Three Sisters Minority Communication, Inc.	Union City, GA	830	AM14	II
New	William B. McCarter	Suwanee, GA	830	AM14	II
KTRB	Bessie Grillos d/b/a The Pete Pappas Company	San Francisco, CA	860	AM15	I
New	Bessie Grillos d/b/a The Pete Pappas Company	Modesto, CA	840	AM15	I
KABN	Chester P. Coleman	Palmer, AK	840	AM15	I
New	Children's Cross Cultural Communications Foundatio	Sonoma, CA	840	AM15	I
New	Pamplin Broadcasting, Inc.	Del Rey Oaks, CA	840	AM15	I
New	Timothy C. Cutforth	Burns, WY	890	AM16	II
New	Timothy C. Cutforth	Fountain, CO	890	AM16	II
New	Horizon Broadcasting Group LLC	Prineville, OR	1060	AM17	I
New	James K. Zahn	Clovis, CA	1040	AM17	I
New	Kidd Communications	Sparks, NV	1060	AM17	I
New	KM Communications, Inc.	Fowler, CA	1040	AM17	I
New	KM Communications, Inc.	Elk Grove, CA	1030	AM17	I
New	Pamplin Broadcasting-Washington, Inc.	Union Gap, WA	1060	AM17	I
New	ROYCE INTERNATIONAL BROADCASTING COMPANY	Folsom, CA	1030	AM17	I
KTCT	Susquehanna Radio Corp.	San Mateo, CA	1050	AM17	I
New	Susquehanna Radio Corp.	Folsom, CA	1030	AM17	I
WOAP	1090 Investments, L.L.C.	Waverly, MI	1080	AM18	I
New	Great Lakes Community Broadcasting, Inc.	Mecosta, MI	1070	AM18	I
New	Richard J. Vanden Berg	Iron Mountain, MI	1080	AM18	I
New	Palmetto Radio Group, Inc.	Dilworth, MN	1100	AM19	II
New	Timothy C. Cutforth	Lamar, CO	1100	AM19	II
New	KEMP COMMUNICATIONS, INC	Las Vegas, NV	1100	AM20	II
New	Lotus Broadcasting Corp.	Las Vegas, NV	1100	AM20	II
New	Palmetto Radio Group, Inc.	Sunrise Manor, NV	1100	AM20	II
New	ROBERT E. COMBS	Boise, ID	1100	AM20	II
New	Amedia	St. Cloud, FL	1160	AM21	I
New	Brantley Broadcast Associates	Saraland, AL	1160	AM21	I
WRPM	Dowdy & Dowdy Partnership	Poplarville, MS	1170	AM21	I
New	Alpine Broadcasting Corporation	Cleveland, MO	1160	AM22	II
New	Maple River, LLC	Hornick, IA	1160	AM22	II

Call	Company Name	Location	Freq	MX Grp	Category
KEX	Citicasters Co.	Portland, OR	1190	AM23	I
KMYL	Interstate Broadcasting Systems of Arizona, Inc.	Tolleston, AZ	1190	AM23	I
New	Kidd Communications	Truckee, CA	1180	AM23	I
New	Pamplin Broadcasting-Oregon, Inc.	Jacksonville, OR	1180	AM23	I
New	Brantley Broadcast Associates	Pace, FL	1180	AM24	II
New	KM Communications, Inc.	Lizella, GA	1180	AM24	II
New	D&E Communications	Baxter, MN	1180	AM25	I
KPHN	KCBR-AM Limited Partnership	Kansas City, MO	1190	AM25	I
KKOJ	KLEVEN BROADCASTING CO. OF MINNESOTA	Jackson, MN	1190	AM25	I
New	Nelson Enterprises, Inc.	Plano, IL	1180	AM25	I
WKOX	Fairbanks Communications, Inc.	Newton, MA	1200	AM26	I
New	Sunrise Broadcasting of New York Inc.	Kingston, NY	1200	AM26	I
New	Powell Meredith Communications Company	Abilene, TX	1210	AM27	I
New	Sharon Berlin Ingles	Bixby, OK	1210	AM27	I
KGYN	Telns Broadcasting Company, Inc.	Oklahoma City, OK	1210	AM27	I
New	Jeffrey B. Bate	Mesquite, NV	1250	AM28	II
New	Jeffrey N. Eustis	Johnstown, CO	1250	AM28	II
New	Go and Tell, Inc.	Central Point, OR	1340	AM29	II
New	Lyle S. Reynolds	Central Point, OR	1340	AM29	II
New	Oregon State Board of Higher Education/S. OR Univ	Mt. Shasta, CA	1340	AM29	II
New	Alpine Broadcasting Limited Partnership	Taos, NM	1340	AM30	III
New	Garcia, Richard L. and Cardova, Darren	Taos, NM	1340	AM30	III
New	Conner Media Corporation	Jacksonville, NC	1400	AM31	I
WBTB	Eastern Carolina Broadcasting Co., Inc.	Pine Knoll Shores, NC	1400	AM31	I
New	J.L. Richardson	Hartman, AR	1460	AM32	I
KKTK	M&M Broadcasters, Ltd.	Burleson, TX	1460	AM32	I
KTNO	Mortenson Broadcasting Company of Canton, LLC	University Park, TX	1440	AM32	I
New	Andrew Johnson	Winchester, NV	1500	AM33	II
New	Jeffrey B. Bate	St. George, UT	1490	AM33	II
New	Dominant Communications Corp. of MS	Flowood, MS	1550	AM34	I
New	Flag Radio, Inc.	Bunnell, FL	1550	AM34	I
WINV	WGUL-FM, INC.	Iverness, FL	1560	AM34	I
KZIZ	KRIZ BROADCSSTING, INC.	Pacific, WA	1560	AM35	I
New	Pamplin Broadcasting-Washington, Inc.	Burbank, WA	1560	AM35	I
New	CTC Media Group, Inc	Winterville, NC	1570	AM36	I
WGSR	RJM Communications, Inc.	Orange Park, FL	1570	AM36	I
New	mark himmler	Waterford, PA	1580	AM37	II
New	R. J. Stalvey	Georgetown, SC	1580	AM37	II
New	Alvin Lou Media, Inc.	Spring Valley, NV	1590	AM38	II
New	Powell Meredith Communications Company	Las Vegas, NV	1590	AM38	II
New	Victor A. Michael, Jr.	Cheyenne, WI	1590	AM38	II
New	Alvin Lou Media, Inc.	Waipahu, HI	1600	AM39	II
New	KM Communications, Inc.	Makaha, HI	1600	AM39	II

MARKET WATCH: Philadelphia, Page 35

Rambling Without Gambling

William O'Shaughnessy reflects on the end of a dynasty at WOR.

Page 13

Five Stations, No Tower

Iceberg Media.com is no bare-bones basement Webcaster.

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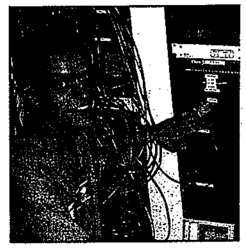

Radio World®

The Newspaper for Radio Managers and Engineers

December 6, 2000

INSIDE

NEWS

▼The FCC: What it did, what it didn't do in 2000.

Page 3

▼Ben Hill wonders whether radio groups are ignoring qualified minorities in their search for job candidates.

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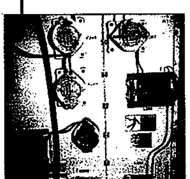
ENGINEERING



▼John Bisset helps you prepare your AM array site for winter.

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GM JOURNAL

▼Millions of dollars are at stake in the struggle between stations and performance rights organizations. Do you pay for more than you play?

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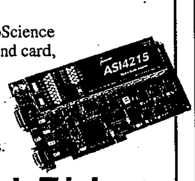
STUDIO SESSIONS



▼The AudioScience ASI4215 sound card, Adaptec SCSI cables and getting the most out of PZM mics.

In This Issue

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CFA, EH: Crows or Swans?

by Ted Nahil

Tests may soon show whether two new antenna designs would be viable for AM broadcasters in the United States.

Manufacturers of both systems claim that, because these antennas are small and they do not require the customary ground system, radio stations may well benefit from reduced land use and easier zoning approval for building antenna sites.

In the meantime, controversy reigns over performance claims made by manufacturers of the CFA, or Crossed-Field Antenna, and the EH antenna, which takes its name from the two fields of propagation, the E or electric field and the H or magnetic field.

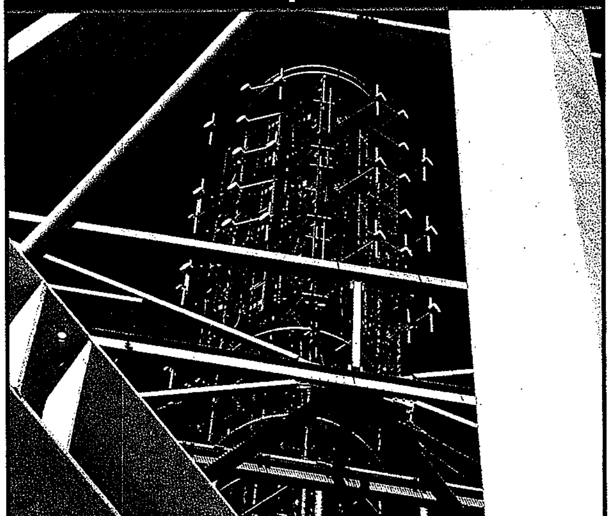
Inventors of both designs have tried to allay concerns raised by station and consulting engineers, manufacturers, the Institute of Electrical and Electronics Engineers Inc. and the NAB.

But the companies behind these antennas have yet to prove their designs are suitable for use in the United States as replacement radiators for the standard vertical antenna with wire ground system.

One of the antennas, the CFA, is being

See ANTENNAS, page 6 ▶

A Times Square Combo



Clear Channel has switched on a five-station auxiliary site atop New York's spectacular new Condé Nast building at 4 Times Square. RW takes you on a photo tour in this issue. Shown: the Shively Master FM Antenna is on the inner tower. Visible are the vertical and horizontal elements, with round radomes on the junctions. Each bay of the three-bay antenna has four elements on each face of the four-sided tower.

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Photo copyright John Lyons, used with permission

Antennas

▶ Continued from page 1

used overseas, but neither has been FCC type-certified.

The CFA was developed in the 1980s by Scottish university professor Brian Stewart, Dr. Maurice Hately and one of his students, Dr. Fathi Kabbary. Patents are held only in the names of Hately and Kabbary, who share equally in any profits, said Robert Richer, president of Crossed Field Antennas Ltd.

Richer and Kabbary formed CFA Ltd. in Farmington, Conn., in 1999, to pursue worldwide distribution for the antenna. Richer said the company holds CFA distribution rights for everywhere but Egypt.

EH on the scene

Debate over the CFA has been going on for some years. Newer to the discussion is the EH antenna.

Ted Hart, its engineer and inventor, said his product is an evolution of the CFA. Hart said his work on the EH antenna dates to 1998. He has since formed EH Antenna Systems in Eatonton, Ga. Prior to that, Hart wrote articles about the CFA for an amateur radio publication.

Hart is CEO of the company and Bob Zimmerman is vice president of engineering.

Representatives for both Crossed Field Antennas Ltd. and EH Antenna Systems have spoken at conventions in recent months to try to prove to broadcasters that the designs, which both manufacturers claim to be revolutionary, work as promised.

Yet engineers continue to question those claims.

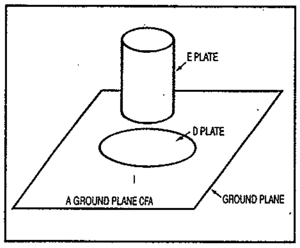


Fig. 1: CFA antenna

Caution appears warranted. According to several antenna consultants contacted by RW, neither company has demonstrated, using controlled and accepted test methods, that their antennas work and are a viable replacement for the familiar AM broadcast tower.

Displacement current

The inventors of both antennas have based their designs on the creation of a displacement current within the antenna. This displacement current is formed by exciting an electric voltage across the capacitive coupling between a base and a cylinder or cone portion of the antenna that, in turn, produces a magnetic field.

RF or electro-magnetic radiation comprises both an electric field and a magnetic field.

At the heart of the debate over the viability of these antennas is how the inventors are interpreting the mathematical theory contained primarily in Maxwell's equations of how antennas work.

The CFA and EH proponents say their designs are revolutionary and that they should be viewed as a radical departure from conventional antenna theory. (See sidebar, page 7.)

They claim broadcasters can achieve the same coverage area and eliminate real estate-hogging AM tower arrays by using these smaller, shorter antennas.

Critics say these claims are not supported by data and that both designs are based on an incorrect interpretation of antenna theory.

Ted Hart atop the newest EH antenna. In the background are earlier designs

In a standard, vertical wire antenna, the electric and magnetic fields combine to form an electro-magnetic (EM) wave in the far field at a finite distance from the radiator.

Standard antennas also create separate electric and magnetic fields that are not in phase in the near field. These near fields are the cause of substantial EM interference.

Supporters of the CFA and EH antennas claim the products create EM radiation directly at the antenna, eliminating or greatly reducing the separate E and H near-field radiation and EM interference.

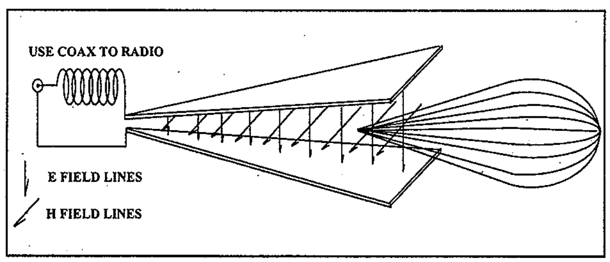


Fig. 2: EH antenna

Electrically, both of these antennas are extremely short, generally under 8 percent of a wavelength. Most experts claim that their behavior is simply that of short, fat antennas, which tend to be poor radiators.

Poor radiators may be inefficient or have narrow bandwidth or they may produce lots of skywave signal or react unpredictably to weather changes. The tests planned for both antennas will help determine whether this is the case with the CFA and EH antennas.

The CFA uses a disc that acts like a capacitor and a modified cylinder, each fed separately (see Fig. 1). The EH antenna uses a single cone (Fig. 2). Both manufacturers claim extraordinary improvements in bandwidth and efficiency.

Part of the efficiency dispute stems from differences in fundamental definitions used by the inventors and the critics.

For example, the CFA inventors say that, because no power is wasted in the creation of any near-field energy, their antenna is automatically more efficient than a standard, quarter-wave radiator with a 120-radial ground plane.

Critics reply that these near-field characteristics are part of the radiation process of conventional monopole antennas. Dr. John S. Belrose, senior radio scientist with the Canadian Radio-Television & Telecommunications Commission in Ottawa, presented test results of a CFA built in Canada and modeled after the CFA in service in Tanta, Egypt. He made his presentation to the IEEE Broadcast Technology Society Annual Broadcast Symposium in Vienna, Va. in late September.

Eric Wandel, director of product development for antenna manufacturer Electronics Research Inc., moderated that session. Several consulting engineers sought to refute the mathematics and physics claims of both the CFA and EH antennas.

Many questioners challenged some of the fundamentals behind their antenna design, specifically, the efficiency and bandwidth claims.

While the CFA was invented in the late 1980s, its inventors have not formally released much data on the radiation characteristics of the antennas and what has been released has not been validated.

Crossed Field Antennas Ltd.

Principals: Robert Richer, president; Maurice Hately and Fathi Kabbary, other investors. Richer is president of the company; Kabbary and Hately, the co-inventors, are "involved on a daily basis."
HQ: Farmington, Conn.
Founded: 1999
Contact: (860) 676-0051, Fax (860) 677-9639

EH Antenna Systems

Ted Hart

Principals: Ted Hart, CEO; Bob Zimmerman, VP of engineering. The company is a division of R&A Management LLC.
HQ: Eatonton, Ga.
Founded: 1998
Contact: (706) 484-1984
E-mail: *w5qjr-@netcommander.com*

But the public will soon get a chance to learn more. Consulting engineering firms Hatfield & Dawson and duTreil, Lundin & Rackley will supervise testing of a demonstration CFA in Shropshire, England, where a 1 kW CFA is being built in an open field (RW, Oct. 25, p. 3).

The test site is not near any existing structures.

"One of the criticisms of the CFA is that it is merely having its signal re-radiated by other structures," said CFA President Robert Richer. "This will eliminate that concern."

Richer said construction was to be complete by mid-November and that test results should be known by the end of December.

Recommendations

"(We were) asked to recommend a test plan and supervise/conduct the necessary tests," Dawson said. "(We) have provided such a plan, which was reviewed by a number of others in our firms and elsewhere, and we will supervise/conduct the tests we have recommended."

Anecdotal data collected by some of the inventors and users of the CFAs in operation overseas lack substantive measurements including field intensity readings and skywave performance, because the conditions under which measurements have been taken have not included critical baseline parameters such as input power determination, observers said.

Data collected using the model built by CRC indicate numerous shortcomings in the CFA's performance, said Canadian radio scientist Belrose. According to his tests, the antenna is difficult to tune and has impedance characteristics of an electrically very small antenna.

To real-world broadcasters, one of the most critical issues will be the antenna'sscalability. If an antenna is scalable, it works across a band of frequencies with equally predictable performance.

Any new antenna to be sold for this market would have to conform to FCC regulations pertaining to efficiency and skywave radiation. However, getting that approval may be difficult because another major issue standing between

See ANTENNAS, page 7 ▶

Antennas

▶ Continued from page 6

the proponents and opponents concerns how the antenna will be modeled.

Standard broadcast antennas are modeled using computer programs that were developed based on well-documented antenna performance and accepted mathematical and physics principles. FCC definitions of conductivity and inverse field characteristics of standard vertical antennas are based on these data as well as the empirical data collected over the years describing standard antenna performance.

Critics say today's computer models based on classic physics and antenna theory such as Maxwell's fourth equation accurately describe the performance of the CFA and EH antenna.

The inventors insist that these classic computer models, among them NEC-4D, cannot be used. They think the physics behind the NEC-4D modeling program, for example, does not account for the displacement current in the antenna. Displacement current is what they base their claim on about how the antenna works.

Some observers dispute these claims. For example, Silliman, Hatfield, Belrose and Stanley maintain that NEC-4D modeling shows the antenna to be what they believe it is: an electrically short, fat antenna.

Others still leave room for doubt.

"I choose to remain open-minded," said Rackley. "One thing is for sure: Conclusive test results will give at least one side in the debate cause to go back and rework their analysis."

> **If you could turn the thing on and prove that it works, how can you refute hard data?**
>
> — Carl Gluck

Dawson said, "There is no question that the full-scale CFA antennas which are in operation radiate, but many short, fat antennas can be made to radiate moderately well, just not with high efficiency. Such short, fat antennas can also exhibit fairly reasonable bandwidth. On that basis, the antenna very well may have useful applications."

The EH antenna, facing the same efficiency and bandwidth challenges as the CFA, is about to undergo similar testing. EH Antenna Systems has applied for an experimental license at 1590 kHz on the test site being constructed in Eatonton, Ga.

Hart is hopeful that the tests, which will be conducted by Stu Graham of Graham Brockman Consulting Engineers, Atlanta, will support his claims as well.

The EH antenna will be tested against a 65-foot vertical radiator with a 120-radial ground system. Hart said, "When

See ANTENNAS, page 8 ▶

You Can Look It Up

Hankering to brush up on Maxwell's Fourth Equation? Looking for an elusive reference on Poynting Vector synthesis? Forgot Ampere's Law?

Useful resources include a college physics book, Reference Data for Radio Engineers or The NAB Engineering Handbook.

You can also check out these books, articles and Web sites for information on electromagnetic theory, fundamental concepts using a minimum of mathematics, and the CFA and EH antennas.

- Information on Numerical Electromagnetic Coding is provided at the University of Missouri-Rolla Web site at *www.emclab.umr.edu/* Click on "Numeric Electromagnetic Modeling" under EMC Modeling Tools.

- The presentation given by John Stanley at the IEEE symposium, including text, slides and AVI files, is available at *http://members.aol.com/jnrstanley/*
  For information relating to the IEEE symposium, go to *www.ieee.org*

- The original CFA patent can be researched at *www.uspto.gov*
  Search for patent # 5,155,495.

- A discussion of how electromagnetic waves are created is included in the article "Antennas without Maxwell," Journal of Electrical and Electronics Engineering, Australia, Vol. XVIII, No. 4 (December 1999), by H.E. Green.

- Recent articles about the CFA and EH antenna systems are archived in the Reference Room in Radio World's Web site at *www.rwonline.com*

- Two sites that require you to register and subscribe to online publications (one for free, one for a fee) are *www.ednmag.com/ednmag/* and *www.antennex.com* Both have articles on the CFA antenna and on electromagnetic theory and practice.

NEWS MAKER

RAI's Fassio on Italian CFA

Former Project Manager Details the Installation and Performance of a CFA in San Remo, Italy

Crossed-field antenna installations can be found in other parts of the world, including Italy, the United Kingdom, Brazil and Egypt.

Dr. Alberto Fassio of Radiotelevisione Italiana, the national public service radio, television and telex broadcaster for Italy, worked closely on the installation and testing of a CFA antenna near San Remo in northern Italy.

Fassio was responsible for RAI's AM department and was CFA project manager until May of 1999. He then changed his responsibilities to TV, FM, digital video broadcasting and Eureka 147 DAB installations.

Installed last year, the San Remo CFA is being tested and operated.

RW Technical Adviser Thomas R. McGinley conducted an e-mail interview with Fassio regarding his experiences with this CFA antenna.

RW: You were closely involved with the successful installation of a CFA antenna. Tell us more about it. Where exactly is it and who owns it and/or paid for the installation? What frequency and power input are used?

Fassio: I discovered the CFA while reading Wireless World in 1994. I then contacted Mr. Hateley and asked him how to contact Mr. Kabbary in Egypt. I went to Cairo, Egypt, in January 1995 to survey the Tanta installation where I evaluated the behavior of their 6 kW CFA.

(Ed. note: Maurice Hateley and Fathi Kabbary are two of the the inventors of the antenna.)

Due to the fact that this CFA was a very small structure, it seemed a very good solution for many of our AM transmission sites. RAI decided to build and test one in Italy. The test site is at San Remo with an old 6 kW transmitter on 1182 kHz.

Even though the contract was awarded in late 1996, RAI and RAI WAY, our new company in charge of RF installations and maintenance, both had problems with the local city council and the Italian laws governing electromagnetic pollution. That stopped the works for about two years until 1999 when the installation began.

RW: Who installed and measured its performance?

Fassio: The installation was handled by Kabbary himself with an Egyptian assistant, according to the terms of the contract. RAI WAY and Kabbary did a lot of measurements in the region around the site with good results.

Field strength values of the CFA measured very close to those radiated by the old 80-m mast, which was removed. *(80 meters is 262.4 feet or 0.31 wavelength at 1182 kHz. That is a "tall quarter-wave" tower.)*

RW: What did it cost to install? Who created the design?

Fassio: The installation was not expensive. I cannot provide the exact amount. Kabbary designed and installed it as I said before.

Different installation?

RW: Did this CFA antenna replace a conventional vertical antenna with a buried ground system? Does this CFA antenna differ in any significant way from those installed in Egypt?

Fassio: Yes, it did replace the 80-meter vertical mast but for the moment is still under test. Our CFA is similar to the Egyptian CFA, but I cannot comment about their phasor since I was not able to see it at the time of my visit in Tanta.

RW: Were complete "before and after" field measurements of the old antenna and the new CFA taken? What was the average effective ground conductivity of the area around this antenna?

Fassio: The measurements were completed after the time I left the project so I have not seen those papers. The average effective conductivity is low along the cost but it increases to the north of the site towards the mountains. I do not have the data with me.

RW: What specific measurement methods and test equipment were employed to evaluate its performance?

Fassio: Field measurements were made by a portable field intensity receiver. The phasor was tuned up with an HP 8753C network analyzer.

The RAI AM department is waiting to do other measurements regarding efficiency. I want to point out that for us as broadcasters, it was important to replace the old mast with a small antenna, due to the laws, as I said before.

It is not our core business to perform specific studies on it. We are not a research center. So all special measurements will be made later, taking into account the free time our AM department will have for that.

RW: Were the measurement results ever made public? If not yet, will they be? Did the achieved performance match your expectations?

Fassio: Yes. The final measurements matched the designer's and our expectations. Further details will be available in the near future.

Tricky modifications

RW: How long did it take to construct and tune up the antenna to achieve the performance it is producing now? What specific problems did you encounter, if any, in getting it to perform properly? Is it hard or "tricky" to get tuned up?

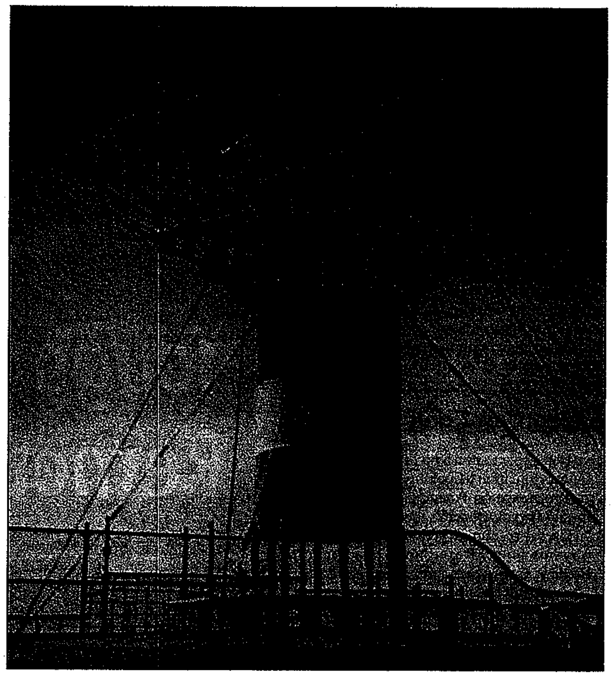
Fassio: The antenna was built in three weeks and the tuneup was tricky. The phasor design was changed due to modifications that were necessary during the assembly of the disc and its distance to ground. So the phasor needed some mods.

RW: Was the antenna intended to deliver any skywave coverage? If so, was skywave performance measured or evaluated?

Fassio: No. No skywave was requested.

RW: Now that this CFA antenna is up and running and you have 20/20 hindsight, what would you have done differently in its implementation?

Fassio: If any future installations of CFA antennas are done, the work will be done by an Italian installer. The installation was not carried out in the same way as we normally do, requesting a local company. This was an experiment and it was more easily accepted by the authorities that way.



San Remo, Italy CFA installation

RW: Do you think that the CFA antenna is truly a scientific breakthrough in antenna design?

Fassio: As I said, it is not our business, especially in AM, to carry out specific studies on antennas. I can say that the CFA solves installation problems and maintenance costs. And it satisfied concerns of Italian authorities regarding electromagnetic pollution. The near field was effectively lower than before.

RW: What applications or situations would be ideal for a CFA antenna and where would be someplace a CFA antenna would not be appropriate, in your opinion?

Fassio: Ideal situations for the CFA for example would be transmitters on top of buildings or where the broadcaster has problems with local authorities gaining permission to erect masts. I cannot say anything about the "not appropriate" situations because the tests we conducted were limited.

RW: Would you recommend the CFA antenna to others?

Fassio: I recommend it for anyone to test. All broadcasters have their own specific problems. For me, it is not important to decide if the Kabbary theory is right or wrong or to push a theory against someone who thinks "Maxwell is Maxwell and its theory cannot be changed."

The important thing, for a company making a business decision, is to find a solution to a problem to possibly reduce the expenses. And the CFA does that.

Antennas

▶ Continued from page 7

that test data is available, it will be furnished to all interested parties." He hopes that EH Antenna Systems will receive its authorization to test soon.

Waiting for data

Broadcasters want hard evidence on the performance of both the CFA and EH antennas before they can believe the manufacturers' claims.

"The FCC and others will almost assuredly not accept anecdotal evidence; they require comprehensive, hard data," said Milford Smith, vice president, engineering for Greater Media Inc.

Carl Gluck, vice president of technical research for Salem Communications Inc., agreed. He wants to see an FCC directional proof of performance conducted.

"If you could turn the thing on and prove that it works, how can you refute hard data?"

Once the single antenna questions are answered, the effect that might be most beneficial to U.S. broadcasters is how these antennas might be used in a directional antenna array.

Cost for both products is unknown. Richer said the CFA will be priced by power requirements with a typical 10 kW antenna going for about $250,000, installed and tested.

Hart estimates the EH antenna may be priced as low as $40,000, but prefers to wait to give firm numbers until the tests are complete.

3

PLEASE FORWARD TO THE ENGINEERING DEPARTMENT

National Association of Broadcasters NAB

Radio TechCheck ✓

The weekly newsfax for ***Radio*** *broadcast engineers* *August 7, 2000*

NAB Ad Hoc Group Urges FCC to Eliminate Field Proofs for Certain AM Arrays

On August 2, 2000, NAB filed joint supplemental comments on behalf of broadcasters, broadcast engineering consultants and equipment manufacturers in FCC Docket 93-177 concerning AM directional antennas. The joint commenters urged the FCC to permit some AM broadcasters with directional antenna systems to "proof" their systems using computer modeling techniques in place of time consuming, expensive field measurements.

The joint filing was the result of work that a NAB *ad hoc* engineering committee began early this year. Three meetings were held at NAB headquarters to develop an industry consensus position for presentation to the FCC.

AM directional antennas (AM DA) are one of the more complicated types of transmission systems in the broadcasting industry. Stations that employ these arrays are required to perform proofs when they first put them into operation, and partial proofs whenever they have reason to believe that their radiated fields may be exceeding the values for which they are licensed. A full proof currently requires that measurements be taken at a minimum of 30 points along each of eight radials in both the directional and non-directional mode, resulting in a total of 480 measurements. Complex arrays require more radials and, thus, more measurements. Performing this sort of work typically costs an AM broadcaster tens of thousands of dollars.

The FCC is already considering a proposal to reduce the number of measurements required for full and partial proofs. The supplemental comments filed last week by the NAB *ad hoc* group urged the FCC to reduce the number of measurements even further by allowing some proofs to be conducted by computer model.

AM directional computer modeling techniques were first developed for personal computers about twenty years ago. They are based on Maxwell's equations, which relate the current flowing in a wire to the electric and magnetic fields around the wire. AM DA computer models use the current flowing in each tower of a directional array (a known quantity that can be easily measured) to predict the electric and magnetic fields that will be produced by that tower.

One of the major advantages of computer modeling is that the model can use the radiated field from each tower to accurately predict the current that will be induced by this field into the other towers. By doing this calculation for each tower in an array, and then combining the fields created by each tower, computer models can predict the overall pattern from the AM antenna system.

The ability to perform numerous complex computations to accurately predict the current induced in any given tower by the other towers in an array enables today's computer modeling programs to predict the actual fields from each tower in the array with greater accuracy than ever before possible. Prior to the availability of these programs, it was necessary to assume that there was a sinusoidal distribution of current in each tower in order to keep the number of calculations necessary to predict the array's pattern at a manageable number. However, the current distribution in each tower is not sinusoidal, due mainly to the current induced in each tower by the fields from the other towers in the array.

Some arrays and their environments are too complex to model accurately. For example, bridges, sports arenas and other buildings close to an array can be very difficult, if not impossible, to model accurately, and thus the reradiation of the AM signal caused by these objects is nearly impossible to predict without field measurements. In cases like this, the consensus of the *ad hoc* group was that actual field measurements should still be required for proofs. At the other extreme, it was agreed that a simple two-tower array with no reradiators within several miles should be easy to model. Much of the *ad hoc* group's time was spent identifying the criteria that, in the opinion of the participants, would be characteristic of an array that could be modeled relatively easily, and accurately, at the current state of the art.

The criteria developed by the *ad hoc* group were put into checklist form in an effort to make them compatible with the FCC's electronic filing procedures. A few of the basic eligibility criteria for computer modeling that have been proposed are that the array have no more than six towers, that the sampling system transmission lines have solid outer conductors, constant impedance and equal electrical lengths, and that the parameters input into the computer model conform to certain specific guidelines.

Interested parties may download a copy of the joint supplemental comments, including the complete proposed checklist, from the NAB members-only site at www.nab.org. The comments are listed under the Engineering heading. To access the members-only site type **NAB Member** in the user name field and **269** in the password field.

Courtenay S. Brown, Editor **Tel: +1 (202) 429-5341** **Fax: +1 (202) 775-4981**

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AM 4

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
WRHC Broadcasting Corp.	)	Control No. 9808327
	)	NAL/Acct. No. x32080008
Licensee of Station WRHC(AM)	)	
Coral Gables, Florida	)	
Facility ID #73945	)	

FORFEITURE ORDER

Adopted: July 21, 2000 **Released:** July 25, 2000

By the Chief, Enforcement Bureau:

1. This Forfeiture Order ("Order") imposes a forfeiture against WRHC Broadcasting Corp. ("WBC") in the amount of twenty-two thousand five hundred dollars ($22,500). It also directs WBC to inform us within thirty (30) days whether it is continuing to operate Station WRHC in an unauthorized manner. We conclude that WBC willfully and repeatedly violated sections 73.1615, 73.1620 and 73.1745 of the Commission's rules.[1] The violations include operation of a directional AM station, purportedly in accordance with a construction permit, without first requesting and obtaining authority from the Commission, commencement of program tests prior to staff approval, and operation at variance from licensed facilities. The violations also resulted in interference to another station.

BACKGROUND

2. Following receipt of a complaint from Interstate Broadcasting Company, Inc. ("Interstate"),[2] licensee of Station WQEW(AM), New York, New York,[3] that its nighttime operations were experiencing interference attributable to Station WRHC, the staff conducted an investigation which revealed that WRHC had repeatedly broadcast at night from an unlicensed location in an unauthorized manner (omnidirectionally and on a different frequency) with power well above that authorized by its license. The investigation further revealed that such operation had occurred repeatedly notwithstanding Interstate's notification to WBC that WRHC was causing interference. Finally, the investigation disclosed that, for years, WRHC had been broadcasting during the day at an unauthorized location on an unlicensed frequency.

[1] 47 C.F.R. §§ 73.1615, 73.1620 and 73.1745.

[2] On November 30, 1998, following Commission staff approval of a *pro forma* assignment, the licensee became The New York Times Electronic Media Company. For ease of reference, we will continue to refer to the licensee of Station WQEW as Interstate.

[3] WQEW is a Class A station operating on 1560 kHz at 50 kW. *See* sections 73.21(a)(1) and 73.25(b) of the Commission's rules, 47 C.F.R. §§ 73.21(a)(1) and 73.25(b).

Accordingly, on March 21, 2000, we issued a Notice of Apparent Liability ("NAL") to WBC.[4] In addition to proposing a forfeiture of $22,500, the NAL notified WBC that its apparent unauthorized operations had to cease; otherwise, further proceedings could ensue, which could result in revocation of the station's license.

3. In its May 8, 2000, response to the NAL, WBC acknowledges that it operated substantially as alleged, and it concedes that it is continuing to operate without authority. WBC apparently seeks to justify its current operations by claiming that discontinuance of station operations would bring it economic disaster. Regarding the proposed forfeiture, WBC argues that reduction is warranted because it believed its operations were permitted by virtue of its construction permit. Further, WBC contends that it ceased nighttime operations upon notification that they were causing interference. Finally, WBC argues that, although it made full disclosure of its operations to Commission staff, it was never advised to cease operations but simply to regularize operations. In view of the foregoing, and considering the "hardships"[5] with which it was forced to contend, WBC believes that the proposed upward adjustment for intentional violation should be eliminated and that the base forfeitures should be reduced substantially.

4. Section 503(b)(2)(D) of the Act directs us to consider two distinct matters in determining the appropriate amount of a forfeiture.[6] First, as to the violations, we must take into account their nature, circumstances, extent, and gravity. Second, with respect to the violator, we must consider the degree of culpability, history of prior offenses, ability to pay, and such other matters as justice may require.

5. The record before us reflects that WBC has never operated from its licensed daytime site and that, following eviction from its nighttime site in February 1996, WBC began operating WRHC from its construction permit site in the fall of 1996 on 1560 kHz both during the day and at night. WBC never obtained Commission authorization for these operations. WBC also began to operate WRHC since the end of December 1997 or the beginning of January 1998 with a new transmitter set at 5 kW. However, WBC never obtained Commission authorization to do so. Further, notwithstanding Interstate's complaints, WBC continued to broadcast, without Commission authority, for periods of time before local sunrise and after local sunset between August 1998 and February 1999. Moreover, with respect to WBC's failure to obtain authority for its daytime operations, the Mass Media Bureau, on August 5, 1999, dismissed WBC's July 1999 license application (File No. BL-19990707DC) as patently defective. Although WBC petitioned for reconsideration of that action, resubmitted the application, and contended that it supplied sufficient information to obtain program test authority, the Mass Media Bureau, by letter dated March 7, 2000,

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[4] WRHC Broadcasting Corp., 15 FCC Rcd 5551 (Enf. Bur. 2000).

[5] The referenced hardships included Hurricane Andrew, litigation, and an airplane crash that temporarily affected access to an authorized site.

[6] 47 U.S.C. § 503(b)(2)(D). *See also* In the Matter of the Commission's Forfeiture Policy Statement and Amendment of Section 1.80 of the Rules to Incorporate the Forfeiture Guidelines, 12 FCC Rcd 17087, 17100-01 (1997), *recon. denied*, 15 FCC Rcd 303 (1999) ("Forfeiture Policy Statement").

determined that the resubmitted application contained several serious discrepancies. Accordingly, the Mass Media Bureau informed WBC that further action on the application would be withheld to allow WBC to file a corrective amendment. The Mass Media Bureau further informed WBC that failure to supply the amendment would result in dismissal of its application. To date, WBC has not submitted the requested amendment. Even though the Mass Media Bureau has not authorized program tests, as required in this situation, WBC has continued to operate WRHC during the day.

DISCUSSION

6. Section 73.1745 of the Commission's rules[7] provides that no station shall operate at times or with modes of power other than those specified in the station's license. Section 73.1615(d) of the Commission's rules, 47 C.F.R. § 73.1615(d), provides that a licensee of AM stations holding a construction permit which authorizes both a change in frequency and directional facilities must request and obtain authority from the Commission prior to using the facilities authorized by the permit. Finally, section 73.1620(a)(4) of the Commission's rules, 47 C.F.R. § 73.1620(a)(4), provides that an AM permittee with a directional antenna that has requested program test authority may not commence program test operations prior to the issuance of staff approval. The evidence before us shows that WBC has not operated Station WRHC in accordance with the terms of its license since, at least, the date of its last renewal. WBC has not used its licensed daytime facilities since their destruction by Hurricane Andrew, and WBC has not used the licensed nighttime facilities since its eviction from that site. Nevertheless, and despite the absence of special temporary authorization ("STA")[8] or any other authority, WBC has broadcast on WHRC from its daytime construction permit site on 1560 kHz from the beginning of the current license term to the present. Compounding matters, at various times up to February 1999, WBC operated WRHC at night at an unauthorized power, which resulted in interference to WQEW. Finally, even when WBC sought program test authority, it did not wait for staff approval before operating with the facilities described in its license application, as required in these circumstances.

7. Section 503(b) of the Communications Act of 1934, as amended (the "Act"), 47 U.S.C. § 503(b)(1),[9] provides that any person who willfully or repeatedly fails to comply with the terms and conditions of his license or the Commission's rules shall be liable for a forfeiture penalty. In this context, the term "willful" means that the violator knew it was taking the action in question, irrespective of any intent to violate the Commission's rules,[10] while "repeatedly" means more than once.[11] Considering the

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[7] 47 C.F.R. § 73.1745.

[8] *See* section 73.1635 of the Commission's rules, 47 C.F.R. § 73.1635.

[9] 47 U.S.C. § 503(b)(1). *See also* section 1.80(a)(1) and (2), 47 C.F.R. § 1.80(a)(1) and (2).

[10] *See* Jerry Szoka, 14 FCC Rcd 9857, 9865 (1999); Southern California Broadcasting Co., 6 FCC Rcd 4387 (1991).

[11] *See* Hale Broadcasting Corp., 79 FCC 2d 169, 171 (1980).

information before us, we conclude that WBC knew that it was operating WRHC at variance from its license; that, for years, WBC had not requested or received permission to operate with the facilities specified in its permit; and that, even when WBC had submitted such a request, it continued to operate the facilities despite the fact that it did not receive staff approval as required. We therefore reject WBC's contention that its violations were not intentional. Rather, we conclude that WBC's violations were both willful and intentional. Further, we conclude that each of the violations was repeated. Finally, we note that WBC has apparently ignored our warning in paragraph 8 of the NAL to cease unauthorized operation of Station WRHC or risk further enforcement proceedings. Accordingly, we will direct WBC to inform us within 30 days after release of this Order whether, and, if so, when, it ceased unauthorized operations on Station WRHC. If WBC has continued to operate Station WRHC unlawfully, WBC may be subject to a proceeding to revoke the station's license.

8. In assessing a forfeiture, we take into account the statutory factors set forth in Section 503(b)(2)(D) of the Act,[12] which include the nature, circumstances, extent and gravity of the violation, and, with respect to the violator, the degree of culpability, any history of prior offenses, ability to pay, and such other matters as justice may require. The Commission's forfeiture guidelines currently establish base amounts of $7,000 for interference, $4,000 for using an unauthorized frequency, and $4,000 for operation at an unauthorized location.[13] The guidelines include "upward adjustment criteria," such as intentional violation and repeated or continuous violation. After considering the information before us, we conclude that, as proposed, the base amounts, which total $15,000, should be adjusted upward by 50 percent to take into account the licensee's intentional and continuous violations. In this regard, we contrast the situation now before us with the licensee in PNI Spectrum, LLC, DA 00-1335 (Enf. Bur., released June 19, 2000). Among other things, that licensee, upon discovery of its mistaken construction and operation of land mobile stations, voluntarily ceased service at significant cost to itself. Consequently, we reduced a proposed forfeiture from $78,000 to $25,000. WBC, on the other hand, continued to operate from its daytime construction permit site, both during the day and often at night, even after it had been specifically put on notice (and then admitted) that its operations were not authorized. Once WBC received such notice its continued operation of WRHC must be deemed intentional irrespective of whether the staff explicitly advised WBC to cease operations.[14] Thus, unlike the PNI licensee, WBC has not demonstrated that its conduct warrants a reduction of its proposed forfeiture. Quite the opposite, WBC's intentional misconduct justifies use of the upward adjustment criteria cited in the NAL. The proposed forfeiture is fully justified and should be imposed.

ORDERING CLAUSES

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[12] 47 U.S.C. § 503(b)(2)(D).

[13] *See* Forfeiture Policy Statement, *supra* note 6.

[14] *See* Bay Broadcasting Corporation, DA 00-1190 (Enf. Bur., released May 31, 2000)

9. Accordingly, IT IS ORDERED THAT, pursuant to section 503(b) of the Act,[15] and sections 0.111, 0.311 and 1.80 of the Commission's rules,[16] WRHC Broadcasting Corp. FORFEIT to the United States the sum of twenty-two thousand five hundred dollars ($22,500) for violating the terms and conditions of its license and the Commission's rules requiring operation within the parameters set forth in the license, and requiring express permission prior to a permittee's operation or commencement of program tests involving directional AM facilities and/or a change in frequencies.

10. IT IS FURTHER ORDERED THAT payment of the forfeiture shall be made in the manner provided for in section 1.80 of the Commission's rules,[17] within thirty (30) days of this Order. If the forfeiture is not paid within the period specified, the case may be referred to the Department of Justice for collection pursuant to section 504(a) of the Act.[18] Payment of the forfeiture may be made by credit card through the Commission's Credit and Debt Management Center at (202) 418-1995 or by mailing a check or similar instrument, payable to the order of the Federal Communications Commission, to the Forfeiture Collection Section, Finance Branch, Federal Communications Commission, P.O. Box 73482, Chicago, Illinois 60673-7482. The payment should note the NAL/Acct. No. referenced above. Requests for payment of the full amount of this forfeiture under an installment plan should be sent to: Chief, Credit and Debt Management Center, 445 12th Street, S.W., Washington, D.C. 20554.[19]

11. IT IS FURTHER ORDERED THAT, within thirty (30) days of the release of this Order, WBC state in writing whether, and, if so, when, it has ceased unauthorized operations on Station WRHC. WBC shall file its response with the Secretary of the Commission and direct a copy thereof to: Charles W. Kelley, Chief, Investigations and Hearings Division, Enforcement Bureau, Federal Communications Commission, 445 12th Street, S.W., Room 3B-443, Washington, D.C. 20554.

12. IT IS FURTHER ORDERED THAT a copy of this Order shall be sent by Certified Mail Return Receipt Requested to WRHC Broadcasting Corp., in care of Lawrence M. Miller, Esq., Schwartz, Woods & Miller, 1350 Connecticut Avenue, N.W., Suite 300, Washington, D.C. 20036-1717.

FEDERAL COMMUNICATIONS COMMISSION

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[15] 47 U.S.C. § 503(b).

[16] 47 C.F.R. §§ 0.111, 0.311, 1.80.

[17] 47 C.F.R. § 1.80.

[18] 47 U.S.C. § 504(a).

[19] *See* 47 C.F.R. § 1.1914.

David H. Solomon
Chief, Enforcement Bureau

Sent: Tuesday, May 02, 2000 6:22 PM
Subject: [MOM] Items for Discussion at Friday MOM meeting

Greetings:

I have reactions/comments from some of the group members and promises from several others to have additional comments by Wednesday. It seems that everyone has been busy with DTV filings or computer crashes and spare time has been difficult to find for everyone involved (self included).

Dave Wilson has indicated that Friday will be the last meeting for the group and that the NAB will probably file comments in the NPRM which include whatever criteria the group can endorse. Restated, if you have thoughts on how to make the final report better and it isn't in the mix by the end of Friday, it won't be part of the report.

At the beginning of this process, many of the parties were miles apart and it was commonly believed that many firms would be filing individual comments. However, due to the large amount of progress made toward a single position in the afternoon session of the last meeting, it may be possible to have a single position paper. Of course, this would make the Commission's task more straightforward. Receiving a single position statement which is endorsed by the entire consulting community is prefereable to receiving several conflicting positions which they must massage together into a single Rule change. [Compare the outcome of the TV stereo proceeing with the outcome of the AM stereo proceeding.]

Under the heading of "new" issues, Ted Schober suggested a specification of how much ground system truncation would be permissible with a MOM tuneup. At what point would the ground system be so asymmetrical that a field proof would be required? Ted suggested a trial balloon cutoff value of 85% of the area of a "full" radial field (90 degrees around all bases).

Additionally, Ted asked for futher discussion about reradiating "loops". Specifically, the closed rectangular path formed by a high-tension tower, the "sky wire" from it to the next tower, that second tower and the ground path back to the first high tension tower. Ted indicated that with short towers and a widespacing, he was able to get significant disruption of a directional pattern, even though the towers themselves were well under the "glideslope" criteria contianed in Dave Wilson's email of Feb 24. Ted also inidicated the bridge overpasses can have the same effect.

Tom Jones and Jim Hatfield suggested further discussion of the criteria for when torroidal samplers are appropriate. Both were concerned that stray capacitances (either to the ATU or through the base insulator) could make the torroid register a total current that was the sum of the radiation current plus the leakage current, introducing significant errors in the model.

Jack Sellmeyer suggested specifying the surveyor's tolerence in electrical degrees rather than in feet, as specification in feet provides a tight electrical tolerance in the low end of the band and a very loose one at the top end of the band.

Peter Montcure endorsed the group's position that there must be one, single, authoritative MOM code to prevent "code wars" which have developed in other venues. Peter also pointed out that the same source code can get different results when compiled with different compilers or when run on different hardware. Perhaps a standardized test case is in order, such as the one in Part 73.150(c)?

Further comments on any of these points before Friday are welcome. I will try to get one more revision of the draft posted to the web before I leave for DC. This will probably be Wednesday (tomorrow) evening and will include everything I have received up to that point. Comments/suggestions received after that draft goes out but before I leave for DC on Thursday at noon will be added to a list of agenda items for discussion.

Glen Clark
Working Group Chairman

Sent: Tuesday, May 02, 2000 7:22 PM
Subject: [MOM] Items for Discussion at Friday MOM meeting

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Glen Clark
Working Group Chairman

7

ENGINEERING CHECK SHEET
CATEGORY - D

CALL ____________
FILE NO. ____________

Class C
kHz

1230	1400
1240	1450
1340	1490

1.) In determining overlap caused to other Class C stations, an application for new or modified nondirectional facilities with a power of 250 watts or greater shall be considered on the assumption that the proposal operates with 250 watts. All existing stations are considered at actual operating power. ____________

2.) In determining overlap received by the proposal, an application for new or modified nondirectional facilities with a power of 250 watts or greater shall be considered on the assumption that both the proposed operation and all existing Class C stations operate with 250 watts and utilize a nondirectional antenna. (§ 73.37(b)) ____________

3.) Directional operation is not permitted for nighttime hours. (§ 73.182(a)(3)) ____________

4.) If directional operation is proposed for daytime hours, the assumed radiation for purposes of determining interference caused shall in no case be less than that which would be produced by a hypothetical nondirectional 250 watt operation. (see § **73.182(4)(e) for details. Minimum efficiency at 250 watts is 126 mV/m. See § 73.182(m) for Class C stations.)** ____________

ENGINEERING CHECK SHEET
CATEGORY - D

CALL ______________
FILE NO. ______________

5.) If the proposed 0.025 mV/m contour overlaps the 0.5 mV/m contour of any existing Class C station, assuming actual operating power for both the proposal and existing stations, then a "two-step waiver" and justification of non-routine grant must be prepared. Such proposals must not cause prohibited overlap when analyzed in accordance with paragraph #1 above. ______

6.) This is not a successive application as defined in § 73.37(c). ______

7.) The proposed nighttime operation may not increase the RSS limit to any Canadian, Mexican, or foreign station included in the Region 2 Agreement. A full computer nighttime channel study must be run to make this determination. ______

NOTE: For further background information regarding the across-the-board nighttime power increase for Class C stations, see the Report and Order In the Matter of Amendment of Part 73 of the Commissions Rules and Regulations concerning Nighttime Power Limitations for Class IV AM Broadcast Stations, MM Docket 79-265, Released March 23, 1984 (55 RR 2d 1015 (1984))

CALL SIGN ____________
FILE NO. ____________

ENGINEERING CHECK SHEET
CATEGORY - D

Class C
kHz

1230	1400
1240	1450
1340	1490

1.) In determining overlap caused to other Class C stations, an application for new or modified nondirectional facilities with a power of 250 watts or greater shall be considered on the assumption that the proposal operates with 250 watts. All existing stations are considered at actual operating power.

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CATEGORY - D FILE NO. ____________

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AM 8

OFFICE MEMORANDUM

TO: All Engineers and AM Permanent Interest File

FROM: Warren Powis

TOPIC: Local Channel AM Station Applications

DATE: March 28, 2000

Attached is an FCC engineering check sheet received from Bill Ball of the FCC Mass Media Bureau concerning the processing of local channel (Class C) AM applications; and the associated conditions where each Class C station operating at 1 kW can be assumed to be operating at 250 watts.

ENGINEERING CHECK SHEET
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FILE NO. ____________

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OFFICE MEMORANDUM

TO: All Engineers

FROM: Don Everist

TOPIC: New AM Technical Box Clarification

DATE: March 27, 2000

See the attached.

Sent: Thursday, March 23, 2000 5:10 PM
Subject: AFCCE - FCC 301-AM RMS Clarification

Many of you may have noted that the new FCC 301 Form, AM Engineering section, requests that the Theoretical RMS field be provided for non-directional applications, but does not specify for "one kilowatt" as in the former edition.

Consequently, some applications are being submitted to the FCC that identifies the "system" RMS rather than the traditional RMS value per kilowatt.

However, the RMS field should be specified for one kilowatt according to Son Nguyen in Mass Media.

Nguyen requests that all non-directional AM applications specify the per kilowatt RMS value. The forms will eventually be updated.

Also, if you use the CDBS, be advised of the possible discrepancy in the RMS data field in pending AM applications.

Message from AFCCE

RMS mV/m/kW

COHEN, DIPPELL AND EVERIST, P. C.

FROM: Don Everist

TOPIC: Proposed MOM Conditions

DATE: March 8, 2000

I will be reviewing in greater detail the proposed antennas that would fit the tentative MOM profile. I find the initial list very constructive. I expect to have comments regarding certain aspects of the initial list shortly.

However, I wish to see a separate step included at this time which would incorporate consideration of the elevation pattern computation into this process. Briefly as outlined in the morning in my remarks on NAB's suggested goals under the Item 2(a) and the word "design", I offer the following:

1. Concurrent to this process consider using MOM to compute elevation performance.

2. If the MOM program computes the elevation pattern correctly, then the nighttime null depth could possibly be relaxed and reduce the need of complicated arrays. This would potentially allow for more MOM adjusted arrays.

3. Make the process complete such that it lessens or at least does not increase the burden on FCC staff.

Further, an issue was raised that using MOM for elevation pattern would be hampered by existing international and bilateral agreements with Canada and Mexico. As I indicated based on my experience as a U.S. Industrial Delegate at numerous international conferences including the Region 2 conferences (First and Second Session) as well as the Panel of Experts meeting in Geneva that this item should not be insurmountable.

If there are any questions, please do not hesitate to contact this office.

ASSOCIATION OF

FEDERAL COMMUNICATIONS CONSULTING ENGINEERS

WASHINGTON, D.C.

February 29, 2000

Magalie Roman Salas, Esq.
Secretary
Federal Communications Commission
Room TW-B204
445 12th Street, S.W.
Washington, DC 20554

RE: Public Notice, DA 99-2605
"Window Filing Opportunity for Certain Pending Applications and Allotment Petitions for New Analog TV Stations" (Released November 22, 1999)

Dear Ms. Salas,

Transmitted herewith are an original and four copies of a "Support for Request for Extension of Window Filing Period", filed in connection with the above-referenced FCC Public Notice.

If any questions arise in this matter, please contact the undersigned.

Sincerely,

Joseph M. Davis
AFCCE President
c/o Cavell, Mertz & Davis, Inc.
10300 Eaton Place, Suite 200
Fairfax, VA 22030
703-591-0110

cc (w/ encl:): Roy J. Stewart, Keith Larson, Shaun Maher, Clay Pendarvis, Kimberly Matthews

Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	Public Notice
Window Filing Opportunity for Certain	)	DA 99-2605
Pending Applications and Allotment	)	
Petitions for New Analog TV Stations	)	Released November 22, 1999
	)	

SUPPORT FOR REQUEST FOR EXTENSION OF WINDOW FILING PERIOD

The Association of Federal Communications Consulting Engineers (AFCCE), celebrating over 50 years, is an organization that includes approximately 90 full members who are Registered Professional Engineers engaged in the practice of consulting engineering before the Federal Communications Commission.

On February 28, 2000, Fletcher, Heald & Hildreth, P.L.C. (*"FH&H"*) filed a request to extend the window filing period announced in the *Public Notice*, DA 99-2605 (released November 22, 1999) ("Mass Media Bureau Announces Window Filing Opportunity for Certain Pending Applications and Allotment Petitions for New Analog TV Stations") "*Window Filing Notice*", for a period of 90 days. AFCCE supports this request, and suggests that a minimum of 120 days is appropriate.

The filing window is currently scheduled to close on March 17, 2000, and permits the filing of amendments to certain applications for new NTSC stations. The amendments are intended to allow changes to pending NTSC proposals to move out of the Channel 60-69 spectrum, or to resolve a conflict with a DTV station.

Class A Television Service

As noted in the *FH&H* request, the Commission has been directed by Congress[1] to act by March 28, 2000 in releasing regulations to establish a Class A Television service.[2] The *Community Broadcasters Protection Act of 1999 ("CBPA")* was signed into law on November 29, 1999, which was after the *Window Filing Notice* was issued by the Commission.

Depending on the final Class A Television rules adopted by the Commission, protection to LPTV stations that are eligible for Class A status may have to be afforded by the proposed new NTSC stations that would file during the window. Since the window is currently scheduled to close on March 17, 2000, prior to the Class A regulations being finalized, it becomes impossible to determine whether a LPTV station requires protection. An extension of the filing window would permit NTSC applicants to review the Class A regulations and provide protection as may be required to eligible Class A stations.

May 1, 2000 DTV Filing Activity

Additionally, the *CBPA* sets forth a May 1, 2000 deadline for the filing of maximization applications for DTV stations without regard to protection of eligible LPTV stations.[3] It is anticipated that many applications will be filed to maximize DTV facilities by May 1, 2000 (including those for non-commercial, educational stations who must file their DTV applications by May 1, 2000). Current FCC policy does not permit NTSC proposals to create any new interference to DTV stations.[4] Should the March 17, 2000 filing window close as currently scheduled, it is likely that the anticipated filing activity associated with the May 1, 2000 deadline would create additional DTV conflicts for NTSC proposals, requiring more Commission Staff processing time and further amendments.

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[1] *Community Broadcasters Protection Act of 1999* Section 5008 of Pub. L. No. 106-113, 113 Stat. 1501 (1999), Appendix I, *codified at* 47 U.S.C. §336(f).

[2] *Order and Notice of Proposed Rule Making, In the Matter of Establishment of a Class A Television Service*, MM Docket No. 00-10 and 99-292, RM-9260, FCC 00-16 (released January 13, 2000).

[3] Public Notice *"'Community Broadcasters Protection Act of 1999' Sets Deadline of December 31, 1999 for Full Service Stations to File Letters of Intent to Maximize the DTV Facilities"* December 7, 1999, DA 99-2739.

[4] Public Notice *"Additional Application Processing Guidelines for Digital Television"* August 10, 1998.

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Consolidated Database System

The Commission's Mass Media Bureau is in the midst of converting its engineering database into the Consolidated Database System (CDBS).[5] It is our understanding that the Commission's former database has not been globally updated since December 30, 1999, that the transition to the CDBS is continuing, and that the accuracy and completeness of the CDBS is still being validated.

The integrity of the database is essential not only to Commission Staff in processing applications, but also for applicants to properly be aware of other nearby stations and to provide requisite protection. An extension in the window closing would permit Commission Staff to complete their work in the initiation of the CDBS and permit engineering consultants to adapt to using the revised format. Otherwise, it is expected that some proposals may require further amendments, draining Commission Staff time and resources due to additional conflicts.

Canadian Letter of Understanding

The Commission's Staff is working towards development of a *Letter of Understanding*[6] regarding protection of trans-border U.S. and Canadian DTV stations. An informal meeting was held at the Commission's offices on February 18, 2000 with Office of Engineering and Technology Staff and industry representatives (including a representative from AFCCE). Based on that meeting, the draft *Letter of Understanding* may undergo further changes. Specifically, industry representatives are tasked with presenting a unified statement to the Commission outlining issues and, if possible, offering solutions. A three-week period has been informally set for receipt of this response. Given this time line, final disposition may not occur until after the current March 17, 2000 window closing date.

Canadian coordination is required for proposals within 400 km of the common border between the U.S. and Canada. Since the evaluation of protection to Canadian DTV assignments is not finalized, NTSC applicants considering alternate channels in this region will not be able to

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[5]Public Notice *"Mass Media Implements Consolidated Database System (CDBS) Public Access"* February 28, 2000, DA 00-414.

[6]*"Letter Of Understanding Between the Federal Communications Commission of the United States of America and Industry Canada Related to the Use of the 54-72 MHz, 76-88 MHz, 174-216 MHz and 470-806 MHz Bands for the Digital Television Broadcasting Service Along the Common Border"*

fully evaluate prospective channels or facility modifications. An extension in the Window Filing Period would help to alleviate this situation.

Summary

Due to the "mix" of issues summarized above, much needs to be settled before confidence in a prospective solution to a new NTSC proposal can be gained. The November 22, 1999 Public Notice references the November 1, 1999 filing deadline (for commercial DTV stations) and states that the Mass Media Bureau "is currently entering into its computer database the many applications that were filed and expects to complete this entry by the end of the year." This statement suggests that the November 1, 1999 DTV filing activity would impact possible NTSC solutions. The subsequent CBPA action and associated May 1, 2000 filing activity will have a similar impact on NTSC modifications. An extension in the Window Filing Period of at least 120 days is appropriate, which would allow the Commission's Staff to enter all May 1, 2000 filing activity and validate the resulting CDBS data.

Therefore, AFCCE supports the FH&H request for an additional 90 days (and suggests a minimum of 120 days) in the Window Filing Opportunity. Should an additional period not be granted, then AFCCE requests that the Commission accept subsequent amendments and channel change petitions that would become necessary in the event of a conflict with an eligible Class A station or DTV proposal. Finally, AFCCE requests that the Commission act on the extension requests very soon so applicants/petitioners will not have to continue spending time and money on potential proposals that may never be filed.

Respectfully submitted,

Joseph M. Davis
AFCCE President

c/o Cavell, Mertz & Davis, Inc.
10300 Eaton Place Suite 200
Fairfax, VA 22030
703-591-0110

COHEN, DIPPELL AND EVERIST, P.C.

TO: Lou Williams

FROM: Don Everist

TOPIC: NAB Industry Meeting on Method of Moments ("MOM")

DATE: February 29, 2000

On February 24, 2000, John Marino convened the MOM meeting. See the attached agenda. Everist announced that he was acting in the capacity as AFCCE Rules and Regulations representative as well as representing Cohen, Dippell and Everist, P.C.

With reference to item 2(a), Everist commented on the word "design" and offerred the following.

1. Concurrent to this process consider using MOM to compute elevation performance.
2. If the MOM program computes the elevation pattern correctly, then the null depth would be relaxed and reduce the need of complicated arrays. This would potentially allow for more MOM adjusted arrays.
3. Make the process complete such that it lessens or at least does not increase the burden on FCC staff.

Issue was raised that using MOM for elevation pattern would be hampered by existing international and bilateral agreements with Canada and Mexico. Everist indicated based on his experience as an U.S. Industrial Delegate at the Region 2 conferences (First and Second Session) as well as the panel of experts that this item should not be insurmountable. In absence of Ron Rackley, Ben Dawson began discussing what might be consideration for candidate antenna systems for Method of Moments.

a. Flat site
b. Thin radiator
c. Equal height towers
d. Monitoring system
e. RMS/RSS ratio
f. Current loop versus radiated field

Everist indicated that RMS/RSS ratio was nothing new as when he joined the firm in 1961 that was an array test. Glen Clark asked what was the maximum RMS/RSS criteria used. Everist responded not to exceed 2.0. There was no alternate views presented.

Everist raised the issue of null depth out of concern of issues of reradiation beyond the property limits. After some discussion, Everist withdrew the issue to be raised at a later time.

Ron Rackley came in and reviewed some material regarding current and voltage monitoring. Several criteria emerged that current sampling may be accurate up to 110°. Some comments were generated that the rules on monitoring were too restrictive. Everist reported that he was chairman of the Rules and Standard Committee when the last sample system monitoring rule making was issued. Everist reported older "more experienced" engineers reluctance to consider other alternatives.

Discussion then moved to the issue what was important.

a. No. of towers
b. RMS/RSS ratio
c. Terrain flatness

At that juncture, a recess was called for lunch.

Everist left before the afternoon session. See the NAB version of the agreement reached in the afternoon.

13

Aan

MININEC Development

A Historical Note

The original version of MININEC was written in BASIC for use on a limited (16K memory with 8-bit word length) desk top computer (e.g. an Apple II). The first version was written by John W. Rockway in his spare time while on vacation. Subsequent work by Alred J. Julian and James C. Logan wrung out the bugs and proved the utility and accuracy. It was first published in 1982 as Naval Ocean Systems Center Technical Document 516 [1].

A significantly improved version, MININEC(2) was published in 1982 as one of 25 computer programs (in BASIC) in the Artech book by Li, et.al. [2] Again the improvements to the code were done in spare time on home computers.

Working on an Army funded project, the authors added a few capabilities and made other improvements, such as changing the input format. The improved MININEC(3) was published in 1986 as Naval Ocean Systems Center Technical Document 516 [3]. It was designed to run under DOS on a PC. All third-party commercial and "free" versions are based on MININEC(3). MININEC(3) was written in BASIC using a Galerkin solution routine with pulse basis functions. (Galerkin is a moment method procedure using identical expansion and testing functions). Some experimental versions have been produced in FORTRAN and C by various people, including some special versions by the authors. In at least one case, parts or all of the program were converted to machine language. But all of these versions were virtually a one-for-one translation from the BASIC code. In BASIC the complex arithmetic is part of the code. Complex arrays are handled as two separate real number arrays. The translations into FORTRAN, for example, did not take advantage of the complex arithmetic of the language. The authors experience is that these versions were sometimes not as accurate, longer (requiring more lines of code and storage) and generally slower. In the PC environment of the times, BASIC seemed to provide the best all-around performance.

In 1988, the MININEC authors published a new version with Artech House [4]. The MININEC System used BASIC and sported a significantly improved user interface. Unfortunately, the work was completed just prior to the release of the Microsoft Windows Operating System. Although this work was a significant improvement, it could not take advantage of the Windows operating environment. When this version went out of print, Artech House returned the copyright to the authors.

In 1995 and 1996, the authors published new "Windows" versions of MININEC [5] [6] [7]. The computational engines of the MININEC Professional Series are written in FORTRAN. The user interface is in Visual BASIC. These codes are fully integrated into Windows, i.e. they are Windows applications. The user interface provides on-line context sensitive help with entries in multiple input windows or dialog boxes. The solution is accomplished in a Galerkin procedure but using triangular expansion functions rather than pulses. This results in improved accuracy and stability. The FORTRAN computational engines are executed automatically from a DOS level command for greater speed.

In 1999, the authors published another improved set of codes, the Expert MININEC Series. The new series features "*Expert*" assistance in selecting appropriate input dialog boxes while constructing a model. The "*Expert*" also opens supporting windows when needed. Data can be easily transferred from the supporting windows to the dialog entry boxes with a click of the mouse. Context sensitive help is still an important feature. Accuracy and speed have also been improved. For further information on the attributes of the "Expert MININEC Series", please see the EM Scientific, Inc. web site at http://www. Emsci.com/.

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Feature Article

Electromagnetic Surface Waves

Ronold W. P. King

Gordon McKay Laboratory
Harvard University
Cambridge, MA 02138

1. Introduction

Electromagnetic waves that are guided along a boundary between two electrically different media are called surface waves. Actually there are a number of types of such waves with quite different properties. Among the best known are those that travel along so-called surface waveguides, like dielectric-coated, corrugated, or otherwise modified metal surfaces. These are not lateral waves. Surface waves along the smooth boundary between two dielectrics with permittivities $\epsilon_1 > \epsilon_2$ occur in the less dense region 2 when the angle of incidence in region 1 exceeds the critical angle. The incident field is then totally reflected in region 1 and there is no refracted field in region 2. However, the boundary conditions require the plane wave that travels parallel to the boundary in region 1 to extend into region 2 where its amplitude decreases exponentially in the direction perpendicular to the surface and to the direction of propagation. This is a true surface wave in region 2 but it is not a lateral wave.

When a vertical electric dipole with the electric moment $Ih_e = 1$ Am is erected on the earth or sea for radio communication, as shown in Fig. 1, the electric field in the air is often represented in the spherical coordinates r, Θ, Φ in the form:

$$E_\Theta = -\frac{i\omega\mu_0}{4\pi}\frac{e^{ik_2 r}}{r}(1 + f_{er})\sin\Theta, \tag{1}$$

where Θ is measured from the vertical axis, r is the radial distance to the point of observation, and

$$f_{er} = \frac{N^2\cos\Theta - (N^2 - \sin^2\Theta)^{1/2}}{N^2\cos\Theta + (N^2 - \sin^2\Theta)^{1/2}} \tag{2}$$

is the plane-wave reflection coefficient. N is the complex index of refraction. The wave number of the earth or sea is $k_1 = \beta_1 + i\alpha_1 = \omega[\mu_0(\epsilon_1 + i\sigma_1/\omega)]^{1/2}$, that of the air is $k_0 = \omega(\mu_0\epsilon_0)^{1/2}$. The magnitude of E_Θ is shown in Fig. 1 for sea water, lake water, and dry earth. Also shown is the field when region 1 is a perfect conductor ($N \to \infty$). It is seen that since from (2) $f_{er} = -1$ when $\Theta = \pi/2$ for all *finite* values of N, $E_\Theta = 0$ along the entire equatorial plane. On the other hand, with the perfect conductor $f_{er} = 1$ when $\Theta = \pi/2$, so that E_Θ has a maximum. Actually, the field is not zero over any of the media represented in Fig. 1. The formula (1) is incomplete. The field of the vertical dipole is not a plane wave and the boundary conditions on the tangential electric and magnetic fields are not satisfied (as are plane waves) by an incident and reflected field in the air and a refracted field in the earth or sea. A surface wave with unusual properties is also required. The complete field was derived by Sommerfeld [1]. In its association with radio communication over the earth, the associated surface wave was called the *Norton surface wave* after K. A. Norton [2], [3] who pioneered in its approximate evaluation and graphical representation in the manner illustrated in Fig. 2. In more general occurrences it is known as a lateral wave.

2. Vertical Dipole in Air on the Surface of the Earth

a. The Field in the Air; Radio Transmission

The complete field of a unit vertical electric dipole (electric moment $I_z h_e = 1$ Am) located in the air (region 2, $z' \geq 0$) at a height d over the surface of the earth or sea (region 1, $z' \leq 0$) consists of the three cylindrical components E_ρ, $E_{z'}$, and B_ϕ. At (ρ, z') in the air it is accurately given by three integrals [4, eqs. (29)–(31)] of which the following one for $E_{2z'}$ is representative:

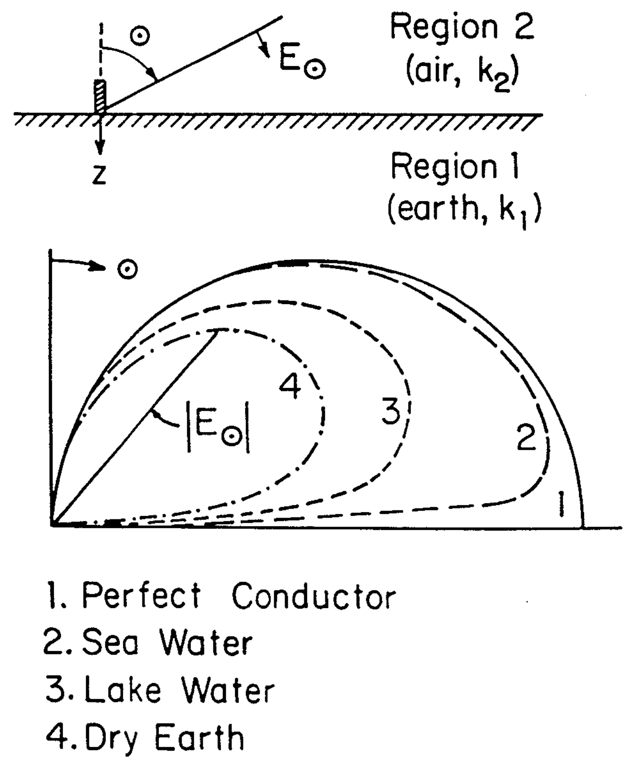

Figure 1. Far field of vertical dipole, not including the lateral wave.

$$E_{2z'}(\rho,z') = -\frac{\omega\mu_0 k_1^2}{2\pi k_2^2}\int_0^\infty \frac{e^{i\gamma_2 z'}}{N} J_0(\lambda\rho)\lambda^3\,d\lambda, \tag{3}$$

where $N = k_1^2\gamma_2 + k_2^2\gamma_1$ and $\gamma_j = (k_j^2 - \lambda^2)^{1/2}$ with $j = 1, 2$. This formula is equivalent to the expressions of Sommerfeld [1], Baños [5], and others who express the components of the field as unevaluated derivatives of the Hertz potential. Subject to the inequality

$$|k_1^2| \gg k_2^2 \qquad \text{or} \qquad |k_1| \geq 3k_2, \tag{4}$$

the integral (3) and those for the other components have been evaluated with the following result for $E_{2z'}$:

$$E_{2z'}(\rho,z') = E^d_{2z'}(\rho,z') + E^i_{2z'}(\rho,z') + E^L_{2z'}(\rho,z'), \tag{5}$$

where

$$E^d_{2z'}(\rho,z') = \frac{\omega\mu_0}{4\pi k_2} e^{ik_2r_1}\left[\left(\frac{ik_2}{r_1} - \frac{1}{r_1^2} - \frac{i}{k_2r_1^3}\right) - \left(\frac{z'-d}{r_1}\right)^2\left(\frac{ik_2}{r_1} - \frac{3}{r_1^2} - \frac{3i}{k_2r_1^3}\right)\right] \tag{6a}$$

is the direct field of the dipole as if in an infinite medium at $(0,d)$;

$$E^i_{2z'}(\rho,z') = \frac{\omega\mu_0}{4\pi k_2} e^{ik_2r_2}\left[\left(\frac{ik_2}{r_2} - \frac{1}{r_2^2} - \frac{i}{k_2r_2^3}\right) - \left(\frac{z'+d}{r_2}\right)^2\left(\frac{ik_2}{r_2} - \frac{3}{r_2^2} - \frac{3i}{k_2r_2^3}\right)\right] \tag{6b}$$

is the field of an identical image dipole at $(0,-d)$; and

$$E^L_{2z'}(\rho,z') = -\frac{\omega\mu_0}{2\pi k_2} e^{ik_2\rho} e^{ik_2(z'+d)^2/2\rho} \times \frac{k_2^3}{k_1}\left(\frac{\pi}{k_2\rho}\right)^{1/2} e^{-iP}\mathcal{F}(P) \tag{6c}$$

is the lateral-wave field. In (6a-c),

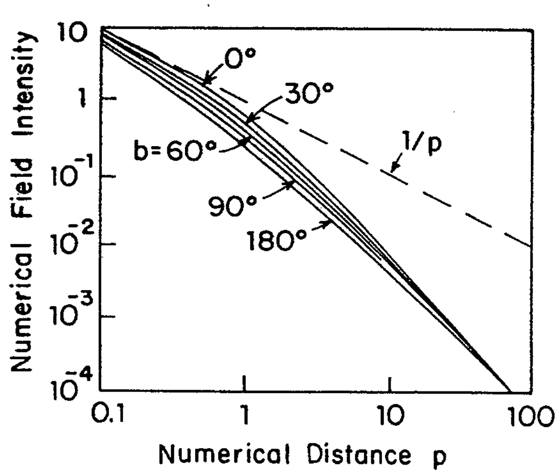

Figure 2. Decay of ground wave intensity with radial distance ϱ as contained in numerical distance $p = |p|\exp(ib) = ik_2^3\varrho/2k_1^2$ (Norton's graphs).

$$r_1 = [\rho^2 + (z'-d)^2]^{1/2}, \quad r_2 = [\rho^2 + (z'+d)^2]^{1/2}, \quad z' = -z, \tag{7a}$$

$$P = (R + Z' + D)^2/R, \tag{7b}$$

$$R = k_2^3\rho/2k_1^2, \quad Z' = k_2^2z'/2k_1, \quad D = k_2^2d/2k_1; \tag{7c}$$

$$\mathcal{F}(P) = \tfrac{1}{2}(1+i) - C_2(P) - iS_2(P) = \int_P^\infty \frac{e^{it}}{\sqrt{2\pi t}}\,dt. \tag{8}$$

Here, $C_2(P) + iS_2(P)$ is the Fresnel integral.

The field on the boundary $z' = 0$ when the dipole is also on the boundary, i.e., when $d = 0$, is:

$$E_{1z'}(\rho,0) = E_{2z'}(\rho,0) = \frac{\omega\mu_0}{2\pi k_2} e^{ik_2\rho} g(k_2\rho, k_1), \tag{9}$$

where

$$g(k_2\rho,k_1) = \frac{ik_2}{\rho} - \frac{1}{\rho^2} - \frac{i}{k_2\rho^3} - \frac{k_2^3}{k_1}\left(\frac{\pi}{k_2\rho}\right)^{1/2} e^{-iR}\mathcal{F}(R). \tag{10}$$

The quantity $R = k_2^3\rho/2k_1^2$ is the magnitude of the well known "numerical distance" of Sommerfeld. In (10), the first three terms are the field in the equatorial plane of a z'-directed unit electric dipole in air. They are dominant in the near field where $R < 1$, since there the Fresnel-integral term is negligibly small. They constitute the entire field at all radial distances when region 1 is a perfect conductor with $\sigma_1 = \infty$, $k_1 \sim \infty$, since then the Fresnel-integral term vanishes identically. In the far field defined by $R \geq 4$, the $1/\rho$ term in (10) dominates among the first three so that the field over a perfect conductor reduces to the familiar form

$$E_{2z'}(\rho,0) \sim \frac{i\omega\mu_0}{2\pi}\frac{e^{ik_2\rho}}{\rho}. \tag{11}$$

For all other types of media, the Fresnel-integral term assumes the following far-field form:

$$-\frac{k_2^3}{k_1}\left(\frac{\pi}{k_2\rho}\right)^{1/2} e^{-iR}\mathcal{F}(R) = -\frac{ik_2}{\rho} - \frac{k_1^2}{k_2^2\rho^2}, \tag{12}$$

so that the complete far field becomes

$$E_{2z'}(\rho,0) \sim -\frac{\omega\mu_0k_1^2}{2\pi k_2^3}\frac{e^{ik_2\rho}}{\rho^2}. \tag{13}$$

Thus, along the air–earth boundary, the far field has the form $1/\rho^2$ and not $1/\rho$. It is determined by the Fresnel-integral term in which the $1/\rho$ part exactly cancels the $1/\rho$ far field (11) of the dipole with image. The vertical electric field given by (5) and along the boundary by (9) is that used in all radio communication over the surface of the earth or sea when both the transmitter and receiver are on the surface. The field patterns are like those in Fig. 1 except that with finite σ they do not vanish when $\Theta = \pi/2$ but reduce to the relatively small value given by (9).

b. The Field in the Earth or Sea; Communication with Submarines

The field at radial distances ρ and depth z in the ocean (region 1, $z \geq 0$) due to a vertical dipole in the air on the surface of the earth or sea is of importance in communicating with submerged submarines. For this purpose the radial component of the electric field is most useful. It is given by an integral similar to (3) and has the following integrated form:

$$E_{1\rho}(\rho,z) = -\frac{\omega\mu_0}{2\pi k_1} e^{ik_1 z} e^{ik_2\rho} f(k_2\rho, k_1), \qquad (14a)$$

where

$$f(k_2\rho, k_1) = \frac{ik_2}{\rho} - \frac{1}{\rho^2} - \frac{k_2^3}{k_1}\left(\frac{\pi}{k_2\rho}\right)^{1/2} e^{-iR}\mathcal{F}(R). \qquad (14b)$$

Since the far-field form of the Fresnel integral given by (12) applies when $R \geq 4$ and since with it $E_{1\rho}(\rho,z)$ decreases as $1/\rho^2$, it is advantageous to select a frequency for which the desired range of ρ is in the intermediate zone in which the Fresnel-integral term is small and the $1/\rho$ term in (14b) dominates. This occurs when

$$1 \leq k_2\rho \leq |k_1^2/k_2^2|. \qquad (15)$$

The quantity $20\log_{10}|E_{1\rho}(\rho,z)|$ in this range with $\rho = 5{,}000$ km is shown in Fig. 3. For each depth in the ocean there is an optimum frequency for a maximum received signal. This decreases as the depth increases. In the frequency range from 20 to 30 kHz—used by the Navy transmitter at Cutler, ME—the optimum depth is seen to be in the range from $z = 10$ to $z = 20$ m. As the depth increases further, the magnitude of the electric field decreases very rapidly. In order to communicate with submarines at greater depths, lower frequencies must be used. This is not practical using vertical dipoles.

3. Vertical Dipole in the Sea; Conductivity of the Earth's Crust

An interesting application of the vertical dipole near a boundary and the lateral waves it generates is to the measurement of the conductivity of the oceanic crust (region 2, $z \leq 0$). For this purpose the dipole is located in the sea (region 1, $z \geq 0$) at a small height d above the sea floor or it is extended from this all the way to the surface of the sea [6]. Measurements are made on or at a small height z above the sea floor. The preferred quantity to be measured is the magnetic field at very low frequencies. This is given by an integral similar to (3). It has the following integrated form:

$$B_{1\phi}(\rho,z) = B_{1\phi}^d(\rho,z) + B_{1\phi}^i(\rho,z) + B_{1\phi}^L(\rho,z), \qquad (16a)$$

with

$$B_{1\phi}^d(\rho,z) = -\frac{\mu_0}{4\pi} e^{ik_1 r_1}\left(\frac{ik_1}{r_1} - \frac{1}{r_1^2}\right)\left(\frac{\rho}{r_1}\right), \qquad (16b)$$

$$B_{1\phi}^i(\rho,z) = \frac{\mu_0}{4\pi} e^{ik_1 r_2}\left(\frac{ik_1}{r_2} - \frac{1}{r_2^2}\right)\left(\frac{\rho}{r_2}\right), \qquad (16c)$$

$$B_{1\phi}^L(\rho,z) = -\frac{\mu_0 k_2^2}{2\pi k_1^2} e^{ik_1(z+d)} e^{ik_2\rho} f(k_2\rho, k_1), \qquad (16d)$$

where $r_1 = [\rho^2 + (z-d)^2]^{1/2}$, $r_2 = [\rho^2 + (z+d)^2]^{1/2}$, and $f(k_2\rho, k_1)$ is defined in (14b). The direct field of the dipole is given by (16b), the field of the image dipole is given by (16c), and the lateral wave by (16d). Note that when the source dipole is in the denser region 1 and the point of observation is on the boundary surface $z = 0$, the image field is the *negative* of the direct field, so that the lateral-wave field $B_{1\phi}^L(\rho, 0)$ is the entire field.

In practice measurements are made at extremely low frequencies and within relatively small radial distances where the Fresnel-integral term is negligibly small and the significant magnetic field is

$$B_{1\phi}(\rho,0) = B_{1\phi}^L(\rho,0) \sim -\frac{\mu_0\sigma_2}{2\pi\sigma_1}\left(\frac{ik_2}{\rho} - \frac{1}{\rho^2}\right) e^{ik_2\rho} e^{ik_1 d}. \qquad (17)$$

The application of this formula [7] to actual measurements made on the sea floor [6] is illustrated in Fig. 4. The dipole extended from the surface to the floor of the sea—a distance

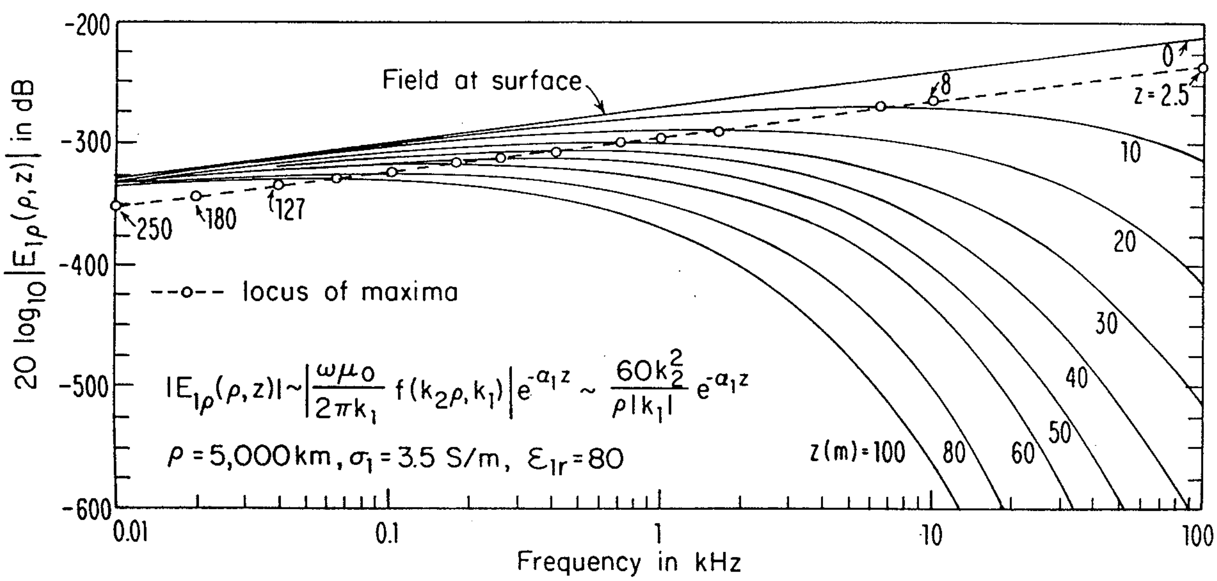

Figure 3. Radial electric field at depth z and ρ = 5,000 km due to vertical electric dipole in air on the surface of sea water as a function of the frequency, with z as parameter.

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ELECTROMAGNETIC WAVES AND RADIATING SYSTEMS

EDWARD C. JORDAN
Professor of Electrical Engineering
College of Engineering
University of Illinois

Englewood Cliffs, N. J.
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PREFACE

A KNOWLEDGE of electromagnetic radiation and propagation is now required of virtually all communication and electronic engineers. This book is designed to provide a course in this field for electrical engineers and physicists. It is an outgrowth of courses given by the author at Ohio State University and at the University of Illinois. The level of the first part of the book is suitable for seniors and beginning graduate students; the later chapters are primarily for more advanced graduate students. Although there is sufficient material for a two-semester course, many instructors may prefer to select only certain chapters to be covered in a one-semester or one-quarter course. The division of material among chapters has been made with this fact in mind.

In a text of this scope it is necessary to draw from the writings of many specialists. I am indebted to Professor Erik Hallén for the use of his antenna impedance curves in Chapter 13. For the chapters on propagation, material from the papers of K. A. Norton and C. R. Burrows has been used. The writings of S. A. Schelkunoff are already classics and are largely responsible for many engineering concepts, such as wave impedance and magnetic currents, now in general use. References to his papers and book will be found throughout the text.

It is a pleasure to acknowledge the assistance given by the author's associates at the University of Illinois and elsewhere. W. G. Albright, R. S. Elliott, P. K. Hudson, Ray DuHamel, Edgar Hayden, John Myers, Douglas Royal, John Bell, and many others gave freely of their time in checking the manuscript and reading proof. Discussions with George Sinclair were always helpful. I am especially indebted to J. A. Barkson, who read much of the manuscript and offered many suggestions, and to Nicholas Yaru, who drew the originals for the illustrations.

Several years ago it was my privilege to take a graduate course in

Inspection of eqs. (9) and (10) shows that the total field may be divided into two parts, a "space wave," given by the inverse-distance terms, and a "surface wave" that contains the additional attenuation factor F. Combining (9) and (10) and separating into these two types of waves, there results

$$E_{\text{total space}} = E_\psi\ (\text{space}) = \sqrt{E_z^2\ (\text{space}) + E_\rho^2\ (\text{space})}$$

$$= j30\beta I\ dl \cos\psi \left(\frac{e^{-j\beta R_1}}{R_1} + R_v \frac{e^{-j\beta R_2}}{R_2} \right) \qquad (16\text{-}11)$$

$$E_{\text{total surface}} = j30\beta I\ dl(1 - R_v)F \frac{e^{-j\beta R_2}}{R_2}$$

$$\sqrt{1 - 2u^2 + (\cos^2\psi)u^2\left(1 + \sin^2\frac{\psi}{2}\right)} \qquad (16\text{-}12)$$

In equations (11) and (12), terms involving the factor u^4 have been discarded.

The Space Wave. The expression for the space wave of a vertical dipole over a plane earth as given by eq. (11), consists of two terms. The first term $e^{-j\beta R_1}/R_1$ represents a spherical wave originating at the position of the dipole. $e^{-j\beta R_1}$ is the phase factor (the time factor $e^{j\omega t}$ has been dropped) and $1/R_1$ is the inverse-distance factor. Similarly the second term represents a spherical wave originating at the position of the image of the dipole, but in this case the magnitude and phase of the wave have been modified by the *plane* wave reflection factor R_v. Thus the space wave part of the field consists of a direct wave and a reflected wave, and the expression for the reflected wave contains the reflection factor R_v that would apply if the incident wave were plane. When the dipole is located far from the earth, the incident wave is essentially a plane wave, and, in this case, the space wave field is the total (ground wave) field. On the other hand, when the dipole is located close to the earth, the incident wave will not be plane, and the expression for the total reflected field must contain terms in addition to those given by the space wave field. These additional terms are just those which account for the surface wave.

Space Wave Patterns of a Vertical Dipole. In order to determine the effect of a finitely conducting earth upon the radiation pattern of an actual antenna, it is desirable first to investigate the radiation pattern of an elementary dipole above the earth. Expression (11)

gives the space wave field of a vertical dipole located at any height above a finitely conducting earth having the reflection coefficient R_v. The expression has been evaluated and plotted as a function of frequency for a range of ground conductivities and several dipole heights (Figs. 16-7 to 16-9).

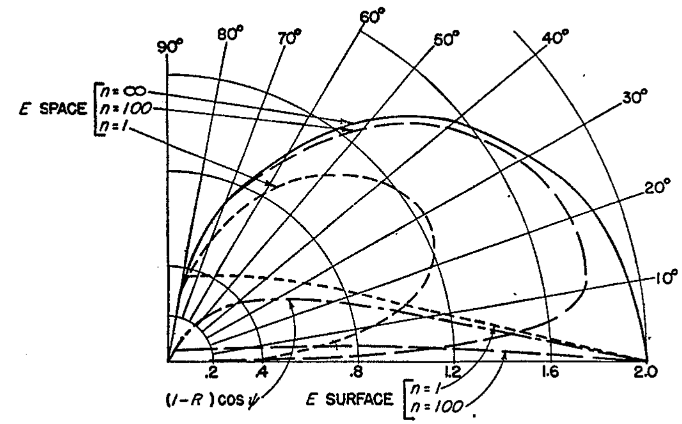


FIG. 16-7. Vertical radiation pattern of a vertical dipole at the surface of an earth having finite conductivity. The parameter $n = x/\epsilon_r$ and an average value $\epsilon_r = 15$ has been used. Both space wave and unattenuated surface wave terms are shown.

Figure 16-7 shows the vertical radiation pattern of a vertical dipole located at the surface of a finitely conducting earth. The parameter $n = x/\epsilon_r$, where as before

$$x = \frac{\sigma}{\omega\epsilon_v} = \frac{18 \times 10^3\sigma}{f_{mc}}$$

σ is the earth conductivity in mhos per meter and f_{mc} is the frequency in megacycles. An average value of 15 has been used for ϵ_r, the relative dielectric constant of the earth. The curve $n = \infty$ represents the case of a perfectly conducting earth. $n = 100$ represents conditions at low broadcast frequencies over a good (high conductivity) earth. $n = 10$ corresponds to high broadcast frequencies over an earth of average conductivity. The curve $n = 1$ represents conditions at the medium-high frequencies. The solid curves are the space wave patterns. Shown dotted is the unattenuated surface

wave curve, which will be discussed later. Figs. 16-8 and 16-9 show the vertical radiation patterns, which result when the dipole is elevated one-quarter wavelength and one-half wavelength above the earth.

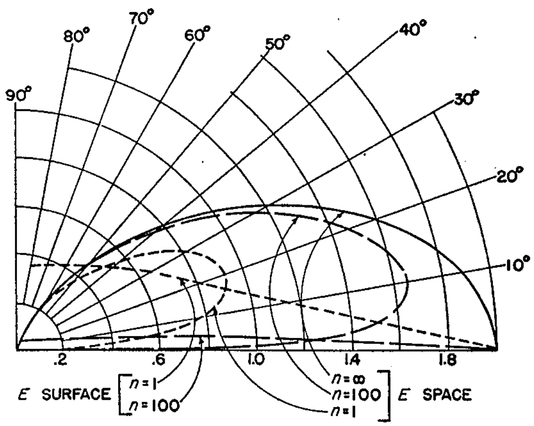


FIG. 16-8. Vertical radiation of a vertical dipole located a quarter wavelength above an earth of finite conductivity. $n = x/\epsilon_r$ and $\epsilon_r = 15$.

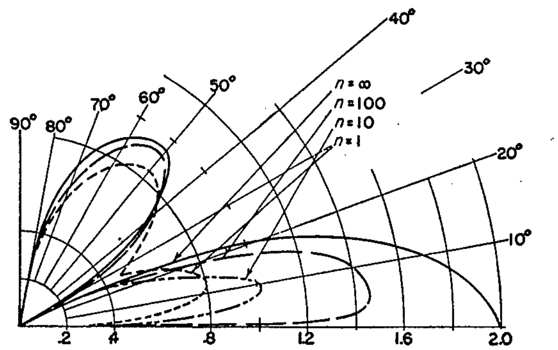
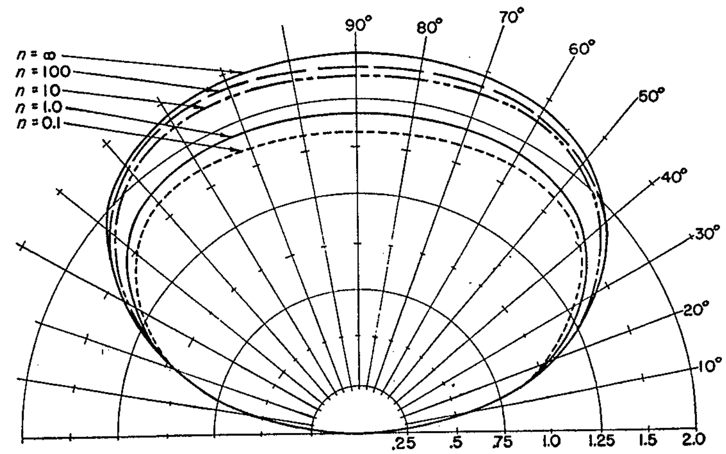


FIG. 16-9. Vertical radiation pattern of a vertical dipole one half wavelength above an earth of finite conductivity. $n = x/\epsilon_r$ and $\epsilon_r = 15$.

From these figures it is apparent that the chief effect of the finite conductivity of the earth on the vertical radiation patterns occur at the low angles where the space wave is much reduced from its value over a perfectly conducting earth. This is because of the

phase of the reflection factor R_v, which changes rapidly for angles of incidence near the pseudo-Brewster angle. Above this angle the phase of R_v is nearly zero, whereas below this angle near grazing incidence the phase of R_v approaches -180 degrees. The phase of R_v is always -90 degrees at the pseudo-Brewster angle. This rapid change of phase of the reflection coefficient near the critical pseudo-Brewster angle is responsible for many of the propagation characteristics peculiar to vertical polarization.



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ELECTROMAGNETIC WAVES AND RADIATING SYSTEMS

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Professor of Electrical Engineering

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University of Illinois

Englewood Cliffs, N. J.

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$$E_{\text{total surface}} = j30\beta I\ dl(1 - R_v)F \frac{e^{-j\beta R_2}}{R_2}$$
$$\sqrt{1 - 2u^2 + (\cos^2\psi)u^2\left(1 + \sin^2\frac{\psi}{2}\right)} \qquad (16\text{-}12)$$

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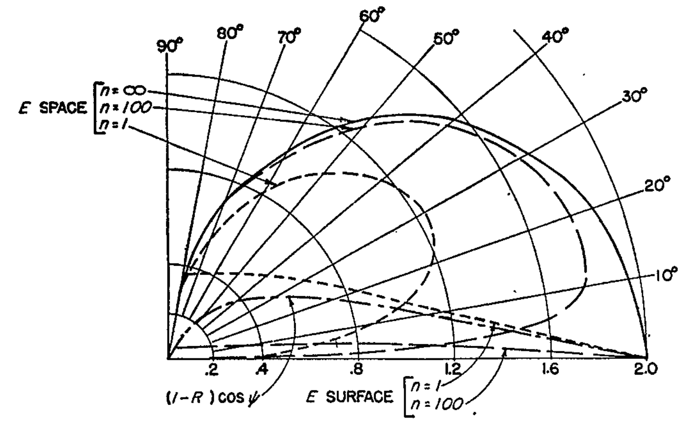

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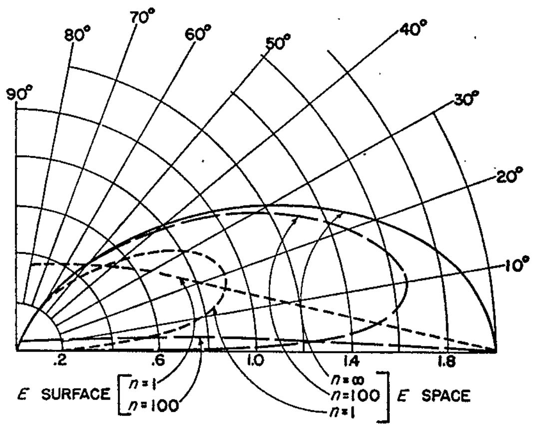

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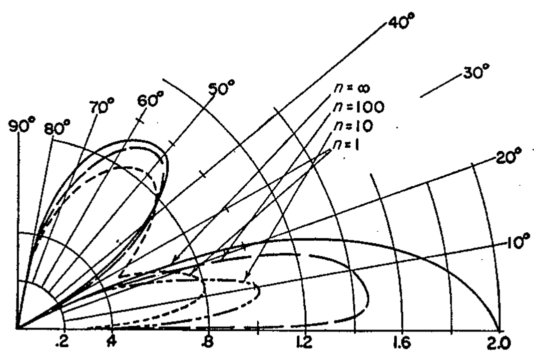

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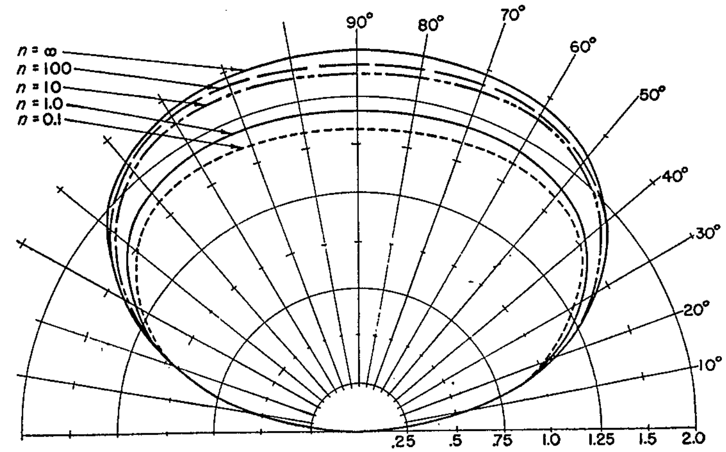

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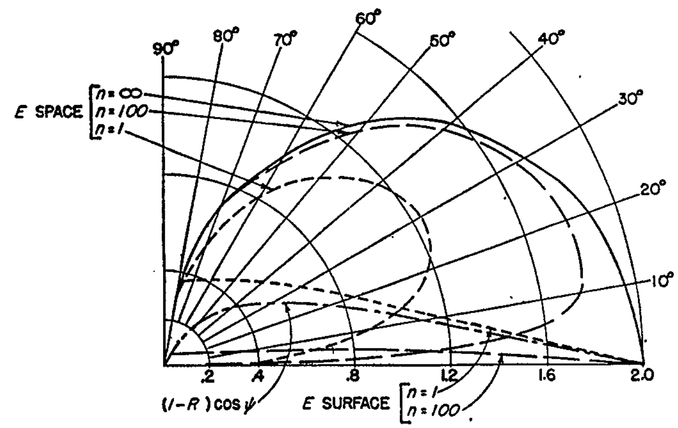

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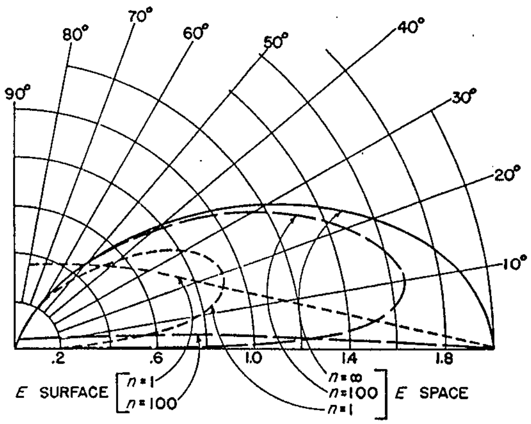

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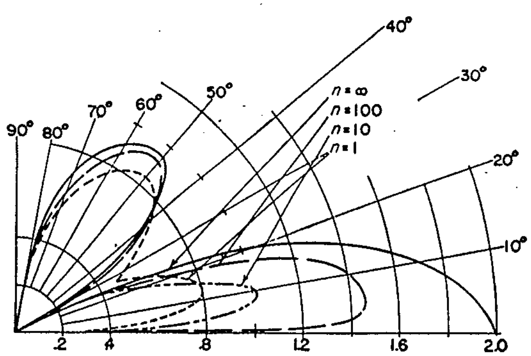

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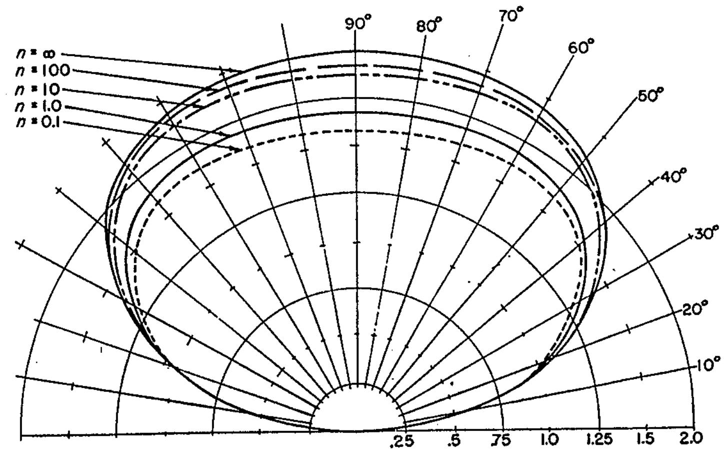

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Feature Article

Electromagnetic Surface Waves

Ronold W. P. King

Gordon McKay Laboratory
Harvard University
Cambridge, MA 02138

1. Introduction

Electromagnetic waves that are guided along a boundary between two electrically different media are called surface waves. Actually there are a number of types of such waves with quite different properties. Among the best known are those that travel along so-called surface waveguides, like dielectric-coated, corrugated, or otherwise modified metal surfaces. These are not lateral waves. Surface waves along the smooth boundary between two dielectrics with permittivities $\epsilon_1 > \epsilon_2$ occur in the less dense region 2 when the angle of incidence in region 1 exceeds the critical angle. The incident field is then totally reflected in region 1 and there is no refracted field in region 2. However, the boundary conditions require the plane wave that travels parallel to the boundary in region 1 to extend into region 2 where its amplitude decreases exponentially in the direction perpendicular to the surface and to the direction of propagation. This is a true surface wave in region 2 but it is not a lateral wave.

When a vertical electric dipole with the electric moment $Ih_e = 1$ Am is erected on the earth or sea for radio communication, as shown in Fig. 1, the electric field in the air is often represented in the spherical coordinates r, Θ, Φ in the form:

$$E_\Theta = -\frac{i\omega\mu_0}{4\pi}\frac{e^{ik_2 r}}{r}(1 + f_{er})\sin\Theta, \tag{1}$$

where Θ is measured from the vertical axis, r is the radial distance to the point of observation, and

$$f_{er} = \frac{N^2\cos\Theta - (N^2 - \sin^2\Theta)^{1/2}}{N^2\cos\Theta + (N^2 - \sin^2\Theta)^{1/2}} \tag{2}$$

is the plane-wave reflection coefficient. N is the complex index of refraction. The wave number of the earth or sea is $k_1 = \beta_1 + i\alpha_1 = \omega[\mu_0(\epsilon_1 + i\sigma_1/\omega)]^{1/2}$, that of the air is $k_0 = \omega(\mu_0\epsilon_0)^{1/2}$. The magnitude of E_Θ is shown in Fig. 1 for sea water, lake water, and dry earth. Also shown is the field when region 1 is a perfect conductor ($N \to \infty$). It is seen that since from (2) $f_{er} = -1$ when $\Theta = \pi/2$ for all *finite* values of N, $E_\Theta = 0$ along the entire equatorial plane. On the other hand, with the perfect conductor $f_{er} = 1$ when $\Theta = \pi/2$, so that E_Θ has a maximum. Actually, the field is not zero over any of the media represented in Fig. 1. The formula (1) is incomplete. The field of the vertical dipole is not a plane wave and the boundary conditions on the tangential electric and magnetic fields are not satisfied (as are plane waves) by an incident and reflected field in the air and a refracted field in the earth or sea. A surface wave with unusual properties is also required. The complete field was derived by Sommerfeld [1]. In its association with radio communication over the earth, the associated surface wave was called the *Norton surface wave* after K. A. Norton [2], [3] who pioneered in its approximate evaluation and graphical representation in the manner illustrated in Fig. 2. In more general occurrences it is known as a lateral wave.

2. Vertical Dipole in Air on the Surface of the Earth

a. The Field in the Air; Radio Transmission

The complete field of a unit vertical electric dipole (electric moment $I_z h_e = 1$ Am) located in the air (region 2, $z' \geq 0$) at a height d over the surface of the earth or sea (region 1, $z' \leq 0$) consists of the three cylindrical components E_ρ, $E_{z'}$, and B_ϕ. At (ρ, z') in the air it is accurately given by three integrals [4, eqs. (29)–(31)] of which the following one for $E_{2z'}$ is representative:

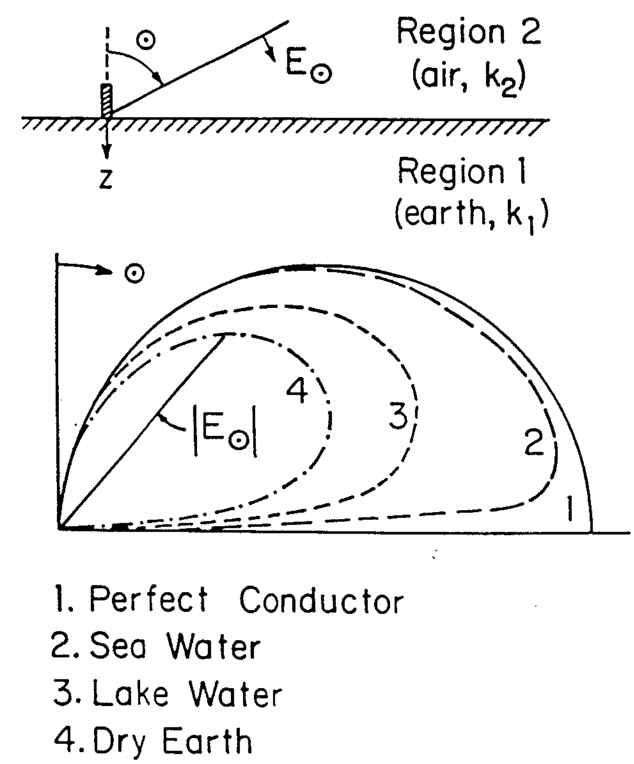

Figure 1. Far field of vertical dipole, not including the lateral wave.

$$E_{2z'}(\rho,z') = -\frac{\omega\mu_0 k_1^2}{2\pi k_2^2}\int_0^\infty \frac{e^{i\gamma_2 z'}}{N} J_0(\lambda\rho)\lambda^3\,d\lambda, \tag{3}$$

where $N = k_1^2\gamma_2 + k_2^2\gamma_1$ and $\gamma_j = (k_j^2 - \lambda^2)^{1/2}$ with $j = 1, 2$. This formula is equivalent to the expressions of Sommerfeld [1], Baños [5], and others who express the components of the field as unevaluated derivatives of the Hertz potential. Subject to the inequality

$$|k_1^2| \gg k_2^2 \qquad \text{or} \qquad |k_1| \geq 3k_2, \tag{4}$$

the integral (3) and those for the other components have been evaluated with the following result for $E_{2z'}$:

$$E_{2z'}(\rho,z') = E^d_{2z'}(\rho,z') + E^i_{2z'}(\rho,z') + E^L_{2z'}(\rho,z'), \tag{5}$$

where

$$E^d_{2z'}(\rho,z') = \frac{\omega\mu_0}{4\pi k_2} e^{ik_2 r_1}\left[\left(\frac{ik_2}{r_1} - \frac{1}{r_1^2} - \frac{i}{k_2 r_1^3}\right) - \left(\frac{z'-d}{r_1}\right)^2\left(\frac{ik_2}{r_1} - \frac{3}{r_1^2} - \frac{3i}{k_2 r_1^3}\right)\right] \tag{6a}$$

is the direct field of the dipole as if in an infinite medium at $(0,d)$;

$$E^i_{2z'}(\rho,z') = \frac{\omega\mu_0}{4\pi k_2} e^{ik_2 r_2}\left[\left(\frac{ik_2}{r_2} - \frac{1}{r_2^2} - \frac{i}{k_2 r_2^3}\right) - \left(\frac{z'+d}{r_2}\right)^2\left(\frac{ik_2}{r_2} - \frac{3}{r_2^2} - \frac{3i}{k_2 r_2^3}\right)\right] \tag{6b}$$

is the field of an identical image dipole at $(0,-d)$; and

$$E^L_{2z'}(\rho,z') = -\frac{\omega\mu_0}{2\pi k_2} e^{ik_2\rho} e^{ik_2(z'+d)^2/2\rho} \times \frac{k_2^3}{k_1}\left(\frac{\pi}{k_2\rho}\right)^{1/2} e^{-iP}\mathcal{F}(P) \tag{6c}$$

is the lateral-wave field. In (6a-c),

$$r_1 = [\rho^2 + (z'-d)^2]^{1/2}, \quad r_2 = [\rho^2 + (z'+d)^2]^{1/2}, \quad z' = -z, \tag{7a}$$

$$P = (R + Z' + D)^2/R, \tag{7b}$$

$$R = k_2^3\rho/2k_1^2, \quad Z' = k_2^2 z'/2k_1, \quad D = k_2^2 d/2k_1; \tag{7c}$$

$$\mathcal{F}(P) = \tfrac{1}{2}(1+i) - C_2(P) - iS_2(P) = \int_P^\infty \frac{e^{it}}{\sqrt{2\pi t}}\,dt. \tag{8}$$

Here, $C_2(P) + iS_2(P)$ is the Fresnel integral.

The field on the boundary $z' = 0$ when the dipole is also on the boundary, i.e., when $d = 0$, is:

$$E_{1z'}(\rho,0) = E_{2z'}(\rho,0) = \frac{\omega\mu_0}{2\pi k_2} e^{ik_2\rho} g(k_2\rho, k_1), \tag{9}$$

where

$$g(k_2\rho,k_1) = \frac{ik_2}{\rho} - \frac{1}{\rho^2} - \frac{i}{k_2\rho^3} - \frac{k_2^3}{k_1}\left(\frac{\pi}{k_2\rho}\right)^{1/2} e^{-iR}\mathcal{F}(R). \tag{10}$$

The quantity $R = k_2^3\rho/2k_1^2$ is the magnitude of the well known "numerical distance" of Sommerfeld. In (10), the first three terms are the field in the equatorial plane of a z'-directed unit electric dipole in air. They are dominant in the near field where $R < 1$, since there the Fresnel-integral term is negligibly small. They constitute the entire field at all radial distances when region 1 is a perfect conductor with $\sigma_1 = \infty$, $k_1 \sim \infty$, since then the Fresnel-integral term vanishes identically. In the far field defined by $R \geq 4$, the $1/\rho$ term in (10) dominates among the first three so that the field over a perfect conductor reduces to the familiar form

$$E_{2z'}(\rho,0) \sim \frac{i\omega\mu_0}{2\pi}\frac{e^{ik_2\rho}}{\rho}. \tag{11}$$

For all other types of media, the Fresnel-integral term assumes the following far-field form:

$$-\frac{k_2^3}{k_1}\left(\frac{\pi}{k_2\rho}\right)^{1/2} e^{-iR}\mathcal{F}(R) = -\frac{ik_2}{\rho} - \frac{k_1^2}{k_2^2\rho^2}, \tag{12}$$

so that the complete far field becomes

$$E_{2z'}(\rho,0) \sim -\frac{\omega\mu_0 k_1^2}{2\pi k_2^3}\frac{e^{ik_2\rho}}{\rho^2}. \tag{13}$$

Thus, along the air–earth boundary, the far field has the form $1/\rho^2$ and not $1/\rho$. It is determined by the Fresnel-integral term in which the $1/\rho$ part exactly cancels the $1/\rho$ far field (11) of the dipole with image. The vertical electric field given by (5) and along the boundary by (9) is that used in all radio communication over the surface of the earth or sea when both the transmitter and receiver are on the surface. The field patterns are like those in Fig. 1 except that with finite σ they do not vanish when $\Theta = \pi/2$ but reduce to the relatively small value given by (9).

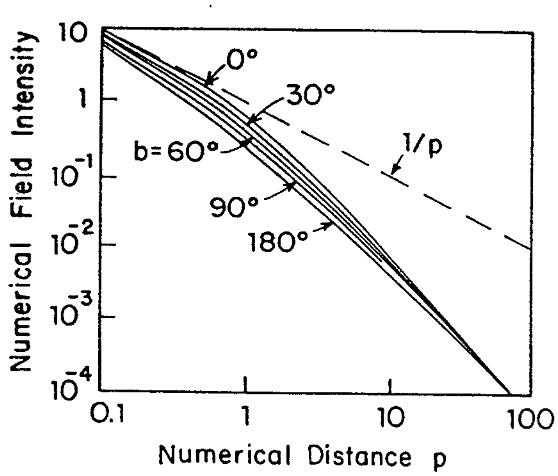

Figure 2. Decay of ground wave intensity with radial distance ϱ as contained in numerical distance $p = |p| \exp(ib) = ik_2^3\varrho/2k_1^2$ (Norton's graphs).

b. The Field in the Earth or Sea; Communication with Submarines

The field at radial distances ρ and depth z in the ocean (region 1, $z \geq 0$) due to a vertical dipole in the air on the surface of the earth or sea is of importance in communicating with submerged submarines. For this purpose the radial component of the electric field is most useful. It is given by an integral similar to (3) and has the following integrated form:

$$E_{1\rho}(\rho, z) = -\frac{\omega\mu_0}{2\pi k_1} e^{ik_1 z} e^{ik_2\rho} f(k_2\rho, k_1), \tag{14a}$$

where

$$f(k_2\rho, k_1) = \frac{ik_2}{\rho} - \frac{1}{\rho^2} - \frac{k_2^3}{k_1}\left(\frac{\pi}{k_2\rho}\right)^{1/2} e^{-iR}\mathcal{F}(R). \tag{14b}$$

Since the far-field form of the Fresnel integral given by (12) applies when $R \geq 4$ and since with it $E_{1\rho}(\rho, z)$ decreases as $1/\rho^2$, it is advantageous to select a frequency for which the desired range of ρ is in the intermediate zone in which the Fresnel-integral term is small and the $1/\rho$ term in (14b) dominates. This occurs when

$$1 \leq k_2\rho \leq |k_1^2/k_2^2|. \tag{15}$$

The quantity $20\log_{10}|E_{1\rho}(\rho, z)|$ in this range with $\rho = 5{,}000$ km is shown in Fig. 3. For each depth in the ocean there is an optimum frequency for a maximum received signal. This decreases as the depth increases. In the frequency range from 20 to 30 kHz—used by the Navy transmitter at Cutler, ME—the optimum depth is seen to be in the range from $z = 10$ to $z = 20$ m. As the depth increases further, the magnitude of the electric field decreases very rapidly. In order to communicate with submarines at greater depths, lower frequencies must be used. This is not practical using vertical dipoles.

3. Vertical Dipole in the Sea; Conductivity of the Earth's Crust

An interesting application of the vertical dipole near a boundary and the lateral waves it generates is to the measurement of the conductivity of the oceanic crust (region 2, $z \leq 0$). For this purpose the dipole is located in the sea (region 1, $z \geq 0$) at a small height d above the sea floor or it is extended from this all the way to the surface of the sea [6]. Measurements are made on or at a small height z above the sea floor. The preferred quantity to be measured is the magnetic field at very low frequencies. This is given by an integral similar to (3). It has the following integrated form:

$$B_{1\phi}(\rho, z) = B_{1\phi}^d(\rho, z) + B_{1\phi}^i(\rho, z) + B_{1\phi}^L(\rho, z), \tag{16a}$$

with

$$B_{1\phi}^d(\rho, z) = -\frac{\mu_0}{4\pi} e^{ik_1 r_1}\left(\frac{ik_1}{r_1} - \frac{1}{r_1^2}\right)\left(\frac{\rho}{r_1}\right), \tag{16b}$$

$$B_{1\phi}^i(\rho, z) = \frac{\mu_0}{4\pi} e^{ik_1 r_2}\left(\frac{ik_1}{r_2} - \frac{1}{r_2^2}\right)\left(\frac{\rho}{r_2}\right), \tag{16c}$$

$$B_{1\phi}^L(\rho, z) = -\frac{\mu_0 k_2^2}{2\pi k_1^2} e^{ik_1(z+d)} e^{ik_2\rho} f(k_2\rho, k_1), \tag{16d}$$

where $r_1 = [\rho^2 + (z-d)^2]^{1/2}$, $r_2 = [\rho^2 + (z+d)^2]^{1/2}$, and $f(k_2\rho, k_1)$ is defined in (14b). The direct field of the dipole is given by (16b), the field of the image dipole is given by (16c), and the lateral wave by (16d). Note that when the source dipole is in the denser region 1 and the point of observation is on the boundary surface $z = 0$, the image field is the *negative* of the direct field, so that the lateral-wave field $B_{1\phi}^L(\rho, 0)$ is the entire field.

In practice measurements are made at extremely low frequencies and within relatively small radial distances where the Fresnel-integral term is negligibly small and the significant magnetic field is

$$B_{1\phi}(\rho, 0) = B_{1\phi}^L(\rho, 0) \sim -\frac{\mu_0\sigma_2}{2\pi\sigma_1}\left(\frac{ik_2}{\rho} - \frac{1}{\rho^2}\right) e^{ik_2\rho} e^{ik_1 d}. \tag{17}$$

The application of this formula [7] to actual measurements made on the sea floor [6] is illustrated in Fig. 4. The dipole extended from the surface to the floor of the sea—a distance

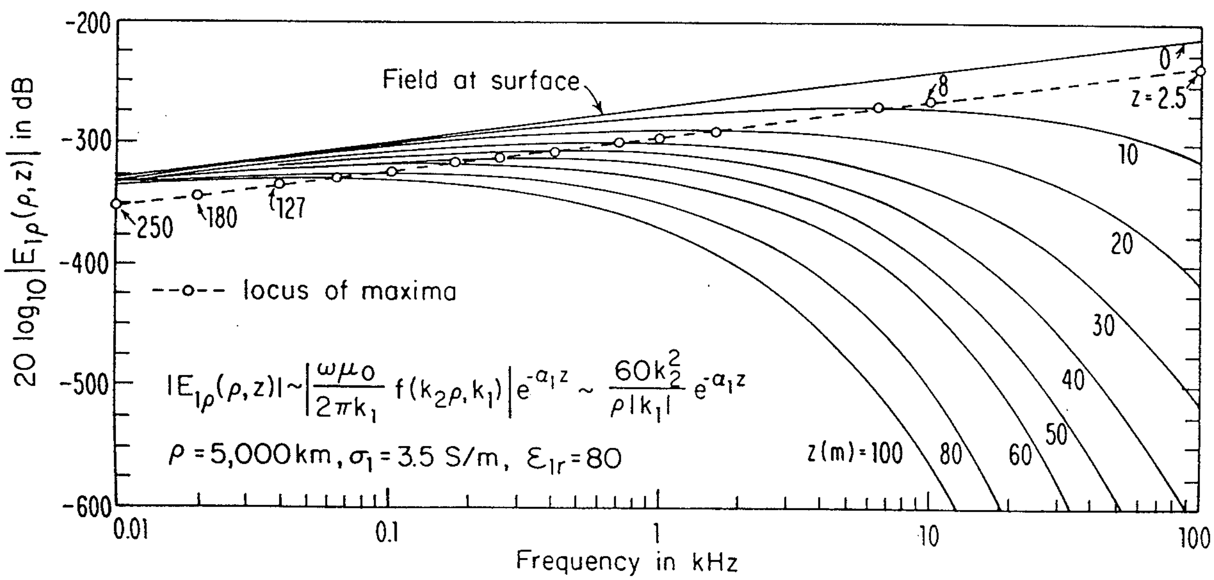

Figure 3. Radial electric field at depth z and $\varrho = 5{,}000$ km due to vertical electric dipole in air on the surface of sea water as a function of the frequency, with z as parameter.