FIELD STRENGTH CONTOUR MAPS

All technical briefs in support of applications for new AM, FM or TV broadcasting stations, or for changes in facilities of existing stations, shall include contour maps as prescribed under the relevant broadcast procedure. Reproducible transparencies shall also be included with the DOC application. The maps are used by the Department for its technical evaluation of the proposal and reproduced for circulation to broadcast consultants, the CRTC, the broadcasting industry and other interested agencies.

1. PREPARATION OF CONTOUR MAPS

1.1 The following is a summary of the requirements for contour maps:

a) Geographic co-ordinate information shall appear at least at two adjacent edges of all maps supplied.

b) A dimensional scale shall be clearly shown on all maps.

c) Antenna location shall be plotted as illustrated below:

Antenna Location

51°	51'	51" N.
99°	30'	45" W.

d) All contours shall be labelled clearly. The preferred technique is to place labels along the contour lines, thereby avoiding unnecessary arrows.

e) A title block, containing sufficient information to identify the proposal and stamped by a professional engineer entitled to practice in Canada, shall be shown. An acceptable specimen is illustrated below:

Name of Broadcast Engineering Consultant ______________________		
Applicant's Name Proposed location of Station Call Sign		
Parameters of Proposed Operation (freq. of channel; power; mode of operation, etc.)		
Date Map Prepared	Seal of Engineer	Signature or Initials

f) In cases of proposed changes in facilities, a separate map showing comparative contours shall be submitted (See 2.1 c) and 2.2 c)).

1.2 Notes:

a) For most contour representations, Energy, Mines and Resources (Surveys and Mapping Branch) maps with a scale of 1:500,000 have been found satisfactory. However, it will sometimes be necessary to utilize expanded or compressed scales in order to more clearly demonstrate the coverage areas. These are quite acceptable, provided the scales are shown.

b) Energy, Mines and Resources maps shall normally be used in the submission. However, should more up-to-date official Provincial Government maps be available, these may be used when, for instance, there is a particular significance in determining the latest metropolitan area limits.

c) All map reproductions supplied shall be clear in all details ensuring the significant information is not hidden by labelling.

2. REPRODUCIBLE MAP TRANSPARENCY REQUIREMENTS

Reproducible direct positive photographic transparencies must be prepared in the standard format size i.e. 37 cm x 28 cm (14½ " x 11"). Acceptable materials for transparencies are clear acetate, Mylar and Cronaflex. The transparencies must bear a stamp or seal and full name of the professional engineer according to the respective requirements of the Provincial Associations of Professional Engineers.

2.1 For TV and FM Applications

The following transparencies are required:

a) One transparency of the contour map bearing the title block defined in 1.1 e);

b) one transparency of the contour map with a 11.5 cm x 9.5 cm (4½" x 3 3/4") space left (preferably in the lower right-hand corner) for insertion of the DOC title block;

*c) in case of change in facilities, one additional transparency for the 'comparative contours' map, showing the existing and proposed 'A' and 'B' contours for the TV service or the existing and proposed 3 mV/m, 500 uV/m and 50 uV/m contours for the FM service, with the appropriate space for insertion of the DOC title block defined in 2.1.b).

NOTE:

The above requirements are not applicable to applications for low power TV and FM stations in accordance with Broadcast Procedure 22 and Broadcast Procedure 14 respectively, or to very low power TV and FM stations in accordance with Broadcast Procedure 15.

2.2 For AM Applications

The following transparencies are required:

a) One transparency of each contour map required in the technical brief bearing the identification block defined in 1.1 e);

* Erratum dated September 14, 1979

b) one transparency of each map to show in clear detail the following proposed service coverage contours:

i) for day time: showing the 25 mV/m, 5 mV/m and 0.5 mV/m contours only;

ii) for night-time: showing the night-time interference free (NIF) contour, and if enclosed within the NIF, the 25 mV/m and the 5 mV/m night-time contour(s).

c) for changes in facilities, additional transparencies showing both the existing and the proposed contours (as in 2.2 b);

d) all transparencies under sub-section 2.2 (b) and (c) should have a 11.5 cm x 9.5 cm (4 ½" x 3 3/4") space left for the insertion of the DOC title block.

2.3 <u>For AM Final Proof of Performance Submissions</u>

One transparency of the map showing the proved-in location of the 0.5 mV/m day-time and the night-time limitation contours with the appropriate space left for insertion of the DOC title block is required.

Broadcast Procedure 8
Issue 1
Effective Date: December 1, 1974
Release Date: November 1, 1974

REQUIREMENTS FOR TECHNICAL OPERATION OF BROADCAST TRANSMITTER PLANTS

1. The holder of a Technical Construction and Operating Certificate for a broadcast transmitter plant is responsible for maintaining frequency, modulation, total power and directional power within permitted tolerances at all times. This Procedure sets out the minimum requirements for controlling, measuring and monitoring a broadcast transmitter plant.

2. Compliance with the minimum requirements may be achieved either by operating the plant under local control (attended) or under remote control (unattended). If the plant normally is operated unattended via a remote control system, and that system fails, the plant must be operated under local control until the remote control system is again operative.

3. The holder of a Technical Construction and Operating Certificate shall submit a description of the technical facilities he will have at his disposal enabling him to comply with the minimum requirements specified in paragraph 4. Details to be included are described in paragraph 8. If unattended operation is proposed a technical brief shall also be provided as detailed in paragraph 9.

4. MINIMUM REQUIREMENTS

Minimum requirements for controlling, measuring and monitoring of transmitter plants are as follows:

4.1 CONTROLS

4.1.1 Carrier ON-OFF

4.1.2 Selection of day and night power and/or radiation pattern selection where applicable.

4.1.3 Overload reset, if applicable.

4.2 ACCURATE MEASUREMENTS

4.2.1 Frequency

The carrier frequency shall be measured.

4.2.2 Modulation

Peak modulation under normal program conditions shall be measured.

4.2.3 Power

The power output of the transmitter shall be measured. Measurements shall be made of the rf current at the transmitter output or at the common point. For an AM transmitter with directional antenna(s) measurements shall also be made of the tower currents (or ratios) and phases for each radiation pattern authorized.

4.3 MONITORING

During periods between accurate measurements, stations shall be monitored either locally at the transmitter or remotely. Stations shall be capable of being monitored continuously as follows:

4.3.1 AM Stations

4.3.1.1 AM transmitters may be monitored with a fixed-tuned receiver. At the control point there shall be available a means for monitoring modulation, such as:

- an audio level meter connected to the output of the receiver
- an oscilloscope displaying the modulated rf signal
- any other audible or visible signalling device which will indicate the level of modulation.

In all cases, the off-air program audio shall be available at the control point for monitoring quality and modulation.

Monitoring of rf power may be interpreted from either the transmitter final plate current, transmission line or antenna current, or rf field strength. The minimum requirement is an indication from an "S" meter incorporated into a fixed-tuned monitor receiver at the control point. For directional arrays, indication of additional antenna parameters may be required at the control point. The selection of these parameters shall be justified in the description of the technical facilities submitted by the holder of the Technical Construction and Operating Certificate.

4.3.1.2 Rebroadcasting stations from which the off-air signals are not available at the control point shall be monitored by a person designated by the holder of the Technical Construction and Operating Certificate. This person shall be equipped with an AM receiver. Telecommunication between the monitoring and control points shall be available.

4.3.2 FM Stations

4.3.2.1 FM transmitters may be monitored with a fixed-tuned receiver. For monitoring modulation an audio level meter driven by the receiver shall be visible at the control point, or an alternative audible or visible signalling device which will indicate the level of modulation may be used. The off-air program audio shall be available at the control point for monitoring signal quality and modulation; if applicable, facilities shall also be provided for aural monitoring of stereophonic and other signals.

Monitoring of rf power may be interpreted from either the transmitter final plate current, transmission line or antenna current, or rf field strength. The minimum requirement is an indication from an "S" meter incorporated into a fixed-tuned monitor receiver at the control point.

4.3.2.2 Rebroadcasting stations from which the off-air signals are not available at the control point shall be monitored by a person designated by the holder of the Technical Construction and Operating Certificate. This person shall be equipped with an FM receiver including capability of also receiving stereophonic and other signals if applicable. Telecommunication between the monitoring and control points shall be available.

4,3.3 TV Stations

4.3.3.1 Stations which have manned control facilities within reach of off-air signals shall meet the following requirements:

A demodulated off-air TV signal shall be available together with picture and waveform monitors, a means of indicating the depth of the modulation of the visual carrier, and a means of monitoring aural program level and quality. Where colour is transmitted a colour monitor shall be used. Monitoring of the rf power of the visual transmitter may be interpreted from a peak reading transmission line power, voltage or current meter or rf field strength. The minimum requirement is an indication from a fixed-tuned receiver of the signal strength during the synchronizing peak. Monitoring of rf power of the aural transmitter may be interpreted from a transmission line power, voltage or current meter, plate current, or rf field strength. Remote monitoring of aural rf power is not mandatory.

4.3.3.2 Rebroadcasting stations from which the off-air signals are not available at the control point shall be monitored by a person designated by the holder of the Technical Construction and Operating Certificate. This person shall be equipped with a TV receiver, colour if the station transmits colour. Telecommunication between the monitoring and control points shall be available.

5. Measurements in 4.2 shall be logged and the logs shall be retained for inspection by the Department for a minimum period of six years for AM stations and two years for others. Also, any significant plant abnormalities and corrective action taken shall be logged.

Further, since it is the responsibility of the holder of the Technical Construction and Operating Certificate to maintain the plant within permitted tolerances at all times, if any parameter is out of tolerance at the time of accurate measurements, then corrective action shall be taken and more frequent measurements shall be made until the parameter is controlled within tolerance.

6. Normally, measurements in 4.2 shall be made weekly. However, if the broadcaster requests that accurate measurements be taken less frequently, and can demonstrate to the satisfaction of the Department that frequency, modulation and power remain stable, then the Department may permit measurements to be made and logged less frequently.

7. The holder of a Technical Construction and Operating Certificate is responsible for ensuring that the painting and lighting of antenna support structures are maintained in accordance with the Technical Construction and Operating Certificate.

8. <u>DESCRIPTION OF TECHNICAL FACILITIES</u>

A submission in triplicate shall be provided and approval obtained prior to "on-air" operation of any station. The submission shall include:

8.1 Transmitter manufacturer, model and D.O.C. type approval number.

8.2 A list of equipment available for the accurate measurements required in 4.2. If the measuring equipment does not normally remain at the transmitter plant, its normal location and availability is to be described.

8.3 A list of equipment available for monitoring as in paragraph 4.3.

9. <u>TECHNICAL BRIEF FOR UNATTENDED OPERATION</u>

A technical brief in triplicate is to be submitted and approval obtained prior to any unattended operation.

The Department requires that the design of a remote control system or a major change to an existing system be carried out under the responsible supervision of a professional engineer who shall certify as to the adequacy of the design by affixing his signature and seal to the technical brief.

The brief shall include:

(1) A general description of the construction and operation of the proposed control and supervisory systems, including mediums used to interconnect the transmitter plant with control point.

(2) The location of the control point and the reason for its choice if other than the main studio.

(3) A list of <u>all</u> control functions performed by remote control.

(4) A list of <u>all</u> information returned to the control or monitoring point.

(5) A description of operating procedures including control, telemetering and calibration, if applicable.

(6) A block diagram of the system.

(7) A functional or schematic diagram of control equipment if not already on Department files.

(8) A diagram showing interface equipment and changes (if any) to be made in the broadcast transmitter.

Issued under the authority of
the Minister of Communications

G C Brooks

G.C. Brooks
Director
Telecommunication Engineering Branch

Broadcast Procedure No. 16
Issue 2
Effective Date: March 25, 1965
Release Date: March 25, 1965

MARKING OF RADIO ANTENNA MASTS

1. General

Since radio masts are usually located so that they extend considerably higher than their immediate surroundings, they constitute a potential hazard to aerial navigation. Consequently, it is necessary that these masts be marked to make them as conspicuous as possible, thereby reducing this hazard to a minimum. Reference is drawn to the current issue of the Department of Transport "Recommended Standards for Marking Obstructions", a copy of which is attached.

2. Painting

2.1 All radio masts, designated to be marked by painting only, regardless of height, must be painted as specified in Section 3.0, "Recommended Standards for Marking Obstructions".

2.2 In the case of masts for AM broadcasting stations, where these are the actual radiating elements, individual structural members or complete sections may be shop painted prior to assembly, provided that every precaution is taken to maintain the lowest possible electrical contact resistance at all joints. Welding is preferred in assembling these masts, but bolts or rivets may be used if the requisite low contact resistance can be achieved by a thorough cleaning of the metallic surface.

3. Lighting

3.1 All radio masts designated to be marked by lighting, in addition to painting, regardless of height, must be lighted as specified in Section 4.0 and 4.20, "Recommended Standards for Marking Obstructions".

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3.2 Lights shall be operated at all times between local sunset and local sunrise, and in addition shall be turned on when the light intensity from the north sky drops to 35 foot candles and may be turned off when this light intensity rises to 58 foot candles.

3.3 Lights may be operated throughout the twenty-four hour period to avoid switching, if this arrangement is preferred.

3.4 In areas where flying operations are so sporadic that lighting of radio masts is not considered necessary, the masts should nevertheless be wired for lights. The growth of the aviation industry in Canada is such that most areas will eventually be subject to flying activities in which case lighting of radio masts definitely will be required. Installation of lights at the time of the erection of the masts is much more economical than installation after erection.

3.5 Where obstruction lights are required on radio antenna masts, in accordance with 3.1 above, provision must be made for temporary lighting during the period of construction and until the regular lighting can be put into operation. Such temporary lighting shall be required as soon as the construction of the mast reaches the level at which the lowest obstruction light would be installed. Additional temporary lights shall be installed at each level normally lighted as construction proceeds, and in addition, the highest part of the structure shall also be lighted. Temporary lights shall, where possible, be the same type of fixture as will be installed permanently.

Issued under the authority
of the Minister of Communications

F. G. Nixon,
Director General, Telecommunications Bureau

Guidelines for the Assignment of Call Signs to AM, FM and TV Broadcasting Stations

Introduction

Article 19 of the ITU Radio Regulations specifies the allocation of call signs for all countries and the requirements for their transmission. Section 5(b) of the Radio Act requires the Minister to assign call signs to broadcasting transmitting undertakings. The purpose of this procedure is to outline the guidelines used by the Department in assigning call signs to broadcast stations in Canada.

Guidelines

1. The Department will assign call signs to broadcasting stations from the series "CF", "CH", "CI", "CJ" and "CK".

2. By special arrangement, broadcasting stations owned and operated by the Canadian Broadcasting Corporation may be assigned call signs beginning with "CB".

3. Call signs are to be requested at the time of submitting an application for a Technical Construction and Operating Certificate (TCOC). The Department will assess the operational suitability of the call sign proposed by the applicant, may request advice from the Canadian Radio-television and Telecommunications Commission (CRTC), and make a provisional decision. The provisional call sign

will then be reserved for the period that the application is considered active. Information concerning provisional call signs may be obtained by examining TCOC applications on file in the Department after the CRTC has published its public notice in respect of related licence applications. Comments relating to call signs may be submitted to the Director of the Broadcasting Regulation Branch of DOC. Normally, a final decision on the call sign will be taken when authority to construct is granted, after due consideration of the comments received up to that time.

4. Licensees of existing stations who wish to change their call signs shall make their request in writing to the Director of the Broadcasting Regulation Branch, Telecommunication Regulatory Service, Department of Communications, 300 Slater Street, Ottawa, Ontario K1A 0C8. The Department will assess the operational suitability of the call sign proposed by the licensee, may request advice from the CRTC, and then render a decision.

5. There are three categories of broadcasting transmitting stations, namely AM, FM and TV. Four letter basic call signs, of the series reserved for broadcasting stations, will be assigned. In special cases, three letter call signs may be assigned to national network stations. Suffixes "FM" and "TV" will identify FM and TV stations. Numerical suffixes will be appended to identify rebroadcasting stations, where the same basic call sign is assigned to the originating as well as the rebroadcasting station. (Rebroadcasting stations are those that broadcast simultaneously the programs of another station for at least half of the broadcasting schedule).

6. Normally, a distinctive basic call sign will be assigned to each broadcasting station. Additionally, the same basic call sign may be assigned:

(a) to stations of different categories owned by the same individual, the same corporation or wholly-owned subsidiaries of the same corporation, and serving the same community; or

(b) to rebroadcasting stations owned by the same individual, the same corporation or wholly-owned subsidiaries of the same corporation (with a numerical suffix).

7. Where the same basic call sign is used by more than one station, the Department may impose a change in call sign if there is a change in ownership of a station, or, in the case of a rebroadcasting station, the proportion of rebroadcast programs becomes insufficient.

8. The Department will not assign a proposed call sign to a station where,

(a) in the Department's opinion, there is a phonetic similarity between the proposed call sign and the call sign of another station located within a radius of 300 km;

(b) the service areas of stations with phonetic similarity overlap; or

(c) if the Department considers that positive identification of the stations might be impaired.

Issued under the Authority of
the Minister of Communications

Dr. John deMercado
Director General
Telecommunication Regulatory
Service

Government
of Canada
Department of Communications

TRC - 38

TELECOMMUNICATIONS REGULATION CIRCULAR

SUPPRESSION OF INDUCTIVE INTERFERENCE
ANTENNA FACTOR: TO CONVERT MEASURED VOLTS (µV) TO FIELD STRENGTH (µV/m)

MARCH 31, 1977
(REPLACES S11-13-48 OF AUGUST 1, 1962)

TELECOMMUNICATION REGULATORY SERVICE

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Telecommunications Regulation Circulars are issued from time to time as the need arises and are intended for the guidance of those actively engaged in telecommunications in Canada. The information contained in these circulars is subject to change at any time in keeping with the development of the art of telecommunications. It is therefore suggested that interested persons should consult the nearest Superintendent of Telecommunication Regulation to ascertain whether this circular is still current.

SUPPRESSION OF INDUCTIVE INTERFERENCE

ANTENNA FACTOR: TO CONVERT MEASURED VOLTS (μV) TO FIELD STRENGTH (μV/m)

1. The attached curve sheet gives the factor by which the measured microvolts, from various types of resonant antennas, must be multiplied to obtain field strength in microvolts per meter. They are intended for use particularly with Servicemen's type TV field strength meters, and it should be noted that in every case they apply only to a particular impedance transmission line and instrument. If, for example, a 300 ohm input impedance meter is connected to the antenna by a 72 ohm line, the factor will vary with length of lead-in, as well as with frequency, and so be indeterminate.

2. The accuracy is of course only that of the meter, so when a new instrument is received, field staff should take and record measurements on as many local TV, FM and other stations as possible, using some permanent or reproducible antenna set-up, so that the meter can be checked, and corrections made for any subsequent loss of sensitivity.

3. As mentioned above, a 300 ohm instrument should not be connected directly to a 72 ohm line. Instead a balun (72 ohm unbalanced to 300 ohm balanced) should be used. This is a matching transformer to match the 72 ohm input from the antenna system to the 300 ohm balanced input to the television set.

4. The two upper curves are for the car dipoles, when used away from the car. When the dipole is above the car (approximately 66 cm) the measured values will be somewhat smaller. In a limited number of cases tested, the indicated field strength was between 0.67 and 0.75 of the free space field strength, at the same antenna height (2.25 m). It can vary more widely than this, and it is advisable that the individual car be checked, on the frequency most used locally, and that the effect of the orientation of the car be also checked.

5. The Departmental car dipoles can be telescoped in to a 0.5 wavelength only up to about 290 MHz. At higher frequencies, however, they can be used as 1.5 wave dipoles and in this way be made to cover the UHF TV bands also. There is little difference between the antenna factor for a 0.5 wave dipole and for a 1.5 wave dipole (simple dipoles with 300 ohm load), and so the antenna factor for the 0.5 wave dipole, at the frequency actually received, can be used for the major lobes of a 1.5 wave dipole also. The dipole rods are of course set at a length on the dipole measuring rule which corresponds to 0.33 times the received frequency.

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6. The response patterns of a 0.5 wave and a 1.5 wave dipole are as shown on page 3. It will be noted that the major lobes of the 1.5 wave dipole are at about 45 degrees to the axis of the rod, with a lesser response broadside. The above mentioned antenna factor should be used with readings taken on the major lobes. The side nulls of the 1.5 wave dipole are easily obscured by any unbalance, but the null in line with the end of the rod can usually be clearly identified and used for taking bearings.

7. In open areas, in the Class B coverage, the field strength 9.1 m above the ground will be approximately 4 times that at a 2.25 m height (see Circular SII-13-47 "Variation of Field Strength with Distance"). In built-up areas, the difference is likely to be much greater, especially near steel frame buildings.

8. The curves for a folded dipole-plus-reflector, and for a 12 element Yagi (300 ohm) are intended for use in checking the field strength at a complainant's antenna, by disconnecting the lead-in from his TV set, and connecting it to a field strength meter. The antenna factor is based on optimum performance of the antenna (4.5 dB and 14 dB respectively), and it can safely be assumed that the field strength is not less than that indicated. The array gain will obtain only on the channel to which the antenna is cut; on any other channel the gain will be less, and the field strength correspondingly greater than the indicated value. The same will be true of a defective or incorrectly oriented antenna.

9. The Yagi curve applies equally to 12 elements in line, or 6 stacked above 6, or to practically any domestic TV antenna of that number of elements, and intended for feeding a 300 ohm line and set. Values can be interpolated between the dipole-plus-reflector curve and the 12 element Yagi curve on a linear proportional basis, for intermediate numbers of elements. That is, the factor for a 7 element Yagi would be half-way between the 2 element (dipole-plus-reflector) and the 12 element.

10. In cases where there is a booster amplifier installed at the masthead or other point such that the measurement cannot be made ahead of it, then the measured microvolts must be correspondingly reduced. 20 dB is about the maximum gain claimed by any manufacturers, on a single pre-adjusted channel, and most claim 12 to 18 dB. The average gain, after being in use for some time, can reasonably be estimated as 14 dB; the meter reading should therefore be divided by 5 before applying the antenna factor.

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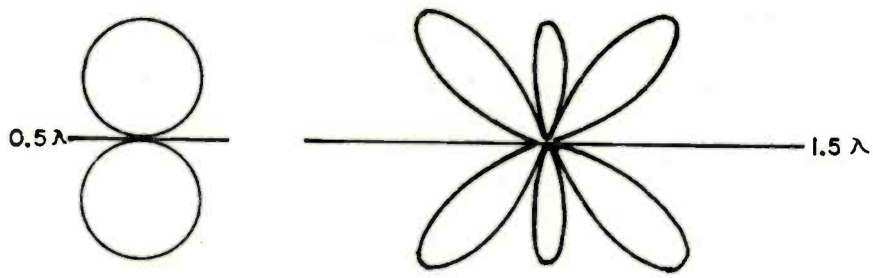
11. The antenna factor curves are based on the following relations: The open circuit voltage of a resonant 0.5 wave dipole is $\lambda/3.14$ times the field strength; the output voltage is equal to the open circuit voltage times the load resistance, divided by the load resistance plus the radiation resistance; the watts output of a folded dipole to a matched load is equal to the watts output of a simple dipole to a matching load.



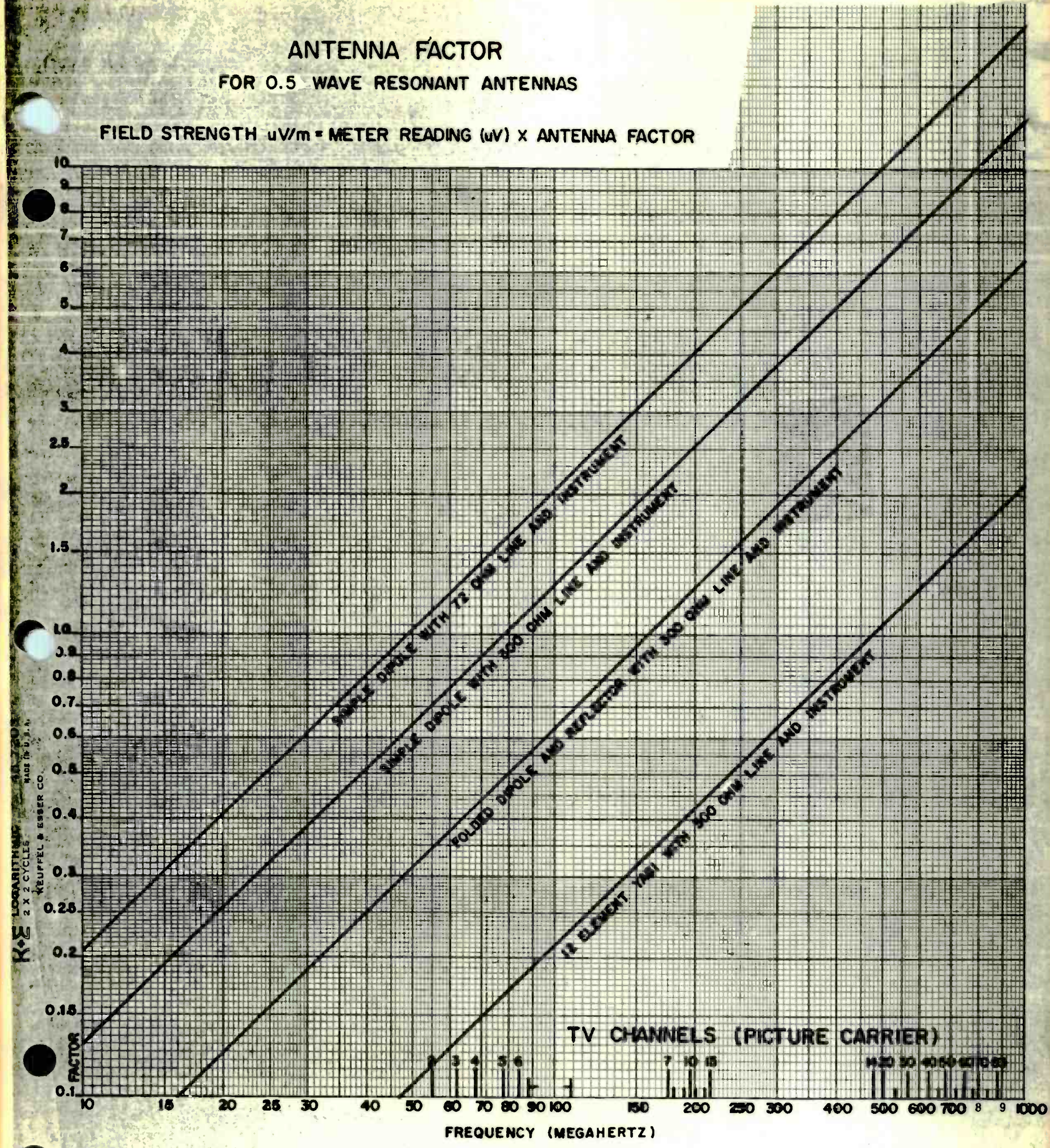
S.N. Ahmed

Nisar Ahmed,
Director,
Engineering Programs Branch,
Telecommunication Regulatory Service.

ANTENNA FACTOR

FOR 0.5 WAVE RESONANT ANTENNAS

FIELD STRENGTH uV/m = METER READING (uV) X ANTENNA FACTOR



Government of Canada
Department of Communications

TRC-43

TELECOMMUNICATIONS REGULATION CIRCULAR

NOTES REGARDING DESIGNATION OF EMISSION (INCLUDING NECESSARY BANDWIDTH AND CLASSIFICATION), CLASS OF STATION AND NATURE OF SERVICE

OCTOBER 09, 1982

TELECOMMUNICATION REGULATORY SERVICE

1. INTRODUCTION

To facilitate spectrum management, radio stations and their emissions are classified into various categories as detailed in this document. A radio station may be classified as to type, nature of service and hours of operation as shown in Section 2. The emission is designated according to the classification as shown in Sections 3, 4 and 5. The method of determining necessary bandwidth is shown in Section 6.

When making an application for a licence to operate a radio station in accordance with the procedures established by the Department, an applicant should as far as possible use the methods and symbols contained in this document.

2. SOME USEFUL DEFINITIONS

The following ITU definitions of operational terminology may assist in the designation of radio emissions.

2.1 Telegraphy: A form of telecommunication which is concerned in any process providing transmission and reproduction at a distance of documentary matter, such as written or printed matter or fixed images, or the reproduction at a distance of any kind of information in such a form. For the purposes of the Radio Regulations, unless otherwise specified therein, telegraphy shall mean a form of telecommunication for the transmission of written matter by the use of signal code.

2.2 Telecommand: The use of telecommunication for the transmission of signals to initiate, modify or terminate functions of equipment at a distance.

2.3 Telemetry: The use of telecommunications for automatically indicating or recording measurements at a distance from the measuring instrument.

2.4 Telephony: A form of telecommunication set up for the transmission of speech or, in some cases, other sounds.

3. CLASS OF STATION AND NATURE OF SERVICE DESIGNATORS

3.1 Class of Station Designators

AL	Aeronautical radionavigation land station
AM	Aeronautical radionavigation mobile station
AT	Amateur station
AX	Aeronautical fixed station
BC	Broadcasting station, sound
BT	Broadcasting station, television
CA	Cargo ship
EA	Space station in the amateur
EB	Space station in the broadcasting-satellite service (sound broadcasting)
EC	Space station in the fixed-satellite service
ED	Space telecommand space station
EG	Space station in the maritime mobile-satellite service
EH	Space research space station
EK	Space tracking space station
EM	Meteorological-satellite space station
EN	Radionavigation-satellite space station
ER	Space telemetering space station
EV	Space station in the broadcasting-satellite service (Television)
EX	Experimental station
FA	Aeronautical station
FB	Base station
FC	Coast station
FL	Land station
FP	Port station

FR Receiving station only, connected with the general network of telecommunications channels

FS Land station established solely for the safety of life

FX Fixed station

GS Station on board a warship or a military or naval aircraft

LR Radiolocation land station

MA Aircraft station

ME Space station

ML Land mobile station

MO Mobile station

MR Radiolocation mobile station

MS Ship station

NL Maritime radionavigation land station

OD Oceanographic data station

OE Oceanographic data interrogating station

PA Passenger ship

RA Radio astronomy station

RC Non-directional radiobeacon

RD Directional radiobeacon

RG Radio direction-finding station

RM Maritime radionavigation mobile station

RT Revolving radiobeacon

SM Meteorological aids station

SS Standard frequency and time signal station

TA Space operation earth station in the amateur-satellite service

TC Earth station in the fixed-satellite service

TD Space telecommand earth station

TE Transmitting earth station

TF Fixed earth station in the radiodetermination-satellite service

TG Mobile earth station in the maritime mobile-satellite service

TH Earth station in the space research service

TI Earth station in the maritime mobile-satellite service at a specified fixed point

TK Space tracking earth station

TL Mobile earth station in the radiodetermination-satellite service

TM Earth station in the meteorological-satellite service

TN Earth station in the radionavigation-satellite service

TP Receiving earth station

TR Space telemetering earth station

TS Television, sound channel

TT Earth station in the space operation service

TV Television, vision channel

3.2 Nature of Service Designators

C Continuous operation during hours shown

CO Station open to official correspondence exclusively

CP Station open to public correspondence

CR Station open to limited correspondence

CV Station open exclusively to correspondence of a private agency

D30° Directive antenna having maximum radiation in the direction of 30° (expressed in degrees from true north, from 0 to 360 clockwise)

GMT Greenwich Mean Time

UTC Coordinated universal time (also referred to as Greenwich Mean Time (GMT))

H Scheduled operation

H8 8 hour service

H16 16 hour service

H24	Continuous throughout the 24 hours
HJ	Day service
HN	Night service
HT	Transition period service
HX	Intermittent throughout the 24 hours, or station having no specific service hours
I	Intermittent operation during the time indicated
ND	Non-directional antenna
OT	Station open exclusively to operational traffic of the service concerned.

4. DESIGNATION OF EMISSIONS

Emissions are designated according to their necessary bandwidth and their classification.

In writing the designation of an emission, one first writes 4 characters which describe the necessary bandwidth. These four characters are followed by 3 to 5 additional characters which describe the classification.

Examples of emissions designated in accordance with sections 4 and 5 of this TRC are contained in this document starting on page 11.

5. DESIGNATION OF NECESSARY BANDWIDTH

The necessary bandwidth as determined in accordance with the examples given in this TRC are expressed by three numerals and one letter. The letter occupies the position of the decimal point and represents the unit of bandwidth. The first character shall be neither zero nor K, M, or G.

Necessary bandwidths:

between 0.001 Hz and 999 Hz shall be expressed in Hz (letter H);

between 1.00 kHz and 999 kHz shall be expressed in kHz (letter K);

between 1.00 MHz and 999 MHz shall be expressed in MHz (letter M);

between 1.00 GHz and 999 GHz shall be expressed in GHz (letter G).

Examples of designated necessary bandwidths would be:

0.002 Hz	= H002	6 kHz	= 6K00	1.25 MHz	= 1M25
0.1 Hz	= H100	12.5 kHz	= 12K5	2 MHz	= 2M00
25.3 Hz	= 25H3	180.4 kHz	= 180K	10 MHz	= 10M0
400 Hz	= 400H	180.5 kHz	= 181K	202 MHz	= 202M
2.4 kHz	= 2K40	180.7 kHz	= 181K	5.65 GHz	= 5G65

6. CLASSIFICATION OF EMISSIONS

A minimum of three symbols are used to describe the basic characteristics of radio waves. These are:

1. The first symbol - indicates the type of modulation of the main carrier;
2. The second symbol - indicates the nature of the signal(s) modulating the main carrier, and:
3. The third symbol - indicates the type of information being transmitted.

In addition a fourth and/or fifth symbol may be used to indicate the following:

4. The fourth symbol - indicates details about the signal(s), and;
5. The fifth symbol - indicates the nature of multiplexing.

Note: When either one or both of the two optional symbols are not used it is usual to replace that symbol with a dash (-).

6.1 First symbol - type of modulation of the main carrier

6.1.1 Emission of an unmodulated carrier N

6.1.2 Emission in which the main carrier is amplitude-modulated (including cases where sub-carriers are angle-modulated).
- 6.1.2.1 Double-sideband A
- 6.1.2.2 Single-sideband, full carrier H
- 6.1.2.3 Single-sideband, reduced or variable level carrier R
- 6.1.2.4 Single-sideband, suppressed carrier J
- 6.1.2.5 Independent sidebands B
- 6.1.2.6 Vestigial sideband C

6.1.3 Emission in which the main carrier is angle-modulated.
- 6.1.3.1 Frequency modulation F
- 6.1.3.2 Phase modulation G

6.1.4 Emission in which the main carrier is amplitude and angle-modulated either simultaneously or in a pre-established sequence D

6.1.5 Emission of pulses[1]
- 6.1.5.1 Sequence of unmodulated pulses P
- 6.1.5.2 A sequence of pulses
  - 6.1.5.2.1 modulated in amplitude K
  - 6.1.5.2.2 modulated in width/duration L
  - 6.1.5.2.3 modulated in position/phase M
  - 6.1.5.2.4 in which the carrier is angle-modulated during the period of the pulse Q
  - 6.1.5.2.5 which is a combination of the fore-going or is produced by other means V

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[1] Emissions, where the main carrier is directly modulated by a signal which has been coded into quantized form (e.g. pulse code modulation), should be designated in 6.1.2 or 6.1.3.

6.1.6 Cases not covered above, which an emission consists of the main carrier modulated, either simultaneously or in a pre-established sequence, in a combination of two or more of the following modes amplitude, angle pulse — W

6.1.7 Cases not otherwise covered — X

6.2 <u>Second symbol - nature of signal(s) modulating the main carrier</u>

6.2.1 No modulating signal — 0

6.2.2 A single channel containing quantized or digital information without the use of a modulating sub-carrier[1] — 1

6.2.3 A single channel containing quantized or digital information with the use of a modulating sub-carrier[2] — 2

6.2.4 A single channel containing analogue information — 3

6.2.5 Two or more channels containing quantized or digital information — 7

6.2.6 Two or more channels containing analogue information — 8

6.2.7 Composite system with one or more channels containing quantized or digital information, together with one or more channels containing analogue information — 9

6.2.8 Cases not otherwise covered — X

6.3 <u>Third symbol - type of information to be transmitted</u>[3]

6.3.1 No information transmitted — N

6.3.2 Telegraphy - for aural reception — A

6.3.3 Telegraphy - for automatic reception — B

6.3.4 Facsimile — C

6.3.5 Data transmission, telemetry, telecommand — D

6.3.6 Telephony (including sound broadcasting) — E

6.3.7 Television (video) — F

6.3.8 Combination of the above — W

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1 Emissions, where the main carrier is directly modulated by a signal which has been coded into quantized form (e.g. pulse code modulation), should be designated in 6.1.2 or 6.1.3.

2 This excludes time-division multiplex

3 In this context the word "information" does not include information of a constant unvarying nature such as provided by standard frequency emissions, continuous wave and pulse radars, etc.

6.3.9 Cases not otherwise covered X

6.4 Fourth symbol - Details of signal(s)

6.4.1	Two-condition code with elements of differing numbers and/or durations	A
6.4.2	Two-condition code with elements of the same number and duration without error-correction	B
6.4.3	Two-condition code with elements of the same number and duration with error-correction	C
6.4.4	Four-condition code in which each condition represents a signal element (of one or more bits)	D
6.4.5	Multi-condition code in which each condition represents a signal element (of one or more bits)	E
6.4.6	Multi-condition code in which each condition or combination of conditions represents a character	F
6.4.7	Sound of broadcasting quality (monophonic)	G
6.4.8	Sound of broadcasting quality (stereophonic or quadraphonic)	H
6.4.9	Sound of commercial quality (excluding categories given in sub-paragraphs 6.4.10 and 6.4.11)	J
6.4.10	Sound of commercial quality with the use of frequency inversion or band-splitting	K
6.4.11	Sound of commercial quality with separate frequency-modulated signals to control the level of demodulated signal	L
6.4.12	Monochrome video	M
6.4.13	Colour video	N
6.4.14	Combination of the above	W
6.4.15	Cases not otherwise covered	X

6.5 Fifth symbol - Nature of multiplexing

6.5.1	None	N
6.5.2	Code-division multiplex*	C
6.5.3	Frequency-division multiplex	F
6.5.4	Time-division multiplex	T
6.5.5	Combination of frequency-division multiplex and time-division multiplex	W
6.5.6	Other types of multiplexing	X

* This includes bandwidth expansion techniques.

7. DETERMINATION OF NECESSARY BANDWIDTHS

For the full designation of an emission, the necessary bandwidth, indicated in four characters, shall be added just before the classification symbols. When used, the necessary bandwidth shall be determined by one of the following methods:

a. use of the formulae included in the following table which also gives examples of necessary bandwidths and designation of corresponding emissions;

b. computation in accordance with methods detailed in an applicant's submission and subsequently accepted by the Department;

c. measurement, in cases not covered by 1. and 2. above. Such measurements must be conducted in accordance with CCIR Report 324 (latest revision).

However, the necessary bandwidth so determined is not the only characteristic of an emission to be considered in evaluating the interference that may be caused by that emission.

In the formulation of the table, the following terms have been employed:

B_n = necessary bandwidth in hertz

B = modulation rate in bauds

N = maximum possible number of black plus white elements to be transmitted per second, in facsimile

M = maximum modulation frequency in hertz

M_v = maximum significant frequency in megahertz of the NTSC television signal (frequency to be used is 3.8 MHz)

C = subcarrier frequency in hertz

D = peak deviation,i.e., half the difference between the maximum and minimum values of the instantaneous frequency. The instantaneous frequency in hertz is the time rate of change in phase in radians divided by 2π. For information on the derivation of D refer to Table 1.

D_v = peak video deviation in megahertz

D_s = video deviation in megahertz caused by one or more audio subcarriers

t = pulse duration in seconds at half-amplitude

t_r = pulse rise time in seconds between 10% and 90% amplitude

R = maximum transmission speed in bits per-second

S = number of signalling states

K = an overall numerical factor which varies according to the emission and which depends upon the allowable signal distortion

N_C = number of baseband channels in radio systems employing multichannel multiplexing

P = continuity pilot subcarrier frequency in megahertz. The terms f_p and P may be interchanged.

O = main carrier frequency offset due to luminance picture component (at low Average Picture Level) of the 525 line NTSC television signal. This produces the effective carrier for chroma and subcarrier signals. The carrier offset to be used is 0.2 D_v e.q. 0.8 MHz offset for 4 MHz peak deviation.

A = maximum significant sideband frequency caused by FM modulation of the highest FM modulated audio program subcarrier calculated according to the equation:

$$A = fsc + (Ba + 1) \times fa$$

where fsc = highest audio program subcarrier frequency in megahertz

Ba = modulation index for the peak deviation of the subcarrier caused by the top audio signal frequency. The peak deviation is normally considered to be 10 dB greater than the peak deviation caused by a reference audio test tone. The modulation index, Ba, is given by:

$$Ba = \frac{\text{peak audio deviation}}{\text{top audio signal frequency}}$$

fa = top audio signal frequency in megahertz modulating the highest audio program subcarrier frequency.

V_B = video baseband bandwidth in megahertz

E_D = energy dispersal bandwidth in megahertz

8. EXAMPLES OF DESIGNATION OF EMISSIONS

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
I. NO MODULATING SIGNAL			
Continuous wave emission	-	-	NON
II. AMPLITUDE MODULATION			
1. Signal with Quantized or Digital Information			
Continuous wave Telegraphy Morse Code	B_n = BK K = 5 for fading circuits K = 3 for non-fading circuits	25 words per minute; B = 20, k = 5 Bandwidth : 100 Hz	100HA1AAN
Telegraphy by on-off keying of a tone modulated carrier, Morse Code	B_n = BK + 2M K = 5 for fading circuits K = 3 for non-fading circuits	25 words per minute; B = 20, M = 1 000 K = 5 Bandwidth : 2 100 Hz = 2.1 kHz	2K10A2AAN
Selective calling signal using sequential single frequency code, single-sideband, full carrier	B_n = M	Maximum code frequency is : 2 110 Hz M = 2 110 Bandwidth : 2 110 Hz = 2.11 kHz	2K11H2BFN
Direct printing telegraphy using a frequency shifted modulating subcarrier, with error correction, single-sideband, suppressed carrier (single channel)	B_n = 2M + 2DK M = $\frac{B}{2}$	B = 50 D = 35 Hz (70 Hz shift) K = 1.2 Bandwidth : 134 Hz	134HJ2BCN

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
Telegraphy, multi-channel with voice frequency, error-correction, some channels are time-division multiplexed, single-sideband, reduced carrier	B_n = highest central frequency + M + DK M = B/2	15 channels highest central frequency is : 2 805 Hz B = 100 D = 42.5 Hz (85 Hz shift) K = 0.7 Bandwidth : 2 885 Hz = 2.885 kHz	2K89R7BCW
2. Telephony (Commercial Quality)			
Telephony, double-sideband (single-channel)	B_n = 2M	M = 3 000 Bandwidth : 6 000 Hz = 6 kHz	6K00A3EJN
Telephony, single-sideband full carrier (single channel)	B_n = M	M = 3 000 Bandwidth : 3 000 Hz = 3 kHz	3K00H3EJN
Telephony, single-sideband, suppressed carrier (single-channel)	B_n = M - lowest modulation frequency	M = 3 000 lowest modulation frequency is 300 Hz Bandwidth : 2 700 Hz = 2.7 kHz	2K70J3EJN
Telephony with separate frequency modulated signal to control the level of demodulated speech signal, single-sideband, reduced carrier, (Lincompex) (single channel)	B_n = M	Maximum control frequency is 2 990 Hz M = 2 990 Bandwidth . 2 990 Hz = 2.99 kHz	2K99R3ELN

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
Telephony with privacy, single-sideband, suppressed carrier (two or more channels)	$B_n = N_c M$-lowest modulation frequency in the lowest channel	$N_c = 2$ M = 3 000 lowest modulation frequency is 250 Hz Bandwidth : 5 750 Hz = 5.75 kHz	5K75J8EKF
Telephony, independent side-band (two or more channels)	B_n = sum of M for each sideband	two channels M = 3 000 Bandwidth : 6 000 Hz = 6 kHz	6K00B8EJN
3. Sound Broadcasting			
Sound broad-casting double-sideband	$B_n = 2M$ M may vary between 4 000 and 10 000 depending on the quality desired	Speech and music M = 4 000 Bandwidth : 8 000 Hz = 8 kHz	8K00A3EGN
Sound broad-casting, single-sideband, reduced carrier (single channel)	$B_n = M$ M may vary between 4 000 and 10 000 depending on the quality desired	Speech and music, M = 4 000 Bandwidth : 4 000 Hz = 4 kHz	4K00R3EGN
Sound broad-casting, single-sideband, suppressed carrier	$B_n = M$ - lowest modulation frequency	Speech and music, M = 4 500; lowest modulation = 50 Hz; Bandwidth : 4 450 Hz = 4.45 kHz	4K45J3EGN

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
4. Television			
Television, vision and sound	Refer to relevant CCIR documents for the bandwidths of the commonly used television systems	Number of lines=525; Nominal video bandwidth: 4.2 MHz Sound carrier relative to video carrier=4.5MHz; Total vision bandwidth : 5.45 MHz; FM sound bandwidth including guardbands : 550 kHz RF channel bandwidth : 6.0 MHz	5M45C3F-- 550KF3EGN
5. Facsimile			
Analogue facsimile by sub-carrier frequency modulation of a single-sideband emission with reduced carrier, monochrome	$B_n = C + \frac{N}{2} + DK$ K = 1.1 (typically)	N = 1 100 corresponding to an index of cooperation of 352 and a cylinder rotation speed of 60 rpm. Index of co-operation is the product of the drum diameter and number of lines per unit length. C = 1 900 D = 400 Hz Bandwidth : 2 890 Hz = 2.89 kHz	2K89R3CMN
Analogue facsimile; frequency modulation of an audio frequency subcarrier which modulates the main carrier, single-sideband suppressed carrier	$B_n = 2M + 2DK$ $M = \frac{N}{2}$ K = 1.1 (typically)	N = 1 100 D = 400 Hz Bandwidth : 1 980 Hz = 1.98 kHz	1K98J3C--

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
6. Composite Emissions			
Double-sideband television relay	$B_n = 2C + 2M + 2D$	Video limited to 5 MHz, audio on 6.5 MHz frequency modulated subcarrier, sub-carrier deviation = 50 kHz $C = 6.5 \times 10^6$ $D = 50 \times 10^3$ Hz $M = 15\ 000$ Bandwidth : 13.13×10^6 Hz = 13.13 MHz	13M1A8W--
Double-sideband radio-relay system, frequency division multiplex	$B_n = 2M$	10 voice channels occupying base band between 1 and 164 kHz; $M = 164\ 000$ Bandwidth : 328 000 Hz = 328 kHz	328KA8E--
Double-sideband emission of VOR with voice (VOR = VHF omnidirectional radio range)	$B_n = 2C_{max} + 2M + 2DK$ $K = 1$ (typically)	The main carrier is modulated by : - a 30 Hz subcarrier - a carrier resulting from a 9 960 Hz tone frequency modulated by a 30 Hz tone - a telephone channel - a 1 020 Hz keyed tone for continual Morse identification $C_{max} = 9\ 960$ $M = 30$ $D = 480$ Hz Bandwidth : 20 940 Hz = 20.94 kHz	20K9A9WWF

Description of Emission	Necessary Bandwidth: Formula	Necessary Bandwidth: Sample Calculation	Designation of Emission
Independent sidebands; several telegraph channels with error correction together with several telephone channels with privacy; frequency division multiplex	B_n = sum of M for each sideband	Normally composite systems are operated in accordance with standardized channel arrangements (e.g. CCIR-Rec. 348 (latest revision). 3 telephone channels and 15 telegraphy channels require the bandwidth 12 000 Hz = 12 kHz	12K0B9WWF
III FREQUENCY MODULATION			
1. Signal with Quantized or Digital Information			
Telegraphy without error-correction (single channel)	$B_n = 2M + 2DK$ $M = \frac{B}{2}$ K = 1.2 (typically)	B = 100 D = 85 Hz (170 Hz shift) Bandwidth : 304 Hz	304HF1BBN
Telegraphy, narrowband direct printing with error-correction (single-channel)	$B_n = 2M + 2DK$ $M = \frac{B}{2}$ K = 1.2 (typically)	B = 100 D = 85 Hz (170 Hz shift) Bandwidth : 304 Hz	304HF1BCN
Selective calling signal	$B_n = 2M + 2DK$ $M = \frac{B}{2}$ K = 1.2 (typically)	B = 100 D = 85 Hz (170 Hz shift) Bandwidth : 304 Hz	304HF1BCN

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
Four-frequency Duplex telegraphy	$B_n = 2M + 2DK$ B = Modulation rate in bauds of the faster channel. If the channels are synchronized : $M = \frac{B}{2}$ (otherwise M = 2B) K = 1.1 (typically)	Spacing between adjacent frequencies = 400 Hz; Synchronized channels B = 100 M = 50 D = 600 Hz Bandwidth : 1 420 Hz = 1.42 kHz	1K42F7BDX
2. Telephony (Commercial Quality)			
Commercial telephony	$B_n = 2M + 2DK$ K = 1 (typically, but under certain conditions a higher value may be necessary)	For an average case of commercial telephony, D = 5 000 Hz M = 3 000; Bandwidth : 16 000 Hz = 16 kHz	16K0F3EJN
3. Sound Broadcasting			
Sound broadcasting	$B_n = 2M + 2DK$ K = 1 (typically)	Monaural D = 75 000 Hz, M = 15 000 Bandwidth : 180 000 Hz = 180 kHz	180KF3EGN

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
4. Facsimile			
Facsimile by direct frequency modulation of the carrier; black and white	$B_n = 2M + 2DK$ $M = \frac{N}{2}$ $K = 1.1$ (typically)	N = 1 100 elements/ sec; D = 400 Hz Bandwidth : 1 980 Hz = 1.98 kHz	1K98F1C--
Analogue facsimile	$B_n = 2M + 2DK$ $M = \frac{N}{2}$ $K = 1.1$ (typically)	N = 1 100 elements/ sec; D = 400 Hz Bandwidth : 1 980 Hz = 1.98 kHz	1K98F3C--
5. Composite Emissions (see Table 1)			
Radio-relay system, frequency division multi-plex	$B_n = 2P + 2DK$ $K = 1$ (typically)	60 telephone channels occupying baseband between 60 and 300 kHz; rms per-channel deviation : 200 kHz; continuity pilot at 331 kHz produces 100 kHz rms deviation of main carrier. $D = 200 \times 10^3 \times 3.76 \times 2.02 = 1.52 \times 10^6$ Hz $P = 0.331 \times 10^6$ Hz; Bandwidth : 3.702×10^6 Hz = 3.702 MHz	3M70F8EJF

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
Radio-relay system; frequency division multi-plex having no continuity pilot subcarrier or having a con-tinuity pilot sub-carrier whose frequency is not the highest modulating the main carrier.	$B_n = 2M + 2DK$ $K = 1$ (typically)	960 telephone channels occupying baseband between 60 and 4 028 kHz; rms per-channel deviation 200 kHz; $D = 200 \times 10^3 \times 3.76 \times 5.5 = 4.13 \times 10^6$ Hz $M = 4.028 \times 10^6$; Bandwidth : 16.32×10^6 Hz = 16.3MHz	16M3F8EJF
Radio-relay system; frequency division multi-plex having a continuity pilot* subcarrier whose frequency exceeds that of any other signal modulating the main carrier.	$B_n = 2P$ or $B_n = 2M + 2DK$ whichever is the greater	960 telephone channels occupying baseband between 60 and 4 028 kHz; rms per-channel deviation 200 kHz; continuity pilot at 4 715 kHz produces 140 kHz rms deviation of main carrier $D = 200 \times 10^3 \times 3.76 \times 5.5 = 4.13 \times 10^6$ Hz $M = 4.028 \times 10^6$; $P = 4.715 \times 10^6$; Bandwith: 16.32×10^6 Hz = 16.3Mhz	16M3F8EJF

*These methods of calculating necessary bandwith apply only when the RMS deviation of the main carrier by a continuity pilot subcarrier and/or when the audio subcarrier is small with respect to the main carrier deviation. Typically the RMS deviation of the main carrier by a continuity pilot subcarrier or by audio subcarriers is between 2.5% and 7.5%.

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
Radio-relay system; frequency division multiplex having a continuity pilot subcarrier which causes more than 7.5% of the RMS deviation of the main carrier.	$B_n = 2P$	600 telephone channels occupying baseband between 60 kHz and 2 540 kHz; rms per-channel deviation: 200 kHz; continuity pilot at 8 500 kHz produces 140 kHz rms deviation of main carrier. $D = 200 \times 10^3 \times 3.76 \times 4.36 = 3.28 \times 10^6$ Hz; $M = 2.54 \times 10^6$; $K = 1$; $P = 8.5 \times 10^6$; $(2M + 2DK) < 2P$ Bandwidth 17×10^6 Hz = 17 MHz	17M0F8EJF
Stereophonic sound broad-casting with multiplexed sub-sidiary telephony subcarrier	$B_n = 2M + 2DK$ $K = 1$ (typically)	Pilot tone system $M = 75\ 000$; $D = 75\ 000$ Hz; Bandwidth : 300 000 Hz = 300 kHz	300KF8EHF
FM/Television Satellite Relay with or without audio programming or continuity pilot subcarriers	$B_n = 2(V_B + D_S + E_D + D_V)$	Video Baseband NTSC 525 line Base-band. Video Deviation = 2.0 MHz Energy Dispersal = 1.0 MHz Peak Deviation = 11.0 MHz Bandwidth: =36.4 MHz	36M4F8FNF

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
FM/Television Relay with or without audio programming or continuity pilot subcarriers *	$B_n = 2(M_v+D_v+0)$ or $B_n = 2(P+0)$ or $B_n = 2(A+0)$ or $B_n = 2(M_v + E_D)$	Highest significant video frequency, 3.8 MHz: Peak deviation of video, 4 MHz. Sub-carrier frequencies 6.17 & 6.8 MHz; Modulation of main carrier by sub-carrier 200 kHz rms; Reference modulation of subcarrier 100 kHz peak (+8dBM @ 400Hz producing 100 kHz deviation); Top audio program frequency, 15 kHz; Maximum audio trans-mission level, 10dB above reference of +8dBm; Pilot subcarrier at 8.5 MHz a) $B_n=2(3.8+4+0.8)$ MHz= 17.2MHz b) $B_n=2(8.5+0.8)$ MHz=18.6 MHz c) $B_n=2(A+0.8)$MHz hence $B_n=2(7.131+0.8)$MHz=15.9 MHz Since B_n of calcu-lating (c) is the greatest bandwidth: = 18.6 MHz	18M6F8FNF

*These methods of calculating necessary bandwith apply only when the RMS deviation of the main carrier by a continuity pilot subcarrier and/or audio subcarrier is small with respect to the main carrier deviation. Typically the RMS deviation of the main carrier by a continuity pilot subcarrier or by audio subcarriers is between 2.5% and 7.5%.

Description of Emission	Necessary Bandwidth		Designation of Emission
	Formula	Sample Calculation	
Amplitude modulation used to modulate a carrier with digital bit stream.	$B_n = 2bK$ K = 1 (typically)	Microwave system is digitally modulated at a rate of 5 megabits per second. The carrier is amplitude modulated and 4 signalling states are used. $B = \frac{R}{\log_2 4} = \frac{5\ 000\ 000}{\log_2 4}$ = 2500 kilobaud Bandwidth: 5.0×10^3 kHz=5.0MHz	5M00A1WDN
Phase shift keying is used to modulate a carrier with a digital bit stream	$B_n = 2BK$ K = 1 (typically)	a system is digitally modulated at a rate of 10 megabits per second. The carrier is phase shift keyed and 8 signalling states are used. $B = \frac{R}{\log_2 8} = \frac{10\ 000\ 000}{3}$ = 3333 kilobaud Bandwidth 6.67×10^3kHz=6.67MHz	6M67G1WEN
Frequency shift keying is used to modulate a carrier with a digital bit stream	$B_n = 2DK + B$ K = 1 (typically)	a system is digitally modulated at a rate of 10 megabits per second. The carrier is frequency shift keyed and 2 signalling states are used. D = 2000kHz $B = \frac{R}{\log_2 2}$ = 10 000 kilobaud Bandwidth 14.0×10^3 kHz=14.0MHz	14M0F1WCN

Description of Emission	Necessary Bandwidth: Formula	Necessary Bandwidth: Sample Calculation	Designation of Emission
IV. PULSE MODULATION			
1. Radar			
Unmodulated pulse emission	$B_n = \frac{2K}{t}$ K depends upon the ratio of pulse duration to pulse rise time. Its value usually falls between 1 and 10 and in many cases it does not need to exceed 6	Primary Radar Range resolution : 150 m. K = 1.5 (triangular pulse where $t \approx t_r$, only components down to 27 dB from the strongest are considered) Then $t = \frac{2(\text{range resolution})}{\text{velocity of light}}$ $= \frac{2 \times 150}{3 \times 10^8}$ $= 1 \times 10^{-6}$ seconds Bandwidth : 3×10^6 Hz = 3MHz	3M00P0NAN
2. Composite Emissions			
Radio-relay system	$B_n = \frac{2K}{t}$ K = 1.6	Pulse position modulated by 36 voice channel baseband; pulse width at half amplitude = 0.4 usec Bandwidth : 8×10^6Hz = 8 MHz (Bandwidth independent of the number of voice channels)	8M00M7EJT

TABLE 1

MULTIPLYING FACTORS FOR USE IN COMPUTING D, PEAK FREQUENCY DEVIATION IN FM FREQUENCY DIVISION MULTIPLEX (FM/FDM) MULTI-CHANNEL EMISSIONS	
The value of D, or peak frequency deviation, in these formulae for B_n is calculated by multiplying the rms value of per-channel deviation by the appropriate "Multiplying factor" shown below.	
Number of telephone channels, N_c	Multiplying factor[1]
	(peak factor) x antilog $\left[\dfrac{\text{value in dB above modulation reference level}}{20}\right]$
$3 < N_c < 12$	4.47 x antilog $\left[\dfrac{\text{a value in dB specified by the equipment manufacturer or station licensee, subject to administration approval}}{20}\right]$
$12 \leq N_c < 60$	3.76 x antilog $\left[\dfrac{2.6 + 2 \log N_c}{20}\right]$
$60 \leq N_c < 240$	3.76 x antilog $\left[\dfrac{-1 + 4 \log N_c}{20}\right]$
$N_c \geq 240$	3.76 x antilog $\left[\dfrac{-15 + 10 \log N_c}{20}\right]$

1 In the above chart, the multipliers 3.76 and 4.47 correspond to peak factors of 11.5 dB and 13.0 dB, respectively. It is recognized that some systems that carry appreciable quantities of data or information other than voice, may have different loading factors than the preferred ones shown above.

Government of Canada Department of Communications
Gouvernement du Canada Ministère des Communications

AGREEMENT BETWEEN THE GOVERNMENT OF CANADA AND THE GOVERNMENT OF THE UNITED STATES OF AMERICA RELATING TO THE AM BROADCASTING SERVICE IN THE MEDIUM FREQUENCY BAND

OTTAWA, 1984

BROADCASTING REGULATION BRANCH

Canadä

AGREEMENT BETWEEN THE GOVERNMENT OF CANADA AND THE GOVERNMENT OF THE UNITED STATES OF AMERICA RELATING TO THE AM BROADCASTING SERVICE IN THE MEDIUM FREQUENCY BAND

The Government of Canada and the Government of the United States of America, desiring to continue their mutual understanding and cooperation in the matter of AM broadcasting, to protect the broadcasting stations in the two countries and to improve the utilization of the frequency band 535 to 1605 kHz allocated to this service, have agreed as follows:

Article I

Definitions

For the purpose of this Agreement, the following terms shall have the meanings defined below:

Administration: The Federal Communications Commission of the United States and the Department of Communications of Canada, respectively;

Plan: The frequency assignment plan defined in Annex 1 to the Agreement and the modifications introduced as a result of the application of the procedure of Article III of the Agreement;

Agreement: This Agreement and its Annexes.

Rio de Janeiro Plan: The frequency assignment plan defined in the Regional Agreement for the Medium Frequency Broadcasting Service in Region 2 (Rio de Janeiro, 1981).

Article II

Adoption of the Plan

The Plan set out in Annex 1 to the Agreement consists of assignments with technical characteristics agreed upon by the two Administrations. Broadcasting stations shall be brought into service only when in conformity with Annex 1 or any modification of it resulting from the application of Article III.

Article III

Modification Procedure

3.1 When an Administration proposes to modify the Plan i.e.:

- to change the characteristics of a frequency assignment to a station shown in the Plan, whether or not the station has been brought into use, or

- to introduce a new assignment into the Plan, or

- to bring into use a new station, or

- to cancel a frequency assignment to a station,

the following procedure shall be applied simultaneously with or prior to the notification to the IFRB for modification to the Rio de Janeiro Plan.

3.2 <u>Proposals for changes in the characteristics of an assignment, for the introduction of a new assignment or for the bringing into use of a new station</u>

3.2.1 An Administration proposing to change the characteristics of an assignment in the Plan, introduce a new assignment or bring into use a new station shall seek the agreement of the other Administration.

3.2.2 Any assignment in conformity with the Agreement shall be considered as adversely affected when appropriate calculations based on Annex 2 indicate that objectionable interference would occur as a result of a proposed modification to the Plan. In the event that a proposed modification to the Plan by one Administration is adversely affected by a proposed modification from the other Administration, the proposal bearing the earlier notified transmittal date shall prevail, unless it is found to cause objectionable interference to other assignments in the Plan.

3.2.3 If an affected Administration considers that a proposed modification is acceptable, it shall signify its agreement as soon as possible to the other Administration and shall inform the IFRB accordingly. If an affected Administration considers that a proposed modification to the Plan is unacceptable, it shall communicate its reasons to the notifying Administration within 60 days from the date of notification. If no comment has been received within that 60 day period, the notifying Administration may proceed with its assignment and advise the IFRB that the agreement of the other Administration has been obtained.

3.2.4 The agreement referred to in section 3.2.1 is not required for a proposed change in the characteristics of an assignment in conformity with the Agreement if it entails no increase in the radiated field strength in any direction and, if a change in the site of the station is involved, this change is limited to the greater of 3 km or 5% of the distance to the nearest point on the border of the other country up to a maximum of 10 km. The distance is calculated from the site first registered in the Plan or subsequently registered in the Plan as a result of the application of the provisions of section 3.2. In any event, such site change shall not result in a groundwave contour overlap prohibited under section 4.10.4.2 of Annex 2 to the Agreement. However, no protection will be required beyond the level of protection which was already accepted before the proposed move.

3.3 <u>Cancellation of an assignment</u>

When an Administration decides to cancel an assignment in conformity with the Agreement, it shall immediately notify the other Administration. Simultaneously with such cancellation, the Administration may notify a new assignment to substitute for the cancelled assignment, provided that the new assignment would not cause objectionable interference at a level in excess of that caused by the cancelled assignment and which had been previously accepted.

Article IV

Format of Notification

The information required for the notifications referred to in Article III shall be provided in conformity with Annex 1 to the Agreement. In the case of a modification of technical characteristics, there shall be an indication of which parameter is modified. In order to facilitate the verification of the data, directional antenna parameters shall be supplemented by sample values of calculated radiation in 5 azimuths and vertical angles pertinent to the specific protection requirements involved.

Article V

Technical Criteria

The Administrations shall apply, in carrying out the Agreement, the technical criteria contained in Annex 2, as may be amended from time to time pursuant to Article XI.

Article VI

Groundwave Field Strength Measurements

6.1 The technical criteria contained in the Agreement provide for protection from groundwave interference through the use of theoretical calculations based on the values of ground conductivity as included in Appendix 1 to Annex 2. Nevertheless, it is recognized that in some situations such calculations may not properly reflect actual conditions where the conductivity along a specific path differs from the value shown on the conductivity map.

6.2 Therefore, field strength measurements made within a station's own country in accordance with Appendix 6 to Annex 2 may be employed in these situations to justify an assignment based on measured conductivity values.

6.3 If a station whose parameters were accepted on the basis of measurements submitted in accordance with this Article is found to cause interference within the range of azimuths covered by the data submitted, then the station shall reduce its radiation in the pertinent directions to the levels permitted by calculations using the conductivity map, or to such levels as may be mutually agreed upon by both Administrations.

6.4 <u>Resolution of interference complaints</u>

6.4.1 When it is believed that a station is experiencing objectionable interference above the level previously accepted from a station in the other country, its Administration shall be informed and, after verification, shall refer the interference complaint to its counterpart. The station believed to be the cause of the interference shall be required immediately to verify its authorized operation (including measuring field strength at permanent monitoring points if appropriate) and make any adjustments necessary to resume its authorized operation. The station shall, within 10 days of receipt of the complaint, advise its Administration of the action taken. The responsible Administration shall immediately advise its counterpart of the station's status including corrective measures taken. If, after completion of the above steps, the complaining station is still experiencing objectionable interference above the level previously accepted anywhere within its protected contour, field strength measurements shall be taken in accordance with Appendix 6 to Annex 2.

6.4.2 The Administration responsible for the complaining station shall review the field strength measurement data and, if satisfied that it is well founded, shall forward the complaint to the other Administration. If that Administration is not satisfied that the complaint is valid, it shall advise the other Administration of the reasons therefor, in order to facilitate discussions. If the Administration which receives the complaint is satisfied that it is valid on the basis of the referred data, it shall:

a) evaluate the measurement data as promptly as possible, but in no event later than 20 days after receipt;

b) forward the measurement data to the station causing the interference;

c) notify the station to take any necessary action to eliminate the interference or to prove that it is operating as authorized. The station shall comply as soon as possible within a time period not to exceed 30 days;

d) if necessary corrective action has not been taken within 30 days, order the interfering station to reduce its power at once by any amount necessary, including cessation of operation, to eliminate the interference;

e) refuse authority to resume normal operation until the necessary action specified in c) and d) above has been taken.

6.4.3 Since actual ground conductivities over specific paths may vary from the values indicated in the ground conductivity maps included in Appendix 1 to Annex 2, interference may be experienced even if the station causing the interference is operating in accordance with notified parameters. In such circumstances, except as noted in section 6.3, no action will be required as long as the station can demonstrate that it is operating as authorized. However, each Administration shall endeavor, in cooperation with the other, to mitigate such interference.

Article VII

Extended Hours of Operation

7.1 Scope. "Extended hours of operation" refers to the operation of AM radio broadcasting stations during nighttime hours which occur between 6:00 am and two hours past sunset local time, with protection requirements determined in accordance with Appendix 7 to Annex 2. Operation during this period shall be with daytime or nighttime facilities adjusted as necessary to meet the requirements of this Article.

7.2 Protection.

7.2.1 During extended hours of operation, a station shall provide protection to each co-channel station in the other country in accordance with the method described in Appendix 7 to Annex 2.

7.2.2 A station authorized for extended hours of operation shall not receive protection for that operation.

7.2.3 In applying section 7.2.1, the hours of sunrise and sunset for each month shall be determined as of the 15th day of each month and adjusted to the nearest quarter-hour.

7.2.4 Power radiated during extended hours of operation shall not exceed the highest power that provides the required protection.

7.2.5 Notified nighttime operation has priority over extended hours of operation. Thus, the power used during extended hours of operation shall be adjusted downward as necessary to provide requisite protection to duly notified and accepted nightime assignments, whenever they may be notified.

7.3 Notification. Proposed extended hours of operation by stations meeting the requirements of this Article are deemed to be acceptable. Each such proposal shall be notified in accordance with Articles III and IV. The notification shall include the exact operating characteristics of each station proposing extended hours of operation.

Article VIII

Critical Hours of Operation

8.1 Scope. "Critical hours of operation" refers to the operation of Class B and C AM radio broadcasting stations of either country, assigned to channels on which the other country has a Class A station listed in Part VI of Annex 1, during those daytime hours specified in Appendix 8 to Annex 2.

8.2 Protection

8.2.1 The Class A stations referred to in section 8.1 shall be protected during their critical hours of operation in accordance with the criteria specified in Appendix 8 to Annex 2.

8.2.2 No assignment previously accepted by both Administrations, or subsequent modifications thereto, shall be required to reduce radiation to comply with section 8.2.1.

8.3 Notification. Proposed critical hours of operation by stations meeting the requirements of this Article are deemed to be acceptable. Each such proposal shall be notified in accordance with Articles III and IV. The notification shall include the exact operating characteristics of each station proposing critical hours of operation.

Article IX

Termination of Previous Agreements

9.1 This Agreement supersedes all previous agreements, arrangements and understandings between Canada and the United States relating to the AM broadcasting service, including the provisions of the North American Regional Broadcasting Agreement, 1950 (NARBA) insofar as that agreement relates to mutual undertakings of Canada and the United States. The Agreement also prevails over provisions of the Regional Agreement for the Medium Frequency Broadcasting Service in Region 2, (Rio de Janeiro, 1981), wherever the two agreements are inconsistent, insofar as mutual relations between Canada and the United States are concerned.

9.2 Proposed assignments previously notified pursuant to NARBA, and still pending on the date of entry into force of the Agreement, shall be deemed to be notified under this Agreement, taking into account understandings already reached concerning them.

Article X

Periodic Review

Recognizing that the Agreement is intended to remain in effect for an indefinite period, the Parties agree that, no later than five years after the date of the entry into force of the Agreement pursuant to Article XII, and no later than the expiration of each successive five-year period thereafter, each Party shall designate and notify to the other those of its assignments in the Plan not yet brought into use that it wishes to retain in the Plan. Assignments which have remained unused for at least five years, and which are not so designated and notified shall lapse and be automatically deleted from the Plan at the end of each such five-year period.

Article XI

Amendment of the Annexes

Except for modifications to the Plan, which are governed by Article III, the Annexes hereto may be amended by exchange of letters directly between the Administrations. The adoption of such amendments shall be notified to the Department of External Affairs of Canada and the Department of State of the United States of America by the Administration of each country.

Article XII

Entry into Force and Termination

The Agreement shall enter into force on the date of its signature and shall remain in force thereafter until terminated upon twelve months' notice given in writing by one of the Parties to the other.

IN WITNESS WHEREOF, the undersigned, duly authorized by their respective Governments, have signed this Agreement.

DONE in duplicate at Ottawa, this 17th day of January, 1984, in the English and French languages, each version being equally authentic.

FRANCIS FOX	PAUL H. ROBINSON JR.
For the Government of Canada	For the Government of the United States

Article XII

Entry into Force and Termination

ANNEX 1

to the Agreement

INFORMATION TO BE CONTAINED IN LISTINGS AND IN FORMS FOR NOTIFICATION PURPOSES

1. Parts I through V describe the data to be notified and the forms to be used in notification. Part VI lists the Class A stations to be protected during critical hours of operation. The Plan, a listing of all assignments and their technical parameters, is contained in Part VII.

2. An administration wishing to submit the equivalent information on magnetic tape or by other electronic means, shall submit such data only in the format accepted by the other administration.

3. Five forms and 2 listings are provided; each of which corresponds to the following information:

PART I	:	General information on the transmitting station.
PART II	:	Information on directional antennas consisting of vertical conductors.
PART III	:	Additional information for directional antennas with augmented (modified expanded) patterns.
PART IV	:	Supplementary information for top-loaded or sectionalized towers used for omnidirectional and directional antenna systems.
PART V	:	Supplementary information for extended hours of operation.
PART VI	:	Class A stations (formerly NARBA Class I-A) protected during critical hours of operation.
PART VI-A	:	Class A stations (formerly NARBA Class I-B).
PART VII	:	The Plan

4. Administrations shall use only these forms or reproductions thereof.

5. The administration receiving the notification may return forms which have not been completed correctly.

6. When known, the IFRB Serial Number shall be inserted on each form by the notifying administration. Otherwise, the space provided shall be left blank.

PART I

GENERAL INFORMATION ON THE TRANSMITTING STATION

Instructions for completing the forms

Variable No.
or
Box No.

00 IFRB Serial Number (Indicate only once a Serial No. has been received from IFRB).

01 Administration

Indicate the name of the administration, the sheet number and the date on which the form was completed.

02 Assigned frequency (kHz)

03 Name of the transmitting station

Indicate the name of the locality or the name by which the station is known. Limit the number of letters and numerals to a total of 14.

04 Call sign

This information is optional. Limit the number of letters and numerals to a total of 7.

05 Additional identification

Indicate any additional information which may be considered essential for complete identification. Where this information is not essential, this box may be left blank.

06 Station Class (A, B or C)

Insert A, B or C according to the station classes defined in Chapter 1 of Annex 2.

07 Operational status

Enter 0 for a station already in operation or for a change of characteristics in accordance with 3.2.4 of the agreement, and enter P for a station to be brought into operation, or for any other change of characteristics.

08 Country

Indicate the name of the country or geographical area in which the station is located. Use the symbols in Table 1 of the Preface to the International Frequency List.

Variable No.
or
Box No.

09 **Geographical coordinates for the transmitting station**

Indicate the geographical coordinates (longitude and latitude) of the transmitting antenna site in degrees, minutes and seconds. Seconds need to be entered only if available. If no seconds are indicated, a value of 0 will be used.

11 **Indicate the reason for the application of Article III**

a) New assignment;

b) Modification of the characteristics of an assignment recorded in the Plan for Region 2;

c) Cancellation of an assignment.

12 Indicate whether the modification is of the type specified in section 3.2.4 of Article III of the Agreement.

13 In the case of a new station, indicate the date of bringing into service. In the case of a change in the characteristics of a station already recorded in the Plan, indicate the date of start of operation with the modified characteristics or the date of cessation of operation.

14 Indicate extended hours (E) or critical hours (C) operation. (If extended hours complete Part V).

DAYTIME OPERATION

21 **Station power (kW)**

Indicate the carrier power supplied to the antenna for daytime operation (to the second decimal position for powers less than 1 kW).

25 **r.m.s. value of radiation (mV/m at 1 km) for daytime station power**

26 **Antenna type**

Indicate here the type of antenna used for daytime operation. Use the symbols as follows:

A - Simple omnidirectional antenna

B - Directional antenna (complete Part II)

1 - Top-loaded omnidirectional antenna (complete Part IV)

2 - Sectionalized omnidirectional antenna (complete Part IV).

Variable No.
or
Box No.

27 **Simple vertical antenna electrical height**

Indicate here the electrical height, in degrees, for a simple vertical antenna in use for daytime operation. In the case of an antenna type other than A, this box should be left blank.

NIGHTTIME OPERATION

31 **Station power (kW)**

Indicate the carrier power supplied to the antenna for night-time operation (to the second decimal position for powers less than 1 kW).

35 **r.m.s. value of radiation (mV/m at 1 km) for night-time station power**

36 **Indicate the antenna type used for night-time operation (for symbols, see 26)**

37 (See 27)

44 **Remarks**

Indicate here any necessary additional information, such as the identification of the synchronized network to which the station belongs. If shared time operation is intended, indicate in this box and identify the other assignment involved.

Coordination under Article III

Country - Indicate the name of the countries which may be affected and with which coordination is considered necessary, using the symbols in Table I of the Preface to the International Frequency List.

In progress - Add an "X" if coordination is under way with these countries.

Acceptance obtained - Indicate with an "X" if coordination has been successful.

(00) [ ]
IFRB Serial No.

FORM FOR THE APPLICATION OF ARTICLE 4 OF THE AGREEMENT
CHARACTERISTICS OF A REGION 2 BROADCASTING STATION IN THE BAND 535 - 1 605 kHz

PART I GENERAL INFORMATION

(01) Administration [ ] FORM No. [ ] Date [ ]

Assigned frequency (kHz)		(02)	
TRANSMITTING STATION	Name of the station	(03)	
	Call sign	(04)	
	Additional Identification	(05)	
	Station class	(06)	
	Operational Status	(07)	
Country		(08)	
Geographical coordinates of the transmitting station		(09)	W ° ' " N ° ' "

(11) a) New assignment [ ] b) Modification of characteristic of an assignment recorded in the Plan [ ] c) Cancellation of an assignment [ ]

(12) Modification under Article 3.2.4 (Region 2 Agr. Sec. 4.2.14) Yes [ ] No [ ]

(13) Date of bringing into service or cessation of operation [ ] Year Month Day

(14) Extended/Critical hours of operation [ ]

STATION PARAMETERS	DAYTIME OPERATION	NIGHT-TIME OPERATION
Station power (kW)	(21)	(31)
r.m.s. value of radiation for station power (mV/m at 1 km)	(25)	(35)
Antenna type	(26)	(36)
Simple vertical antenna electrical height (degrees)	(27)	(37)

(44) Remarks

COORDINATION UNDER ARTICLE III:

COUNTRY								
IN PROGRESS								
ACCEPTANCE OBTAINED								

PART II

INFORMATION ON DIRECTIONAL ANTENNAS CONSISTING OF VERTICAL CONDUCTORS

Instructions for completing the form

Variable No.
or
Box No.

00 IFRB Serial Number (only once a Serial No. has been received from IFRB).

01 Indicate the name of the transmitting station.

02 Country

Indicate the country or geographical area in which the station is located. Use the symbols in Table 1 of the Preface to the International Frequency List.

03 Indicate the hours of operation for which the given characteristics of the antenna are applicable. The symbols D or N shall be used to indicate that the station operates for the daytime or night-time period respectively. The symbol C shall be used to indicate critical hours of operation. When the same operation is used for more than one time period, enter the 2 or 3 applicable symbols.

04 Indicate the total number of towers constituting the array.

Column No.

05 Indicate the serial number of towers, as they will be described in columns 06 to 12.

06 Indicate here the ratio of the tower field to the field from the reference tower.

07 Indicate here, in degrees, the positive or negative difference in the phase angle of the field from the tower with respect to the field from the reference tower.

08 Indicate in degrees the electrical spacing of the tower from the reference point. defined in column 10.

09 Indicate, in degrees from True North, the angular orientation of the tower from the reference point indicated in column 10.

10 Define the reference point as follows:

0 = where the spacing and orientation are shown with respect to a common reference point which is generally the first tower.

1 = where the spacing and orientation are shown with respect to the previous tower.

<u>Column No.</u>

11 Indicate the electrical height (degrees) of the tower under consideration.

12 <u>Tower structure</u>

Indicate the structure of each tower using the following code:

0 =	simple vertical antenna	
1 =	top-loaded antenna	Codes 1 to 9 are used in Part IV to indicate the characteristics of the various structures. They are also used for the identification of the appropriate formula for vertical radiation in Appendices 3 and 5 to Annex 2.
2 = to 9 =	sectionalized antenna	

<u>Variable No.</u>
<u>or</u>
<u>Box No.</u>

14 r.m.s. value of radiation (mV/m at 1 km)

15 Type of pattern : T = theoretical
E = expanded
M = augmented (modified expanded).

16 Special quadrature factor for expanded and augmented (modified expanded) patterns in mV/m at 1 km (to replace the normal expanded pattern quadrature factor when special precautions are taken to ensure pattern stability).

17 Supplementary information.

FORM FOR THE APPLICATION OF ARTICLE 4 OF THE AGREEMENT

CHARACTERISTICS OF A REGION 2 BROADCASTING STATION

IN THE BAND 535 - 1605 kHz

(00) IFRB Serial No.

PART II

DESCRIPTION OF A DIRECTIONAL ANTENNA CONSISTING OF VERTICAL CONDUCTORS

Form No. ______ Date ______

(01) Name of transmitting station

(02) Country

(03) Hours of operation

(04) Total number of towers

(05) Tower No.	(06) Tower field ratio	(07) Phase difference of the field (± degrees)	(08) Electrical tower spacing (degrees)	(09) Angular tower orientation (degrees)	(10) Definition point indicator	(11) Electrical height of tower (degrees)	(12) Tower structure
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

(Use a supplementary sheet in cases where there are more than 10 towers.)

(14) r.m.s. value of theoretical radiation	(15) Type of pattern (T, E or M)	(16) Special quadrature factor
mV/m at 1 km		mV/m at 1 km

(17) SUPPLEMENTARY INFORMATION

PART III

ADDITIONAL INFORMATION FOR DIRECTIONAL ANTENNAS WITH AUGMENTED (MODIFIED EXPANDED) PATTERNS

1. Part II contains the information for directional antenna systems operating with theoretical and expanded patterns. However, some stations operate with augmented (modified expanded) directional antenna patterns. In these cases, additional calculations are performed, once the expanded radiation is calculated, to determine the radiation from the augmented (modified expanded) directional antenna pattern. Part III contains the additional parameters required for augmented (modified expanded) patterns.

2. If Part III is submitted, a corresponding Part II must also be submitted.

3. Part III should be submitted only if Box 15 of Part II contains the symbol "M" for "augmented (modified expanded)".

Box No.

00 IFRB Serial Number (Indicate the IFRB Serial No. only once one has been received from IFRB).

01 Indicate the name of the transmitting station

02 Country. Indicate the country in which the station is located, using the symbols in Table I of the Preface to the International Frequency List.

03 Indicate the hours of operation for which the antenna characteristics given are applicable. The symbols D or N shall be used to indicate that the station operates for the daytime and night-time period respectively. The symbol C shall be used to indicate critical hours of operation. When the same operation is used for more than one time period, enter the 2 or 3 applicable symbols.
"N".

04 Indicate the total number of augmentations which are used. It must be 1 or greater than 1.

Column No.

05 Indicate the serial number of the augmentations, as they will be described in columns 06, 07 and 08 (see section 2 of Attachment A, Appendix 3 to Annex 2).

06 Indicate the radiation at the central azimuth of augmentation. This value should always be equal to or greater than the value from the theoretical pattern.

07 Indicate the central azimuth of augmentation. This is the centre of the span.

Box No.

08 Indicate the total span of the augmentation. Half of the span will be on each side of the central azimuth of augmentation. Spans may overlap; if so, augmentations are processed clockwise according to the central azimuth of augmentations.

09 Supplementary information. Indicate any supplementary information concerning augmented (modified expanded) patterns. If a supplementary sheet has been used for further augmentations, please indicate in this box.

I.F.R.B. Serial #

(00)

FORM FOR THE APPLICATION OF ARTICLE 4 OF THE AGREEMENT

CHARACTERISTICS OF A REGION 2 BROADCASTING STATION IN THE BAND 535 - 1605 kHz

PART III

ADDITIONAL INFORMATION FOR DIRECTIONAL ANTENNAS WITH AUGMENTED (MODIFIED EXPANDED) PATTERNS

TO BE SUBMITTED WHENEVER THE SYMBOL M IS ENTERED IN PART II BOX 15

Form No. ______ Date ______

(01) Name of transmitting station

(02) Country

(03) Hours of operation

(04) Total number of augmentations

(05) Augmentation No.	(06) Radiation at central azimuth of augmentation (mV/m at 1 km)	(07) Central azimuth of augmentation (degrees)	(08) Total span of augmentation (degrees)
01			
02			
03			
04			
05			
06			
07			
08			
09			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

(Use a supplementary sheet in cases where there are more than 20 augmentations.)

(09) SUPPLEMENTARY INFORMATION

PART IV

SUPPLEMENTARY INFORMATION FOR TOP-LOADED OR SECTIONALIZED TOWERS USED FOR OMNIDIRECTIONAL AND DIRECTIONAL ANTENNA SYSTEMS

1. Where an omnidirectional antenna is top-loaded or sectionalized, a 1 or a 2 will have been entered in Part I Box 26 and/or 36. Proceed as for a single tower of a directional antenna.

2. When an antenna tower of a directional antenna is either top-loaded or sectionalized, column 12 of Part II will contain either a 1 for top-loaded or 2 to 9. This numeral describes the particular type of top-loaded or sectionalized antenna used, as described below:

Box No.

00 IFRB Serial Number (Indicate the Serial No. only once one has been received from IFRB).

01 Name of the station

02 Country. Indicate the country or geographical area in which the station is located, using the symbols in Table I of the Preface to the International Frequency List.

03 Indicate the hours of operation for which the given characteristics of the antenna are applicable. The symbols D or N shall be used to indicate that the station operates for the daytime or night-time period respectively. The symbol C shall be used to indicate critical hours of operation. When the same operation is used for more than one time period, enter the 2 or 3 applicable symbols.

Column No.

04 Tower number

Columns 5 to 8 contain the values of four characteristics of the elements constituting a top-loaded or sectionalized antenna. Each of these columns may contain a figure representing the value of a given characteristic as described below:

05

Code used in Col. 12 (Part II)	Description of the characteristic for which a value is given in the column. (These values are used in the equations given in Appendices 3 and 5)
1	Electrical height of the antenna tower (degrees)
2	Height of lower section (degrees)
3	Height of lower section (degrees)
4	Height of lower section (degrees)

	5	Height of lower section (degrees)
	6	Total height of tower (degrees)
	7	Height of lower section (degrees)
	8	Height of lower section (degrees)
	9	Height of centre of bottom dipole (degrees).
06	Code used in Col. 12 (Part II)	Description of the characteristic for which a value is given in the column. (These values are used in the equations given in Appendices 3 and 5).
	1	Difference between apparent electrical height (based on current distribution) and actual height (degrees).
	2	Difference between apparent electrical height of lower section (based on current distribution) and actual height of lower section (degrees).
	3	Blank
	4	Blank
	5	Height of upper section (degrees)
	6	Height of lower section (degrees)
	7	Total height of antenna (degrees)
	8	Height of upper section (degrees)
	9	Height of centre of top dipole (degrees).
07	Code used in Col. 12 (Part II)	Description of the characteristic for which a value is indicated in the column. (These values are used in the equations contained in Appendices 3 and 5)
	1	Blank
	2	Total height of antenna (degrees)
	3	Blank
	4	Blank
	5	Current distribution factor
	6	Blank
	7	Ratio of loop currents in the two elements
	8	Scaling factor so that f (Θ) is 1.0 in the horizontal plane
	9	Blank

08

Code used in Col. 12 (Part II)	Description of the characteristics for which a value is indicated in the column. These values are used in the equations entered in Appendices 3 and 5
1	Blank
2	Difference between apparent electrical height (based on current distribution) of the total tower and the actual height of the total tower (degrees)
3	Blank
4	Blank
5	Ratio of maximum current in the top section to maximum currrent in the bottom section
6	Blank
7	Blank
8	The absolute value of the ratio of the real component of current to the imaginary component of current at the point of maximum amplitude
9	Blank

I.F.R.B. Serial #

(00) [ ]

FORM FOR THE APPLICATION OF ARTICLE 4 OF THE AGREEMENT
CHARACTERISTICS OF A REGION 2 BROADCASTING STATION IN THE BAND 535 - 1605 kHz

PART IV

SUPPLEMENTARY INFORMATION FOR TOP-LOADED OR SECTIONALIZED TOWERS USED FOR:

A) DIRECTIONAL ANTENNA SYSTEMS FOR TOWERS ENTERED IN PART II AS TOP-LOADED OR SECTIONALIZED (COLUMN 12), OR

B) NON-DIRECTIONAL ANTENNA TOWERS ENTERED IN PART I AS TOP-LOADED OR SECTIONALIZED (COLUMN 26 OR 36).

Form No. [ ] Date [ ]

(01) [ ] Name of transmitting station

(02) [ ] Country

(03) [ ] Hours of operation

(04) Tower number	(05) A	(06) B	(07) C	(08) D
	•	•	•	•
	•	•	•	•
	•	•	•	•
	•	•	•	•
	•	•	•	•
	•	•	•	•
	•	•	•	•
	•	•	•	•
	•	•	•	•
	•	•	•	•

PART V

SUPPLEMENTARY INFORMATION FOR EXTENDED HOURS OF OPERATION

Instructions for completing the form

1. Information in boxes 02, 03, 04 and the IFRB Serial No. should coincide with information on the station previously notified.

2. If the station is new or if previously notified parameters are being modified, this sheet should be attached to IFRB Form Part I (as well as Parts II, III or IV where appropriate) as described in Annex 3 to the Agreement.

3. This sheet is to be submitted only when modified daytime (sunrise-to-sunset at the local site) or night time (sunset-to-sunrise at the local site) parameters are to be used at other than the previously authorized local times.

4. Fill in the remaining data in the following manner:

Box No.

41 The month and day when the operation in that column (boxes 41 to 46) commences.

42 The month and day when the operation ceases.

43 The hour in UTC (Universal Co-ordinated Time) when the parameters described in that column commence.

44 The hour in UTC when these parameters cease to be used.

45 Carrier power supplied to the antenna (to the second decimal position) in kW.

46 r.m.s. value of radiation, in mV/m at 1 km, for the power in box 45.

47 Antenna system used for extended hours: Indicate Day or Night system.

51-56 Similar to 41-46 for the dates and times indicated.

61-66 as 51-56

5. If more than one sheet is necessary to describe the operation, fill in the sheet number and the total sheets in the boxes provided.

(00) IFRB Serial No. [ ]

FORM FOR THE APPLICATION OF ARTICLE 4 OF THE AGREEMENT

CHARACTERISTICS OF A REGION 2 BROADCASTING STATION IN THE BAND 535-1605 kHz

PART V

SUPPLEMENTARY INFORMATION FOR EXTENDED HOURS OF OPERATION

(02) FREQ. kHz [ ] (03) CITY. STATE/PROV. [ ]

(04) CALL SIGN [ ] FORM NO. [ ] DATE [YR | MO | DAY]

SHEET [ ] OF [ ] SHEETS

Dates of the year inclusive From: To:	(41) [Mo | Day] (42) [Mo | Day]	(51) [Mo | Day] (52) [Mo | Day]	(61) [Mo | Day] (62) [Mo | Day]
Hours of Extended Operation (UTC) From: To:	(43) [ ] (44) [ ]	(53) [ ] (54) [ ]	(63) [ ] (64) [ ]
Station Power in kW during these hours	(45) [.]	(55) [.]	(65) [.]
R.m.s. value of radiation for station power (mV/m at 1 km)	(46) [.]	(56) [.]	(66) [.]
Antenna system used for extended hours	(47) DAY [ ] NIGHT [ ]		
Remarks: (add any other pertinent information)			

PART VI

Class A Stations (formerly NARBA Class I-A)

Protected During Critical Hours of Operation

Channel kHz	Call Sign	Location	Country
540	CBK	Watrous, Sask.	Canada
640	KFI	Los Angeles, Cal.	U.S.A.
650	WSM	Nashville, Tenn.	U.S.A.
660	WNBC	New York, N.Y.	U.S.A.
670	WMAQ	Chicago, Ill.	U.S.A.
690	CBF	Montreal, Que.	Canada
700	WLW	Cincinnati, Ohio	U.S.A.
720	WGN	Chicago, Ill.	U.S.A.
740	CBL	Toronto, Ont.	Canada
750	WSB	Atlanta, Ga.	U.S.A.
760	WJR	Detroit, Mich.	U.S.A.
770	WABC	New York, N.Y.	U.S.A.
780	WBBM	Chicago, Ill.	U.S.A.
820	WBAP	Fort Worth, Tex.	U.S.A.
830	WCCO	Minnesota, Minn.	U.S.A.
840	WHAS	Louisville, Ky.	U.S.A.
860	CJBC	Toronto, Ont.	Canada
870	WWL	New Orleans, La.	U.S.A.
880	WCBS	New York, N.Y.	U.S.A.
890	WLS	Chicago, Ill.	U.S.A.
990	CBW	Winnipeg, Man.	Canada
1010	CBR	Calgary, Alta.	Canada
1020	KDKA	Pittsburgh, Pa.	U.S.A.
1030	WBZ	Boston, Mass.	U.S.A.
1040	WHO	Des Moines, Ia.	U.S.A.
1100	WWWE	Cleveland, Ohio	U.S.A.
1120	KMOX	St. Louis, Mo.	U.S.A.
1160	KSL	Salt Lake City, Utah	U.S.A.
1180	WHAM	Rochester, N.Y.	U.S.A.
1200	WOAI	San Antonio, Tex.	U.S.A.
1210	WCAU	Philadelphia, Pa.	U.S.A.
1580	CBJ	Chicoutimi, Que.	Canada.

PART VI - A

Class A Stations (formerly NARBA Class I-B)

Channel kHz	Call Sign	Location	Country
640	CBN	S. John's, Nfld.	Canada
680	KNBR	S. Francisco, Calif.	U.S.A.
710	WOR	New York, N.Y.	U.S.A.
	KIRO	Seattle, Wash.	U.S.A.
810	KGO	S. Francisco, Calif.	U.S.A.
	WGY	Schenectady, N.Y.	U.S.A.
850	KOA	Denver, Colo.	U.S.A.
940	CBM	Montreal, Que.	Canada
1000	WCFL	Chicago, Ill.	U.S.A.
	KOMO	Seattle, Wash.	U.S.A.
1060	KYW	Philadelphia, Pa.	U.S.A.
1070	CBA	Moncton, N.B.	Canada
	KNX	Los Angeles, Calif.	U.S.A.
1080	WTIC	Hartford, Conn.	U.S.A.
	KRLD	Dallas, Texas	U.S.A.
1090	KAAY	Little Rock, Ark.	U.S.A.
	WBAL	Baltimore, Md.	U.S.A.
1110	KFAB	Omaha, Neb.	U.S.A.
	WBT	Charlotte, N.C.	U.S.A.
1130	CKWX	Vancouver, B.C.	Canada
	KWKH	Shreveport, La.	U.S.A.
	WNEW	New York, N.Y.	U.S.A.
1140	WRVA	Richmond, Va.	U.S.A.
1170	KVOO	Tulsa, Okla.	U.S.A.
	WWVA	Wheeling, W. Va.	U.S.A.
1190	WOWO	Fort Wayne, Ind.	U.S.A.
	KEX	Portland, Ore.	U.S.A.
1500	WTOP	Washington, D.C.	U.S.A.
	KSTP	S. Paul, Minn.	U.S.A.
1510	WLAC	Nashville, Tenn.	U.S.A.
	KGA	Spokane, Wash.	U.S.A.
1520	WKBW	Buffalo, N.Y.	U.S.A.
	KOMA	Oklahoma City, Okla.	U.S.A.
1530	KFBK	Sacramento, Calif.	U.S.A.
	WCKY	Cincinnati, Ohio	U.S.A.
1540	KXEL	Waterloo, Ia.	U.S.A.
1550	CBE	Windsor, Ont.	Canada
1560	WQXR	New York, N.Y.	U.S.A.
	KPMC	Bakersfield, Calif.	U.S.A.

PART VII

THE PLAN

1. The Plan in its entirety shall consist of:

a) the assignments notified, coordinated and accepted by both Administrations pursuant to agreements and arrangements previously in force between them, as they appear in their respective records; and

b) the list of assignments which appears in this Part.

Since it was not possible to attach a complete, accurate list of assignments to this Agreement, the Administrations undertake to exchange their respective lists and to verify them with a view to producing a mutually agreed consolidated version of the Plan for the application of the Agreement, as soon as possible. This version of the Plan shall be adopted by an exchange of notes between the two governments.

2. The assignments in the Plan on 1230, 1240, 1340, 1400, 1450 and 1490 kHz reflect agreement that the night-time power of assignments notified and accepted when the Agreement is signed, on channels hitherto classified as "local" channels, may be increased to 1 kW or, in some individual cases, to other indicated levels. The effective dates of such power increases will be established by exchange of letters between the Administrations. Stations on the above-listed channels which are in operation when the Agreement is signed will be permitted to increase power during daytime hours if they provide protection mutually accepted by both Administrations.

ANNEX 2

to the Agreement

TECHNICAL CRITERIA

To be used in the application of the Agreement

CHAPTER 1

Definitions and symbols

1. Definitions

In addition to the definitions given in the Radio Regulations, the following definitions and symbols apply to this Agreement.

1.1 Broadcasting channel (in AM)

A part of the frequency spectrum, equal to the necessary bandwidth of AM sound broadcasting stations, and characterized by the nominal value of the carrier frequency located at its centre.

1.2 Objectionable interference

Interference caused by a signal exceeding the maximum permissible field strength within the protected contour, in accordance with the values derived from this Annex.

1.3 Protected contour

Continuous line that delimits the area of primary or secondary service which is protected from objectionable interference.

1.4 Primary service area

Service area delimited by the contour within which the calculated level of the groundwave field strength is protected from objectionable interference in accordance with the provisions of Chapter 4.

1.5 Secondary service area

Service area delimited by the contour within which the calculated level of the field strength due to the skywave field strength 50% of the time is protected from objectionable interference in accordance with the provisions of Chapter 4.

1.6 Nominal usable field strength (E_{nom})

Agreed minimum value of the field strength required to provide satisfactory reception, under specified conditions, in the presence of atmospheric noise, man-made noise and interference from other transmitters. The value of nominal usable field strength has been employed as the reference for planning.

1.7 Usable field strength (E_u)

Minimum value of the field strength required to provide satisfactory reception under specified conditions in the presence of atmospheric noise, man-made noise, and interference in a real situation (or resulting from a frequency assignment plan).

1.8 Audio-frequency (AF) protection ratio

Agreed minimum value of the audio-frequency signal-to-interference ratio corresponding to a subjectively defined reception quality. This ratio may have different values according to the type of service desired.

1.9 Radio-frequency protection ratio

The desired radio-frequency signal-to-interference ratio which, in well-defined conditions, makes it possible to obtain the audio-frequency protection ratio at the output of a receiver. These specified conditions include various parameters such as the frequency separation between the desired carrier and the interfering carrier, the emission characteristics (type and percent modulation etc.), levels of input and output of the receiver and its characteristics (selectivity, sensitivity to intermodulation, etc.).

1.10 Class A station (see Note 1 to Section 4.6)

A station intended to provide coverage over extensive primary and secondary service areas, and which is protected against interference accordingly.

1.11 Class B station

A station intended to provide coverage over one or more population centres and the contiguous rural areas located in its primary service area, and which is protected against interference accordingly.

1.12 Class C station

A station intended to provide coverage over a city or town and the contiguous suburban areas located in its primary service area, and which is protected against interference accordingly.

1.13 Daytime operation

Operation between the times of local sunrise and local sunset.

1.14 Night-time operation

Operation between the times of local sunset and local sunrise.

1.15 Synchronized network

Two or more broadcasting stations whose carrier frequencies are identical and which broadcast the same programme simultaneously.

In a synchronized network the difference in carrier frequency between any two transmitters in the network shall not exceed 0.1 Hz. The modulation delay between any two transmitters in the network shall not exceed 100 μs, when measured at either transmitter site.

1.16 Station power

Unmodulated carrier power supplied to the antenna.

1.17 Groundwave

Electromagnetic wave which is propagated along the surface of the Earth or near it and which has not been reflected by the ionosphere.

1.18 Skywave

Electromagnetic wave which has been reflected by the ionosphere.

1.19 Skywave field strength, 10% of the time

The skywave field strength during the reference hour which is exceeded for 10% of the nights of the year. The reference hour is the period of one hour beginning one and a half hours after sunset and ending two and a half hours after sunset at the midpoint of the short great-circle path.

1.20 Skywave field strength, 50% of the time

The skywave field strength during the reference hour which is exceeded for 50% of the nights of the year. The reference hour is the period of one hour beginning one and a half hours after sunset and ending two and a half hours after sunset at the midpoint of the short great-circle path.

1.21 Characteristic field strength(E_c)

The field strength, at a reference distance of 1 km in a horizontal direction, of the groundwave signal propagated along perfectly conducting ground for 1 kW station power, taking into account losses in a real antenna.

Note: a) The gain (G) of the transmitting antenna relative to an ideal short vertical antenna is given in dB by the following equation:

$$G = 20 \log \frac{E_c}{300}$$

where E_c is in units of mV/m.

b) The effective monopole radiated power (e.m.r.p.) is given in dB(1 kW) by the following equation:

$$e.m.r.p. = 10 \log P_t + G$$

where P_t is the station power in kW

1.22 Symbols

Hz	: hertz
kHz	: kilohertz
W	: watt
kW	: kilowatt
mV/m	: millivolt/metre
μV/m	: microvolt/metre
dB	: decibel
dB (μV/m)	: decibels with respect to 1 μV/m
dB (kW)	: decibels with respect to 1 kW
mS/m	: millisiemens/metre

CHAPTER 2

Groundwave propagation

2.1 Ground conductivity

2.1.1 The Atlas of Ground Conductivity forms Appendix 1 to this Annex. It contains the information communicated to the IFRB following a decision of the First Session (Buenos Aires, 1980), the modifications introduced during the Second Session (Rio de Janeiro, 1981) and the modifications submitted in accordance with 2.1.3 below.

2.1.2 The Atlas is recorded as follows:

2.1.2.1 Large-scale maps of ground conductivity in Canada and the United States.

2.1.2.2 A digitized version maintained in a computer data base by the IFRB.

2.1.2.3 The data used in the preparation of the Atlas was digitized from the values contained in the official ground conductivity maps of the two administrations. In the case of discrepancies or errors due to the digitizing process, the values of the official maps of each administration shall prevail. Whenever an administration detects such discrepancies or errors, it shall so inform the other administration and the IFRB as soon as possible.

2.1.3 When an administration notifies to the IFRB data intended to modify the Atlas, the IFRB so informs all administrations having assignments in Region 2. After 90 days from the date on which this information is communicated by the IFRB, the IFRB modifies the Atlas and communicates the modifications to all administrations.

2.1.4 No assignment in the Plan shall at any time be required to be modified as a result of the incorporation of these data.

2.1.5 A proposal to modify the Plan shall be evaluated on the basis of the values in the Atlas on the date the proposal was received by the other administration, except as specified in Article VI of the Agreement.

2.2 Field strength curves for groundwave propagation

The curves shown in Appendix 2 are to be used for determining groundwave propagation in the following frequency ranges:

Graph No.	kHz
1	540 - 560
2	570 - 590
3	600 - 620
4	630 - 650
5	660 - 680
6	690 - 710
7	720 - 760
8	770 - 810
9	820 - 860
10	870 - 910
11	920 - 960
12	970 - 1 030
13	1 040 - 1 100
14	1 110 - 1 170
15	1 180 - 1 240
16	1 250 - 1 330
17	1 340 - 1 420
18	1 430 - 1 510
19	1 520 - 1 610

2.3 Calculation of groundwave field strength

2.3.1 Homogeneous paths

The vertical component of the field strength for a homogeneous path is represented in these graphs as a function of distance, for various values of ground conductivity.

The distance in kilometres is shown on a logarithmic scale on the abscissa. The field strength is shown on a logarithmic scale on the ordinate in m/Vm. Graphs 1 to 19 are standardized for a characteristic field strength of 100 mV/m corresponding to an effective monopole radiated power (e.m.r.p.) of -9.5 dB relative to 1 kW. The straight line marked "100 mV/m at 1 km" is the field strength on the assumption that the antenna is erected on a surface of perfect conductivity.

For omnidirectional antenna systems having a different characteristic field strength, correction must be made according to the following equations:

$$E = E_0 \times \frac{E_c \times \sqrt{P}}{100}$$ if field strengths are expressed in mV/m, and

$$E = E_0 + E_c - 100 + 10 \log P$$ if field strengths are expressed in dB (μV/m).

For directional antenna systems, the correction must be made according to the following equations:

$$E = E_0 \times \frac{E_R}{100}$$ if field strengths are expressed in mV/m, and

$$E = E_0 + E_R - 100$$ if field strengths are expressed in dB (μV/m).

Where

- E : resulting field strength
- E_0 : field strength read from graphs 1 to 19
- E_R : actual radiated field strength at a particular azimuth at 1 km
- E_c : characteristic field strength
- P : station power in kW.

Graph 20 consists of a pair of scales to be used with the other graphs of Appendix 2. The pair contains one scale labelled in decibels and another in millivolts per metre. The pair can be cut out and trimmed as a unit to be used as sliding ordinate scales. The scales allow graphical conversion between decibels and millivolts per metre, and are used to make graphical determinations of field strengths. Other methods of making calculations on graphs 1 to 19 may be used, including the use of dividers to adjust for values of E_R that differ from 100 mV/m at 1 km. However, any method used will follow steps similar to those discussed below.

For both omnidirectional and directional antenna systems the value of E_R must be found. For omnidirectional systems E_R can be determined by using the following equations:

$E_R = E_c \sqrt{P}$ if field strengths are expressed in mV/m, and

$E_R = E_c + 10 \log P$ if field strengths are expressed in dB $(\mu V/m)$.

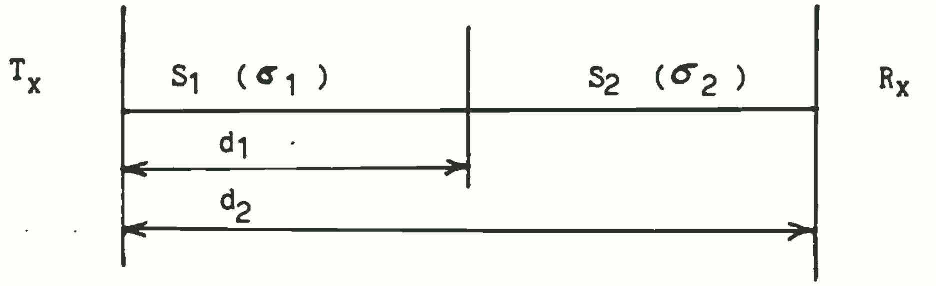
To determine the field strength at a given distance, the scale is placed at the given distance with the 100 m/Vm point of the scale resting on the appropriate conductivity curve. The value of E_R is then found on the scale; the point on the underlying graph (which lies underneath the E_R point of the scale) yields the field strength at the given distance.

To determine the distance at a given field strength, the E_R value is found on the sliding scale and that point is placed directly at the level of the given field strength on the appropriate graph. The scale is then moved horizontally until the 100 m/Vm point of the scale coincides with the applicable conductivity curve. The distance may then be read from the abscissa of the underlying graph.

2.3.2 Non-homogeneous paths

In this case, the equivalent distance or Kirke method is to be used. To apply this method, graphs 1 to 20 can also be used.

Consider a path whose sections S_1 and S_2 have endpoint lengths corresponding to d_1 and $d_2 - d_1$, and conductivities σ_1 and σ_2 respectively, as shown on the following figure:



The method is applied as follows:

a) Taking section S_1 first, we read the field strength corresponding to conductivity σ_1 at distance d_1 on the graph corresponding to the operational frequency.

b) As the field strength remains constant at the soil discontinuity, the value immediately after the point of discontinuity must be equal to that obtained in a) above. As the conductivity of the second section is σ_2, the curve corresponding to conductivity σ_2 gives the equivalent distance to that which would be obtained at the same field strength arrived at in a). This equivalent distance is d. Distance d is larger than d_1 when σ_2 is larger than σ_1. Otherwise d is less than d_1.

c) The field strength at the real distance d_2 is determined by taking note of the corresponding curve for conductivity σ_2 similar to that obtained at equivalent distance $d + (d_2 - d_1)$.

d) For successive sections with different conductivities, procedures b) and c) are repeated.

CHAPTER 3

Skywave propagation

3. The calculation of skywave field strength shall be conducted in accordance with the provisions which follow. (No account is taken in this Agreement of sea gain or of excess polarization coupling loss).

3.1 List of symbols

- d : short great-circle path distance (km)
- E_c : characteristic field strength, mV/m at 1 km for 1 kW
- $f(\theta)$: radiation as a fraction of the value $\theta = 0$ (when $\theta = 0$, $f(\theta) = 1$)
- f : frequency (kHz)
- F : unadjusted annual median skywave field strength, in μV/m
- F_c : field strength read from Figure 4 or Table III for a characteristic field strength of 100 mV/m
- F(50): skywave field strength, 50% of the time, in μV/m
- F(10): skywave field strength, 10% of the time, in μV/m
- P : station power (kW)
- θ : elevation angle from the horizontal (degrees)

3.2 General procedure

Radiation in the horizontal plane of an omnidirectional antenna fed with 1 kW (characteristic field strength, E_c) is known either from design data or, if the actual design data are not available, from Figure 1.

Elevation angle, θ, is given by

$$\theta = \arctan\left(0.00752 \cot \frac{d}{444.54}\right) - \frac{d}{444.54} \text{ degrees} \quad (1)$$

$$0 \leqslant \theta \leqslant 90^\circ$$

While Table I and Figure 2 are included for convenience, formula (1) above is controlling.

The radiation $f(\theta)$ expressed as a fraction of the value at $\theta = 0$ at a pertinent elevation angle θ can be determined from Figure 3 or Table II.

The product $E_c f(\theta) \sqrt{P}$ is determined for both omnidirectional and directional antennas with the field strength at 1 km determined at the appropriate elevation angle from Figure 2 and the pertinent azimuth.

The unadjusted skywave field strength F is given by:

$$F = F_c \left[\frac{E_c f(\theta) \sqrt{P}}{100} \right] \mu V/m \qquad (2)$$

where F_c is the direct reading from the field strength curve in Figure 4 or Table III.

Note : Values of F_c in Figure 4 and Table III are normalized to 100 mV/m at 1 km corresponding to an effective monopole radiated power (e.m.r.p.) of -9.5 dB(kW).

For distances greater than 4,250 km, it should be noted that F_c can be expressed by:

$$F_c = 10^x \quad \mu V/m \qquad (3)$$

$$\text{where} \quad x = \left\{ \frac{\left[\frac{231}{3+d/1000} \right] - 35.5}{20} \right\}$$

3.3 Skywave field strength, 50% of the time

This is given by:

$$F\ (50) = F \qquad \mu V/m \qquad (4)$$

3.4 Skywave field strength, 10% of the time

The skywave field strength exceeded 10% of the time is given by:

$$F(10) = F(50) \times 2.5118 \qquad \mu V/m \qquad (5)$$

3.5 Nocturnal variation of skywave field strength

Hourly median skywave field strengths vary during the night and at sunrise and sunset. Figures 5a and 5b show the skywave diurnal factors with respect to sunrise and sunset at the midpoint of the transmission path. These figures shall be applied in determining field strengths of signals of stations engaging in extended operations under Article VII of this Agreement, for the purpose of determining whether such extended operations protect co-channel stations in the other country. (ref. Appendix 7)

3.6 Sunrise and sunset time

To facilitate the determination of the local time of sunrise and sunset, Figure 6 gives the times for various geographical latitudes and for each month of the year. The time is the local meridian time at the point concerned and should be converted to the appropriate standard time.

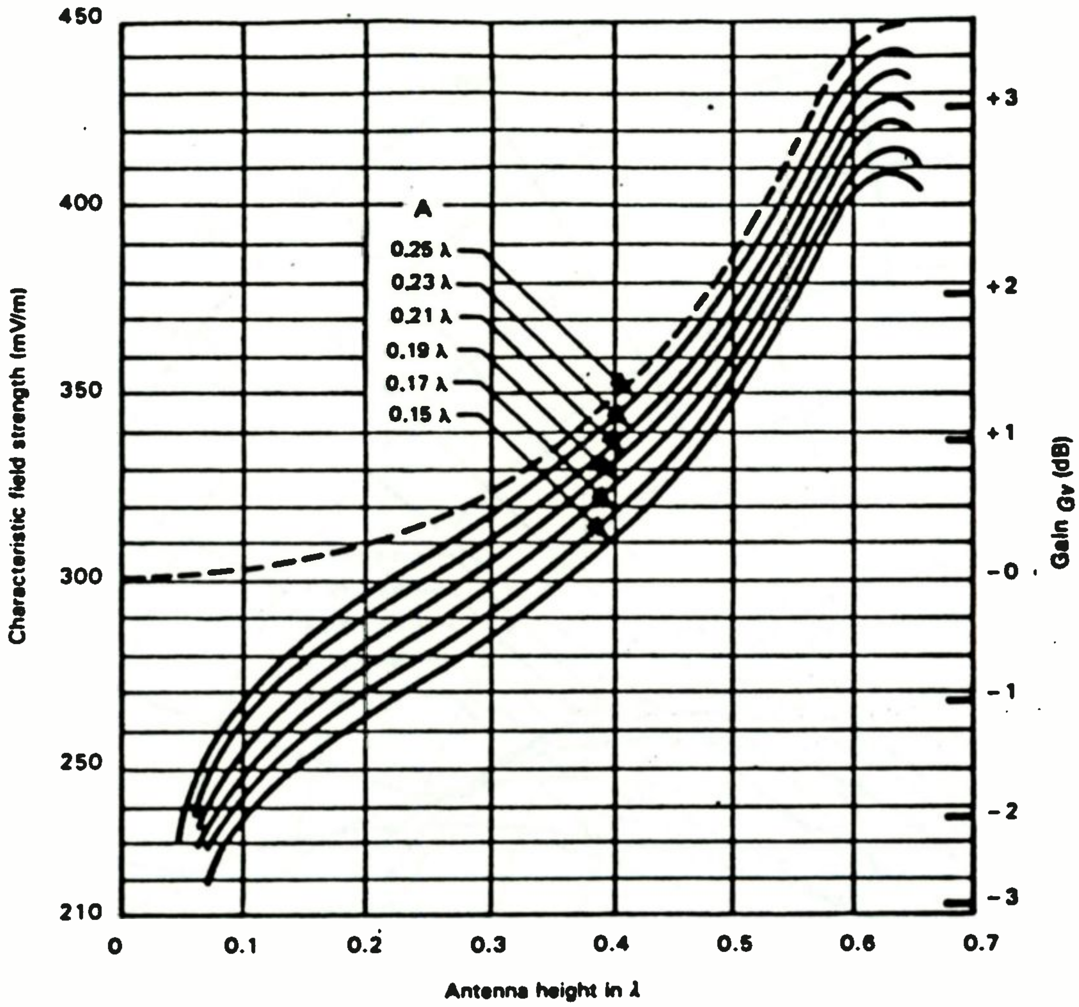


FIGURE 1 - Characteristic field strengths for simple vertical antennas, using 120-radial ground systems

A : radius of ground system

Full lines : real antenna correctly designed

Dashed line : ideal antenna on a perfectly conducting ground

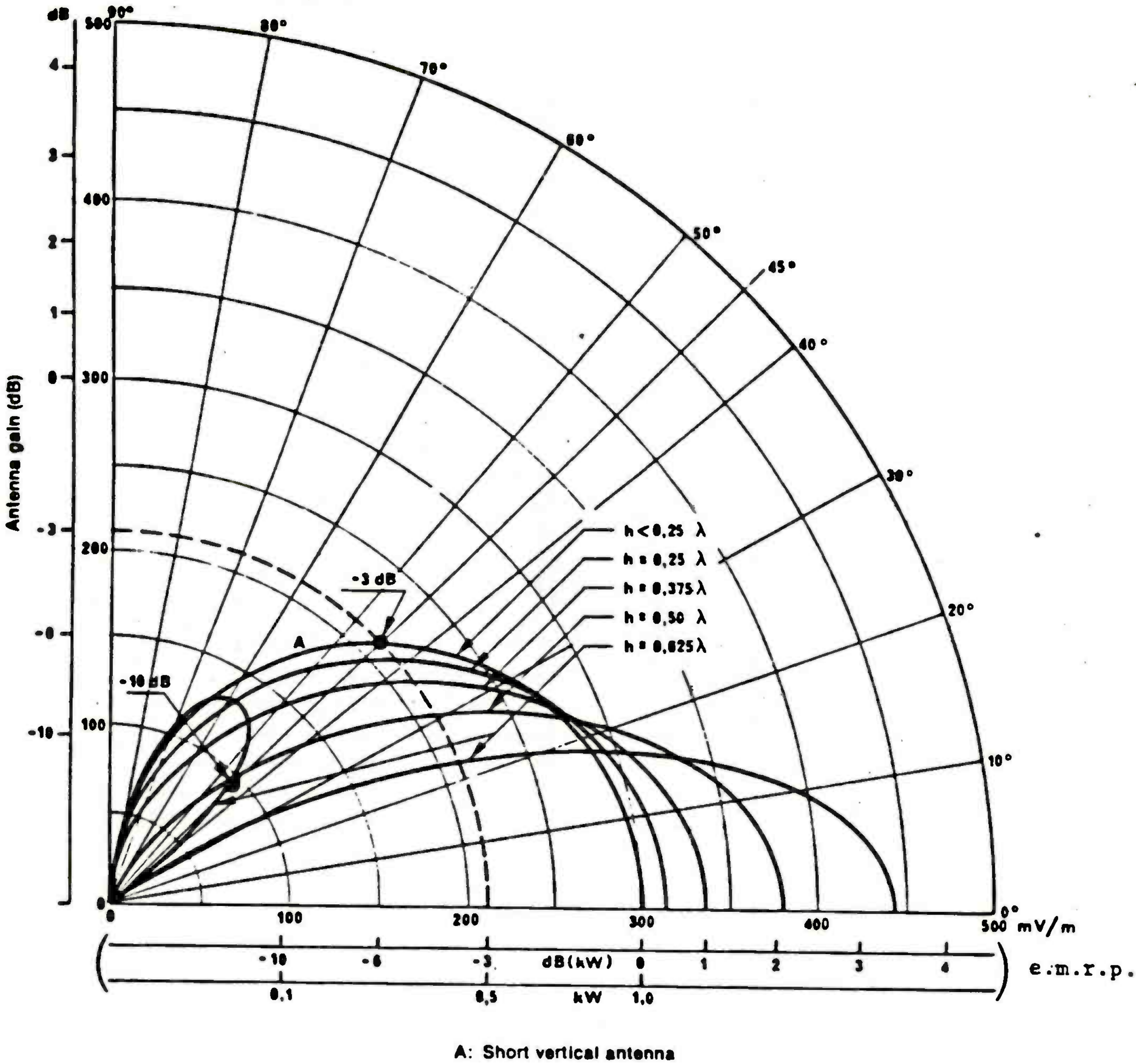
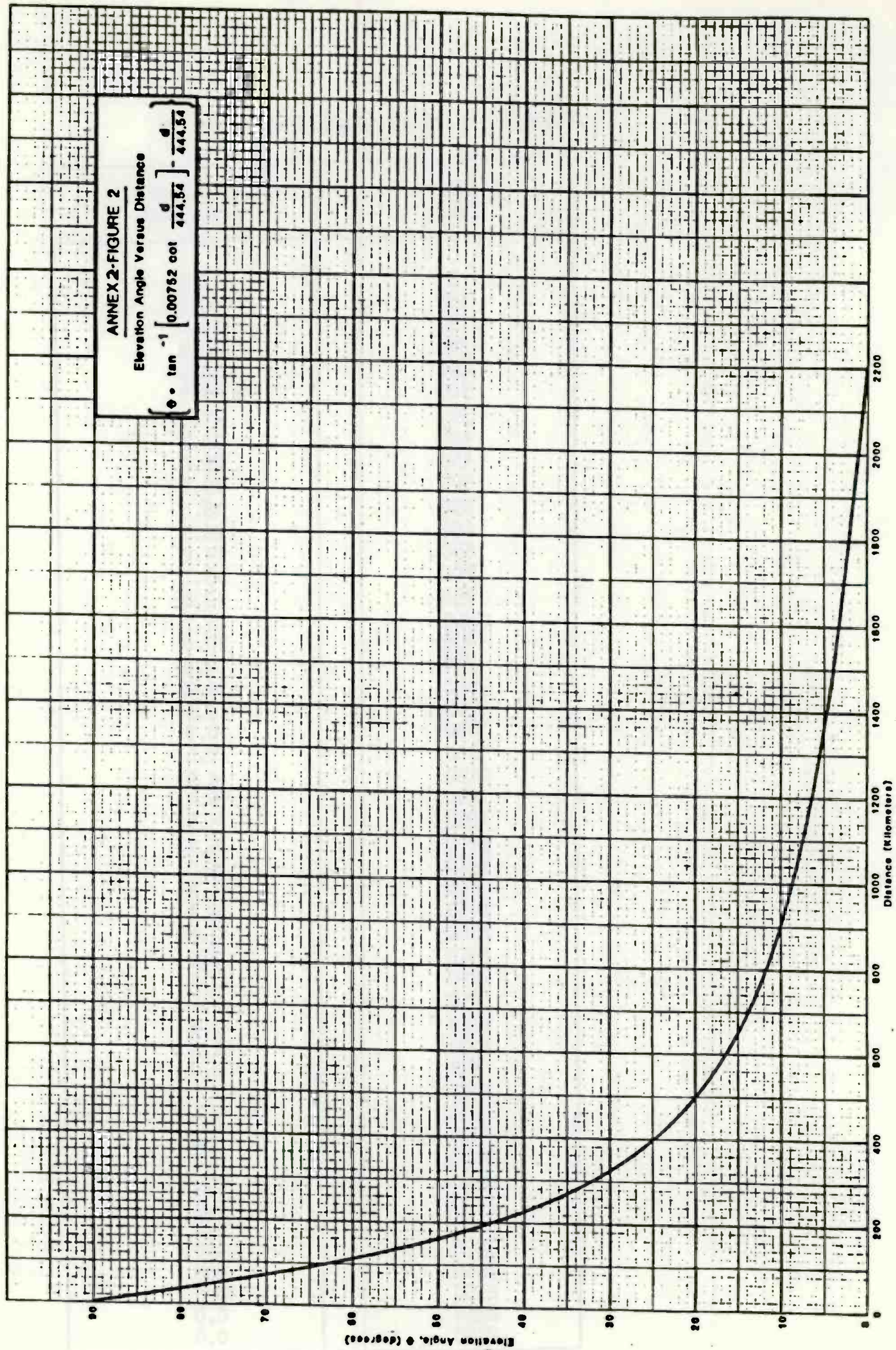


FIGURE 1a - Effective monopole radiated power (e.m.r.p.) and field strength at a distance of 1 km as a function of elevation angle, for different heights of vertical antennae assuming a transmitter power of 1 kW

TABLE I - Elevation angle vs distance

Distance (km)	Elevation angle (degrees)
50	75.3
100	62.2
150	51.6
200	43.3
250	36.9
300	31.9
350	27.9
400	24.7
450	22.0
500	19.8
550	18.0
600	16.3
650	14.9
700	13.7
750	12.6
800	11.7
850	10.8
900	10.0
950	9.3
1000	8.6
1050	8.0
1100	7.4
1150	6.9
1200	6.4
1250	5.9
1300	5.4
1350	5.0
1400	4.6
1450	4.3
1500	3.9
1550	3.5
1600	3.2
1650	2.9
1700	2.6
1750	2.3
1800	2.0
1850	1.7
1900	1.5
1950	1.2
2000	1.0
2050	0.7
2100	0.5
2150	0.2
2200	0.0
2250	0.0
2300	0.0
2350	0.0
2400	0.0



ANNEX 2-FIGURE 2

Elevation Angle Versus Distance

$$\theta = \tan^{-1}\left[0.00752 \cot \frac{d}{444.54}\right] - \frac{d}{444.54}$$

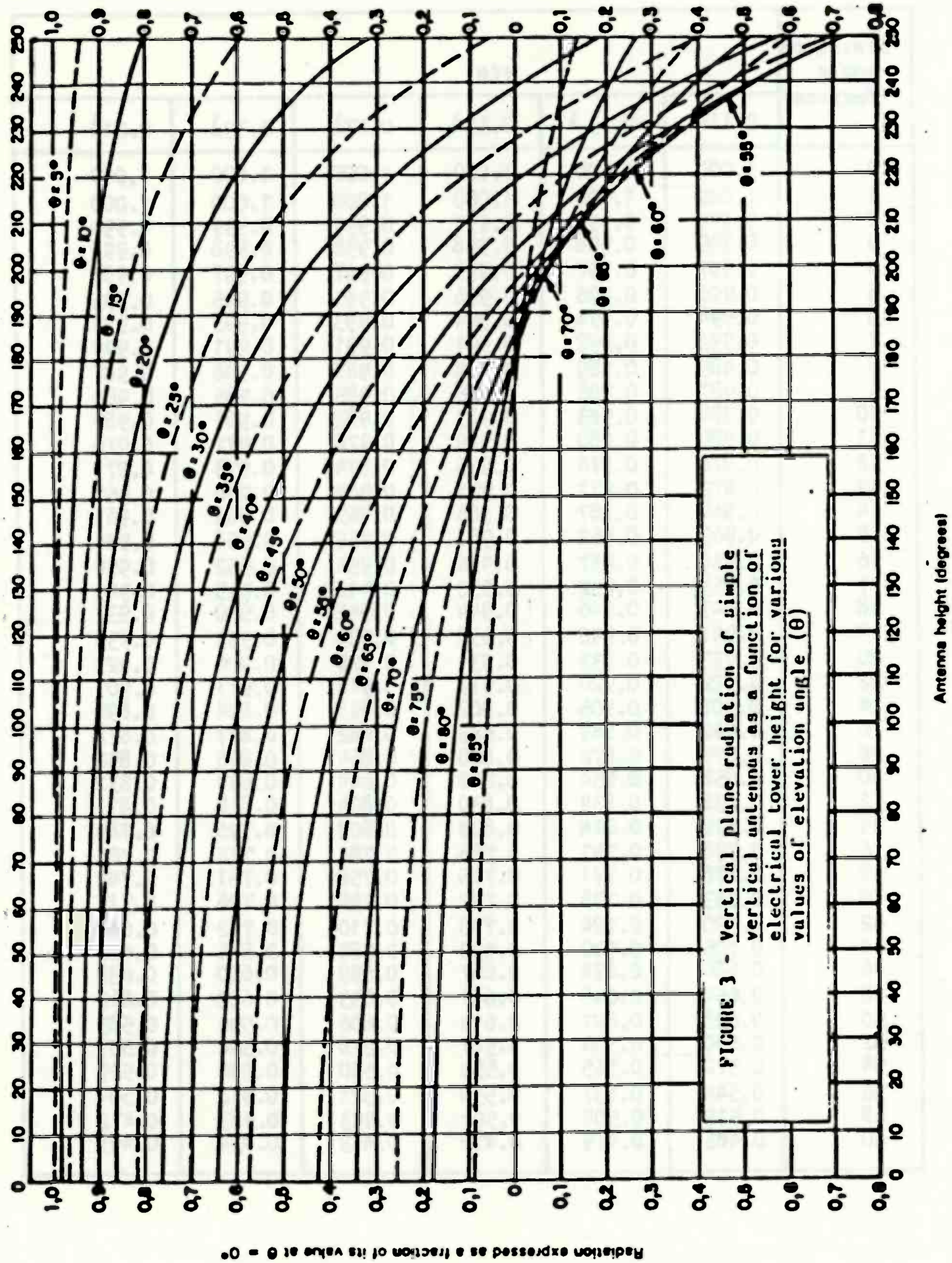


FIGURE 3 - Vertical plane radiation of simple vertical antennas as a function of electrical tower height for various values of elevation angle (θ)

TABLE II - f(θ) values for simple vertical antennas

Elevation angle (degrees)	f(θ)					
	0.11λ	0.13 λ	0.15λ	0.17λ	0.19λ	0.21λ
0	1.000	1.000	1.000	1.000	1.000	1.000
1	1.000	1.000	1.000	1.000	1.000	1.000
2	0.999	0.999	0.999	0.999	0.999	0.999
3	0.999	0.998	0.998	0.998	0.998	0.998
4	0.997	0.997	0.997	0.997	0.997	0.997
5	0.996	0.996	0.996	0.995	0.995	0.995
6	0.994	0.994	0.994	0.993	0.993	0.993
7	0.992	0.992	0.991	0.991	0.991	0.990
8	0.989	0.989	0.989	0.988	0.988	0.987
9	0.987	0.986	0.986	0.985	0.985	0.984
10	0.984	0.983	0.983	0.982	0.981	0.980
11	0.980	0.980	0.979	0.978	0.977	0.976
12	0.976	0.976	0.975	0.974	0.973	0.971
13	0.972	0.972	0.971	0.969	0.968	0.967
14	0.968	0.967	0.966	0.965	0.963	0.961
15	0.963	0.962	0.961	0.959	0.958	0.956
16	0.958	0.957	0.956	0.954	0.952	0.950
17	0.953	0.952	0.950	0.948	0.945	0.943
18	0.947	0.946	0.944	0.942	0.940	0.937
19	0.941	0.940	0.938	0.935	0.933	0.930
20	0.935	0.933	0.931	0.929	0.926	0.923
22	0.922	0.920	0.917	0.914	0.911	0.907
24	0.907	0.905	0.902	0.898	0.894	0.890
26	0.892	0.889	0.885	0.882	0.877	0.872
28	0.875	0.872	0.868	0.864	0.858	0.852
30	0.857	0.854	0.849	0.844	0.839	0.832
32	0.838	0.834	0.830	0.824	0.818	0.811
34	0.819	0.814	0.809	0.803	0.796	0.789
36	0.798	0.793	0.788	0.781	0.774	0.766
38	0.776	0.771	0.765	0.758	0.751	0.742
40	0.753	0.748	0.742	0.735	0.726	0.717
42	0.730	0.724	0.718	0.710	0.702	0.692
44	0.705	0.700	0.693	0.685	0.676	0.666
46	0.680	0.674	0.667	0.659	0.650	0.639
48	0.654	0.648	0.641	0.633	0.623	0.612
50	0.628	0.621	0.614	0.606	0.596	0.585
52	0.600	0.594	0.587	0.578	0.568	0.557
54	0.572	0.565	0.559	0.550	0.540	0.529
56	0.544	0.537	0.530	0.521	0.512	0.501
58	0.515	0.508	0.501	0.493	0.483	0.472
60	0.485	0.479	0.472	0.463	0.454	0.443

TABLE II (continued) - f(θ) values for simple vertical antennas

Elevation angle (degrees)	f(θ)					
	0.23 λ	0.25 λ	0.27 λ	0.29 λ	0.311 λ	0.35 λ
0	1.000	1.000	1.000	1.000	1.000	1.000
1	1.000	1.000	1.000	1.000	1.000	1.000
2	0.999	0.999	0.999	0.999	0.999	0.999
3	0.998	0.998	0.998	0.998	0.998	0.997
4	0.997	0.996	0.996	0.996	0.996	0.995
5	0.995	0.994	0.994	0.994	0.993	0.992
6	0.992	0.992	0.991	0.991	0.990	0.989
7	0.990	0.989	0.988	0.988	0.987	0.985
8	0.987	0.986	0.985	0.984	0.983	0.980
9	0.983	9.932	0.981	0.980	0.978	0.975
10	0.979	0.978	0.977	0.975	0.973	0.969
11	0.975	0.973	0.972	0.970	0.968	0.963
12	0.970	0.968	0.966	0.964	0.962	0.955
13	0.965	0.963	0.961	0.958	0.955	0.949
14	0.959	0.957	0.955	0.952	0.948	0.941
15	0.953	0.951	0.948	0.945	0.941	0.932
16	0.947	0.944	0.941	0.937	0.933	0.924
17	0.941	0.937	0.934	0.930	0.925	0.914
18	0.934	0.930	0.926	0.921	0.916	0.904
19	0.926	0.922	0.918	0.913	0.907	0.894
20	0.919	0.914	0.909	0.904	0.898	0.883
22	0.902	0.897	0.891	0.885	0.877	0.851
24	0.885	0.879	0.872	0.865	0.856	0.837
26	0.866	0.859	0.852	0.843	0.833	0.811
28	0.846	0.833	0.830	0.820	0.809	0.785
30	0.825	0.816	0.807	0.797	0.784	0.768
32	0.803	0.794	0.784	0.772	0.759	0.729
34	0.780	0.770	0.759	0.747	0.732	0.701
36	0.756	0.746	0.734	0.721	0.705	0.671
38	0.732	0.720	0.708	0.694	0.677	0.642
40	0.706	0.695	0.681	0.667	0.649	0.612
42	0.681	0.668	0.654	0.639	0.621	0.582
44	0.654	0.641	0.627	0.611	0.593	0.552
46	0.628	0.614	0.600	0.583	0.564	0.523
48	0.600	0.587	0.572	0.555	0.536	0.494
50	0.573	0.559	0.544	0.527	0.507	0.465
52	0.545	0.531	0.516	0.498	0.479	0.436
54	0.517	0.503	0.487	0.470	0.451	0.408
56	0.488	0.474	0.459	0.442	0.423	0.381
58	0.460	0.446	0.431	0.414	0.395	0.354
60	0.431	0.418	0.403	0.387	0.368	0.328

TABLE II (continued) - f(θ) values for simple vertical antennas

Elevation angle (degrees)	f(θ)					
	0.40λ	0.45λ	0.50λ	0.528λ	0.55λ	0.625λ
0	1.000	1.000	1.000	1.000	1.000	1.000
1	1.000	1.000	0.999	0.999	0.999	0.999
2	0.998	0.998	0.998	0.997	0.997	0.996
3	0.997	0.996	0.996	0.994	0.993	0.989
4	0.994	0.992	0.990	0.989	0.988	0.981
5	0.981	0.988	0.986	0.983	0.981	0.970
6	0.986	0.983	0.979	0.976	0.972	0.957
7	0.932	0.977	0.971	0.967	0.962	0.941
8	0.976	0.970	0.982	0.957	0.951	0.924
9	0.970	0.963	0.953	0.945	0.938	0.904
10	0.963	0.954	0.942	0.933	0.924	0.882
11	0.955	0.945	0.930	0.919	0.909	0.859
12	0.947	0.934	0.917	0.905	0.893	0.834
13	0.936	0.923	0.903	0.889	0.876	0.807
14	0.929	0.912	0.889	0.872	0.857	0.778
15	0.918	0.899	0.873	0.855	0.837	0.748
16	0.908	0.886	0.867	0.836	0.816	0.717
17	0.897	0.873	0.840	0.817	0.795	0.684
18	0.885	0.859	0.823	0.797	0.772	0.651
19	0.873	0.844	0.804	0.776	0.749	0.617
20	0.860	0.828	0.785	0.755	0.726	0.582
22	0.833	0.796	0.746	0.710	0.667	0.510
24	0.805	0.763	0.705	0.666	0.625	0.436
26	0.776	0.728	0.663	0.618	0.574	0.363
28	0.745	0.692	0.621	0.570	0.522	0.290
30	0.714	0.655	0.577	0.522	0.470	0.219
32	0.682	0.619	0.534	0.475	0.419	0.151
34	0.649	0.582	0.492	0.428	0.369	0.085
36	0.617	0.545	0.450	0.383	0.321	0.025
38	0.584	0.509	0.409	0.340	0.276	-0.031
40	0.552	0.473	0.370	0.298	0.231	-0.083
42	0.519	0.438	0.332	0.258	0.190	-0.129
44	0.488	0.405	0.296	0.221	0.162	-0.170
46	0.457	0.372	0.262	0.187	0.117	-0.205
48	0.427	0.341	0.230	0.135	0.085	-0.235
50	0.397	0.311	0.201	0.126	0.056	-0.259
52	0.369	0.283	0.174	0.099	0.031	-0.278
54	0.341	0.257	0.149	0.076	0.009	-0.291
56	0.316	0.232	0.126	0.055	-0.010	-0.300
58	0.289	0.208	0.106	0.037	-0.026	-0.304
60	0.265	0.186	0.087	0.021	-0.039	-0.304
62				0.008	-0.049	-0.300
64				-0.003	-0.056	-0.292
66				-0.011	-0.062	-0.281
68				-0.017	-0.064	-0.267
70				-0.022	-0.065	-0.250
72				-0.025	-0.064	-0.231
74				-0.025	-0.061	-0.210
76				-0.026	-0.056	-0.138
78				-0.024	-0.051	-0.163
80				-0.022	-0.044	-0.138

Note : When the negative sign (-) appears in the Table, it signifies only the existence of a secondary lobe having the opposite phase from the main lobe in the vertical radiation pattern. In order to perform the calculation, ignore the negative (-) and use only the absolute value of f(θ) from the Table.

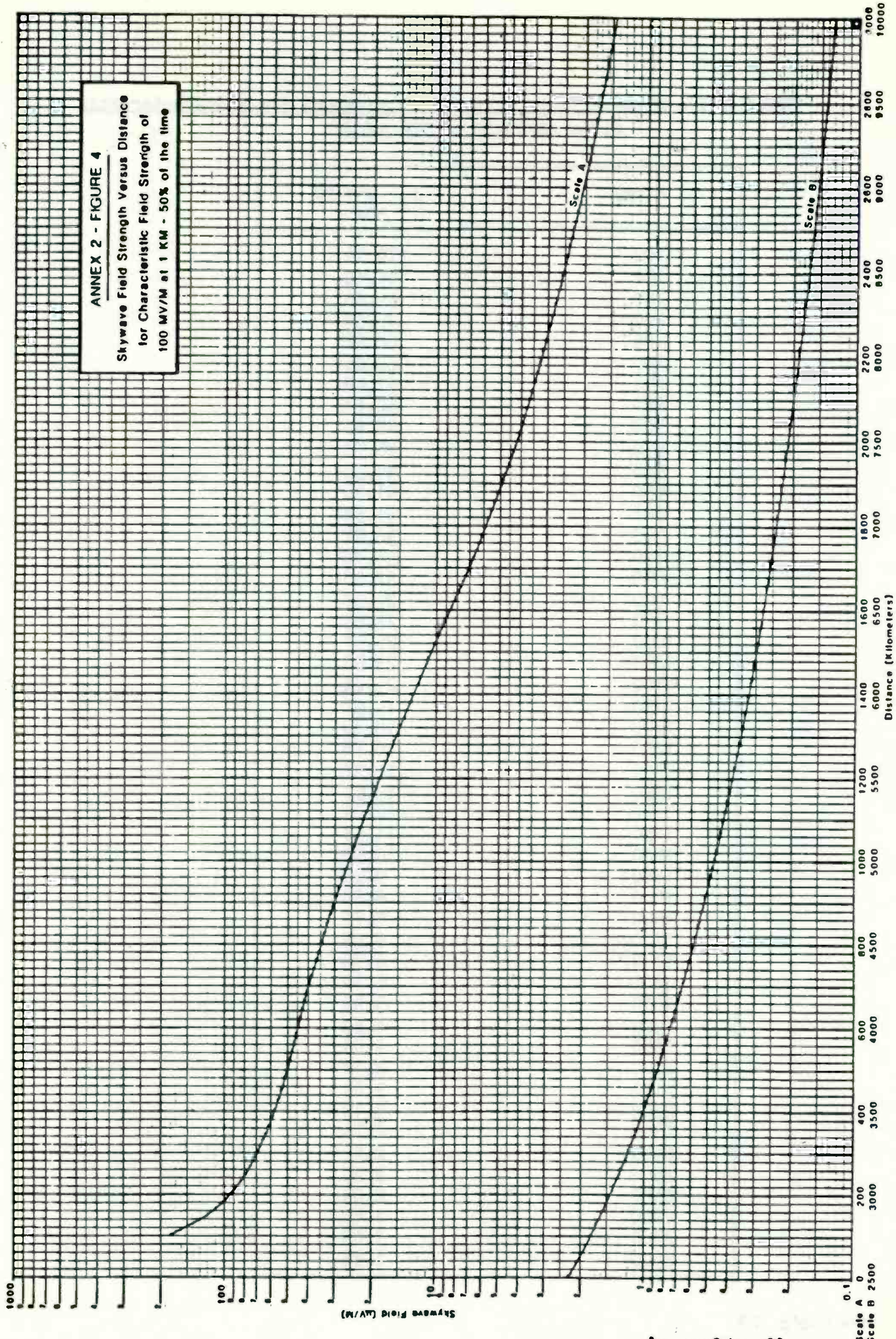
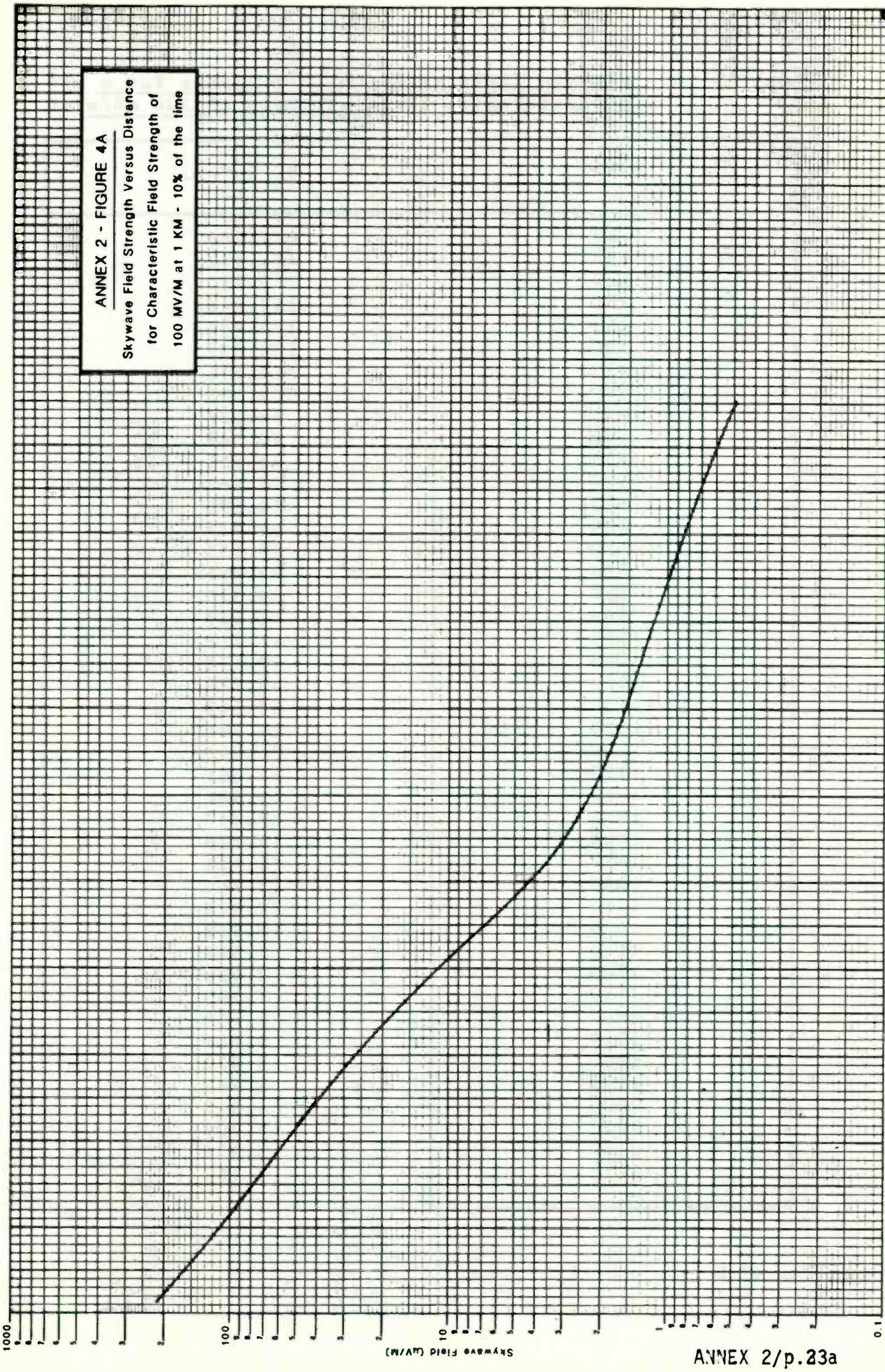

ANNEX 2 - FIGURE 4
Skywave Field Strength Versus Distance
for Characteristic Field Strength of
100 MV/M at 1 KM - 50% of the time
Scale A
Scale B
Skywave Field (μV/M)
1000
100
10
1
0.1
Scale A 0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000
Scale B 2500 3000 3500 4000 4500 5000 5500 6000 6500 7000 7500 8000 8500 9000 9500 10000
Distance (Kilometers)

TABLE III - Skywave field strength vs distance for a characteristic field strength of 100 mV/m

d(km)	F_c (µV/m) 50%
100	179.11
150	117.18
200	92.06
250	77.54
300	68.82
350	62.06
400	57.08
450	52.86
500	49.45
550	46.78
600	44.36
650	41.95
700	39.54
750	36.81
800	34.40
850	32.30
900	29.39
950	27.63
1000	25.54
1050	23.56
1100	21.84
1150	19.91
1200	18.30
1250	16.78
1300	15.32
1350	13.97
1400	12.71
1450	11.55
1500	10.50
1550	9.53
1600	8.57
1650	7.72
1700	6.98
1750	6.34
1800	5.80
1850	5.32
1900	4.89
1950	4.49
2000	4.14
2100	3.61
2200	3.18
2300	2.79
2400	2.45
2500	2.26
2600	2.03
2700	1.85
2800	1.69
2900	1.55

TABLE III (continued)

d(km)	F_c (μV/m) 50%
3000	1.43
3100	1.33
3200	1.13
3300	1.15
3400	1.07
3500	1.00
3600	0.94
3700	0.88
3800	0.83
3900	0.79
4000	0.75
4100	0.71
4200	0.67
4300	0.64
4400	0.61
4500	0.58
4600	0.55
4700	0.53
4800	0.51
4900	0.48
5000	0.46
5100	0.45
5200	0.43
5300	0.41
5400	0.40
5500	0.38
5600	0.37
5700	0.36
5800	0.34
5900	0.33
6000	0.32
6200	0.30
6400	0.28
6600	0.27
6800	0.25
7000	0.24
7200	0.23
7400	0.22
7600	0.21
7800	0.20
8000	0.19
8200	0.18
8400	0.17
8600	0.17
8800	0.16
9000	0.15
9200	0.15
9400	0.14
9600	0.14
9800	0.13
10000	0.13



ANNEX 2 - FIGURE 4A

Skywave Field Strength Versus Distance for Characteristic Field Strength of 100 MV/M at 1 KM - 10% of the time

TABLE III-A - Skywave field strength vs distance for a characteristic field strength of 100 mV/m

d(km)	F_c (uV/m) 10%
50	211.266
100	198.115
150	179.210
200	162.249
250	145.831
300	132.032
350	119.611
400	109.185
450	99.537
500	90.548
550	83.555
600	76.962
650	70.105
700	64.934
750	59.953
800	55.296
850	50.930
900	46.529
950	42.776
1000	39.178
1050	35.779
1100	32.665
1150	29.706
1200	26.846
1250	24.081
1300	21.601
1350	19.347
1400	17.279
1450	15.478
1500	13.740
1550	12.228
1600	10.938
1650	9.682
1700	8.626
1750	7.660
1800	6.758
1850	6.048
1900	5.327
1950	4.782
2000	4.310
2050	3.909
2100	3.555
2150	3.269

TABLE III-A (continued)

d(km)	F_c (uV/m) 10%
2200	3.023
2250	2.797
2300	2.626
2350	2.472
2400	2.331
2450	2.189
2500	2.087
2550	1.983
2600	1.890
2650	1.804
2700	1.721
2750	1.643
2800	1.566
2850	1.508
2900	1.444
2950	1.392
3000	1.343
3050	1.295
3100	1.247
3150	1.198
3200	1.152
3250	1.107
3300	1.068
3350	1.029
3400	0.991
3450	0.952
3500	0.914
3550	0.885
3600	0.843
3650	0.809
3700	0.778
3750	0.752
3800	0.719
3850	0.687
3900	0.657
3950	0.628
4000	0.598
4050	0.570
4100	0.543
4150	0.517
4200	0.500

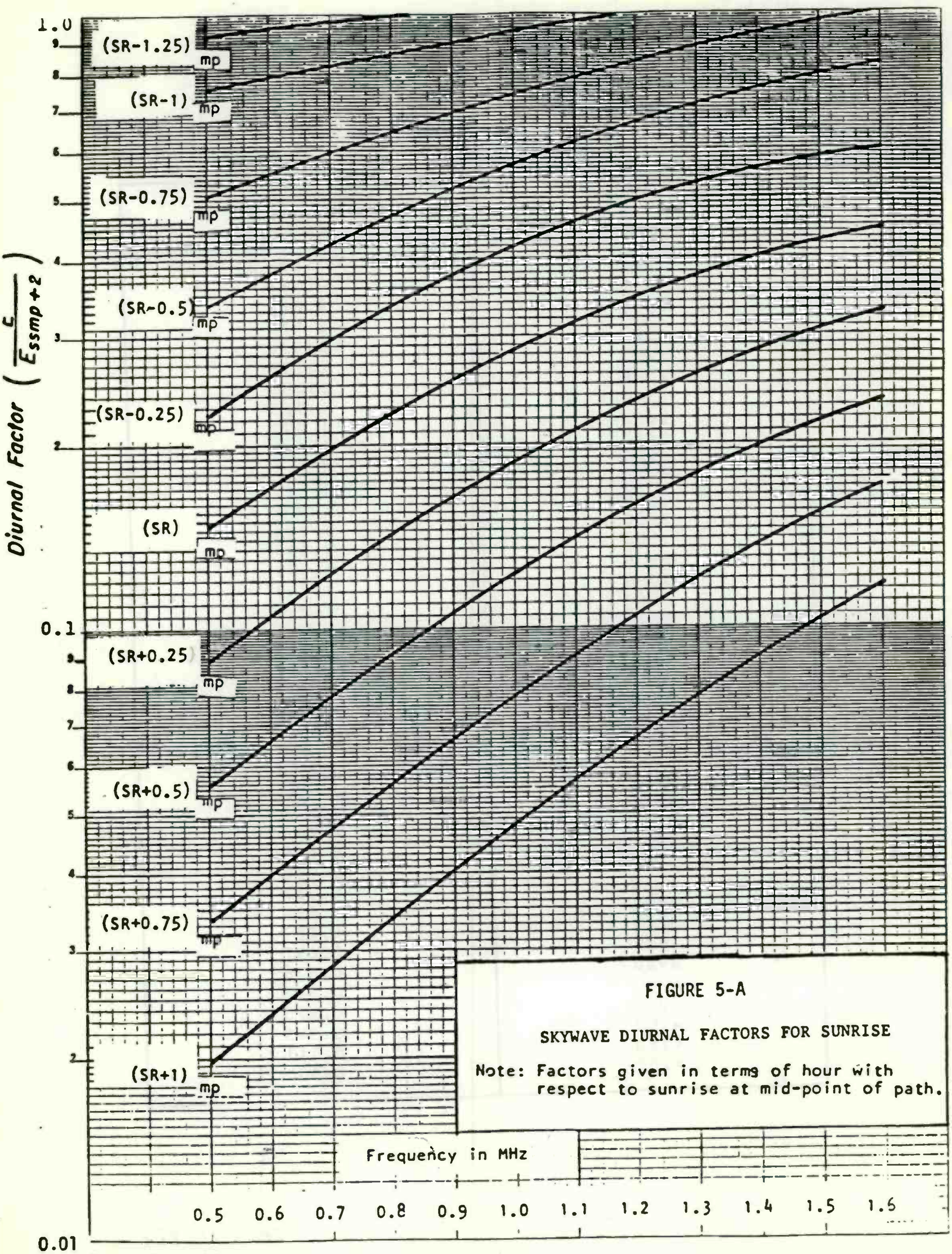


FIGURE 5-A

SKYWAVE DIURNAL FACTORS FOR SUNRISE

Note: Factors given in terms of hour with respect to sunrise at mid-point of path.

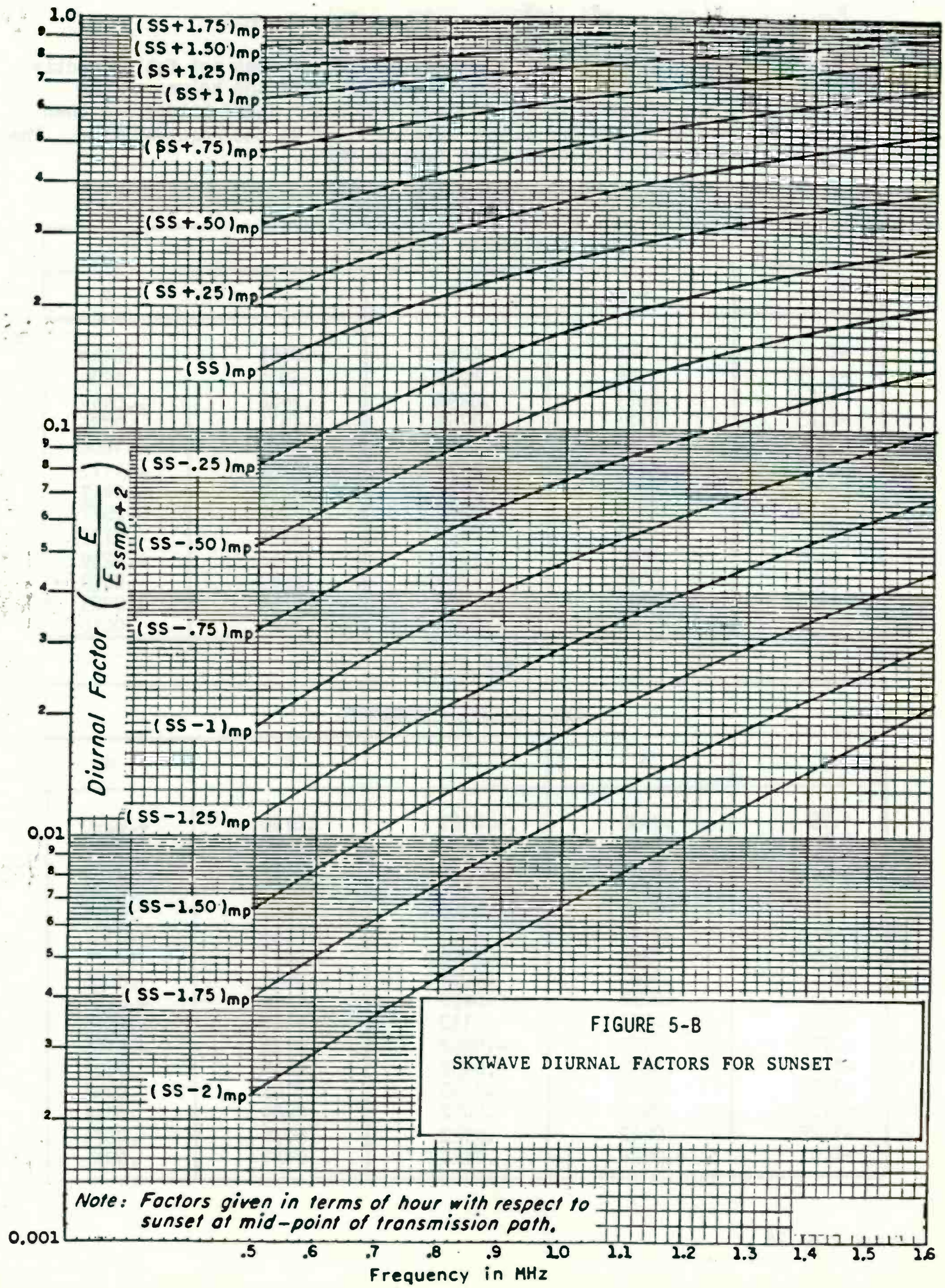


FIGURE 5-B

SKYWAVE DIURNAL FACTORS FOR SUNSET

Formula for diurnal curves of Figures 5A and 5B

$F_{diurnal} = a + bX + cX^2 + dX^3$ (where X is in MHz)

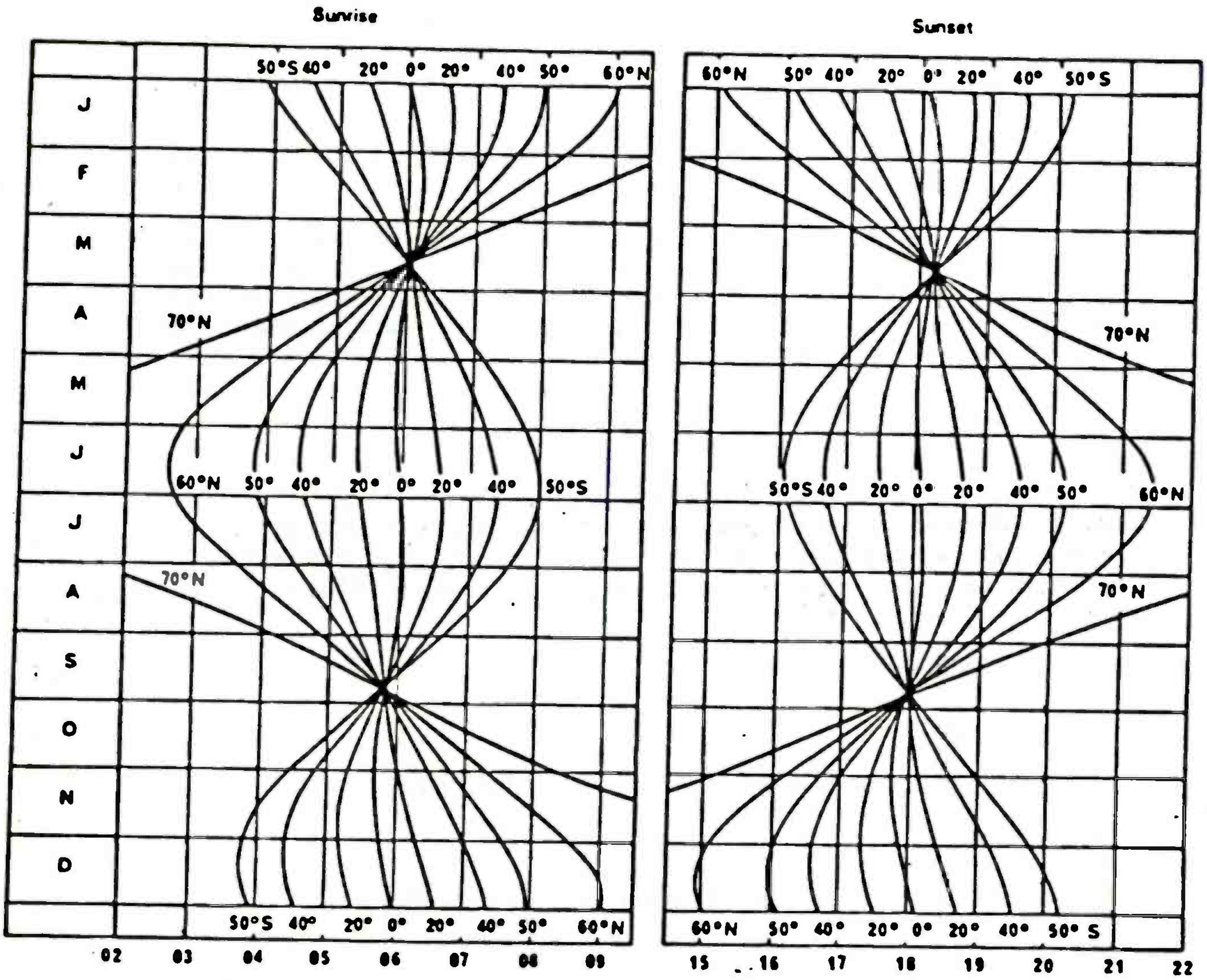
When a point in time relative to sunset or sunrise does not fall directly upon one of the curves, calculations are made using the values on the curves that are adjacent to the time in question. These values are then converted to Log values for linear interpolation at the required time. The antiLog is then taken to obtain the desired value.

TABLE 5-A

Presunrise Constants				
T_{mp}	a	b	c	d
-2	1.3084	.0083	-.0155	.0144
-1.75	1.3165	-.4919	.6011	-.1884
-1.5	1.0079	.0296	.1488	-.0452
-1.25	.7773	.3751	-.1911	.0736
-1	.6230	.1547	.2654	-.1006
-.75	.3718	.1178	.3632	-.1172
-.5	.2151	.0737	.4167	-.1413
-.25	.2027	-.2560	.7269	-.2577
SR	.1504	-.2325	.5374	-.1729
+.25	.1057	-.2092	.4148	-.1239
+.5	.0642	-.1295	.2583	-.0699
+.75	.0446	-.1002	.1754	-.0405
+1	.0148	-.0135	.0462	.0010

TABLE 5-B

Post Sunset Constants				
T_{mp}	a	b	c	d
1.75	.9495	-.0187	.0720	-.0290
1.5	.7196	.3583	-.2280	.0611
1.25	.6756	.1518	.0279	-.0163
1.0	.5486	.1401	.0952	-.0288
.75	.3003	.4050	-.0961	.0256
.5	.1186	.4281	-.0799	.0197
.25	.0382	.3706	-.0673	.0171
SS	.0002	.3024	-.0540	.0086
-.25	.0278	.0458	.1473	-.0486
-.5	.0203	.0132	.1166	-.0340
-.75	.0152	-.0002	.0786	-.0185
-1.0	-.0043	.0452	-.0040	.0103
-1.25	.0010	.0135	.0103	.0047
-1.5	.0018	.0052	.0069	.0042
-1.75	-.0012	.0122	-.0076	.0076
-2.0	-.0024	.0141	-.0141	.0091



Local time at reflection point (hours)

FIGURE 6 - Times of sunrise and sunset for various months and geographical latitudes

CHAPTER 4

Broadcasting Standards

4.1 The Plan is based on a channel spacing of 10 kHz and carrier frequencies which are integral multiples of 10 kHz, beginning at 540 kHz.

4.2 Class of emission

The Plan is based upon double-sideband amplitude modulation with full carrier A3E.

Classes of emission other than A3E, for instance to accomodate stereophonic systems, could also be used on condition that the energy level outside the necessary bandwidth does not exceed that normally expected in A3E emission and that the emission is receivable by conventional receivers employing envelope detectors without increasing appreciably the level of distortion.

4.3 Bandwidth of emission

The Plan assumes a necessary bandwidth of 10 kHz, for which only a 5 kHz audio bandwidth can be obtained. While this might be an appropriate value for some administrations, others have successfully employed wider bandwidth systems having occupied bandwidths of the order of 20 kHz without adverse effects.

4.4 Station Power

4.4.1 Class A

- The maximum station power shall be 50 kW.

4.4.2 Class B

- The maximum station power shall be 50 kW.

4.4.3 Class C

- The maximum station power shall be 1 kW.

provided that the protection criteria given in section 4.9 are met.

4.5 Skywave interference calculations

The values of interfering skywave signals shall be calculated on the basis of 10% of the time, in the manner prescribed in section 3.4.

4.6 TABLE IV - Nominal usable field strength

4.6.1	**Class A station**[1] Groundwave Daytime : co-channel 100µV/m adjacent channel 500µV/m Night-time : 500µV/m Skywave 500µV/m, 50% of the time
4.6.2	**Class B station**[2] Groundwave Daytime : 500µV/m Night-time : 2500µV/m
4.6.3	**Class C station**[2] Groundwave Daytime : 500µV/m Night-time : 4000µV/m

Note 1 : The night-time contour, groundwave or skywave, whichever is the more distant, is to be protected in the case of Class A stations.

Note 2 : The protected contour during night-time operation for Class B and C stations shall be the higher of the groundwave contour in 4.6.2 and 4.6.3 respectively, or the groundwave contour corresponding to the usable field strength of the station as defined in 4.7.

4.7 Use of the root sum square (RSS) method to determine the usable field strength resulting from the weighted interfering signals

4.7.1 General

The overall usable field strength E_u due to two or more individual interference contributions is calculated on an RSS basis, using the expression:

$$E_u = \sqrt{(a_1E_1)^2 + (a_2E_2)^2 + \ldots(a_iE_i)^2 \ldots} \qquad (1)$$

where:

E_i is the field strength of the ith interfering transmitter (in μV/m);

a_i is the radio-frequency protection ratio associated with the ith interfering transmitter, expressed as a numerical ratio of field strengths.

4.7.2 50% exclusion principle

4.7.2.1 The 50% exclusion principle allows a significant reduction in the number of calculations.

4.7.2.2 According to this principle, the values of the individual usable field strength contributions are arranged in descending order of magnitude. If the second value is less than 50% of the first value, the second value and all subsequent values are neglected. Otherwise an RSS value is calculated for the first and second values. The calculated RSS value is then compared with the third value in the same manner by which the first value was compared to the second and a new RSS value is calculated if required. The process is continued until the next value to be compared is less than 50% of the last calculated RSS value. At that point the last calculated RSS value is considered to be the usable field strength E_u.

4.7.2.3 Except as provided in section 4.7.2.4, if the contribution of a new station is greater than the smallest value previously considered in calculating the RSS value of assignments in the Plan, the contribution of the new station adversely affects assignments in conformity with this Agreement even if it is less than 50% of the RSS value. However, the new contribution does not adversely affect assignments in conformity with this Agreement if the RSS value determined by inserting the contribution of the new station in the list of contributors is smaller than the nominal usable field strength E_{nom}.

4.7.2.4 The contribution of a station engaging in extended operation under Article VII of the Agreement shall not be taken into account in the calculation of the E_u.

4.7.3 Other Region 2 Stations

In the above determination of usable field strengths, contributions from stations in other Region 2 countries, which were accepted by Canada or the U.S.A., as included in List A of the Rio de Janeiro Plan, shall be included.

4.8 (Reserved)

4.9 Channel protection ratios

4.9.1 Co-channel protection Ratio

The co-channel protection ratio is 26 dB.

4.9.2 adjacent channel protection ratio

- protection ratio for the first adjacent channel : 0 dB
- protection ratio for the second adjacent channel : -29.5 dB

4.9.3 Synchronized networks

In addition to the standards specified in the Agreement, the following additional standards apply to synchronized networks.

For the purpose of determining interference caused by synchronized networks, the following procedure shall be applied. If any two transmitters are less than 400 km apart, the network shall be treated as a single entity, the value of the composite signal being determined by the quadratic addition of the interfering signals from all the individual transmitters in the network. If the distances between all the transmitters are equal to or greater than 400 km, the network shall be treated as a set of individual transmitters.

For the purpose of determining skywave interference received by any one member of a network, the value of the interference caused by the other elements of the network shall be determined by the quadratic addition of the interfering signals from all of those elements. In any case, where groundwave interference is a factor it shall be taken into account.

The co-channel protection ratio between stations belonging to a synchronized network is 8 dB.

4.10 Application of protection criteria

4.10.1 Value of protected contours

Within the national boundary of a country, the protected contour shall be determined by using the appropriate value of nominal usable field strength, or as otherwise determined in Note 2 to paragraph 4.6 for class B and C stations.

4.10.2 Co-channel protection*

4.10.2.1 Daytime protection of all classes of stations

During the daytime the groundwave contour of class A, B and C stations shall be protected against groundwave interference. The protected contour is the groundwave contour corresponding to the value of the nominal usable field strength. The maximum permissible interfering field strength at the protected contour is the value of the nominal usable field strength divided by the protection ratio. The effect of each interfering signal shall be evaluated separately, and the presence of interference from other stations in excess of this permissible level shall not reduce the necessity to limit interference which would result from proposed modifications or assignments. Where the protected contour would extend beyond the boundary of the country in which the station is located, the maximum permissible interfering field strength at the boundary is the calculated field strength of the protected station along the boundary divided by the protection ratio.

4.10.2.2 Night-time protection of class A stations

The groundwave contour or the skywave contour 50% of the time, whichever is farther from the site of the protected class A station, shall be protected against skywave and possible groundwave interference during the night-time. The protected contour is the groundwave contour or skywave contour 50% of the time, whichever is farther from the station site, corresponding to the value of the nominal usable field strength. The maximum permissible interfering field strength at the protected contour is the value of the nominal usable field strength divided by the protection ratio. The effect of each interfering signal shall be evaluated separately, and the presence of interference from other stations in excess of the level permitted shall not reduce the necessity to limit interference which would result from proposed modifications or assignments. Where the protected contour would extend beyond the boundary of the country in which the station is located, the maximum permissible interfering field strength at the boundary is the calculated field strength of the protected station along the boundary divided by the protection ratio, using the value of the groundwave signal wherever the boundary crosses the primary service area and the value of the skywave signal outside the primary service area. In the case where the protected skywave contour would extend beyond the boundary, the groundwave contour shall also be protected up to the boundary. In applying 4.10.2.2, the nighttime contour of Class A stations not appearing in PARTS VI or VI-A of Annex 1 will be protected from interference calculated using Figure 4-A of Annex 2. In this case the maximum permissible interfering field strength at the protected contour shall be determined in accordance with 4.7.

* See the matrix in section 6 of Appendix 4 to Annex 2.

4.10.2.3 Night-time protection of class B and C stations

During the night-time, the groundwave contour of class B and C stations will be protected against skywave and possible groundwave interference. The protected contour is the groundwave contour corresponding to the value of the greater of the nominal usable field strength or the usable field strength resulting from the Plan as determined at the site of the protected station in accordance with 4.7. The maximum permissible interfering field strength calculated at the site of the protected station in accordance with 4.7 shall not be exceeded at the protected contour where the protected contour is located within the boundary of the country in which the station is located. Where the protected contour would extend beyond the boundary of the country in which the station is located, the protected contour shall follow that part of the boundary and have a value as calculated at the border. Where the maximum permissible interfering field strength is already exceeded at the protected contour by an existing station, any proposal for a change to that existing station shall not cause an increase in the interfering field strength at that portion of the protected contour.

4.10.2.4 Modification of assignments

If a station of one administration causes interference to a station of the other administration and such interference is permitted in accordance with the terms of this Agreement, then in the event of a modification being proposed to the assignment corresponding to the former station, it will not be necessary to protect the assignment corresponding to the latter station beyond the level provided before the proposed modification.

4.10.3 Adjacent channel protection*

During the daytime and night-time, the groundwave contour of class A, B and C station shall be protected against groundwave interference. The protected contour is the groundwave contour corresponding to the value of the nominal usable field strength determined as follows:

- for daytime protection of class A stations, the value specified in 4.6.1 for adjacent channel daytime groundwave;
- for night-time protection of class A stations, the value specified in 4.6.1 for night-time groundwave;
- for daytime and night-time protection of class B stations, the value specified in 4.6.2 for daytime groundwave;
- for daytime and night-time protection of class C stations, the value specified in 4.6.3 for daytime groundwave.

* See the matrix in section 6 of Appendix 4 to Annex 2.

The maximum permissible interfering field strength at the protected contour is the value of the nominal usable field strength divided by the protection ratio. The effect of each interfering signal shall be evaluated separately, and the presence of interference from other stations in excess of this permissible level shall not reduce the necessity to limit interference which would result from the proposed modifications or assignments.

Where the protected contour would extend beyond the boundary of the country in which the station is located, the maximum permissible interfering field strength at the boundary is the calculated field strength of the protected assignment along the boundary divided by the protection ratio.

If a station of one administration causes interference to a station of the other administration and such interference is permitted in accordance with the terms of this Agreement, then in the event of a modification being proposed to the assignment corresponding to the former station, it will not be necessary to protect the assignment corresponding to the latter station beyond the level provided before the proposed modification.

4.10.4 Protection outside national boundaries

4.10.4.1 No station has the right to be protected beyond the boundary of the country in which the station is established.

4.10.4.2 No broadcasting station shall be assigned a nominal frequency with a separation of 10, 20 or 30 kHz from that of a station in the other country if the 25 000 μV/m contours overlap.

4.10.4.3 In addition to the conditions described in 4.10.4.2, when the protected contour would extend beyond the boundary of the country in which the station is located, its assignment shall be protected in accordance with 4.10.2 and 4.10.3.

4.10.4.4 For protection purposes, the boundary of a country shall be deemed to encompass only its land area, including islands.

CHAPTER 5

Radiation Characteristics of Transmitting Antennas

5. In carrying out the calculations indicated in Chapters 2 and 3, the following shall be taken into account:

5.1 Omnidirectional antennas

Figure 1 of Chapter 3 shows the characteristic field of a simple vertical antenna as a function of its length and of the radius of the ground system. The characteristic field of an antenna with a loss-less ground system is also shown for comparison.

It is clear that the characteristic field strength increases as the loss in the ground system is reduced to zero and as the antenna height is increased up to 0.625 wavelengths.

The increased characteristic field strength for antenna lengths up to 0.625 wavelengths is obtained at the expense of radiation at high angles as shown graphically in Figure 1a and numerically in Table II of chapter 3.

5.2 Considerations of the radiation patterns of directional antennas

The procedures for calculating theoretical, expanded and augmented (modified expanded) directional antenna patterns are given in Appendix 3.

5.3 Top-loaded and sectionalized antennas

5.3.1 Calculation procedures are given in Appendices 3 & 5.

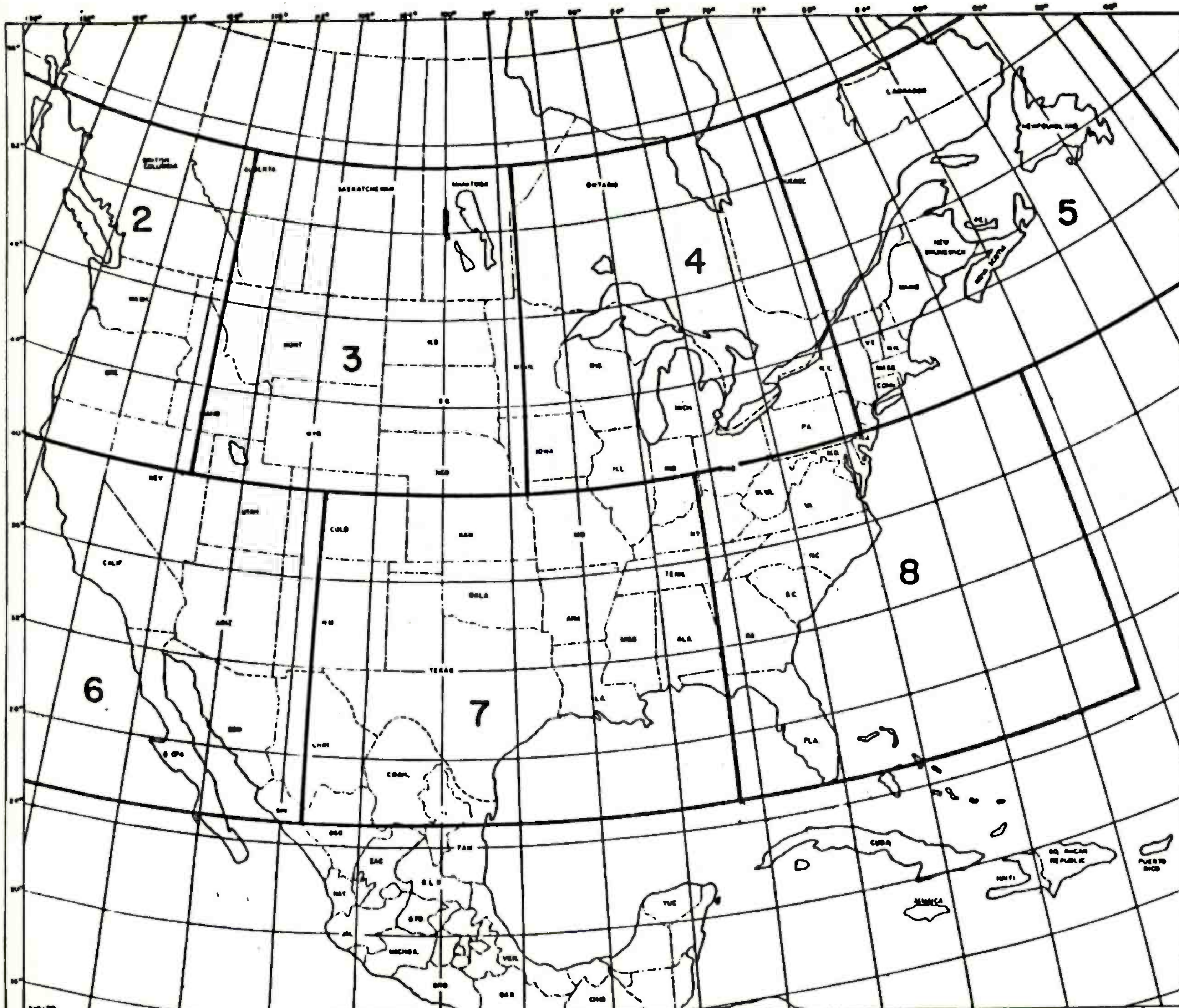
5.3.2 Many stations employ top-loaded or sectionalized towers, either because of space limitations or to vary the radiation characteristics from those of a simple vertical antenna. This is done to achieve desired coverage or to reduce interference.

5.3.3 An adminsitration using top-loaded or sectionalized antennas shall supply information concerning the tower structure of the antennas. Normally, one of the equations in Appendices 3 & 5 shall be employed to determine the vertical radiation characteristics of the antennas. Other equations may also be proposed by an administration and shall be used in determining the vertical radiation characteristics of the antennas of that administration, subject to the agreement of the other administration.

APPENDIX 1

(to Annex 2)

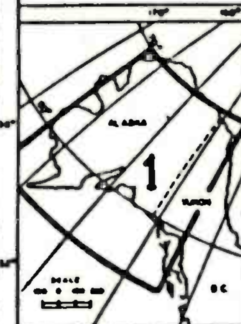
ATLAS OF GROUND CONDUCTIVITY



APPENDIX 1 (ANNEX 2)
APPENDICE 1 (ANNEXE 2)

ATLAS OF GROUND CONDUCTIVITY

ATLAS DE CONDUCTIVITÉ DU SOL

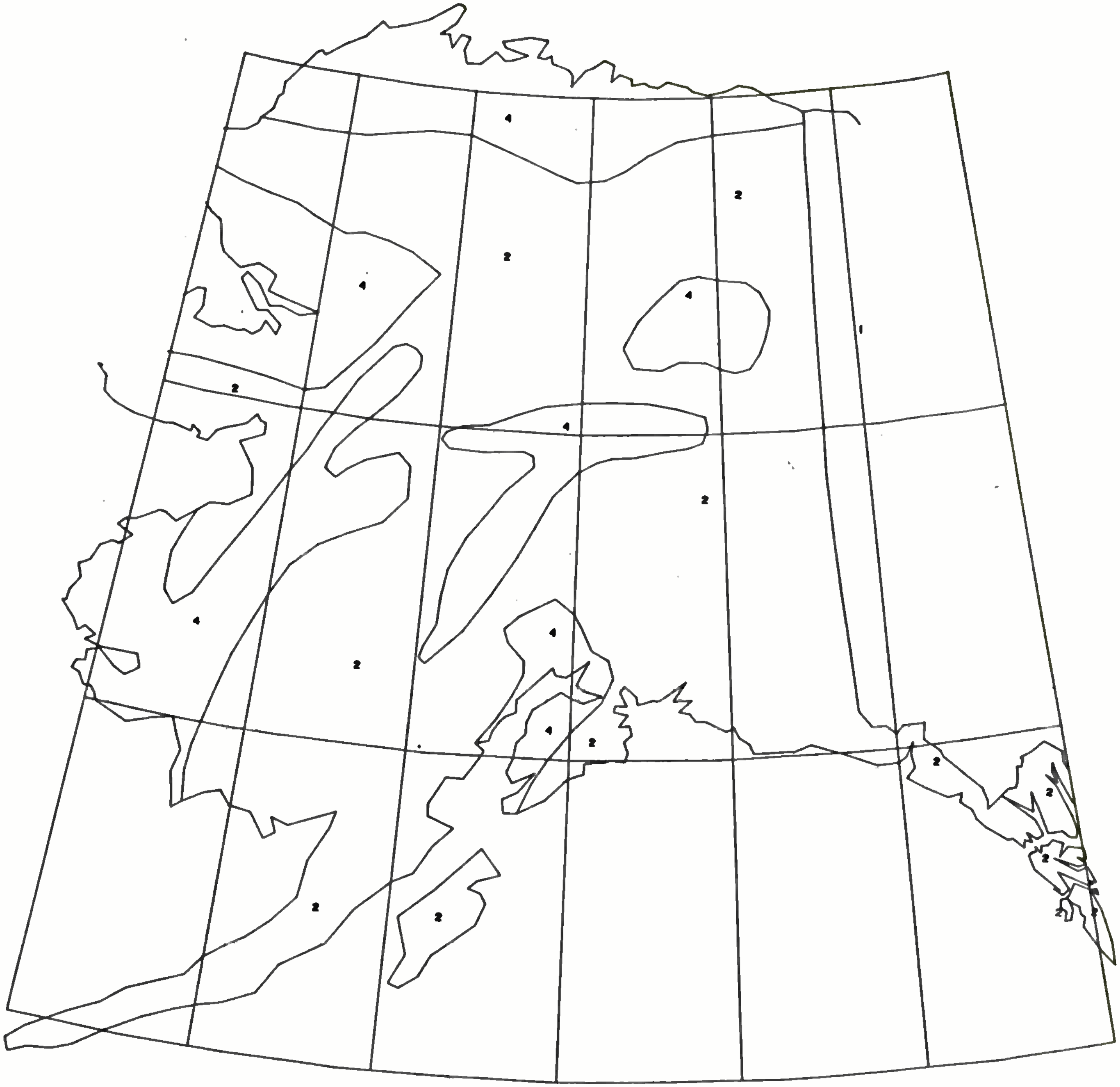


AZIMUTHAL EQUIDISTANT PROJECTION
POLE OF PROJECTION LAT 40°, LONG 100°

RADIATION SCALE

LIMITES/LIMITS 55 70. 135. 168.

BLOC/BLOCK 1

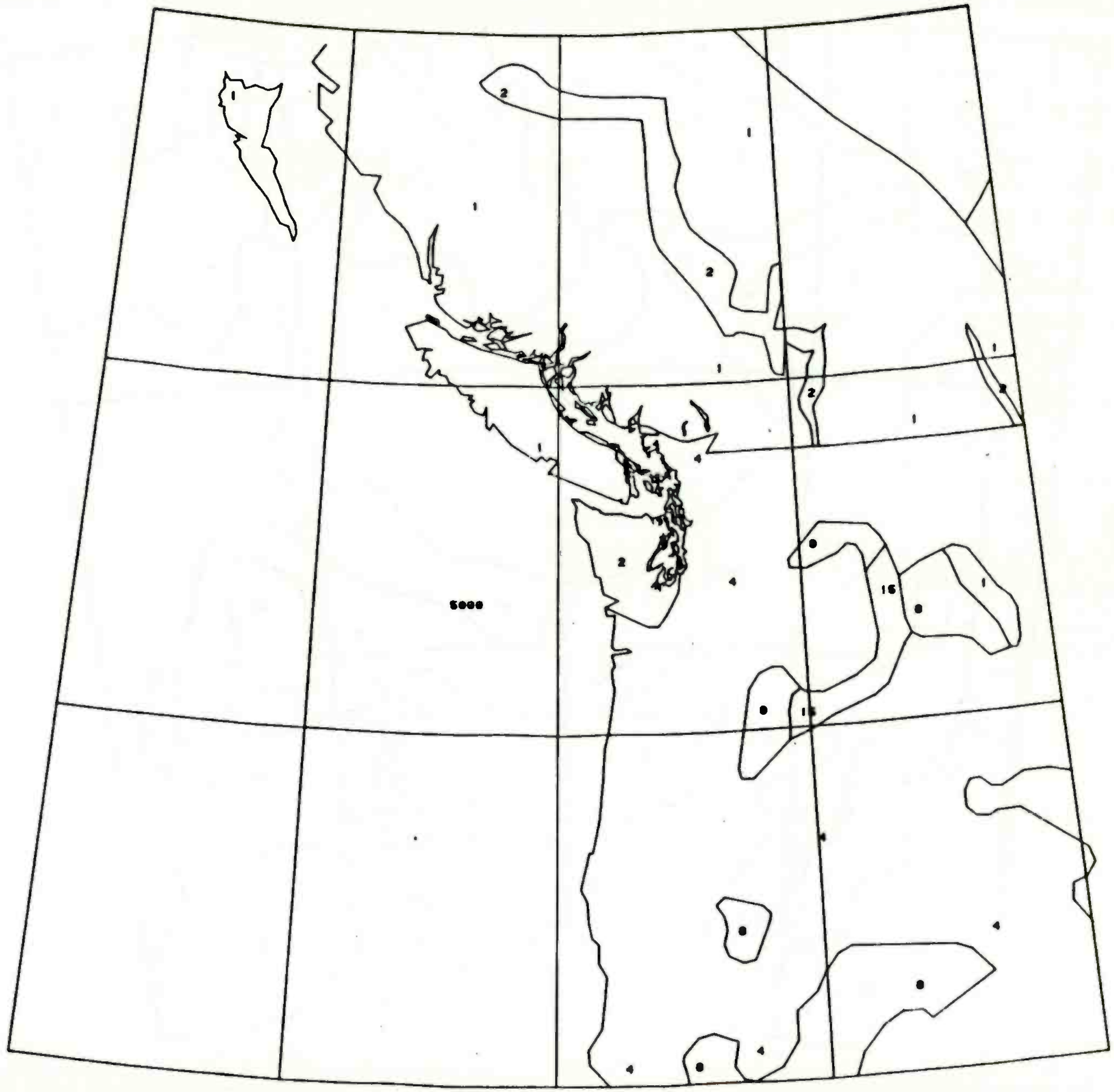


PROJECTION CONIQUE CONFORME DE LAMBERT
PARALLÈLES STANDARDS 37°, 65°

LAMBERT CONICAL CONFORMAL PROJECTION
STANDARD PARALLELS 37°, 65°

SCALE 1:5000000.0

LIMITE ... TS 40. 65. 115. 135.
BLOC ... K 2

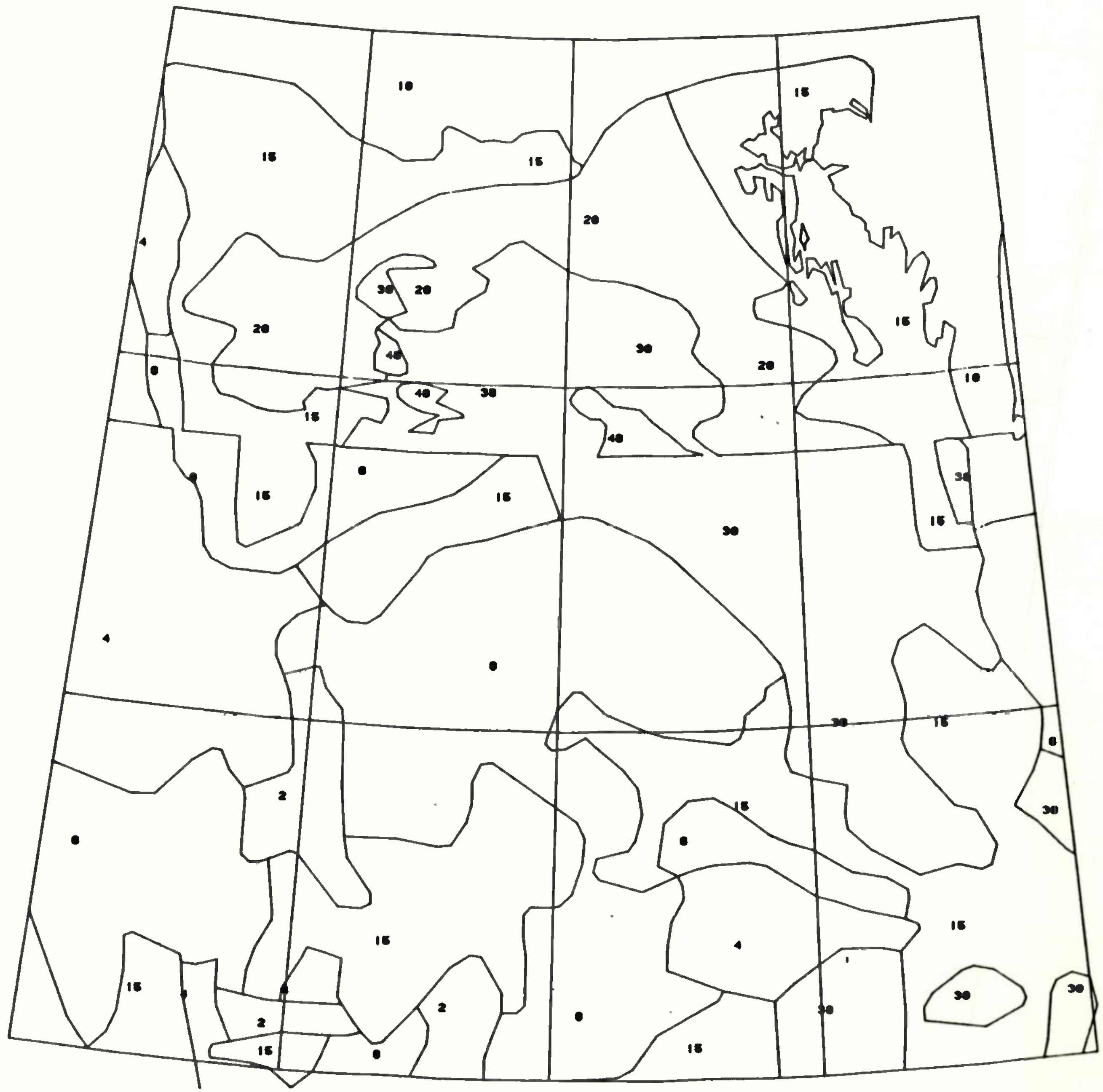


PROJECTION CONIQUE CONFORME DE LAMBERT
PARALLÈLES STANDARDS 37°, 65°

LAMBERT CONICAL CONFORMAL PROJECTION
STANDARD PARALLELS 37°, 65°

ÉCHELLE / SCALE 1:6000000.0

LIMITES/LIMITS 40. 65. 06. 115.
BLOC/BLOCK 3

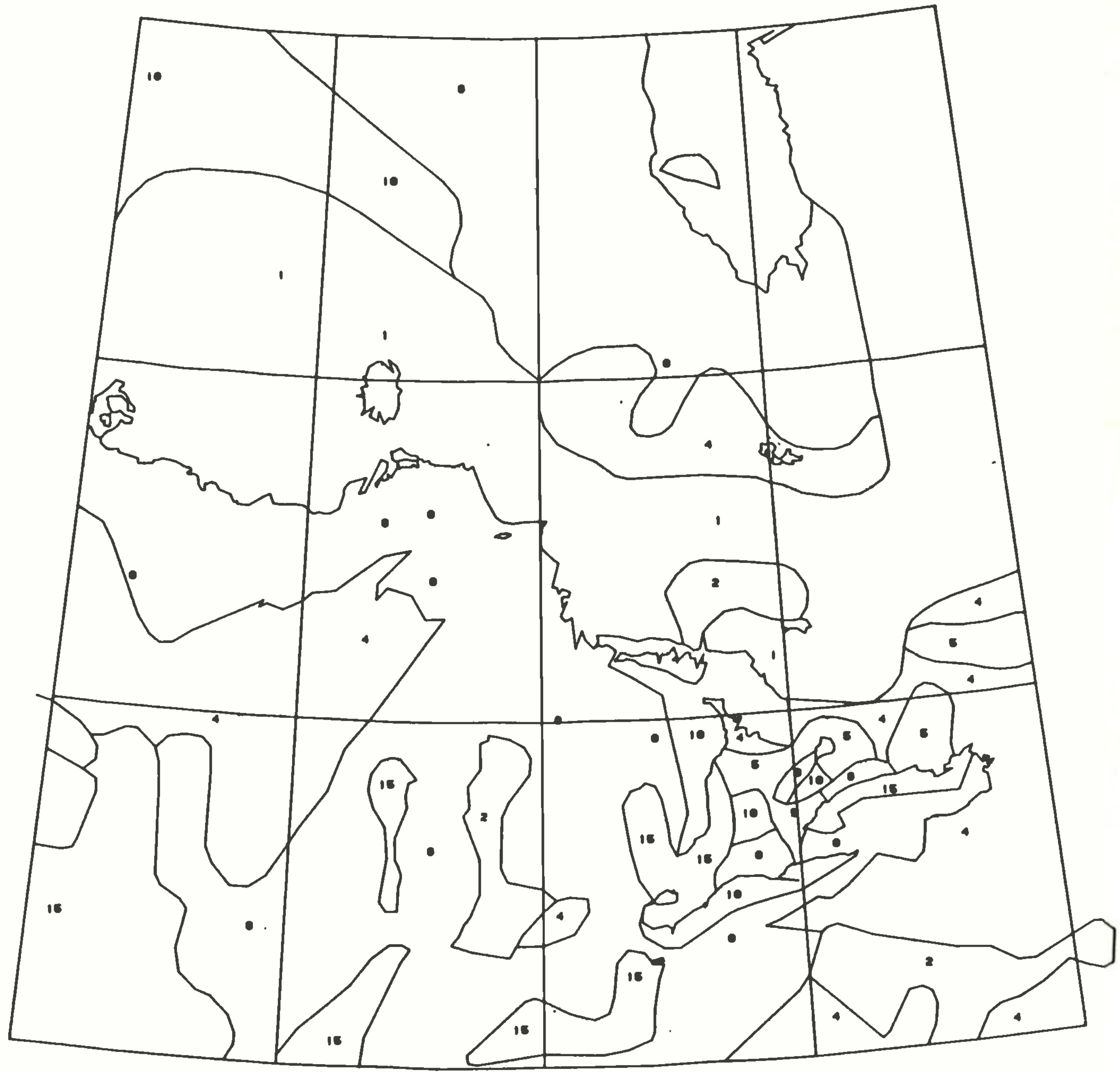


PROJECTION CONIQUE CONFORME DE LAMBERT
PARALLÈLES STANDARDS 37°, 65°

LAMBERT CONICAL CONFORMAL PROJECTION
STANDARD PARALLELS 37°, 65°

SCALE 1:6000000

LIMITES/ 8 40. 65. 75. 85.
BLOC/1 4



PROJECTION CONIQUE CONFORME DE LAMBERT
PARALLÈLES STANDARDS 37°, 65°

LAMBERT CONICAL CONFORMAL PROJECTION
STANDARD PARALLELS 37°, 65°

ÉCHELLE / SCALE 1:5000000.0

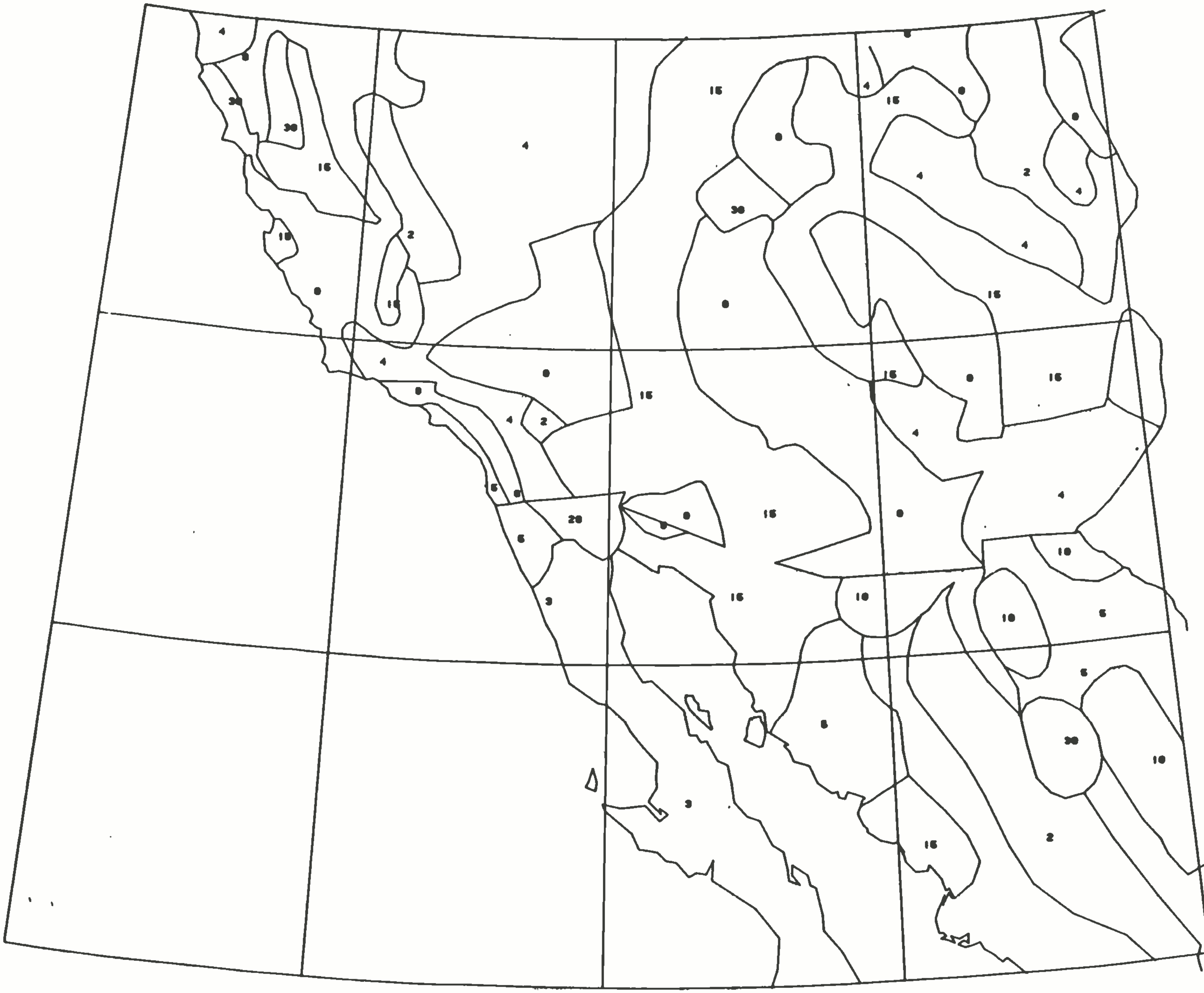
LIMITES / LIMITS 40. 55. 60. 76.

BLOC / BLOCK 5

PROJECTION CONIQUE CONFORME DE LAMBERT
PARALLÈLES STANDARDS 37°, 65°

LAMBERT CONICAL CONFORMAL PROJECTION
STANDARD PARALLELS 37°, 65°

LIMITES/LIMIT 40. 105. 125.
BLOC/BLOCK



PROJECTION CONIQUE CONFORME DE LAMBERT
PARALLÈLES STANDARDS 37°, 65°

LAMBERT CONICAL CONFORMAL PROJECTION
STANDARD PARALLELS 37°, 65°

ÉCHELLE / SCALE 1:5000000

LIMITES/LIMITS 26. 40. 06. 106.
BLOC/BLOCK 7

PROJECTION CONIQUE CONFORME DE LAMBERT
PARALLÈLES STANDARDS 37°, 65°

LAMBERT CONICAL CONFORMAL PROJECTION
STANDARD PARALLELS 37°, 65°

LIMITES/LI 25. 40. 65. 85.
BLOC/BL

PROJECTION CONIQUE CONFORME DE LAMBERT
PARALLÈLES STANDARDS 37°, 65°

LAMBERT CONICAL CONFORMAL PROJECTION
STANDARD PARALLELS 37°, 65°

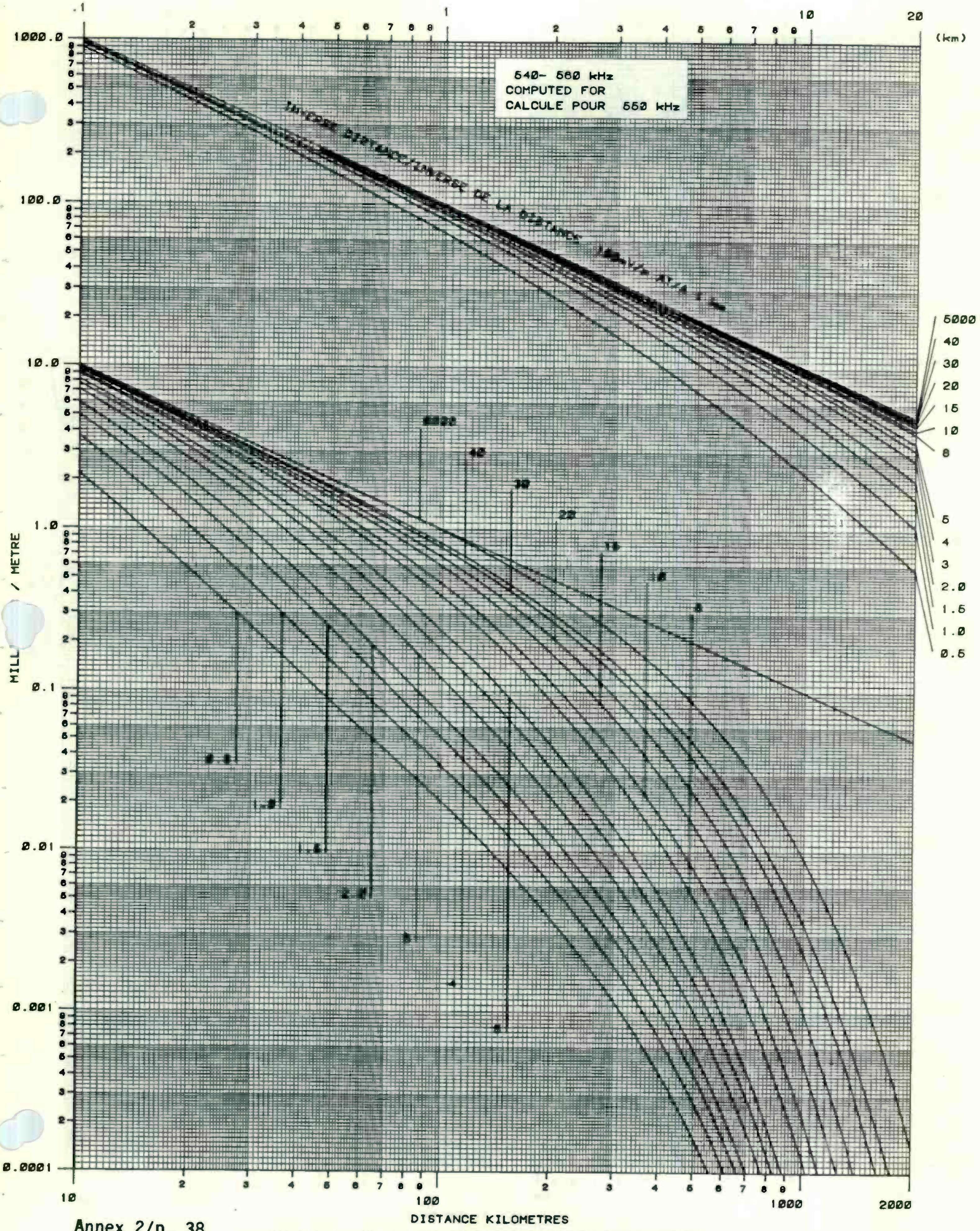
ÉCHELLE / SCALE 1:5000000.0

APPENDIX 2

(to Annex 2)

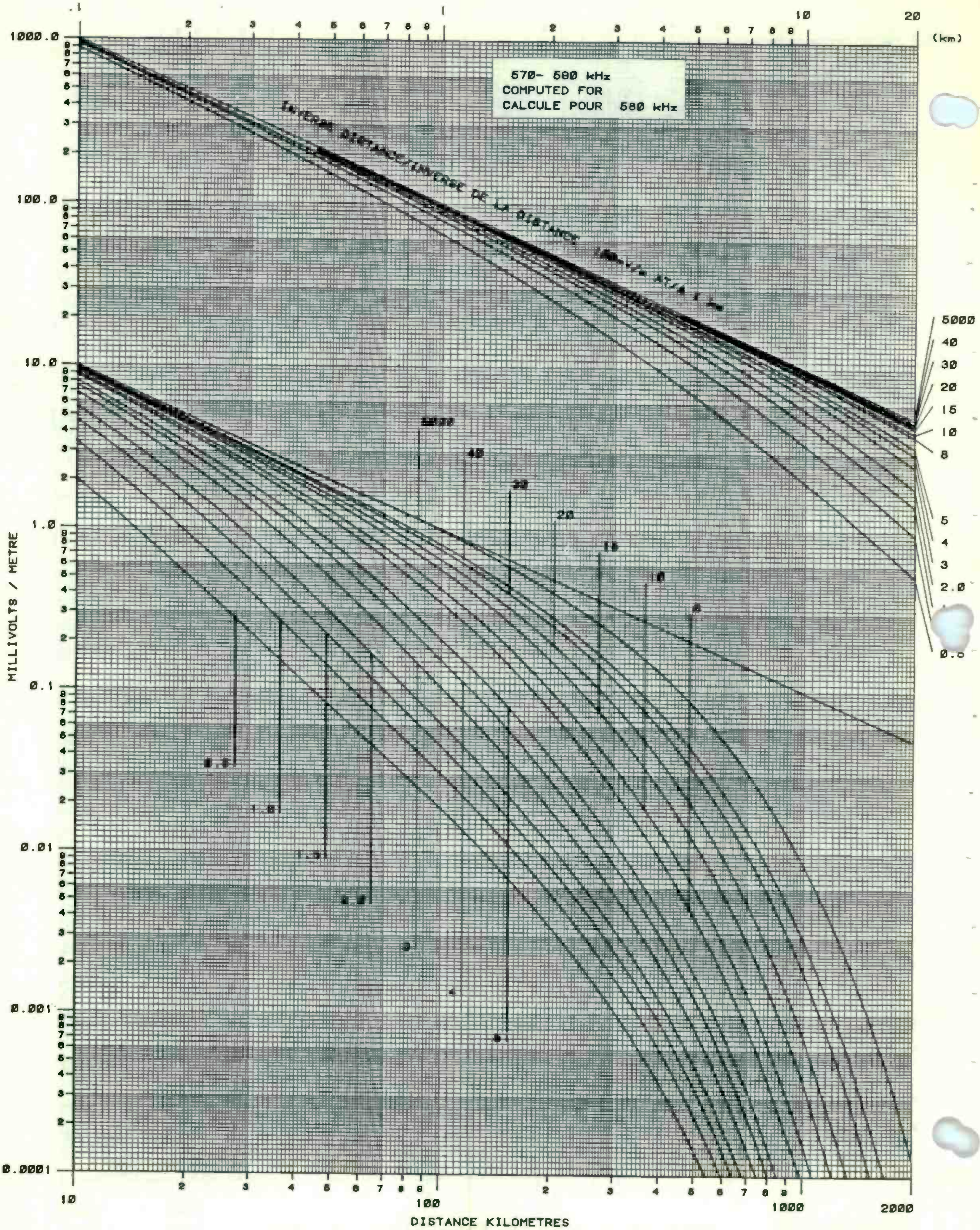
Field-strength curves for groundwave propagation

The curves are labelled with the ground conductivities in millisiemens/metre. All curves, except the 5000 mS/m (sea water) curve, are derived for a relative dielectric constant of 15. The sea water curve is derived for a dielectric constant of 80.



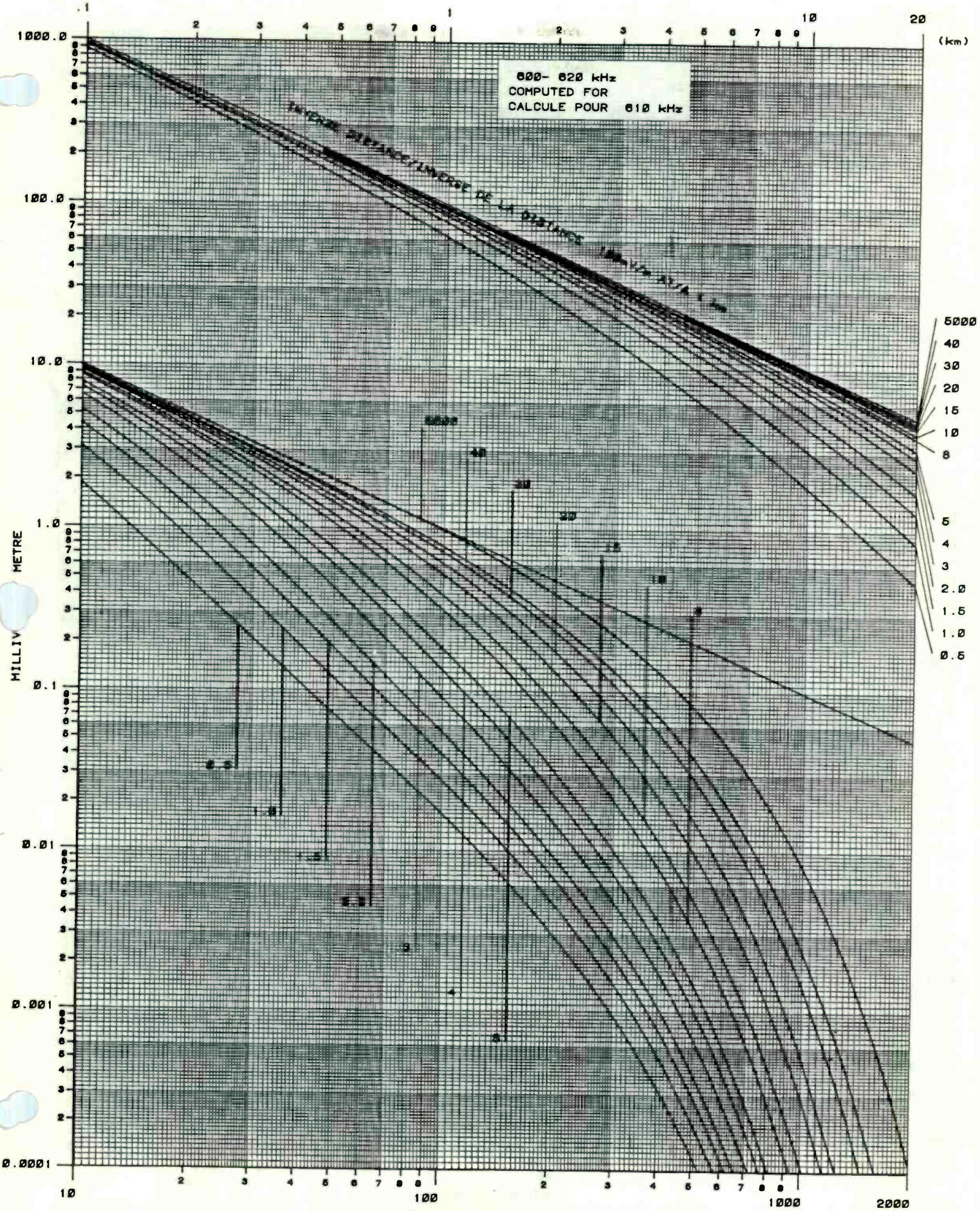
GRAPH 1 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 1 - CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



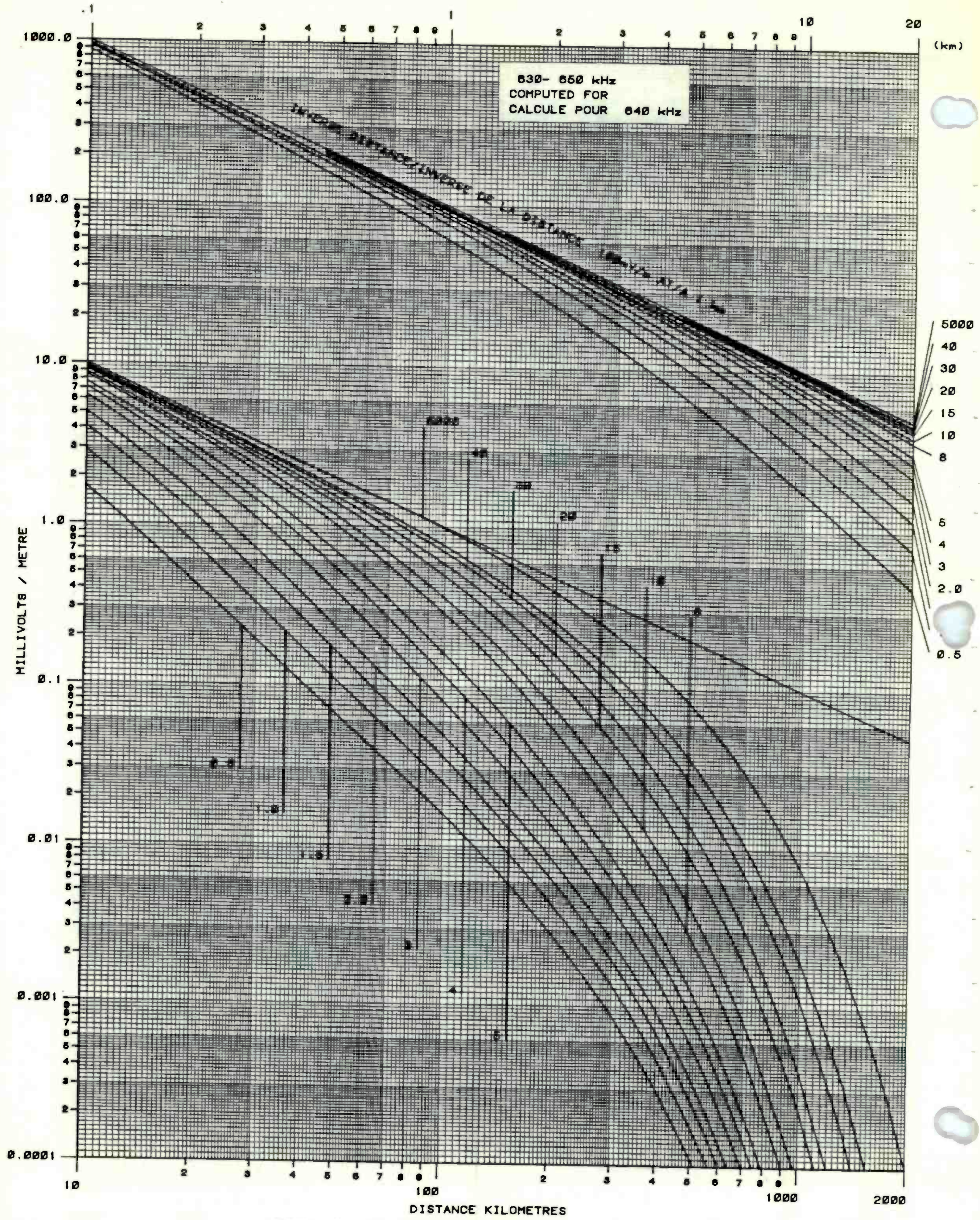
GRAPH 2 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 2 - CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



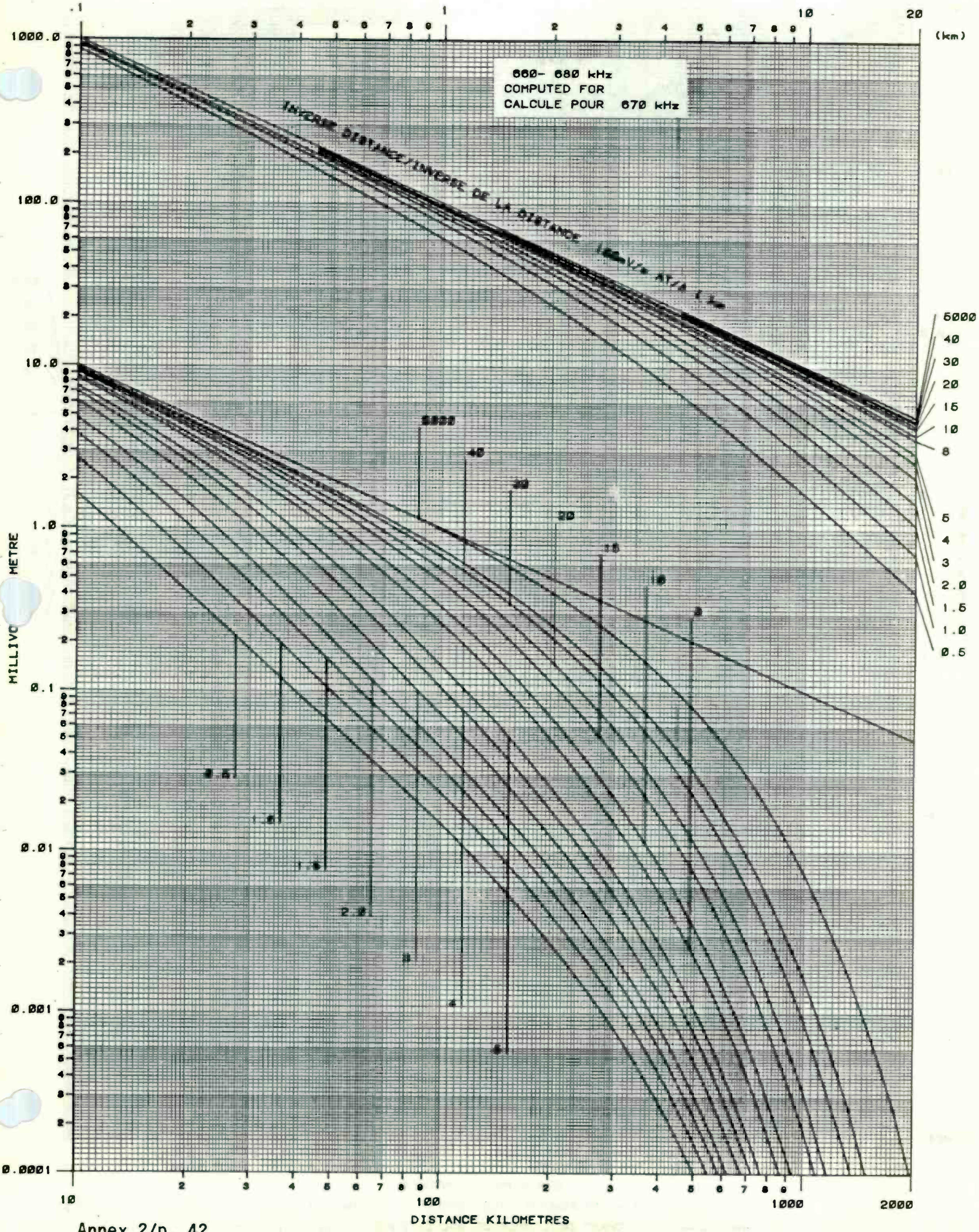
GRAPH 3 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 3 - CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE

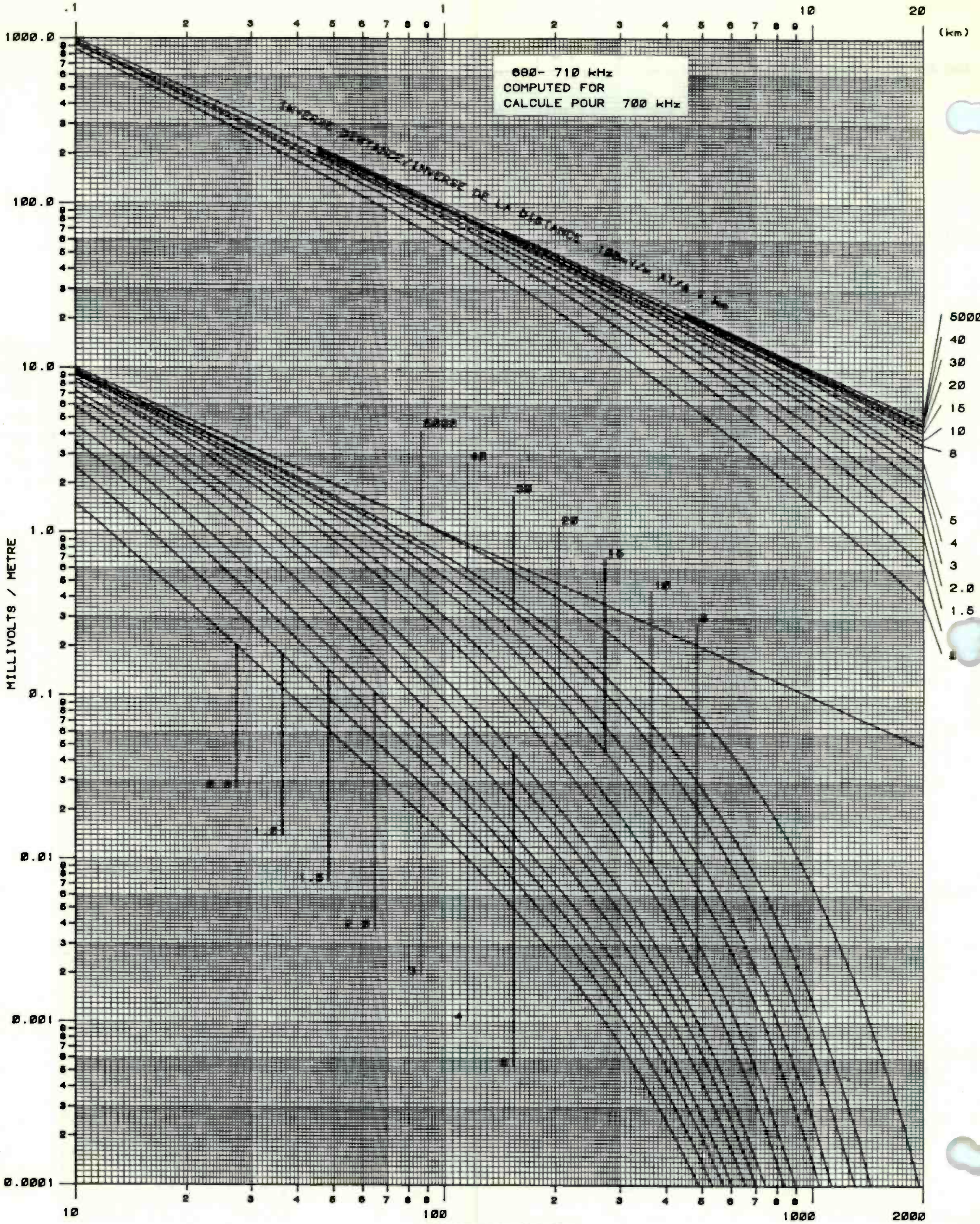


GRAPH 4 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 4 - CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



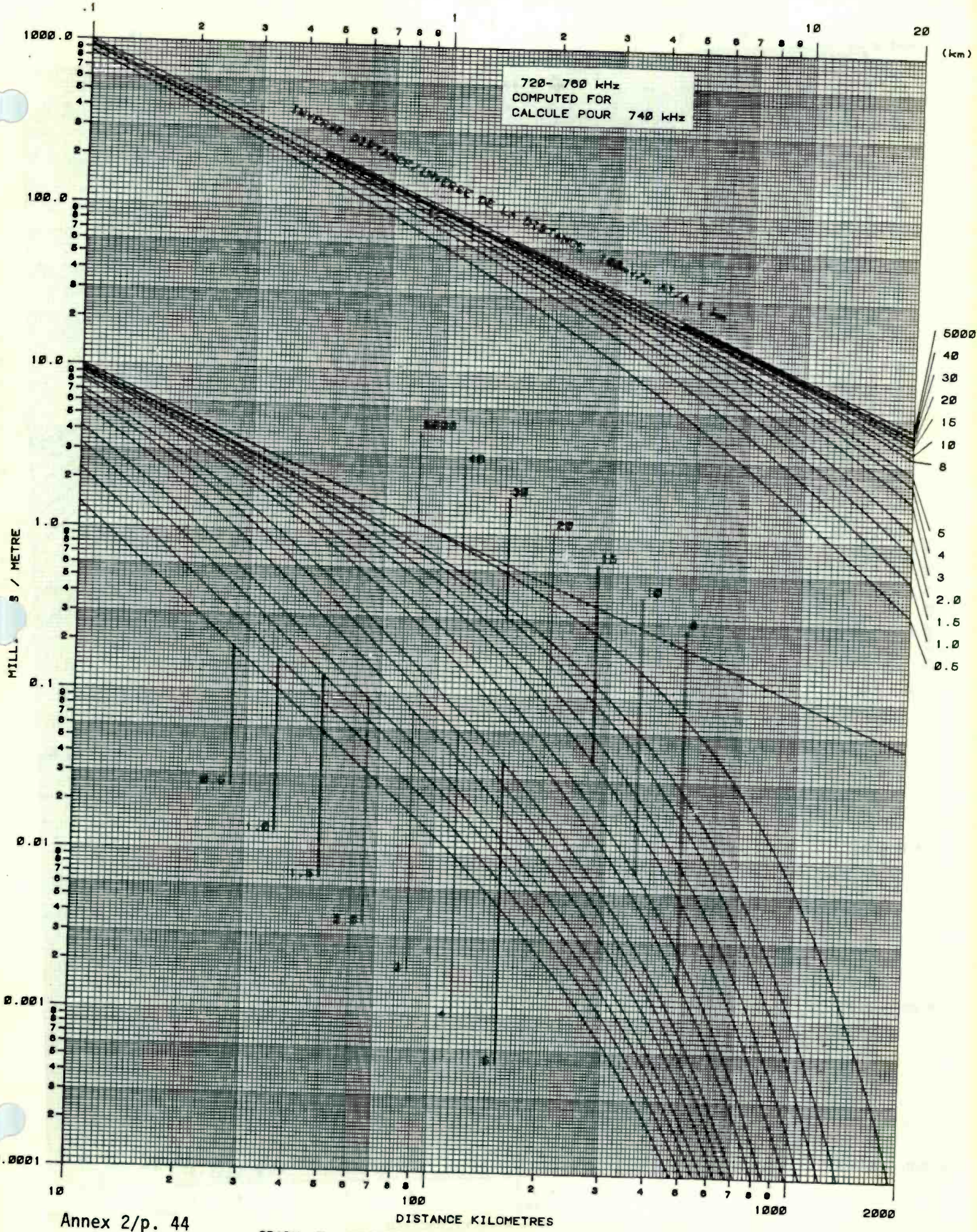
GRAPH 5 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE



DISTANCE KILOMETRES

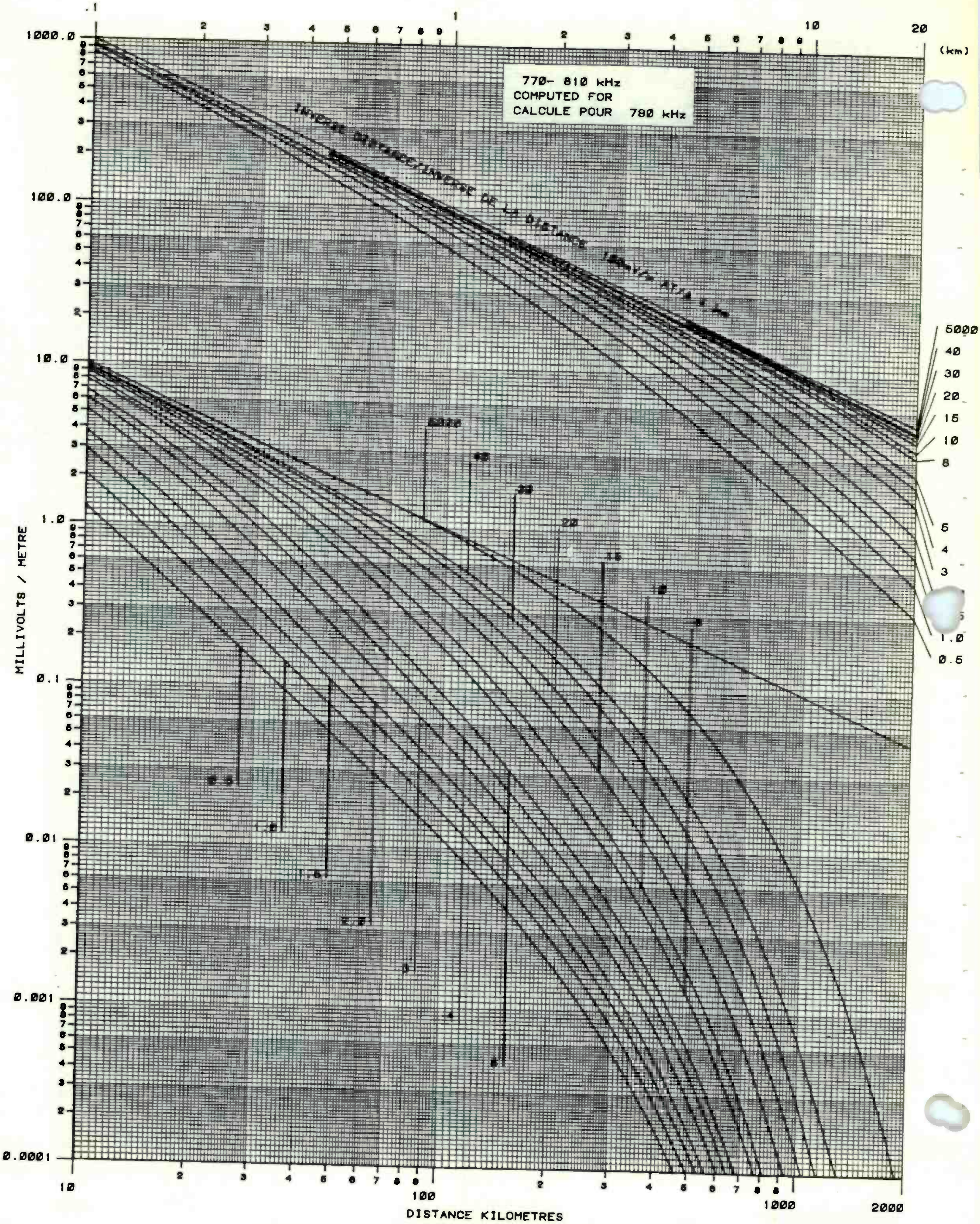
GRAPH 6 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 6 - CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



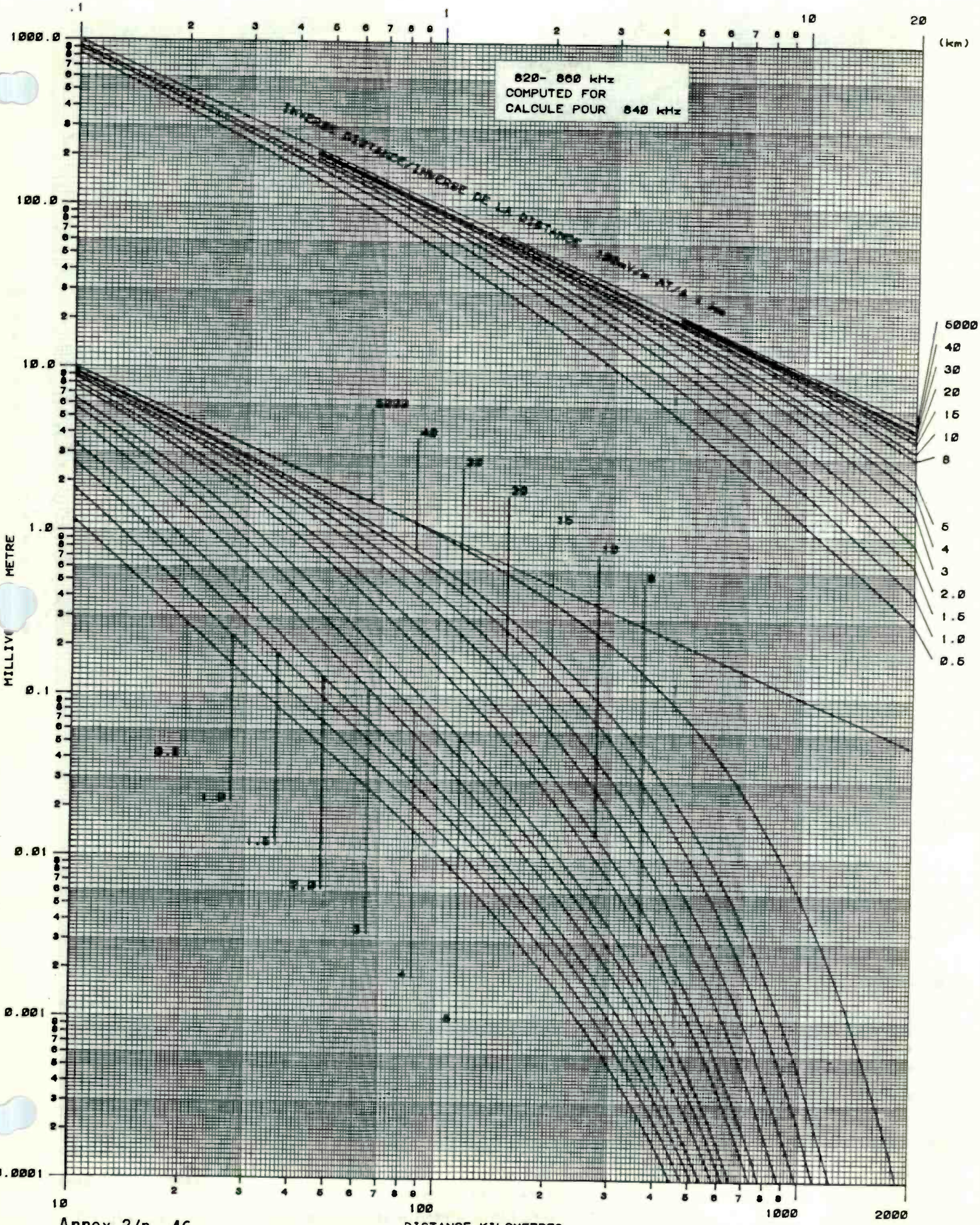
GRAPH 7 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 7 - CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



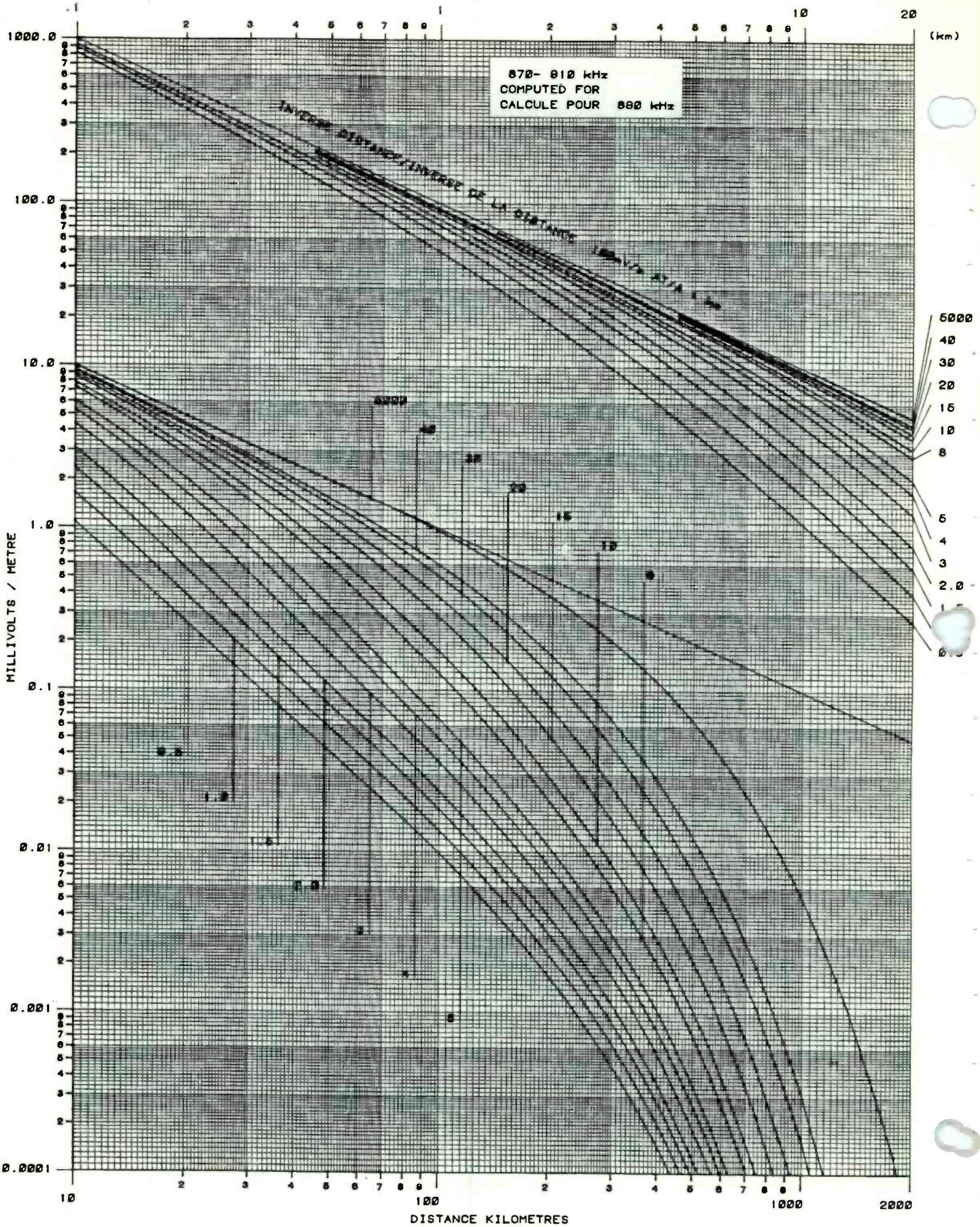
GRAPH 8 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 8 - CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



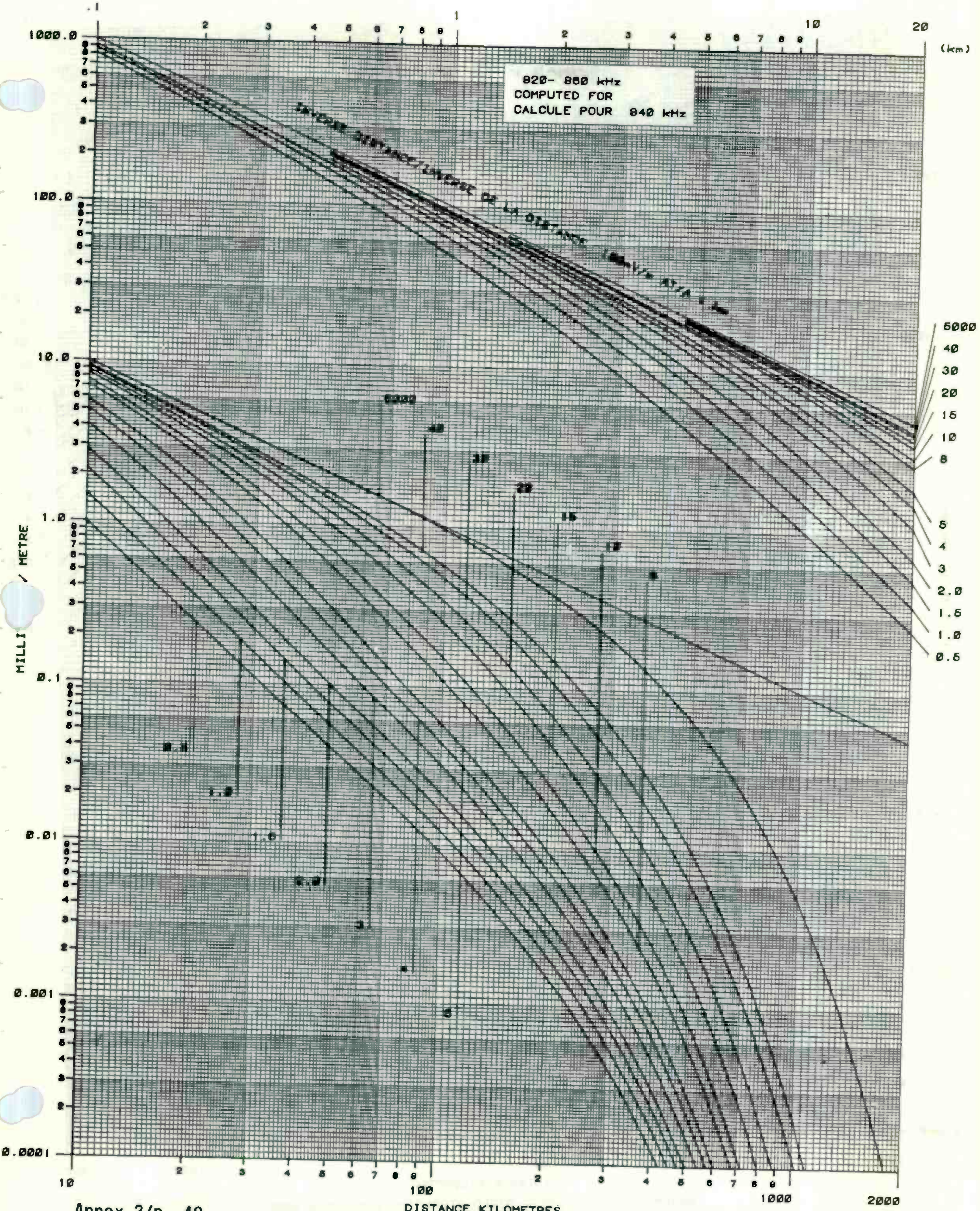
GRAPH 8 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 8 - CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



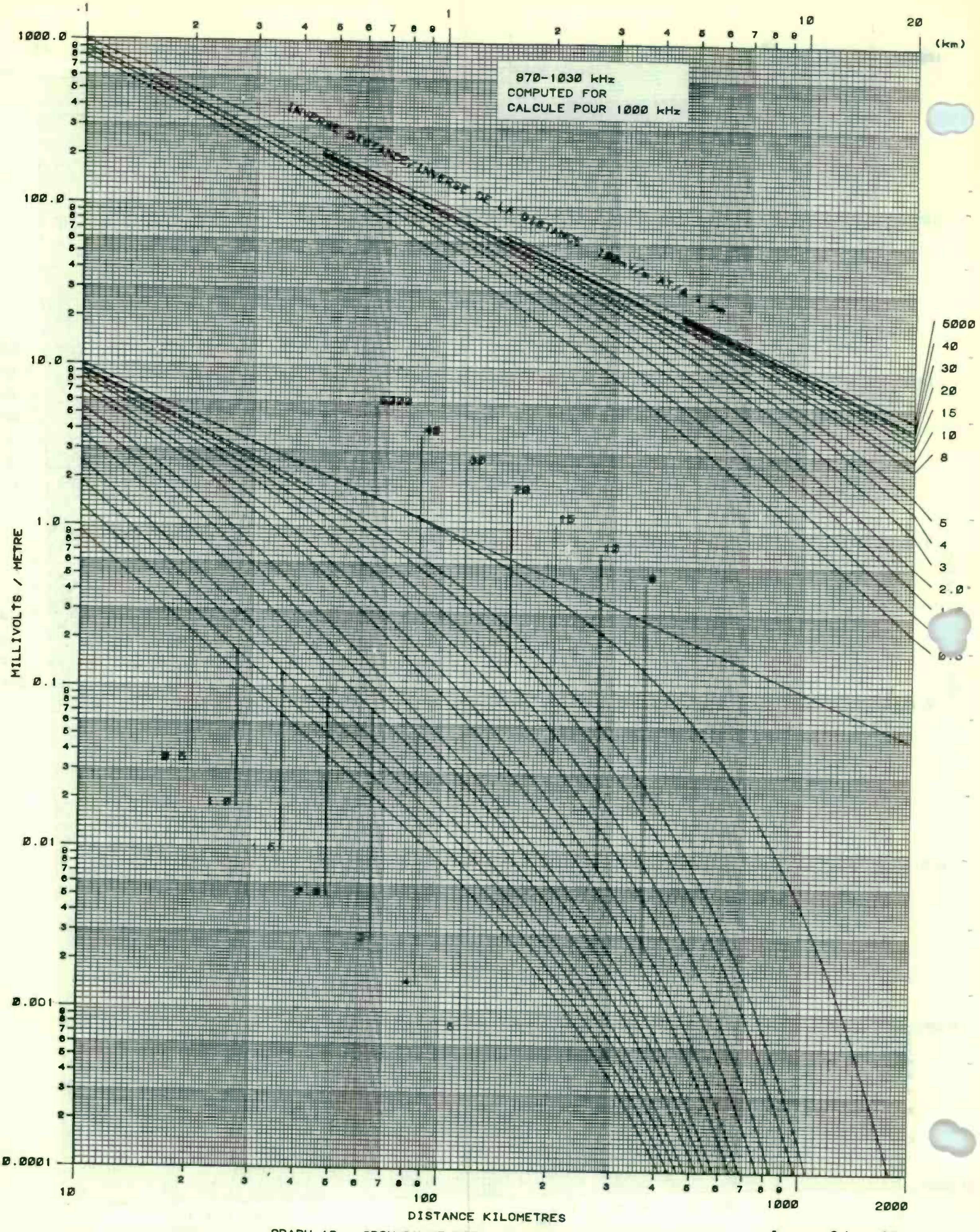
GRAPH 10 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 10 - CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



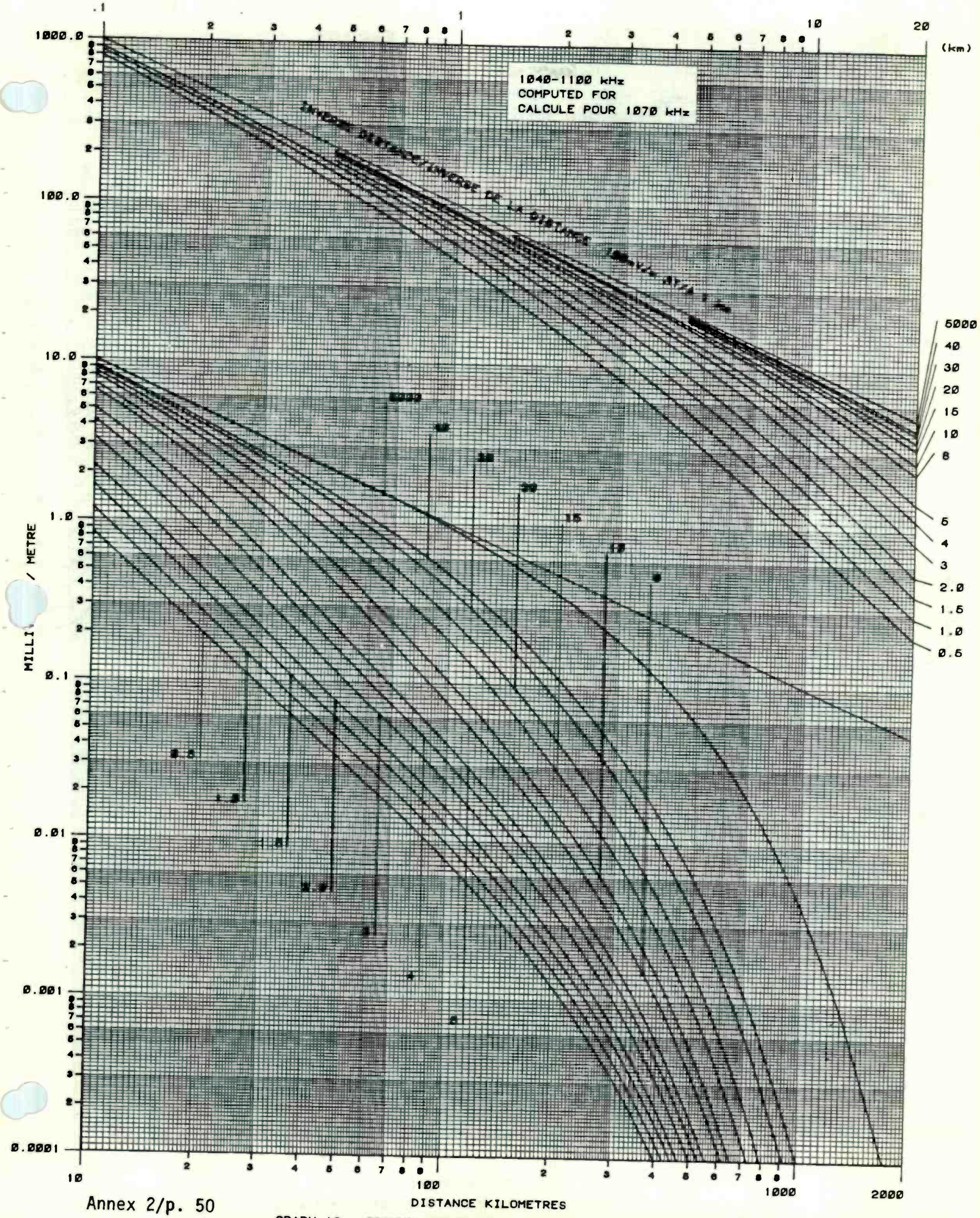
GRAPH 11 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 11 - CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



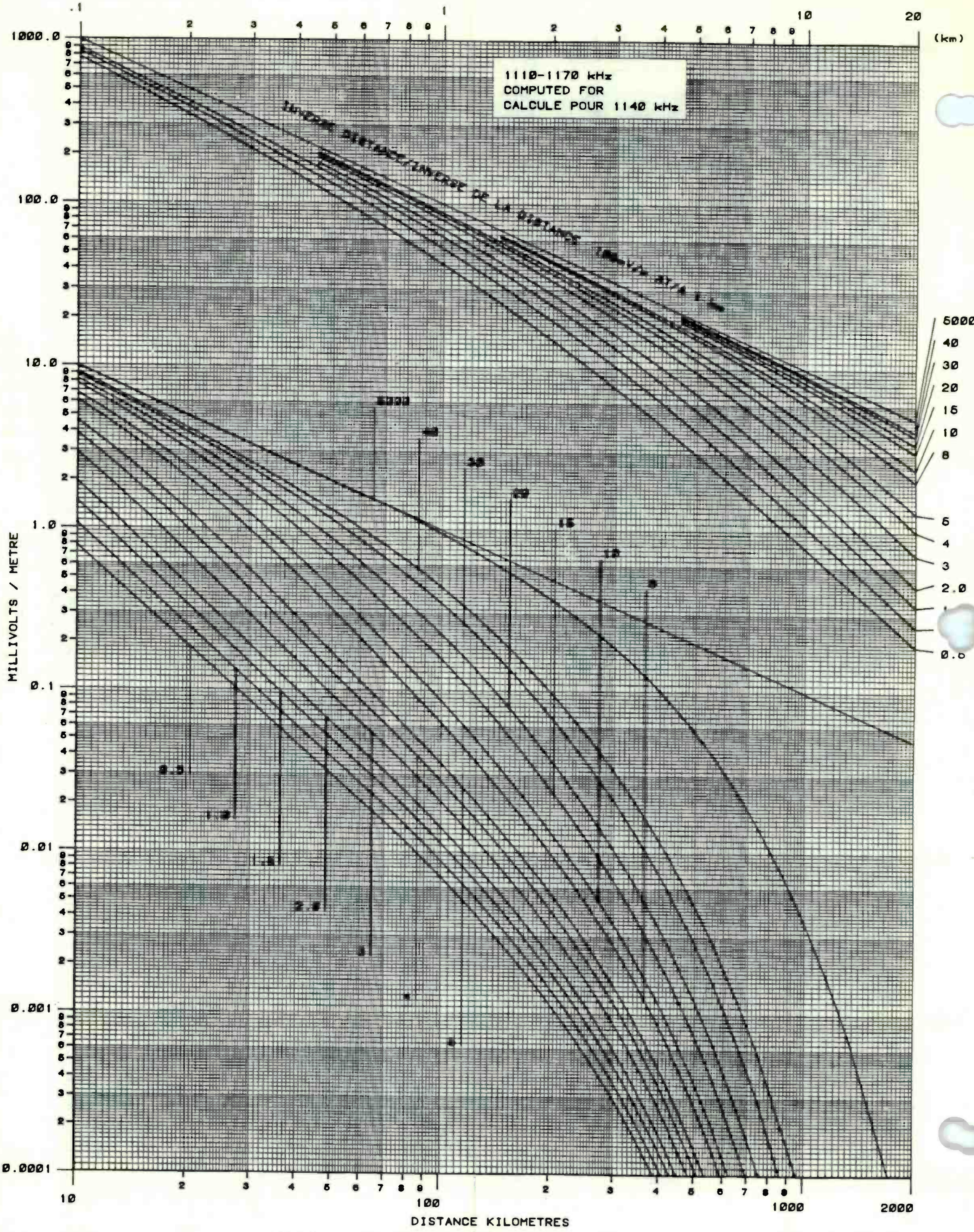
GRAPH 12 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 12 - CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



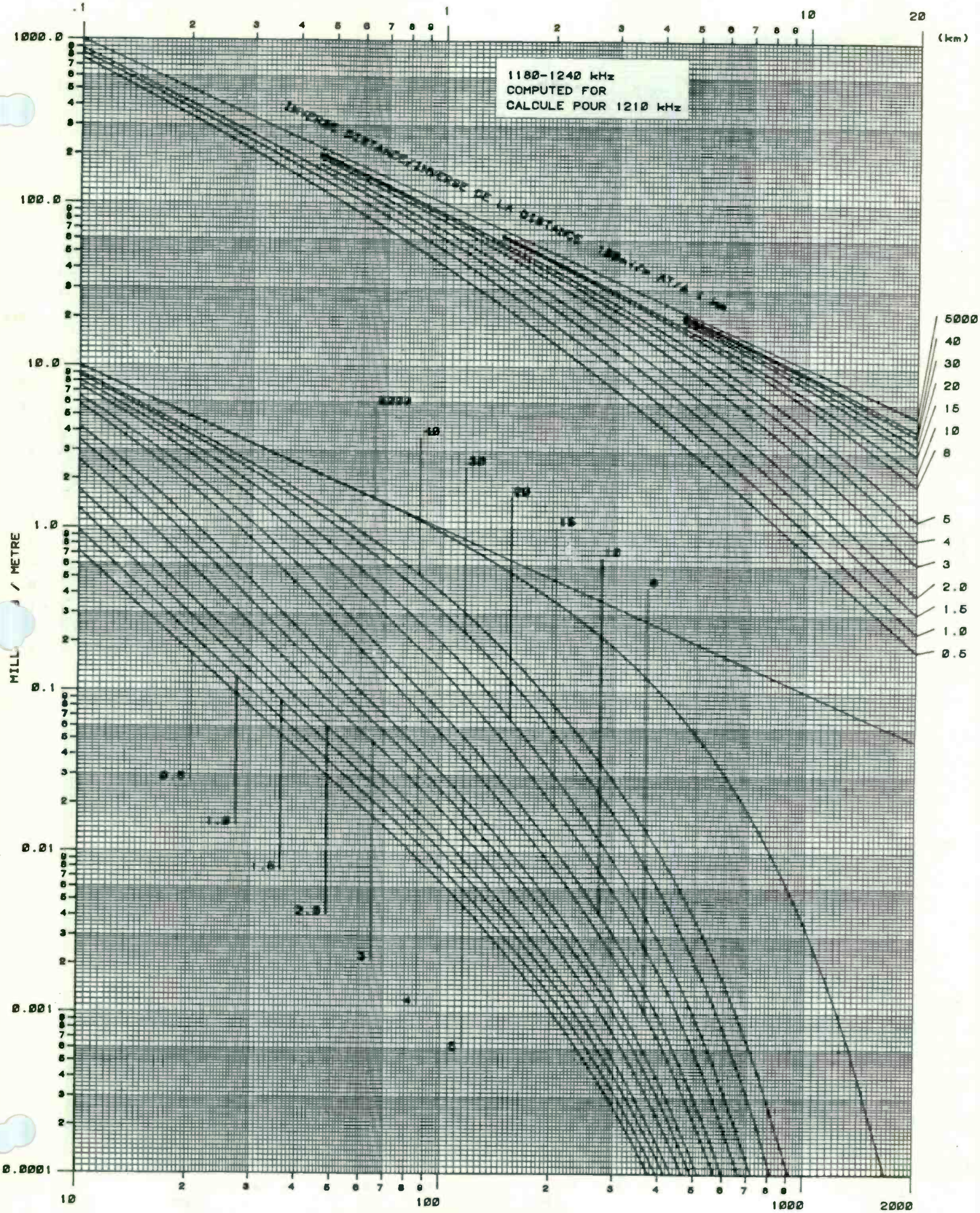
GRAPH 13 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 13 - CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



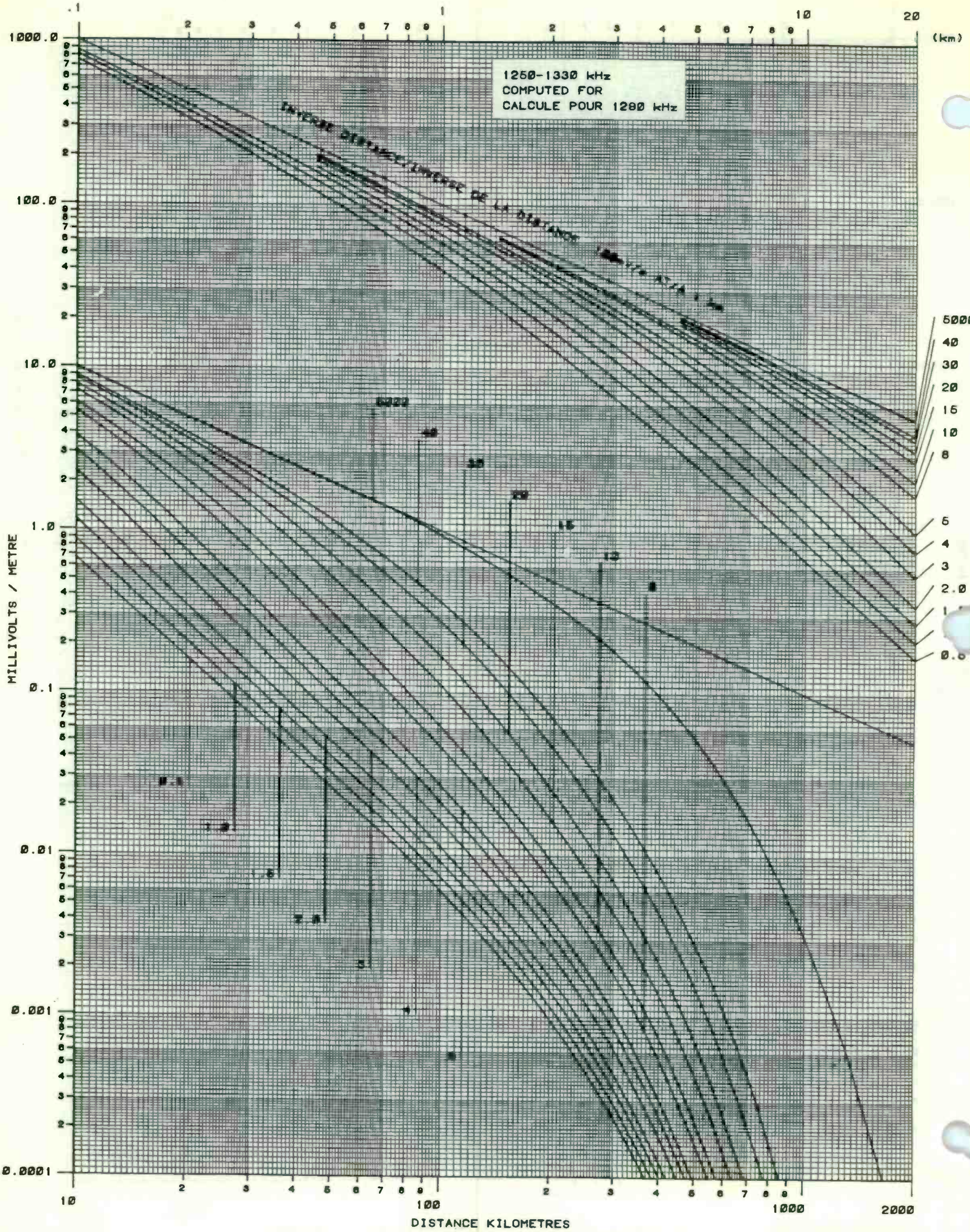
GRAPH 14 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 14 - CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



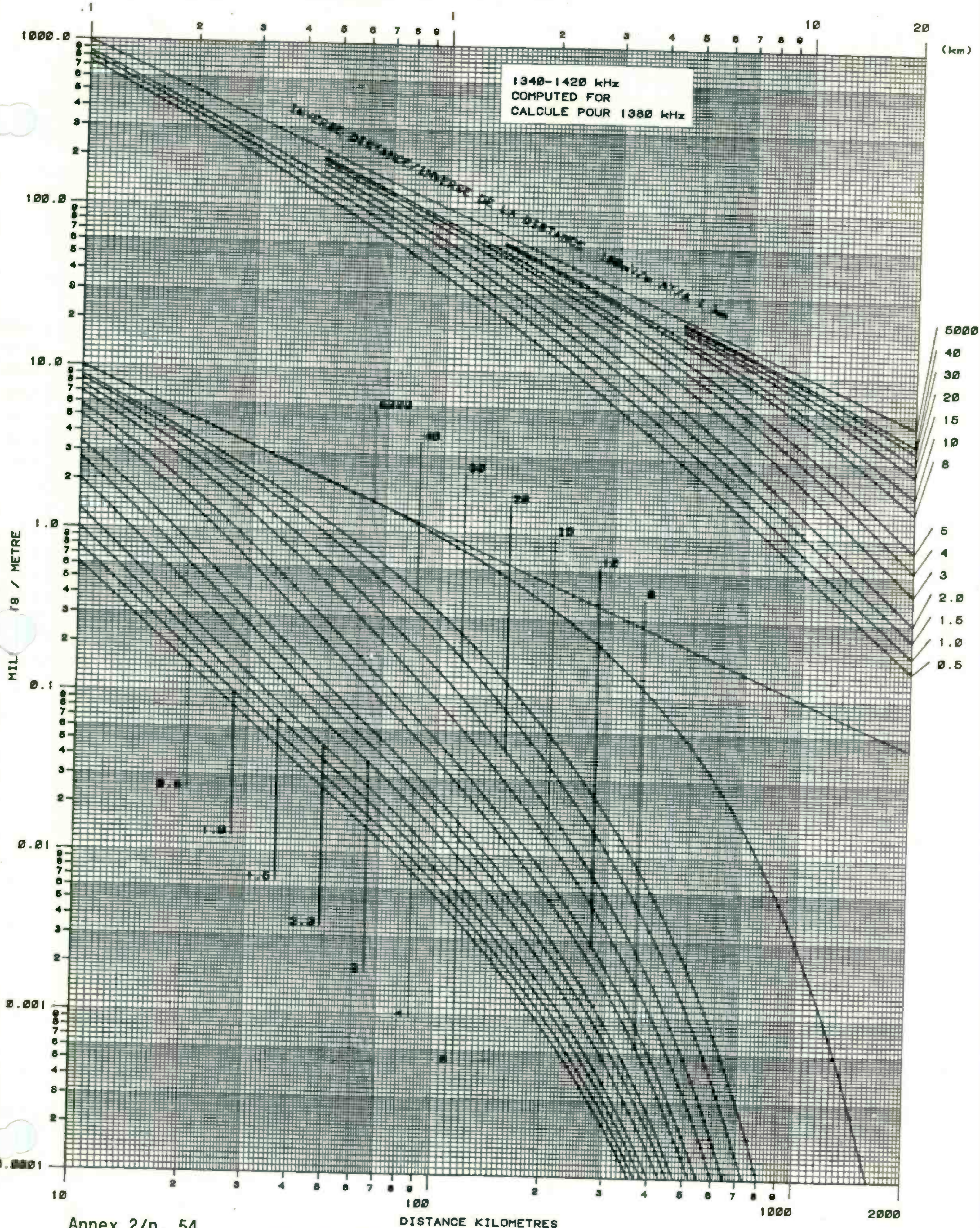
GRAPH 15 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 15 - CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



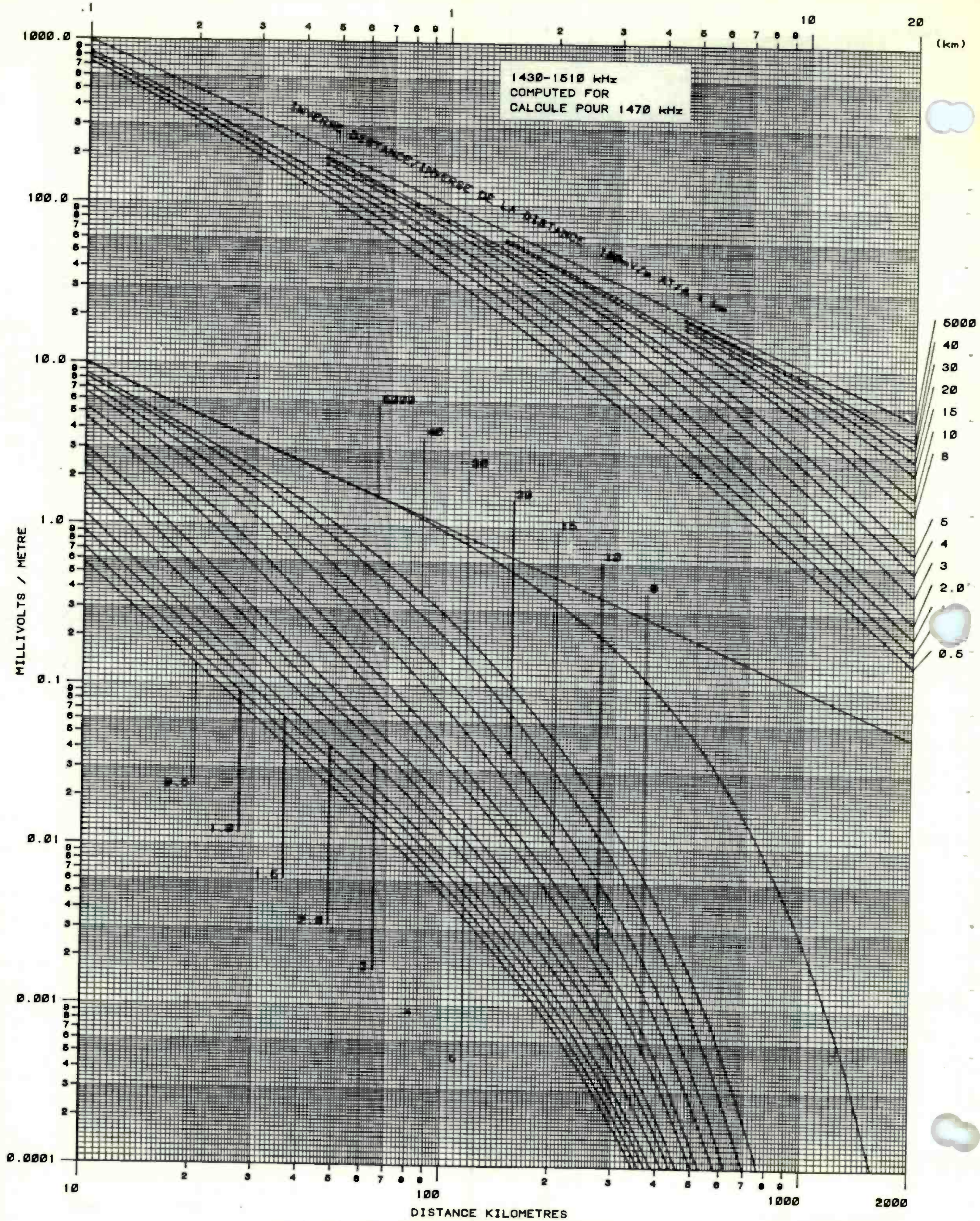
GRAPH 16 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 16 - CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



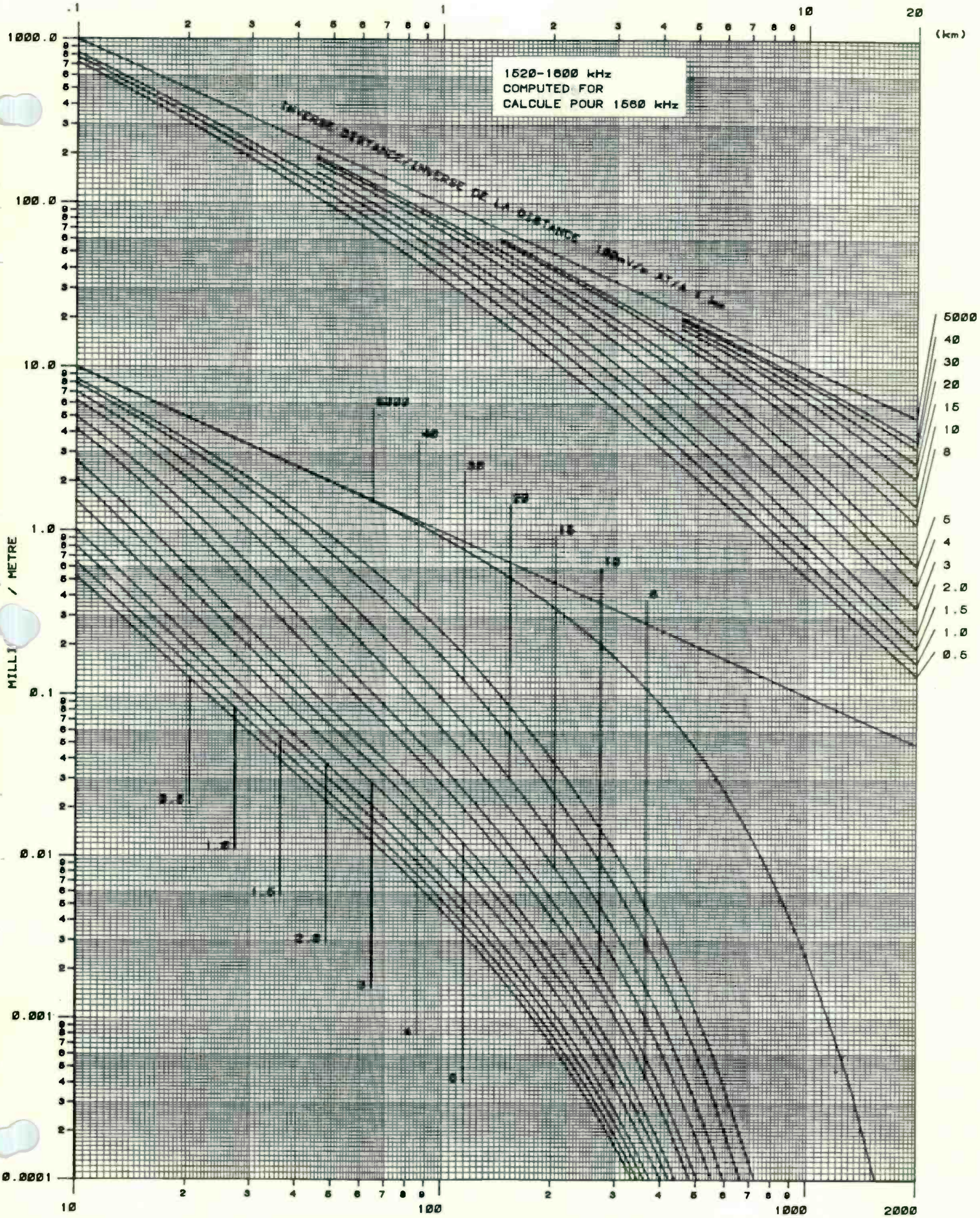
GRAPH 17 – GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 17 – CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



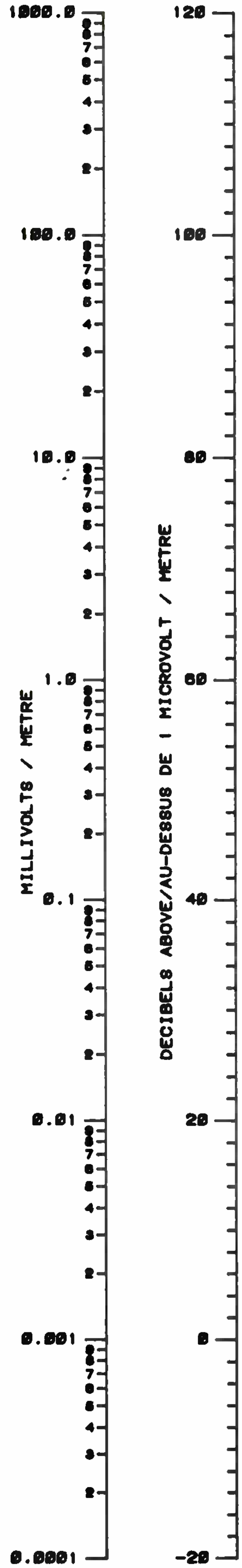
GRAPH 18 – GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 18 – CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



GRAPH 19 - GROUNDWAVE FIELD STRENGTH VERSUS DISTANCE

GRAPHIQUE 19 - CHAMP DE L'ONDE DE SOL EN FONCTION DE LA DISTANCE



GRAPH 20 - SCALE FOR USE WITH GROUND WAVE FIELD STRENGTH GRAPHS 1-19
GRAPHIQUE 20 - ECHELLE A UTILISER POUR LES GRAPHIQUES DU CHAMP DE L'ONDE DE SOL 1-19

APPENDIX 3

(to Annex 2)

Calculation of Directional Antenna Patterns

This Appendix contains the method for calculating radiation for directional antenna systems in order to determine the presence or absence of objectionable interference between stations in the two countries.

1. Definitions

The terms Theoretical Pattern, Expanded Pattern and Modified Pattern refer to directional antenna radiation patterns as defined in Attachment A to this Appendix.

2. Use of expanded patterns or modified patterns

The expanded pattern or the modified pattern shall be used for all stations with directional antenna systems for calculating values of field intensities, limits, contours and permissible values of radiation for the determination of the presence or absence of objectionable interference.

3. Coordination procedure for cases of reduced design tolerance

Assignments involving radiation patterns with reduced design tolerance as defined in Attachment A shall be coordinated between the administrations in advance of formal notification. In the coordination of such proposed assignments, the information required in Attachment B shall be submitted in addition to the information required for notification purposes in paragraph 5. Protection from objectionable interference from subsequent assignments (or proposals to modify the Plan) shall begin on the date this information is transmitted. The criteria for determining acceptable values of reduced tolerance of such proposals are defined in Attachment C which may be amended by exchange of letters directly between the administrations as prediction techniques improve. Attachment C also defines the time frame within which the coordination will be effected dependent upon the complexity of the system. If an objection to a proposal is filed within the time frame specified, the proposal shall not be notified until suitably revised and recoordinated, although protection from subsequent assignments shall be retained for up to 120 days pending revision.

4. Adjustment and maintenance of radiation patterns

The administrations shall ensure that the radiation emitted from directional stations does not exceed notified values of radiation (Expanded or Modified Patterns) in any direction toward the other country. At the time of initial adjustment, and as often as necessary thereafter, sufficient field strength measurements shall be made on each directional station to establish that it has been properly adjusted. In addition, each station shall follow a routine monitoring program whereby periodic measurements of pertinent array parameters (including field strength measurements if required by Attachment B) are made to demonstrate that the array is maintained within authorized values.

5. Notification of technical information

The description of the directional antenna notified using the appropriate part of Annex 1 shall include all technical data necessary to calculate the Theoretical Pattern, Expanded Pattern, or Modified Pattern. It shall also include (5) values of radiation and azimuth and vertical angle to permit verification of the pattern, as well as values of the theoretical RMS radiation and "Q".

Notification of an operation with a reduced "Q" shall be clearly identified and shall include additional information in accordance with Attachment B, or shall clearly identify, by reference, any additional information previously submitted.

Attachment A

FORMULAE FOR CALCULATION OF RADIATION FROM DIRECTIONAL ANTENNA SYSTEMS

1. Theoretical Pattern

$$E(\phi,\theta)_{th} = K\sum_{i=1}^{n} F_i \, f(\theta)_i \, \underline{\left| S_i \cos\theta \cos(\phi_i - \phi) + \psi_i \right.}$$

$$E_{rss} = K\sum_{i=1}^{n} F_i^2$$

where

$E(\phi,\theta)_{th}$ ...	is the theoretical inverse distance field radiation (mV/m) produced by the array at the horizontal angle ϕ measured from a reference aximuth and at the vertical angle θ measured from the horizontal.
E_{rss}	is the theoretical root - sum - square of field intensities.
n	is the number of towers in the array.
K	is a pattern sizing constant related to the notified theoretical RMS radiation of the array.
F_i	is the ratio of the field produced by tower i, with respect to the field produced by a reference tower in the array.
S_i	is the spacing in electrical degrees of tower i from a reference point.
ϕ_i	is the horizontal angle measured from the reference direction clockwise to a line passing through the reference point and tower i.
ψ_i	is the electrical phase angle in degrees of the current in tower i with respect to the phasing of current in a reference tower.
G_i	is the height in electrical degrees of tower i.
$f(\theta)_i$	is the vertical radiation characteristic for tower i where sinusoidal current distribution is assumed.

a) For a typical uniform cross-section vertical radiator,

$$f(\theta)_i = \frac{\cos(G_i \sin\theta) - \cos G_i}{(1 - \cos G_i)\cos\theta}$$

b) for a top-loaded vertical radiator,

$$f(\theta)_i = \left\{\cos B \cos(A\sin\theta) - \sin\theta \sin B \sin(A\sin\theta) - \cos(A + B)\right\} + \left\{\cos\theta \left[\cos B - \cos(A + B)\right]\right\}$$

where:

A is the physical height of the radiator, in electrical degrees.

B is the difference, in electrical degrees, between the apparent electrical height G, (based on current distribution) and the actual physical height of the radiator.

G is the apparent electrical height: A + B.

See Figure 1.

c) for a sectionalized vertical radiator, (tower structure code 2)

$$\begin{aligned} f(\theta) = \; & \sin\Delta \;(\cos B \cos(A\sin\theta) - \cos G) \\ & + \sin B \;(\cos D \cos(C\sin\theta) \\ & - \sin\theta \sin D \sin(C\sin\theta) \\ & - \cos\Delta \cos(A\sin\theta) \\ & + \left\{\cos\theta \left[(\sin\Delta\;(\cos B - \cos G) \right.\right. \\ & \left.\left. + \sin B\;(\cos D - \cos\Delta)\right]\right\} \end{aligned}$$

where:

A is the physical height in electrical degrees, of the lower section of the radiator,

B is the difference between the apparent electrical height (based on current distribution) in electrical degrees of the lower section of the radiator and the physical height of the lower section of the radiator.

C is the physical height of the entire radiator, in electrical degrees,

D is the difference between the apparent electrical height of the radiator (based on current distribution of the upper section) and the physical height of the entire radiator. D will be zero if the sectionalized tower is not top-loaded.

$G = A + B$

$H = C + D$

$\Delta = H - A$

See Figure 2

d) Alternative formulas for use in computing $f(\theta)$ for top-loaded and sectionalized towers may be employed provided they are accompanied by a complete derivation and sample calculations, or are included in Appendix 5.

2. Expanded Radiation Pattern

$$E(\phi,\theta)_{exp} = 1.05 \sqrt{E(\phi,\theta)^2_{th} + Q^2}$$

Q is normally $0.025\, g(\theta)\, E_{rss}$ or $10.0 g(\theta)\sqrt{P_{kW}}$

whichever is greater, where P_{kW} is the station power. A lower value of Q may be notified if the criteria for reduced design tolerance in Attachment B are met. One kW will be used for stations operating with less than one kW.

If antenna height (G) is less than 180 degrees, $g(\theta) = f(\theta)$ where $f(\theta)$ is calculated using the shortest tower in the array. If antenna height (G) is equal to or greater than 180 degrees,

$$g(\theta) = \sqrt{\frac{f(\theta)^2 + 0.0625}{1.030776}}$$

where $f(\theta)$ is calculated using the shortest tower in the array.

Note: The vertical radiation formula for high towers and the shortest tower method for unequal towers apply only in the calculation of Q.

3. Modified Radiation Pattern

The Modified Pattern is a pattern developed by augmentation of the Expanded Pattern by increasing the Theoretical Pattern RMS radiation and/or by sector expansion by use of:

$$E(\phi,\theta)_{Mod} = \sqrt{E(\phi,\theta)_{Exp}^2 + A\left[g(\theta)\cos\frac{(180\, dA)}{S}\right]^2}$$

where

$E(\phi,\theta)_{Exp}$...... is the Expanded Pattern radiation at a particular azimuth and elevation, before augmentation.

$E(\phi,\theta)_{Mod}$...... is the radiation in the direction specified in $E(\phi,\theta)_{Exp}$, after augmentation.

$A = E(\phi,\theta)^2_{Mod} - E(\phi,\theta)^2_{Exp}$ where $E(\phi,\theta)_{Mod}$ and $E(\phi,\theta)_{Exp}$ are fields in the horizontal plane at the main azimuth of augmentation (θ = zero degrees).

S .... is the angular range or span over which augmentation is applied, with the span centered over the main azimuth of augmentation. Overlap of spans of augmentation is permitted.

dA ... is the absolute value of the horizontal angle between the azimuth at which the augmented pattern value is computed, and the main azimuth or center of span of augmentation. dA cannot exceed $\frac{S}{2}$.

Negative augmentation will be permitted only for the purpose of pattern conversion and shall not reduce augmented radiation below theoretical radiation.

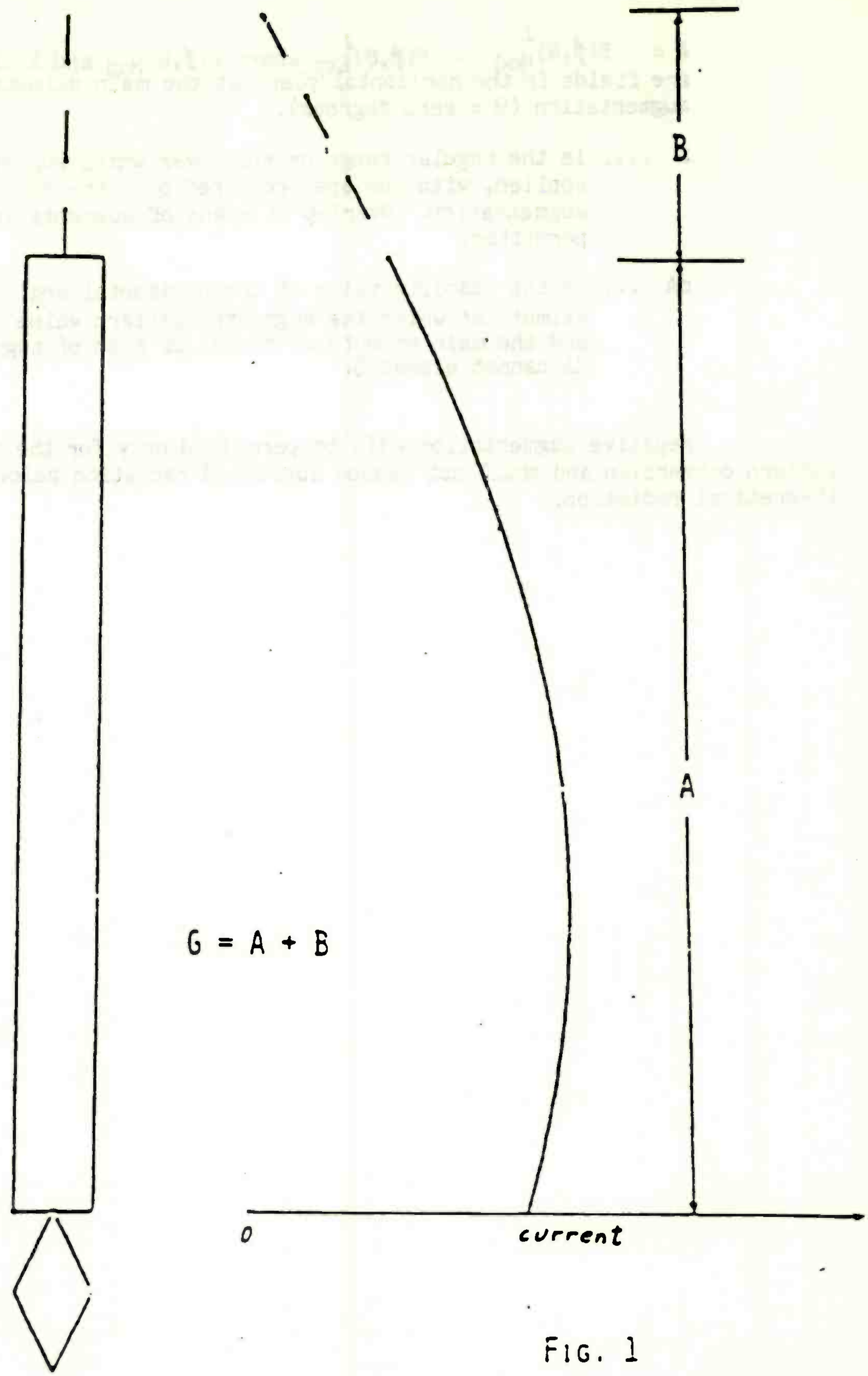


FIG. 1

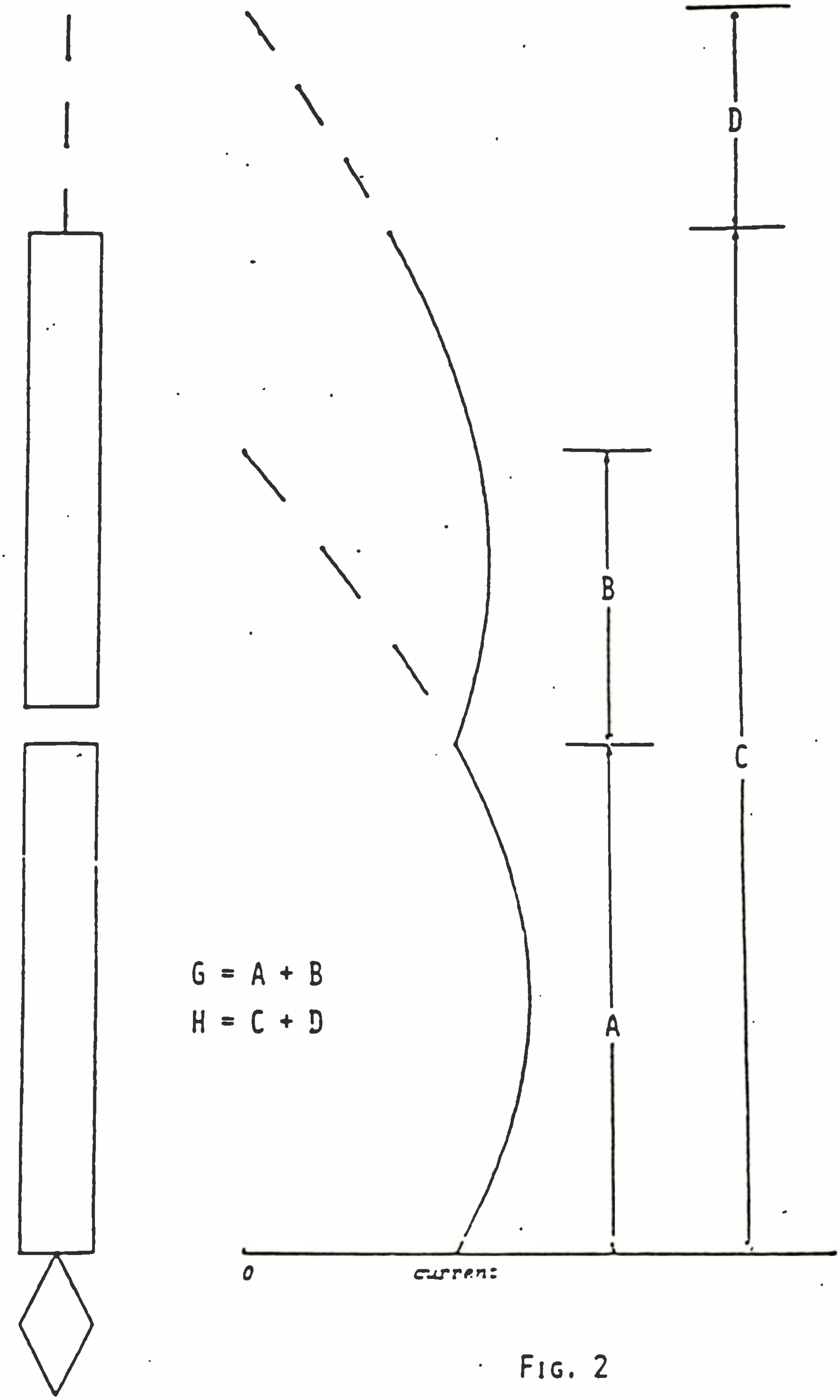


FIG. 2

Attachment B

Criteria for Reduced Design Tolerance

1. The normally notified parameters of the array, the reduced tolerance Q and the accuracy of the current and phase monitoring systems in detecting change shall be submitted, except as provided for in Attachment C.

2. Proposed radiation fields requiring consideration of a reduced tolerance (Q) below that provided for in Attachment A shall be approved only when the notifying administration has given assurance that the following precautions would be taken:

2.1 Site

The proposed antenna site must be suitable in all respects for establishment of the antenna system so that scattering or residual re-radiation from structures on or near the site would be of sufficiently low magnitude so as not to preclude the adjustments of the measured radiation pattern to within the proposed pattern.

Topographical maps of sufficient scale to reveal detailed terrain features within the immediate vicinity of the proposed transmitter site shall be submitted. Aerial photographs, taken in clear weather at appropriate altitudes and angles or photographs taken in eight different directions from an elevated position on the ground, enabling clear identification of all structures in the vicinity of the proposed site shall be submitted.

In addition, a description must be included of the physical terrain, of all metal structures, towers, transmitting facilities, power lines, railroad tracks, etc. within 2 km of the site. On highly directional arrays, distances beyond 2 km shall be considered. The details of all proposed detuning procedures shall be provided.

2.2 Array

An analysis to demonstrate that the electrical and physical design of the array would ensure the necessary stability to maintain the notified pattern is required. Such designs would require specialized equipment and components. Moreover, the design should avoid electrical parameters known to present instability problems such as operating resistances between -5 and +5 ohms, antennas other than base fed, tower spacings less than 70 degrees, and ratios of E_{RSS}/E_{RMS} greater than 2.

The description of the ground system, including special features such as counter-poises if employed, would also be supplied.

A description should be included of any special methods employed to counteract or minimize the effects of climatic changes on the performance of the array.

2.3 Monitoring Systems and Adjustment of the Array

A description of the proposed current and phase monitoring system, including the electrical components and physical design details with a specific evaluation of the ultimate accuracy of the system in detecting changes in current amplitudes or phase relationships, specifically, that the phase/current sampling lines for the antenna monitor have identical physical and electrical characteristics, a low temperature/phase coefficient and have equal lengths subject to the same environmental conditions is required.

In particular, the manufacturer, model number, resolution, and accuracy of the antenna monitor shall be specified. Sample current devices used to feed the antenna monitor shall be installed at or near the current maximum of each tower of the array. A statement should be included specifying the tolerance limits within which the operation parameters (amplitude and phase) will be maintained.

An analysis to determine what levels of system deviation would cause radiation to exceed notified values in any direction toward the other country must be submitted.

The monitoring system must be capable of detecting system deviations equal to or less than half of those which would result in radiation which would exceed the proposed or notified values.

The proposed procedure for monitoring the radiation pattern in the field shall be described and the location of the monitoring points shall be specified. Monitoring points shall be located mainly at azimuths of minimum radiation (nulls) and shall have to adequately monitor the actual radiation pattern of the proposed station toward the other country. Based on the proof of performance, maximum limits of measured field strengths at these monitoring points should be established to assure maintenance of the actual radiation pattern within notified radiation limits toward the other country. The frequency of measurements at these monitoring points shall be at least weekly during the first month of station operation and at least monthly thereafter.

When monitoring point field strength or operating parameter values in excess of the tolerance limits described above are observed, the station concerned shall immediately reduce power or readjust the array to restore radiation to within authorized limits. Except for emergency operation, testing, maintenance or other temporary operation, full power operation shall not resume until the array has been properly readjusted.

2.4 Proofs of Performance

A complete proof of performance shall be conducted on all new installations and on existing installations changing radiation patterns including measurements taken in the nondirectional mode (to establish conductivity) as well as in the directional mode. Measurement point locations for both the nondirectional and directional modes shall be identical and located along a sufficient number of radials corresponding to pattern nulls and maximums (three or more radials per major lobe) to accurately establish the radiation pattern. Where practicable, measurements along each radial should be taken at intervals of approximately two-tenth km up to three km from the antenna excluding points obviously within the induction field of the antenna system, at intervals of approximately 1 km from three to ten km and at intervals of approximately 3 km from ten to 30 km from the antenna. The results should be carefully analyzed utilizing the ground wave field strength curves from Annex 2 for the appropriate frequency.

Attachment C

Guidelines for the Co-ordination of Proposed AM Broadcasting Stations Involving Reduced Design Tolerance

1. Time Frame to Effect Co-ordination

Except for systems rated as "slightly below standard tolerance", the time frame to respond may vary from 60 to 150 days depending on the complexity of the proposed system. A method to rate systems by degree of complexity shall be developed. In the meantime, the administration submitting the proposal will estimate the time required to reply. This estimated time period may be extended by mutual consent at the request of the other administration if further information is required or if the extent of study required has been underestimated.

2. Submission of Information

Except for systems rated as "slightly below standard tolerance", the information referred to in attachment B paragraph 1 shall be transmitted.

3. Determination of Acceptable Values of Reduced Tolerance

In cases involving values of radiation less than those provided by the expanded pattern, expected values of radiation above theoretical radiation values shall be calculated using the two computer routines currently used in both administrations which calculate "stability radiation patterns" for a given variance of phase angles and field ratios. The values of variation used in the routines shall be at least twice the expected resolution of the antenna monitoring system. For systems rated "slightly below standard tolerance", the values of variation will be one degree in phase and one per cent in field ratios. Grounds exist for objection whenever using either routine, the resultant value of radiation in the pertinent directions exceeds that notified.

4. Systems Slightly Below Standard Tolerance

A system is considered slightly below standard tolerance if the reduced quadrature component Q in the horizontal plane is less than $10\sqrt{P_{kW}}$, but greater than $0.025\ E_{rss}$, as these terms are defined in Attachment A, and there would be no interference calculated with a one degree variation in phase and a one per cent variation in field ratios. These systems would be expected to be sited at locations relatively free from sources of re-radiation, to have adequate precautions taken to minimize effects of temperature variation, and to undertake satisfactory monitoring. However, the approval of the system and the assurance of maintenance within tolerance shall be the responsibility of the notifying Administration only and the submission of the information referred to in attachment B will not be required. The data specified in Part II of Annex 1, plus the reduced Q, shall be referred at least 30 days in advance of notification. If the administration receiving the proposal does not concur with the "slightly below standard tolerance" rating, it shall advise the notifying administration by telex or telephone, providing the reason for its opinion and requesting a different rating. If the notifying administration is unable to show that the "slightly below standard tolerance" rating is appropriate, it shall: provide information as in Attachment B, or provide a revision to make the rating appropriate or withdraw the proposal.

APPENDIX 4

(to Annex 2)

Additional Technical Information

This Appendix contains additional technical material and examples of methods of calculation which may be of assistance.

1. Examples of field strength calculations for homogeneous paths (see paragraph 2.3.1 of Annex 2)

a) Determination of the electrical field strength at a given distance from a station

Consider a station with a power of 5 kW at 1 240 kHz. The antenna has a characteristic field strength for 1 kW of 306 mV/m.

The field strength at a distance of 40 km is to be determined for a conductivity of 4 mS/m throughout the path.

From graph 15 (1 180 - 1 240 kHz) we obtain a field strength of 45.5 dB (µV/m) which corresponds to 188 µV/m from the curve corresponding to 4 mS/m.

Therefore

$$E = E_o \times \frac{E_C}{100}\sqrt{P} = \frac{188 \times 306}{100}\sqrt{5} = 1286\,\mu V/m \text{ or } 62.2 \text{ dB } (\mu V/m)$$

b) Determination of the distance at which a given field strength is obtained

On the basis of the data from the preceding example, at what distance can a field strength of 500 µV/m or 54 dB (µV/m) be obtained?

Since the antenna involved has a characteristic field strength for 1 kW of 306 m/Vm and the station power is 5 kW, i.e. conditions different from those of graphs 1 to 19 (100 mV/m at 1 km), the field strength value must be determined before referring to the corresponding graph.

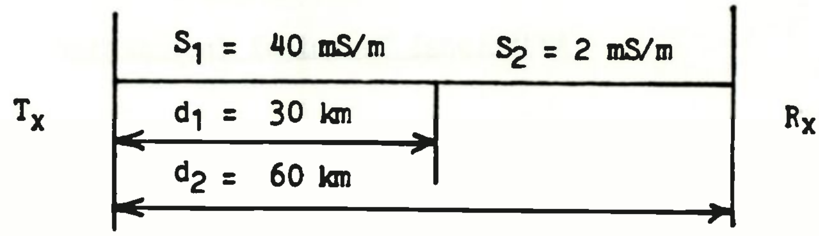
The calculated value is

$$E_o = \frac{100E}{E_c\sqrt{P}} = \frac{100 \times 500}{306 \times \sqrt{5}} = 73.1\,\mu V/m \text{ or } 37.3 \text{ dB } (\mu V/m)$$

Taking the corresponding curve at 4 mS/m in graph 15, we arrive at 37.3 dB (µV/m) at 62 km.

2. <u>Example of a field strength calculation for non-homogeneous paths</u>
(see section 2.3.2 of the technical data)

Consider the following path:



a) For a 25 kW station at 1 000 kHz and an antenna with a characteristic field strength of 100 mV/m, what field strength is obtained at 60 km?

In graph 12 we obtain on the 40 mS/m curve a field strength of 69 dB (µV/m) or 2.8 mV/m at the point of discontinuity (30 km).

We obtain the same field strength at 9.5 km (d=9.5 km) on the 2 mS/m curve.

The equivalent distance for $d_2 = 60$ km, is $d + (d_2 - d_1) = 9.5 + (60-30) = 39.5$ km.

From the 2 mS/m curve, we obtain a field of 43 dB (µV/m) for 1 kW or 141 µV/m at 39.5 km.

Lastly, we calculate the field strength:

$$E = E_0 \times \frac{E_c}{100}\sqrt{P} = 141 \times \frac{100}{100} \times \sqrt{25} = 705\ \mu V/m$$

b) Taking the preceding example, at what distance will the 500 µV/m contour be?

First we determine the field strength:

$$E_0 = \frac{100E}{E_c\sqrt{P}} = \frac{100E}{100\sqrt{25}} \times 500 = 100\ \mu V/m$$

Following the 40 mS/m curve of graph 12, we note that at 30 km the field strength is 69 dB (µV/m) or 2.8 mV/m. This value is higher than the one we seek (0.1 mV/m) and therefore we shall have a distance greater than 30 km.

The equivalent distance for a 2 mS/m conductivity is 9.5 km.

following the 2 mS/m curve, we find the 100 µV/m or 40 dB (µV/m) contour at 46 km giving us the equivalent distance. The true distance is 46 + (30 - 9.5) km = 66.5 km.

3. Path parameters

If a_T and b_T respectively are the latitude and longitude of the transmitting terminal, and a_R and b_R are those of the receiving terminal, the parameters of the short great-circle path may be calculated. The North and East coordinates are considered positive and the South and West coordinates negative.

3.1 Great-circle path distance

$$d = 111.18 \times d^{o} \quad \text{km}$$

where

$$d^{o} = \text{arc cos} \left[\sin a_T \sin a_R + \cos a_T \cos a_R \cos (b_R - b_T) \right]$$

3.2 Azimuth of the path from either terminal

For the transmitting terminal, for example,

$$\alpha_T = \text{arc cos} \frac{\sin a_R - \cos d^{o} \sin a_T}{\sin d^{o} \cos a_T}$$

determined such that $0^{o} \leq \alpha < 180^{o}$. The geographical bearing in degrees East of North to the receiving terminal is α_T if $\sin (b_R - b_T) \geq 0$ or is $(360^{o} - \alpha_T)$ if $\sin (b_R - b_T) < 0$. The same equation, with the latitudes reversed, is used for the receiving terminal.

3.3 Coordinates of a point on a given great-circle path at a distance, d, from a transmitter:

$$a = \text{arc sin} \left[\sin a_T \cos d^{o} + \cos a_T \sin d^{o} \cos \alpha_T \right]$$

$$b = b_T + k$$

where

$$d^{o} = \frac{d}{111.18} \quad \text{km}$$

$$k = \text{arc cos} \left(\frac{\cos d^{o} - \sin a_T \sin a}{\cos a_T \cos a} \right), \text{ if } \sin (b_R - b_T) \geq 0$$

$$k = - \text{arc cos} \left(\frac{\cos d^{o} - \sin a_T \sin a}{\cos a_T \cos a} \right), \text{ if } \sin (b_R - b_T) < 0$$

Note that the transmitting location was used in these equations for a and b, but alternatively the receiving location may be used.

4. <u>Example illustrating the application of the 50% exclusion principle</u> (see section 4.7.2)

Interfering signal (1)	Interfering signal field strength (μV/m)	Protection ratio (dB)	Individual interference contribution (μVm)	Calculated RSS (μV/m)	Remarks
A	140	26	2800		
C	130	26	2600	3821	$\sqrt{A^2 + C^2}$
B	125	26	2500	4555	Individual contribution greater than 50% of $\sqrt{A^2 + C^2}$ therefore $\sqrt{A^2 + C^2 + B^2}$
D	65	26	1300		Individual contribution less than 50% of $\sqrt{A^2 + C^2 + B^2}$ therefore disregard
E	52	26	1040		idem

(1) In descending order of individual interference contribution

5. <u>Receiver image frequency considerations</u>

For planning purposes, an Administration, in seeking the frequency most appropriate for use by a new station, may consider an additional groundwave protection consideration, i.e. the receiver image frequency constraint, to minimize the risk of interference due to the characteristics of receivers when the service areas of several stations overlap.

However, in areas where there are few available channels, administrations may decide to disregard this constraint.

If an administration wishes to ensure this protection, it must ensure that the field strength of a station with a frequency 900 to 920 kHz higher than the frequency of the station to be protected does not exceed by more than 29.5 dB the field strength corresponding to the protected contour of the station. The protection level thus required is the same as for the second adjacent channel.

6. The following matrix shows the conditions of application of the protection criteria as indicated in sections 4.10.2 and 4.10.3

Section number	4.10.2.1	4.10.2.2	4.10.2.3	4.10.3	4.10.3	4.10.3
Channel relationship	co-channel	co-channel	co-channel	adjacent channel	adjacent channel	adjacent channel
Time	daytime	night-time	night-time	daytime	night-time	day and night
Class of protected station	A, B, C,	A 10% criterion	B, C,	A	A	B, C,
Protected from	groundwave	skywave	skywave	groundwave	groundwave	groundwave
Protected contour	groundwave E_{nom}	E_{nom}*	groundwave contour corresponding to the greater of E_{nom} or E_u	groundwave E_{nom}	Groundwave E_{nom}	groundwave contour corresponding to value of daytime E_{nom}
Value to be protected	E_{nom}	E_{nom}	greater of E_{nom} or E_u	Adjacent channel daytime groundwave E_{nom}	night-time groundwave E_{nom}	daytime groundwave E_{nom}
How E_u is calculated	Not applicable	Not applicable	4.7	Not applicable	Not applicable	Not Applicable
Where E_u is calculated	Not applicable	Not applicable	Station site	Not applicable	Not applicable	Not applicable
How protection is applied	$\frac{E_{nom}}{\text{Protection ratio}}$ applied separately	$\frac{E_{nom}}{\text{Protection ratio}}$ applied separately	using 4.7 the maximum permissible field strength at the station site is not to be exceeded at the protected contour	$\frac{E_{nom}}{\text{Protection ratio}}$ applied separately	$\frac{E_{nom}}{\text{Protection ratio}}$ applied separately	$\frac{E_{nom}}{\text{Protection ratio}}$ applied separately

* groundwave or 50% skywave contour, whichever is farther from the site.

6. The following matrix shows the conditions of application of the protection criteria as indicated in sections 4.10.2 and 4.10.3

Section number	4.10.2.1	4.10.2.2	4.10.2.3	4.10.3	4.10.3	4.10.3
Channel relationship	co-channel	co-channel	co-channel	adjacent channel	adjacent channel	adjacent channel
Time	daytime	night-time	night-time	daytime	night-time	day and night
Class of protected station	A, B, C,	A 10% criterion	B, C,	A	A	B, C,
Protected from	groundwave	skywave	skywave	groundwave	groundwave	groundwave
Protected contour	groundwave E_{nom}	E_{nom}*	groundwave contour corresponding to the greater of E_{nom} or E_u	groundwave E_{nom}	Groundwave E_{nom}	groundwave contour corresponding to value of daytime E_{nom}
Value to be protected	E_{nom}	E_{nom}	greater of E_{nom} or E_u	Adjacent channel daytime groundwave E_{nom}	night-time groundwave E_{nom}	daytime groundwave E_{nom}
How E_u is calculated	Not applicable	Not applicable	4.7	Not applicable	Not applicable	Not Applicable
Where E_u is calculated	Not applicable	Not applicable	Station site	Not applicable	Not applicable	Not applicable
How protection is applied	$\frac{E_{nom}}{\text{Protection ratio}}$ applied separately	$\frac{E_{nom}}{\text{Protection ratio}}$ applied separately	using 4.7 the maximum permissible field strength at the station site is not to be exceeded at the protected contour	$\frac{E_{nom}}{\text{Protection ratio}}$ applied separately	$\frac{E_{nom}}{\text{Protection ratio}}$ applied separately	$\frac{E_{nom}}{\text{Protection ratio}}$ applied separately

* groundwave or 50% skywave contour, whichever is farther from the site.

APPENDIX 5

(to Annex 2)

METHOD USED FOR CALCULATING SECTIONALIZED ANTENNA RADIATION CHARACTERISTICS

(The columns referred to below are those of Part II of Annex 1 to the Agreement)

1. Sectionalized tower, when the value entered in column 12 is 3.

$$f(\theta) = \frac{2\cos(90\sin\theta)\cos\left[(A+90)\sin\theta\right] + \cos(A\sin\theta) - \cos A}{\cos\theta\,(3 - \cos A)}$$

Where:

A = electrical height of bottom section

θ = elevation angle

2. Sectionalized tower, when the value entered in column 12 is 4.

$$f(\theta) = \frac{\cos(A\sin\theta)\left[\cos(A\sin\theta) - \cos A\right]}{\cos\theta\left[1 - \cos A\right]}$$

Where:

A = electrical height of bottom section

θ = elevation angle

3. Sectionalized tower, when the value entered in column 12 is 5.

$$f(\theta) = \frac{\dfrac{\cos(A\sin\theta) - \cos A}{\cos\theta} + \dfrac{CD\cos\theta\left\{\cos(A\sin\theta) + \cos\left[(A+B)\sin\theta\right]\right\}}{C^2 - \sin^2\theta}}{1 + \dfrac{2D}{C} - \cos A}$$

Where:

A = electrical height of bottom section

B = electrical height of top section

C = current distribution factor

D = ratio of maximum current in top section to maximum current in bottom section

θ = elevation angle.

4. Sectionalized tower, when the value entered in column 12 is 6.

$$f(\theta) = \frac{\cos(A\sin\theta) - \cos(A-B)\cos(B\sin\theta) + \sin\theta\sin(A-B)\sin(B\sin\theta)}{\cos\theta\left[1 - \cos(A-B)\right]}$$

Where:

A = total electrical height of tower

B = electrical height of lower section

θ = elevation angle.

5. Sectionalized tower, when the value entered in column 12 is 7.

$$f(\theta) = \frac{C\cos(A\sin\theta) - \cos A + \cos(B\sin\theta) - \cos(B-A)\cos(A\sin\theta) + \sin(B-A)\sin\theta\sin(A\sin\theta)}{C\left[1 - \cos A\right] + \cos\theta\left[1 - \cos(B-A)\right]}$$

Where:

A = electrical height of lower section

B = total electrical height of antenna

C = ratio of the loop currents in the two sections

θ = elevation angle.

6. Sectionalized tower, when the value entered in column 12 is 8.

If $\theta = 0$, $f(\theta) = 1$

If $\theta > 0$: $$f(\theta) = \frac{\sqrt{\text{real component}^2 + \text{imaginary component}^2}}{C}$$

The real component is equal to:

$$\left[\frac{2.28 \cos 0}{1.14^2 - \sin^2\theta}\right]\left\{- \cos\left[1.14\,(B-A)\right] + 2\cos(1.14B)\cos(A\sin\theta) - \cos\left[(A+B)\sin\theta\right]\right\}$$

The imaginary component is equal to:

$$D\cos\theta\left\{\frac{\sin\left[(A+B)\sin\theta\right]}{\sin\theta} + \frac{1.14}{1.14^2 - \sin^2\theta}\left[\sin\left[1.14(B-A)\right] - 2\sin(1.14B)\cos(A\sin\theta) + \frac{\sin\theta\,\sin\left[(A+B)\sin\theta\right]}{1.14}\right]\right\}$$

Where:

A = electrical height of lower section of tower

B = electrical height of upper section of tower

C = scaling factor so that $f(\theta)$ is 1 in horizontal plane

D = absolute ratio of the real component of current to the imaginary component of current at the point of maximum amplitude

θ = elevation angle.

Note: 1.14 is the ratio of velocity of light to propagation velocity along radiator.

7. Sectionalized tower, when the value entered in column 12 is 9.

$$f(\theta) = \frac{\cos(A\sin\theta)\left[\cos(B\sin\theta) + 2\cos(A\sin\theta)\right]}{3\cos\theta}$$

Where:

A = electrical height of centre of bottom dipole

B = electrical height of centre of top dipole

θ = elevation angle.

APPENDIX 6

(to Annex 2)

Groundwave Field Strength Measurements

1. This Appendix describes the groundwave field strength measurement method to be used in the application of Article VI of the Agreement.

2. The protected contour of an assignment shall be as defined in conformity with Annex 2 unless specifically agreed otherwise.

3. General Measurement Criteria

3.1 Measurements must be made during daytime hours only. Care must be taken to avoid measurement of skywave signals during early morning and late afternoon hours.

3.2 Measurement data along a radial will be considered to be representative of conductivity through an arc not to exceed ±10 degrees from the azimuth of the radial. Conditions of irregular terrain or other factors indicating a probable difference in conductivity over the arc may require radials every few degrees, unless a showing is made that the radials measured would reasonably be expected to have higher conductivity than other nearby terrain (e.g., a mountainside would be expected to have a lower conductivity than would an adjacent valley).

3.3 All measurement points must be on-radial to the extent possible. Any off radial measurements shall be accompanied by a showing that they are valid for the intended purpose. Off-radial directional measurements will not be considered in a radial analysis unless the directional antenna pattern shows nearly constant radiation.

4. Measurements to determine the presence of interference

4.1 Interference shall be deemed to exist if the measured field strength of the interfering signal at or within the predicted location of the protected contour of an assignment does not meet the protection requirements of Annex 2 or any other protection requirements specifically agreed upon for this assignment.

4.2 Field strengths shall be measured in accordance with good engineering practice along pertinent radials originating from the station believed to be the cause of the interference.

4.3 There shall be a sufficient number of measurements to make an adequate showing of interference. This shall include at least 10 measurements not less than 1 km apart along each radial, within the protected contour.

5. Measurements to justify an assignment based on conductivity values differing from the official map

5.1 Field strengths shall be measured in accordance with good engineering practice. In particular:

5.1.1 There shall be at least one radial in each sector in which it is intended to establish that no interference will be caused.

5.1.2 At least 30 points shall be measured out to a distance of 30 km. At least 15 of these measurement points shall be located within 3 km of the transmitter site, in order that both inverse field and soil conductivity may be determined by best-fit curve analysis. Within each of these ranges, the points measured shall be spaced as nearly equally as possible. Beyond 30 km measurements shall be taken at intervals not exceeding 20% of the distance between the interfering station and the protected contour. In any event, sufficient measurements shall be taken to support the finding required under 4.1 above.

6. Presentation of Measurement Data

The following data shall be presented in support of measurements:

6.1 A tabulation of field strength values, with distance from the transmitter and time each measurement was taken. Also, a general statement as to climate and terrain conditions (damp, dry, hot, cold, marshy, rocky, ets.);

6.2 Maps showing measurement locations in sufficient detail to show elevations, natural and man-made obstructions or formations, and terrain condition;

6.3 The calculation of permissible radiation shall be based on the values of ground conductivity determined from the plotted points for each radial, plus, beyond the boundary, or the end of each radial, the values of conductivity found on the pertinent conductivity maps.

6.4 Description of the instrument used to take the measurements and certifications as to field-strength meter calibration and of operator compliance with manufacturer's instructions for making measurements, along with operator qualifications and experience in making measurements; and

6.5 Description of the transmitter, antenna system, and relevant operating parameters in use by the station when the measurements were taken.

APPENDIX 7

(to Annex 2)

METHOD FOR EXTENDED HOURS OF OPERATION

CALCULATIONS USING DIURNAL FACTORS

1. This Appendix contains the method to be used when applying diurnal factors during periods of extended hours of operation under Article VII of the Agreement. Procedures for calculating nighttime interference on a site-to-site or site-to-contour basis are based on propagation conditions occuring two hours after sunset as a standard reference.

To calculate interference during extended hours of operation periods, the nighttime interference can be calculated and then modified taking into account the diurnal factor. Diurnal factors are calculated from the formulas contained in Tables 5A and 5B of Annex 2, and are represented graphically in Figures 5A and 5B of Annex 2. They are expressed as a ratio of the skywave field strength at any time during the pre-sunrise or post-sunset period to the skywave field strength occuring during the reference hour of two hours past sunset at path mid point.

The following illustration describes the application of the diurnal curves when calculating required protection to the 0.5 mV/m 50% contour of a Class A station from a daytime-only station operating during the post-sunset period. A similar procedure may be used for the pre-sunrise period.

2. Post-Sunset Operations Providing Nighttime Protection

Evaluate the nighttime interference that would be produced by the daytime operation of the station requesting post-sunset authority to points along the protected 0.5 mV/m 50% contour of Class A nighttime co-channel stations. The permissible interfering 10% signal from post-sunset operations is less than 0.025 mV/m at any point along the protected contour of a Class A station. Identify all points on the 0.5 mV/m 50% contour toward which the permissible interfering signal is exceeded. From these calculations the maximum which is permissible can be determined. In many cases full nighttime protection will be quite restrictive and it may be advantageous to apply the diurnal curves.

3. Determine the Diurnal Factor

In order to apply the diurnal curves, it is necessary to determine the time of sunset at the path mid-point. Subtract the sunset time at the path mid-point from the local sunset time (assumed in this illustration to be 6:00 pm). With this time difference, enter the diurnal factor curves, Figure 5B of Annex 2, with the appropriate frequency, interpolate linearly between the diurnal curves and read the diurnal factor.

Example: A hypothetical station is located in Denver, CO, proposing post-sunset operation on 1130 kHz, and a path being analyzed has a mid-point located at N 39° 36' 36", W 97° 02' 15". The sunset time at the path mid-point is calculated to be 4:04. p.m. MST. Assuming that the station in Denver is permitted post-sunset operation until 6:00 p.m. MST, it would be operating 1.93 hours (6:00 p.m. - 4:04. p.m.) beyond sunset at the path mid-point.

Entering Figure 5B with SS + 1.93 on 1130 kHz results in a diurnal factor of approximately 0.99. It should be noted that a diurnal factor greater than 1.0 is never used.

4. Apply the Diurnal Factor for Modified Power

Divide the permissible interfering 10% skywave signal toward the Class A station on the path selected by the diurnal factor. This produces the worst case interfering signal adjusted by the diurnal factor along this path from the daytime operation to the protected contour of the Class A station during the post-sunset operating period. With the proposed interfering signal increased by the diurnal factor, the proposed post-sunset power may be increased by direct ratio (using the square root of the power). This increased power would be permitted for this particular path.

Example: From the previous example, the diurnal factor was determined to be 0.99. For the hypothetical case of the station in Denver, suppose that the permissible antenna radiation for the selected path that provides full nighttime protection is 75 mV/m.

Applying the diurnal factor for this path, the permissible radiation becomes 75 ÷ 0.99 = 75.76 mV/m. If it is necessary to reduce the daytime power to 260 watts to provide full nighttime protection, application of the diurnal factor would permit a modified power of 265.28 watts ($260 \times 75.76^2 \div 75^2$ or 260 watts $\div .99^2$).

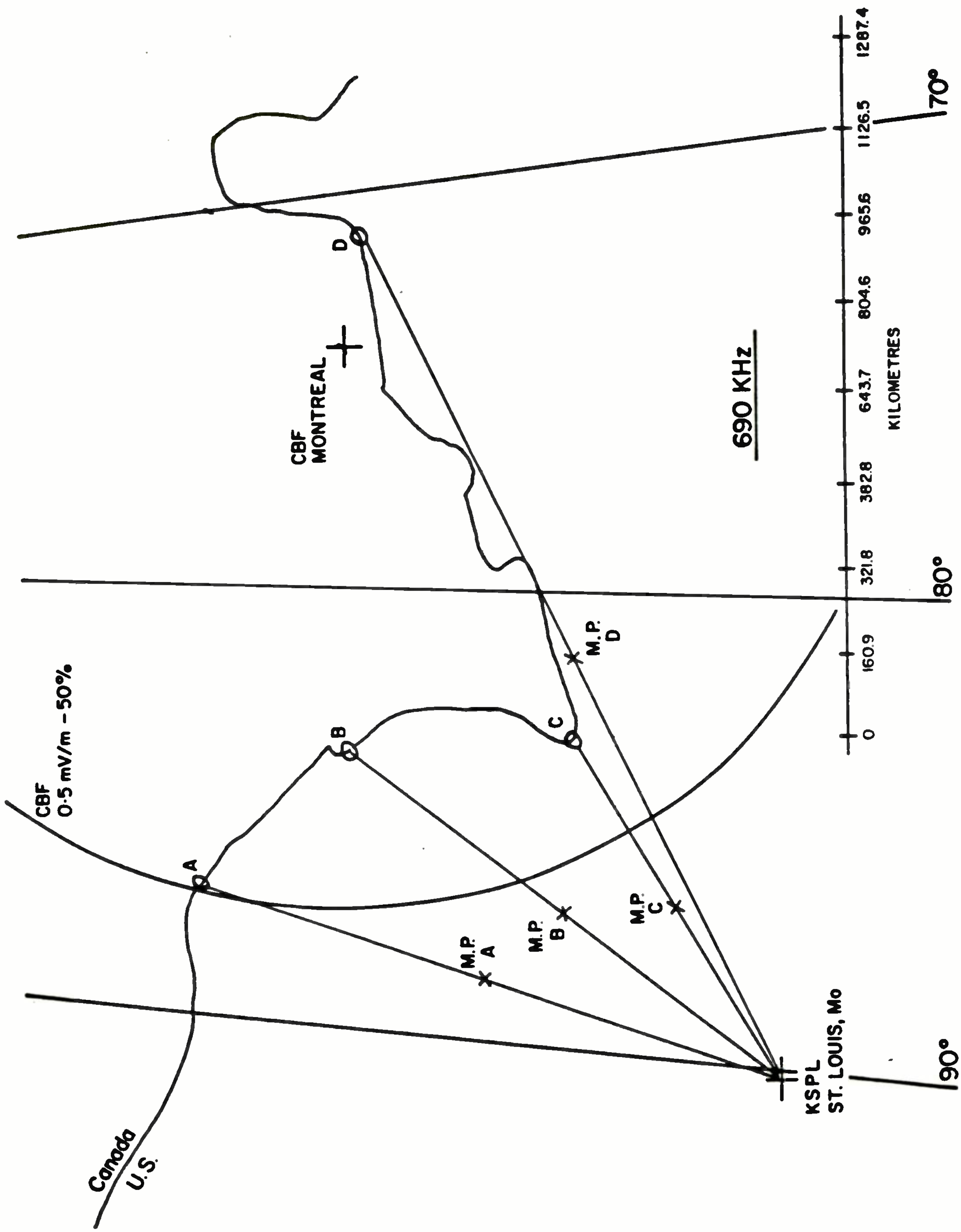
5. Determine the Post-Sunset Operating Power

After analyzing the pertinent paths, the operating power that would be permitted for post-sunset operation is that which is determined for the most restrictive path.

6. Additional Example

The example which follows is more detailed than the above example and illustrates the proposed diurnal calculation method using a Canadian Class A station and a U.S. Class B station as shown on Figure 7A.

FIGURE 7-A


1287.4
1126.5
965.6
804.6
643.7
382.8
321.8
160.9
0
KILOMETRES
70°
80°
90°
690 KHz
CBF
MONTREAL
D
C
B
A
M.P. D
M.P. C
M.P. B
M.P. A
CBF
0·5 mV/m -50%
KSPL
ST. LOUIS, Mo
Canada
U.S.

Assume Points A, B, C and D are points on the border. A, B and C are within the 0.5 mV/m -50% contour. Point D is within the 0.5 mV/m groundwave contour. Determine the mid-point latitude and longitude from the proposal to each point.

Mid-Points	Mid-Point Latitude	Mid-Point Longitude
M.P. A	N 42.9°	W 88.7°
M.P. B	N 41.9°	W 87.2°
M.P. C	N 40.4°	W 86.8°
M.P. D	N 42.0°	W 80.9°

Calculate the earliest time of sunset during the year at each mid-point. Note that St. Louis is in the Central Standard Time Zone.

Entering Figure 7B with Latitude N 42.9° of Mid-Point A, sunset time is approx. 4:25 p.m. CST along standard meridian 90° W. Next, a correction is made for the longitude correction from the standard meridian for Mid-Point A. This correction is + 4 minutes of time per degree West, or -4 minutes of time per degree East of the standard meridian.

Long. of M.P.A. - Std. Meridian = 88.7° - 90° = -1.3°

Time Correction = -1.3° x 4 = -5.2 minutes

The sunset at M.P.A. = 4:25 - 0:05.2 = 4:19.8 p.m. CST

At Latitude of M.P.B., sunset along standard meridian is approx. 4:27 p.m. CST.

Long. of M.P.B. - Std. Meridian = 87.2° - 90° = -2.8°

Time Correction = 2.8° x 4 = -11.2 minutes

The sunset at M.P.B. = 4:27 - 0:11.2 = 4:15.8 p.m. CST

At Latitude of M.P.C., sunset along standard meridian is approx. 4:33 p.m. CST.

Long. of M.P.C. - Std. Meridian = 86.8° - 90° = -3.2°

Time Correction = -3.2° x 4 = -12.8 minutes

The sunset at M.P.C. equals 4:33 - 0:12.8 = 4:20.2 p.m. Central Std. time.

At Latitude of M.P.D., sunset along standard meridian is approx. 4:29 p.m. CST.

Long. of M.P.D. - Std. Meridian = 80.90 - 90° = -9.1°

Time Correction = -9.1° x 4 = -36.4 minutes

The sunset at M.P.D. = 4:29 - 0:36.4 = 3:52.6 p.m. CST.

Mid-Point	SS at M.P.	time = Local Sunset (6:00pm assumed)-SS at M.P.	Diurnal Factor (Figure 5-B)
A	4:19.8	1:40.2	.93
B	4:15.8	1:44.2	.96
C	4:20.2	1:39.8	.93
D	3:52.6	2:07.4	1.00

At Point	Assumed Protected Contour	Assumed permissible radiation to provide full Nighttime Protection
A	0.5 mV/m -50%	25 mV/m
B	1.0 mV/m -50%	35 mV/m
C	0.8 mV/m -50%	30 mV/m
D	0.6 mV/m groundwave	80 mV/m

The permissible radiation to provide full nighttime protection is adjusted in each case by the diurnal factor, to produce the permissible radiation toward each point during the post sunset operating period, i.e.

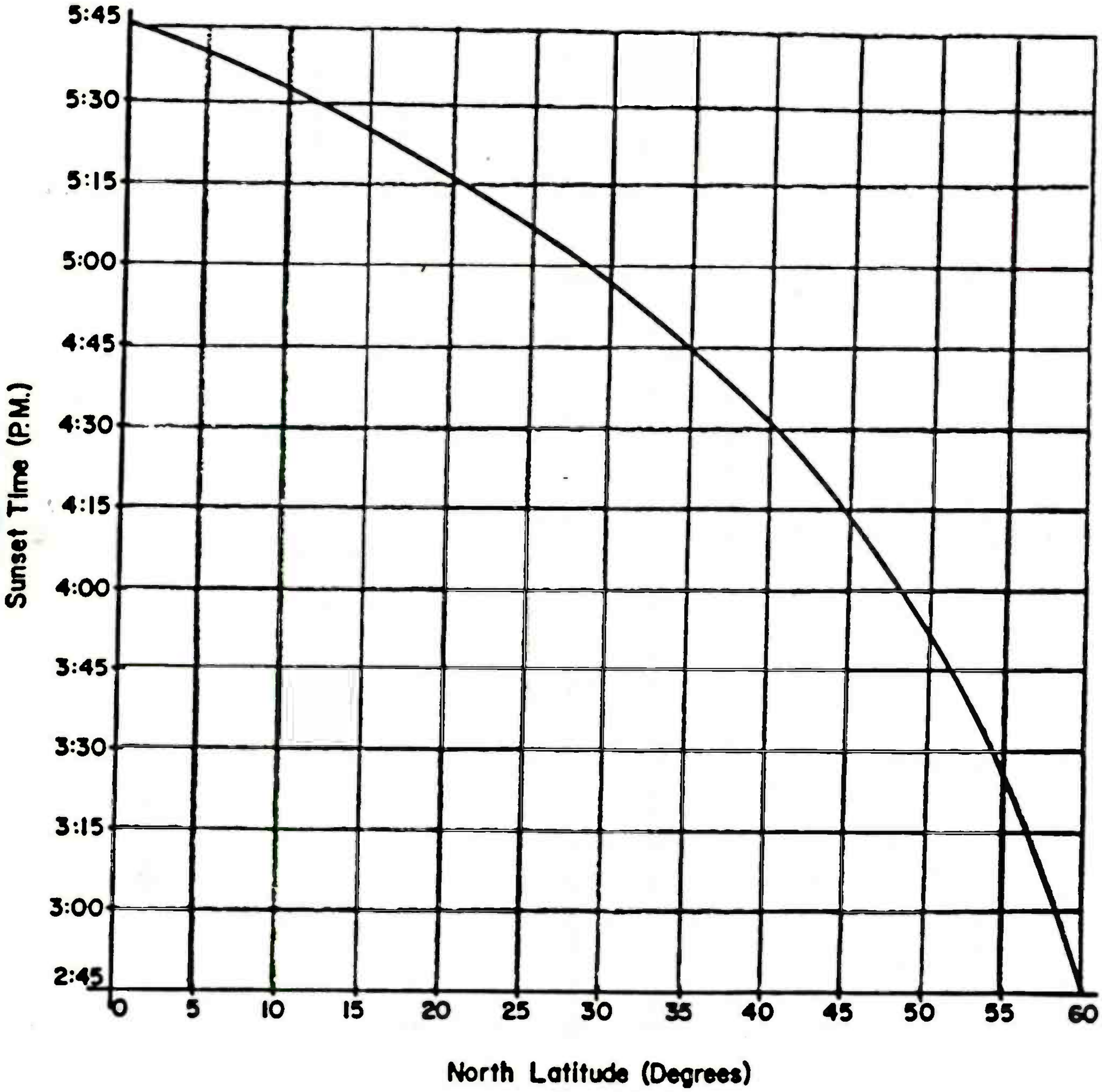
To Point	Diurnal Factor	Permissible Full-Night Radiation	Permissible Post Sunset Radiation
A	.93	25 mV/m	25÷.93 = 26.88 mV/m
B	.96	35 mV/m	35÷.96 = 36.46 mV/m
C	.93	30 mV/m	30÷.93 = 32.26 mV/m
D	1.00	80 mV/m	80÷1.00 = 80 mV/m

Thus, for post sunset operation, the station would have to adjust its power so that protection would be provided in all directions toward points A through D, so that actual radiation would not exceed the permissible Post Sunset radiation.

Although this example shows protection to a Class A station, the same procedure would apply to Class B stations as follows:

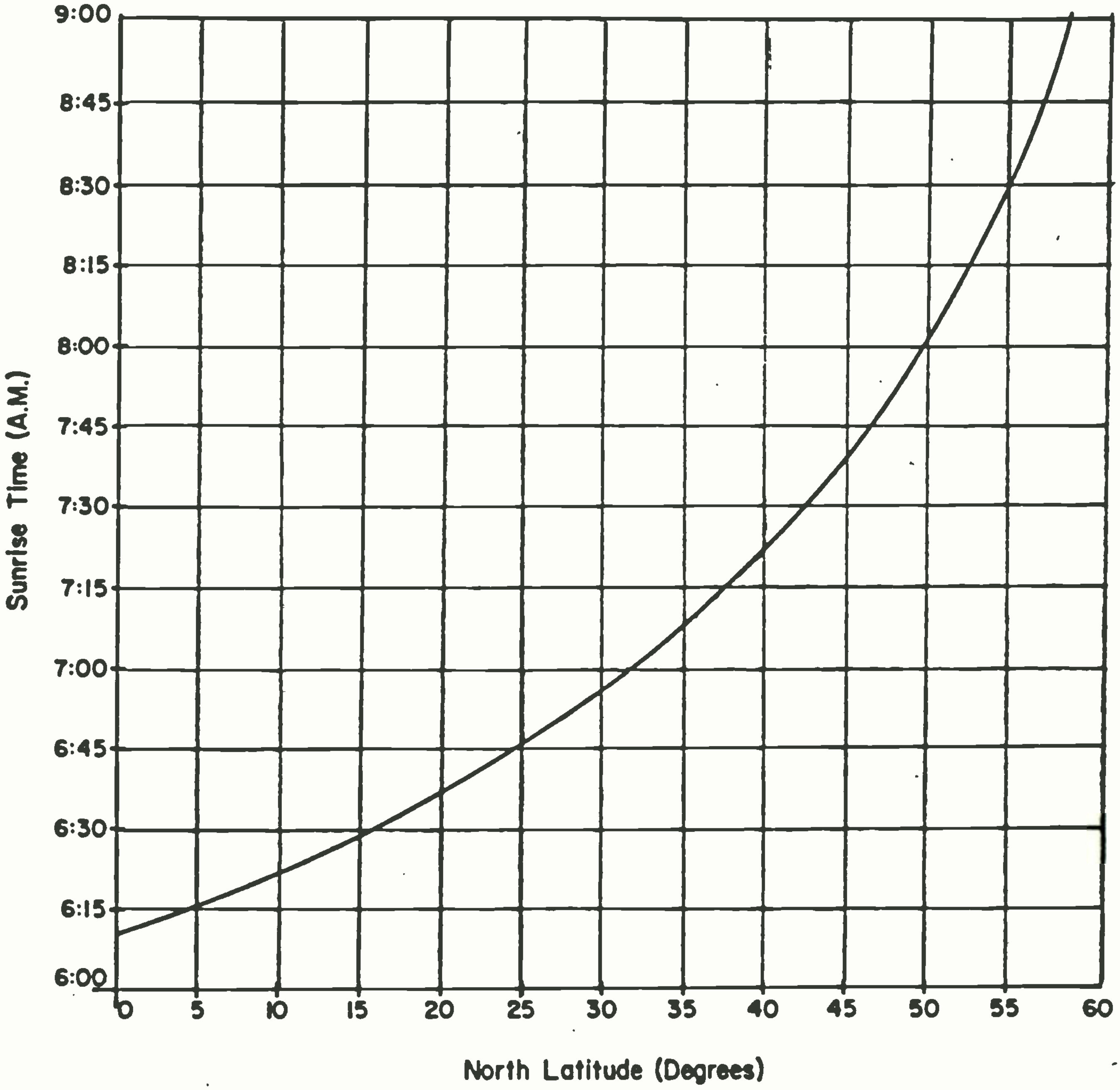
Assume that each point A, B, C and D is a separate Class B station. Calculate the existing R.S.S. for each station and determine the values of permissible radiation for full nighttime protection toward each station, and apply the diurnal factors to produce the permissible Post Sunset Radiation toward each station. Then adjust the power of the station operating during the post sunset period so that the permissible post sunset radiation values are not exceeded.

Figure 7B



Earliest Sunset Time
along a
Standard Meridian

Figure 7.C



Latest Sunrise Time
along a
Standard Meridian

APPENDIX 8

(to Annex 2)

Criteria for Critical Hours of Operation

1. This Appendix specifies the criteria required in the application of Article VIII of the Agreement.

2. Critical hours of operation are defined as follows:

2.1 Beginning at local sunrise at the transmitting antenna site of the Class B or C station, and ending one and one-half hours after the time of sunrise at the geographic midpoint between the transmitting antenna site of the Class B or C station and that of the Class A station.

2.2 Beginning one and one-half hours before the time of sunset at the geographic midpoint between the transmitting antenna site of the Class B or C station and that of the Class A station, and ending at local sunset at the transmitting antenna site of the Class B or C station.

2.3 These periods are established for each month on the basis of sunrise and sunset times for the fifteenth day of the month adjusted to the nearest quarter-hour.

3. The Class A stations shall be protected to their calculated 100 uV/m daytime contour. Where the protected contour would extend beyond the boundary of the country in which the Class A station is located, the protected contour shall follow that part of the boundary.

4. During the critical hours of operation defined in section 2, the maximum permissible radiated field strength of the Class B or C station toward each point on the protected contour of the Class A station, over the vertical arc specified in section 4.2, shall be determined by the distance from the transmitting antenna site of the Class B or C station to the protected point in question in accordance with the following equation which is graphically illustrated in Fig. 8:

4.1 $F = 0.9\,D - 290$

where:

F = Maximum permissible radiated field strength of the Class B or C station in mV/m at one kilometre toward the point on the protected contour of the Class A station.

D = Distance in kilometres from the transmitting antenna site of the Class B or C station to the same point as above.

4.2 The vertical arc for the maximum permissible radiated field strength shall be the arc from the horizontal plane to the elevation angle specified in the Curve of Figure 2 of Annex 2.

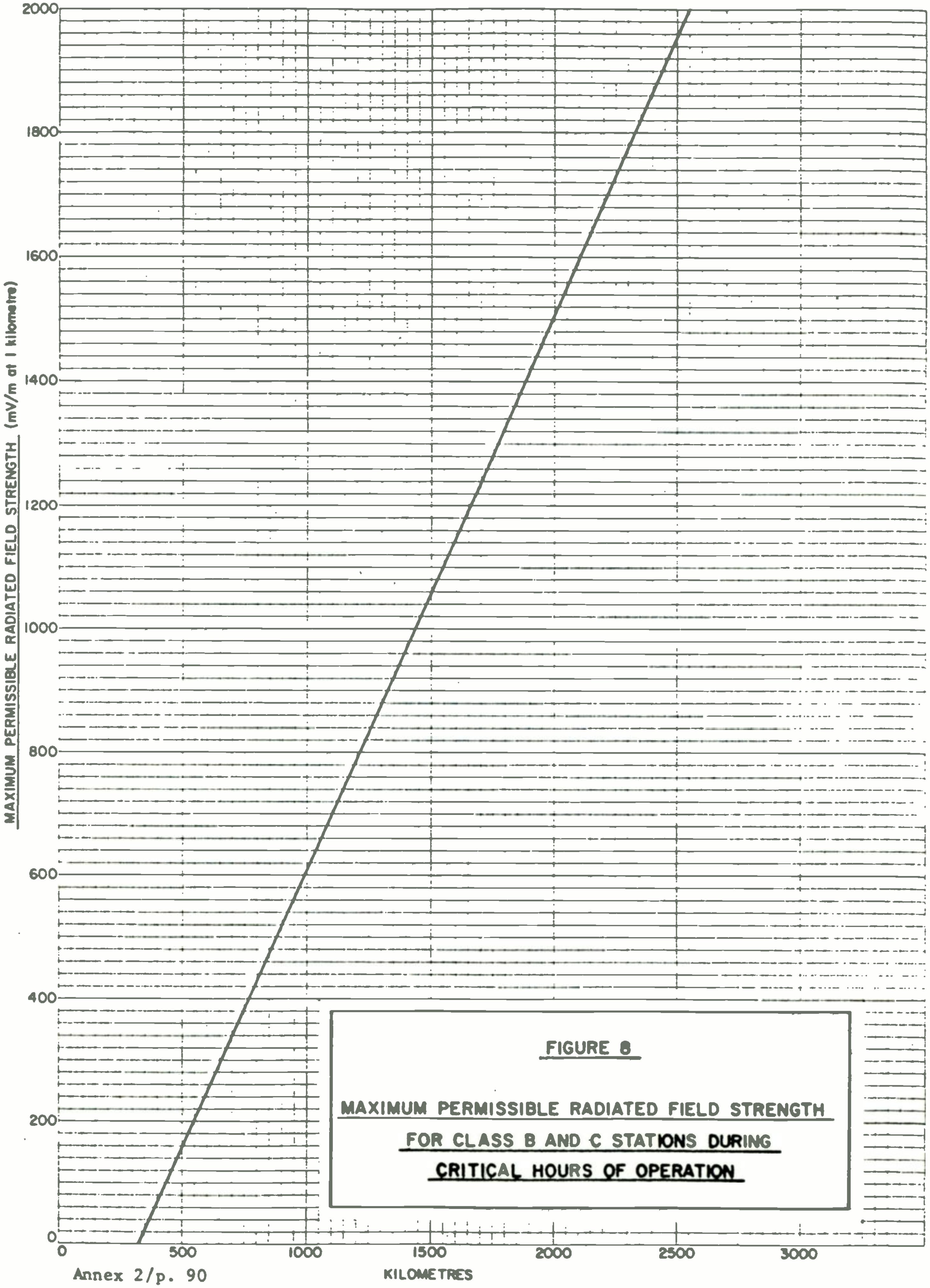


FIGURE 8

MAXIMUM PERMISSIBLE RADIATED FIELD STRENGTH FOR CLASS B AND C STATIONS DURING CRITICAL HOURS OF OPERATION

ERRATA

to the

Agreement Between the Government of Canada And the Government of the United States of America Relating to the AM Broadcasting Service in the Medium Frequency Band Ottawa, 1984

1. Annex 2, page 23

   Table III - third line:

   Change 1.13 to 1.23 - English version

   Change 1,13 to 1,23 - French version

2. Annex 2, page 61 - French version only

   Change equation under a) to:

$$f(\theta)_i = \frac{\cos(G_i \sin\theta) - \cos G_i}{(1 - \cos G_i)\cos\theta}$$

3. Annex 2, page 62 - English and French versions

   Change second equation under 2. to:

$$g(\theta) = \frac{\sqrt{f(\theta)^2 + 0.0625}}{1.030776}$$

The Station listing portion of this agreement is located in the stations lists binder

Government of Canada
Department of Communications
Gouvernement du Canada
Ministère des Communications

PROVISIONAL

BROADCAST PROCEDURES AND RULES

PART II: APPLICATION PROCEDURES AND RULES FOR AM BROADCASTING TRANSMITTING STATIONS

EFFECTIVE DATE: MAY 24, 1986

BROADCASTING REGULATION BRANCH

PROVISOIRE

RÈGLES ET PROCÉDURES SUR LA RADIODIFFUSION

PARTIE II: RÈGLES ET PROCÉDURES DE DEMANDE RELATIVES AUX STATIONS ÉMETTRICES DE RADIO-DIFFUSION AM

MISE EN VIGUEUR: 24 MAI 1986

DIRECTION GÉNÉRALE DE LA RÉGLEMENTATION DE LA RADIODIFFUSION

Page

SECTION A: INTERNATIONAL AGREEMENTS

AM broadcasting assignments in the 535-1605 kHz band in Canada are made in accordance with the Regional Agreement for the Medium Frequency Broadcasting Service in Region 2 (RAMFBC-R2), and the Agreement between the Government of Canada and the Government of the United States of America Relating to the AM Broadcasting Service in the Medium Frequency Band (Canada/USA Agreement). These are international agreements which govern the common use of the broadcasting band in the Region so that each country within the Region may make full effective use of the band with the minimum of interference between broadcasting stations. The governing principles are reflected into technical criteria which have to be followed to avoid excessive interference. While the agreements are in themselves international documents, they are normally implemented in Canada for domestic use, together with additional domestic requirements, through the Department's Procedures and Rules.

SECTION B: PRÉPARATION DES MÉMOIRES TECHNIQUES DEVANT ACCOMPAGNER LES DEMANDES RELATIVES AUX STATIONS DE RADIODIFFUSION AM DANS LA BANDE 535 - 1605 kHz

1. PROCÉDURE DE DEMANDE ET MESURES ULTÉRIEURES

1.1 Préambule

La présente section expose la procédure à suivre lors de la préparation et de la soumission des renseignements techniques nécessaires à l'appui des demandes relatives aux stations de radiodiffusion en modulation d'amplitude (AM) exploitées à des puissances supérieures à 50 W dans la bande de fréquences 535-1605 kHz.

1.2 Exigences

1.2.1 La demande de certificat technique de construction et de fonctionnement (CTCF) pour une station AM devra se faire sur la formule 16-1 du MDC intitulée "Demande d'un certificat technique de construction et de fonctionnement pour une nouvelle station émettrice de radiodiffusion MA (bande normale)" ou la formule 16-4 du MDC intitulée "Demande en vue de la modification des installations d'une station émettrice de radiodiffusion MA (bande normale)", selon le cas. On peut obtenir une formule de demande de licence de radiodiffusion auprès du Conseil de la radiodiffusion et des télécommunications canadiennes (CRTC). Les deux demandes devraient être déposées en même temps.

On peut obtenir toutes les formules nécessaires du MDC auprès de tout bureau régional du Ministère (Vancouver, Winnipeg, Toronto, Montréal, Moncton) ou à l'Administration centrale du Ministère à Ottawa.

1.2.2 Le manuel relatif à la présentation des demandes de CTCF peut s'avérer utile lors de la préparation des documents techniques, qui pour être complets devront comprendre:

1. deux exemplaires de la formule appropriée 16-1 ou 16-4;
2. cinq exemplaires d'un mémoire technique dans des reliures à feuilles volantes, avec étiquettes d'identification. Le mémoire devrait être préparé avec soin et devrait inclure toutes les données techniques détaillées telles que mentionnées dans la présente procédure de demande;
3. les formules dont la liste figure dans les parties I à IV de l'annexe 1 à l'Accord Canada/É.-U., remplies (seulement dans le cadre du mémoire technique);
4. un calque reproductible de chaque carte montrant les contours pertinents d'intensité de champ (RÈGLES GÉNÉRALES, section 3);

SECTION B: PREPARATION OF TECHNICAL SUBMISSIONS REQUIRED WITH THE APPLICATIONS FOR AM BROADCASTING STATIONS IN THE 535-1605 kHz BAND

1. APPLICATION PROCEDURE AND SUBSEQUENT ACTION

1.1 Preamble

This Section outlines the procedure to be followed in preparing and submitting technical information required in support of applications for AM broadcasting stations operating with powers of greater than 50 W in the frequency band 535-1605 kHz.

1.2 Requirements

1.2.1 Application for a Technical Construction and Operating Certificate (TC & OC) for an AM Station shall be made on DOC Form 16-1 "Application for a Technical Construction and Operating Certificate for a New AM (Standard Band) Broadcasting Transmitting Station" or 16-4 "Application for Authority to Change the Facilities of an AM (Standard Band) Broadcasting Station" as applicable. An application form for a broadcasting licence can be obtained from the Canadian Radio-television and Telecommunications Commission (CRTC). The two applications should be filed simultaneously.

All necessary DOC forms may be obtained from any DOC regional office (Vancouver, Winnipeg, Toronto, Montreal, Moncton) or Departmental headquarters in Ottawa.

1.2.2 The Manual for Filing Applications for TC & OC may prove helpful in preparation of technical submissions. A complete technical submission shall include the following:

1. two copies of the appropriate Form 16-1 or 16-4;
2. five copies of an engineering brief in suitable looseleaf binders with identifying labels. The brief should be carefully prepared and include all the detailed technical information as outlined in this application procedure;
3. completed forms listed in Annex 1, Parts I to V of the Canada/USA Agreement (as part of the engineering brief only);
4. one transparent reproducible copy of each map showing the pertinent field strength contours (GENERAL RULES, Section 3);

5. un exemplaire, rempli, de la formule 16-879 du MDC "Détails sur l'emplacement et les bâtis d'antenne radio" et un exemplaire d'une carte topographique montrant l'endroit exact de l'emplacement d'antenne.

6. un exemplaire de la formule 16-846 du MDC intitulée "Liste de contrôle des données administratives de la demande de radiodiffusion".

1.2.3 La formule 16-879 doit être soumise afin d'obtenir l'autorisation d'ériger un bâti d'antenne et elle devrait être déposée avant la demande. Une demande ne sera pas déclarée comme techniquement acceptable par le Ministère, à moins que cette formule soit approuvée par Transports Canada. Cette formule devrait être accompagnée d'une carte (échelle 1/50 000) montrant l'emplacement de l'antenne. On peut obtenir de telles cartes au ministère de l'Énergie, des Mines et des Ressources (Bureau des ventes, Cartes et publications). En ce qui concerne les zones pour lesquelles des cartes à cette échelle n'existent pas, on peut utiliser une carte d'échelle plus petite, jusqu'à l'échelle 1/250 000. La carte devrait être une originale, afin d'éviter toute possibilité d'erreur dans l'indication de l'emplacement de l'antenne.

1.3 Obtention des services d'un ingénieur-conseil en radiodiffusion

La formule 16-653 du MDC devra être déposée lorsque les services d'un ingénieur-conseil en radiodiffusion sont retenus. Il est à noter que si un mémoire technique est jugé incomplet, parce qu'il y manque des renseignements importants et (ou) parce qu'il contient des données techniques incorrectes, il en résulte de longs retards pour le traitement de la demande. Ces omissions ou ces erreurs de données sont souvent dues au manque de connaissance des exigences du Ministère. Les ingénieurs-conseils en radiodiffusion tiennent à jour une bibliothèque contenant tous les renseignements pertinents relatifs aux études de conception et d'assignation; ils sont abonnés au service du Ministère qui leur fournit les derniers renseignements sur les allotissements.

En ce qui concerne la préparation des documents techniques, il incombe à l'ingénieur chargé de la surveillance des travaux de se conformer aux lois pertinentes de la province en question.

1.4 Traitement de la demande

Si lors de l'examen des demandes, le Ministère trouve que les renseignements exigés manquent, sont incomplets ou incorrects, le requérant et/ou l'ingénieur-conseil en sera avisé. Si les renseignements nécessaires ne sont pas fournis après une période spécifiée, la demande sera renvoyée au requérant.

5. one copy of completed DOC Form 16-879 "Particulars of Proposed Site and Radio Antenna Structures" and one copy of a topographical map showing the exact location of the antenna site;

6. one copy of the DOC Form 16-846 "Broadcast Application Administrative Checklist".

1.2.3 Form 16-879 must be filed to obtain clearance for the erection of an antenna supporting structure and should be filed before the time the application is filed. The Department will not declare an application to be technically acceptable unless this form has been approved by Transport Canada. This form should be accompanied by a map (scale 1:50,000) showing the antenna site. Such maps may be obtained from the Department of Energy, Mines and Resources (Sales Office, Maps and Publications). For areas where maps of this scale are not available, a map of smaller scale, up to 1:250,000 could be used. The map should be an original, to avoid any potential error in showing the location of the antenna site.

1.3 <u>Retention of a Broadcast Engineering Consultant</u>

The DOC Form 16-653 shall be filed when a broadcast engineering consultant has been retained. It should be noted that when a technical submission has been found to be incomplete, in that important information has been omitted and/or inaccurate technical data has been found, lengthy delays in processing the application have resulted. Such omissions and inaccuracies are often due to an unfamiliarity with the Department's requirements. Broadcast engineering consultants maintain a library of all pertinent information in reference to design and assignment studies, and subscribe to the Department's service which provides them with the current allotment material.

It is the responsibility of the supervising engineer, insofar as the preparation and the submission of documents are concerned, to comply with the appropriate legislation in the province concerned.

1.4 <u>Application Processing</u>

If during examination of applications, the Department finds that the required information is missing, incomplete, or incorrect, the applicant and/or consultant will be so notified. If the necessary information is not supplied after a specified period of time, the application will be returned.

Si une demande est jugée techniquement inacceptable, le requérant en sera informé. La demande sera gardée en suspens pendant une période déterminée, en attendant des révisions possibles, avant d'être renvoyée au requérant.

Si le Ministère a jugé la demande de certificat de construction et de fonctionnement techniquement acceptable, et si la demande de licence de radiodiffusion est approuvée par le CRTC, le requérant reçoit l'autorisation écrite de commencer la construction de la station.

1.5 Approbation de la mise en onde

Le Gérant du bureau de district du Ministère concerné devra être informé et la formule 16-656 du MDC intitulée "Données requises au sujet de la résistance de la charpente des pylônes d'antenne et des bâtis d'antenne" devra être soumise (à moins qu'il n'y ait aucun changement au bâti d'antenne existant) au préalable de tout essai d'émission en onde. Cet avis devra être donné au moins trois semaines avant la date prévue du début de radiodiffusion.

Une fois la construction achevée et les essais d'émission en onde faits, l'ingénieur-conseil en radiodiffusion retenu par le requérant devra certifier au Ministère que la station peut être exploitée, conformément au mémoire technique approuvé, et il devra demander l'autorisation de commencer l'exploitation. Sauf en ce qui a trait aux stations de faible puissance, la certification devra être appuyée par une preuve de performance préliminaire ou finale.

1.6 Demande d'indicatif d'appel

La demande d'indicatif d'appel relative à une nouvelle station devra se faire par écrit en même temps que la demande de CTCF. Quant aux stations existantes pour lesquelles on demande une modification d'indicatif d'appel, la demande devra être envoyée par écrit au Ministère. Les règles ayant trait aux indicatifs d'appel se trouvent dans les RÈGLES GÉNÉRALES, section 7, "Lignes directrices régissant l'assignation des indicatifs d'appel aux stations de radiodiffusion AM, FM et de télévision". La liste des lettres d'indicatif d'appel inutilisées est disponible, sur demande.

1.7 Définitions

1.7.1 Voie de radiodiffusion à modulation d'amplitude

Partie du spectre des fréquences égale à la largeur de bande nécessaire aux stations de radiodiffusion sonore à modulation d'amplitude et caractérisée par la valeur nominale de la fréquence porteuse située au centre de cette partie du spectre.

If a submission is found to be technically unacceptable, the applicant will be so notified. The application will be held in abeyance for a specified period of time awaiting possible revisions before being returned.

If the application for a broadcasting licence is approved by the CRTC, and the Department has found the application for a TC & OC to be technically acceptable, the applicant is given written authority to commence construction of the station.

1.5 On-Air Approval

The Department's District Manager shall be informed and DOC Form 16-656 "Data Required Regarding the Structural Adequacy of Antenna Towers and Antenna Supporting Structures" shall be submitted (unless there is no change to the existing antenna structure) prior to any on-air transmission tests. This notice shall be given at least three weeks prior to the anticipated date for commencement of broadcasting.

When the construction is complete and the on-air transmission tests have been made, the applicant's consultant shall certify to the Department that the station is ready to commence operation in accordance with the approved technical submission and request permission to commence operation. Except for low power stations, the certification shall be supported by a Preliminary or Final Proof of Performance.

1.6 Application for Call Signs

Application for a call sign for a new station is to be made in writing at the time of the application for the TC & OC. For existing stations requesting a change in call sign, an application is to be made in writing to the Department. The rules pertaining to call signs are contained in the GENERAL RULES, Section 7, "Guidelines for the Assignment of Call Signs to AM, FM and TV Broadcasting Stations". A listing of unassigned call letters is available on request.

1.7 Definitions

1.7.1 AM Broadcasting Channel

A part of the frequency spectrum, equal to the necessary bandwidth of AM sound broadcasting stations, and characterized by the nominal value of the carrier frequency located at its centre.

1.7.2 Zone de service primaire

Zone de service délimitée par le contour à l'intérieur duquel le niveau calculé du champ de l'onde de sol est protégé contre les brouillages opposables conformément aux dispositions du chapitre 4 de l'annexe 2 à l'Accord Canada/É.-U.

1.7.3 Zone de service secondaire

Zone de service délimitée par le contour à l'intérieur duquel le niveau calculé du champ médian de l'onde ionosphérique pendant 50% du temps est protégé contre les brouillages opposables conformément aux dispositions du chapitre 4 de l'annexe 2 à l'Accord Canada/É.-U.

1.7.4 Contour de protection

Ligne continue qui délimite la zone de service primaire ou secondaire protégée contre les brouillages opposables.

1.7.5 Brouillage opposable

Brouillage causé par un signal qui dépasse la valeur maximale admissible du champ à l'intérieur du contour protégé.

1.7.6 Champ nominal utilisable (E_{nom})

Valeur minimale conventionnelle du champ nécessaire pour assurer une réception satisfaisante, dans des conditions spécifiées, en présence de bruit atmosphérique, de bruit artificiel et de brouillages dus à d'autres émetteurs. La valeur du champ nominal utilisable est celle que l'on a utilisée comme référence pour la planification (voir chapitre 4 de l'annexe 2 à l'Accord Canada/É.-U.).

1.7.7 Champ utilisable (E_u)

Valeur minimale du champ nécessaire pour assurer une réception satisfaisante, dans des conditions spécifiées, en présence de bruit atmosphérique, de bruit artificiel et de brouillages dans une situation réelle (ou résultant d'un plan d'assignation de fréquence).

1.7.8 Exploitation diurne

Exploitation entre les heures locales de lever et de coucher du soleil.

1.7.9 Exploitation nocturne

Exploitation entre les heures locales de coucher et de lever du soleil.

1.7.2 Primary Service Area

Service area delimited by the contour within which the calculated level of the groundwave field strength is protected from objectionable interference in accordance with the provisions of Chapter 4 of Annex 2, Canada/USA Agreement.

1.7.3 Secondary Service Area

Service area delimited by the contour within which the calculated level of the field strength due to the skywave field strength 50 % of the time is protected from objectionable interference in accordance with the provisions of Chapter 4 of Annex 2, Canada/USA Agreement.

1.7.4 Protected Contour

Continuous line that delimits the area of primary or secondary service which is protected from objectionable interference.

1.7.5 Objectionable Interference

Interference caused by a signal exceeding the maximum permissible field strength within the protected contour.

1.7.6 Nominal Usable Field Strength (E_{nom})

Agreed minimum value of the field strength required to provide satisfactory reception, under specified conditions, in presence of atmospheric noise, man-made noise and interference from other transmitters. E_{nom} has been employed as the reference for planning (see Annex 2, Chapter 4 of Canada/USA Agreement).

1.7.7 Usable Field Strength (E_u)

Minimum value of the field strength required to provide satisfactory reception under specified conditions in the presence of atmospheric noise, man-made noise, and interference in a real situation (or resulting from a frequency assignment plan).

1.7.8 Daytime Operation

Operation between the times of local sunrise and local sunset.

1.7.9 Night-time Operation

Operation between the times of local sunset and local sunrise.

1.7.10 Onde de sol

Onde électromagnétique qui se propage à la surface de la Terre, ou au voisinage de cette surface, et qui n'a pas subi de réflexion sur l'ionosphère.

1.7.11 Onde ionosphérique

Onde électromagnétique qui a été réfléchie par l'ionosphère.

1.8 Classification

1.8.1 Station de classe A*

Une station de classe A est destinée à couvrir des zones de service primaire et secondaire étendues; elle est protégée en conséquence contre les brouillages.
La puissance maximale d'une station de classe A est 50 kW.

1.8.2 Station de classe B*

Une station de classe B est destinée à couvrir, à l'intérieur de sa zone de service primaire, une ou plusieurs agglomérations ainsi que les zones rurales contiguës; elle est protégée en conséquence contre les brouillages.

La puissance maximale d'une station de classe B est 50 kW.

1.8.3 Station de classe C*

Une station de classe C est destinée à couvrir, à l'intérieur de sa zone de service primaire, une ville, une localité et les zones suburbaines contiguës; elle est protégée en conséquence contre les brouillages.

La puissance maximale d'une station de classe C est 1 kW.

1.8.4 Station de faible puissance

Une station de faible puissance est destinée à couvrir une ville ou un village et la zone contiguë. Elle n'est pas protégée contre le brouillage provoqué par des stations de classe A, B ou C et elle doit prendre des mesures correctives si elle cause du brouillage à de telles stations.

La puissance maximale d'une station de faible puissance est 50 W.

* Pour les critères de protection, se reporter au chapitre 4 de l'annexe 2 à l'Accord Canada/É.-U.

1.7.10 Groundwave

Electromagnetic wave which is propagated along the surface of the earth or near it and which has not been reflected by the ionosphere.

1.7.11 Skywave

Electromagnetic wave which has been reflected by the ionosphere.

1.8 Classification

1.8.1 Class A Station*

A Class A station is intended to provide coverage over extensive primary and secondary service areas, and is protected against interference accordingly.
The maximum power of a class A station shall be 50 kW.

1.8.2 Class B Station*

A Class B station is intended to provide coverage over one or more population centres and the contiguous rural areas located in their primary service area, and which is protected against interference accordingly.

The maximum power of a class B station shall be 50 kW.

1.8.3 Class C Station*

A Class C station is intended to provide coverage over a city or town and the contiguous suburban areas located in its primary service area, and which is protected against interference accordingly.

The maximum power of a class C station shall be 1 kW.

1.8.4 Low Power Station

A low power station is intended to provide coverage over a town or village and the immediate contiguous area. It is not protected against interference from Class A, B or C stations and must take remedial action if it causes interference to such stations.

The maximum power of a low power station shall be 50W.

* For protection criteria see Chapter 4 of Annex 2, Canada/USA Agreement.

1.8.5 <u>Station à courants porteurs</u>

Une station à courants porteurs est destinée à assurer un service à l'intérieur d'une propriété donnée, normalement en injectant le signal RF dans une ligne secteur ou un câble irradiant. Cette station n'est pas protégée contre le brouillage provenant des stations de classe A, B ou C ou des stations de faible puissance et elle doit prendre les mesures correctives nécessaires si elle cause du brouillage à de telles stations.

1.8.5 <u>Carrier Current Station</u>

A carrier current station is intended to provide service within a given property, normally by feeding the RF signal into a power line or leaky cable. It is not protected against interference from Class A, B, C or low power stations and must take remedial action if it causes interference to such stations.

2. APERCU DES SECTIONS DU MÉMOIRE TECHNIQUE ET DÉTAILS EXIGÉS DANS CHACUNE D'ELLES

Ce qui suit est une liste des sections et sous-sections, ainsi que des détails nécessaires, que le mémoire technique devrait comprendre. Suivre l'ordre donné, afin de faciliter le traitement au sein du Ministère.

2.1 Page titre - Elle devrait comprendre le titre de la demande, le numéro de projet ou de référence, la date, le nom du requérant, le nom de l'ingénieur-conseil et l'endroit de la station. Elle devra aussi donner les paramètres suivants du projet: fréquence, puissance, classe et mode d'exploitation.

2.2 Table des matières

2.3 Section principale du mémoire

2.3.1 Introduction - Exposé général du but du mémoire en ce qui concerne la demande.

2.3.2 Discussion - Considérations relatives à la conception et visant à atteindre les objectifs du requérant, y compris le choix de la fréquence et de l'endroit de l'emplacement, surtout en ce qui concerne la limitation du brouillage qui peut être reçu et du brouillage qui peut être causé par l'exploitation projetée. Cette partie devra aussi comprendre des exposés sur les points suivants:

(a) champs minimal et maximal relatifs aux zones métropolitaines (conformément à la section C-3).

(b) service diurne dans les zones rurales (un minimum de 0,5 mV/m devra être assuré).

(c) service nocturne (champ utilisable).

2.3.3 Hypothèses et sources de renseignements - Dresser la liste de toutes les hypothèses faites en ce qui concerne la conductivité, les limitations existantes et la combinaison des signaux de brouillage, etc., et les expliquer. Indiquer également les sources de renseignements, toute équation ne figurant pas dans l'Accord Canada/É.-U., les cartes, diagrammes d'antennes directives d'autres stations, etc.

2.3.4 Analyse du brouillage par onde de sol - Analyse générale et résumé de l'étude détaillée à faire dans une section ultérieure du mémoire. L'ÉCHANTILLON de l'ANNEXE 1 montre les renseignements nécessaires et la présentation préférée.

2.3.5 Analyse du brouillage par onde ionosphérique - Analyse générale et résumé de l'étude détaillée à faire dans une section ultérieure du mémoire. L'ÉCHANTILLON de l'ANNEXE 2 montre les renseignements nécessaires et la présentation préférée.

2. OUTLINE OF SECTIONS AND DETAILS REQUIRED IN EACH SECTION OF THE ENGINEERING BRIEF

The following list of sections and sub-sections with required details, should be included in the engineering brief. The order should be maintained to facilitate processing by the Department.

2.1 Title Page - Should include submission title, project or reference number, date. Name of applicant, name of consultant and location of station. It shall also list the following parameters of the proposal - frequency, power, class and mode of operation.

2.2 Table of Contents

2.3 Main Section of the Brief

2.3.1 Introduction - A general statement of the purpose for the brief in relation to the application.

2.3.2 Discussion - On the design considerations to accomplish the applicant's objectives, including the choice of frequency and location of site, with particular reference to interference limitations which may be received and caused by the proposed operation. Statements shall also be included with reference to the following:

(a) maximum-minimum field strengths for metropolitan areas (in compliance with Section C-3);

(b) daytime rural service (a minimum of 0.5 mV/m to be provided);

(c) night-time service (E_u).

2.3.3 Assumptions and Sources of Information - List and explain all assumptions which are made regarding conductivity, existing limitations, and combination of interference signals, etc. Also list the sources of information, any equation not listed, or referred to in the Canada/USA Agreement, maps, directional antenna patterns of other stations, etc.

2.3.4 Groundwave Interference Analysis - A general analysis and a summary of the detailed study to be made in a later section of the brief. The SAMPLE SHEET of APPENDIX 1 shows the information required in the format prefered.

2.3.5 Skywave Interference Analysis - A general analysis and a summary of the detailed study to be made in a later section of the brief. The SAMPLE SHEET of APPENDIX 2 shows the information required in the format prefered.

2.3.6 <u>Brouillage par fréquence image</u> - (Se reporter à la section C-7). S'il n'est pas possible de satisfaire aux critères de la section C-7, fournir les renseignements supplémentaires qui suivent à l'appui d'une exception:

(a) justification du choix de la fréquence projetée;

(b) carte montrant la zone de chevauchement des contours pertinents des deux stations;

(c) estimation du nombre de récepteurs de radiodiffusion dans la zone de chevauchement;

(d) engagement du requérant à étudier les plaintes de brouillage par fréquence image et à assumer la responsabilité financière entière des mesures de correction.

2.3.7 <u>Brouillage par intermodulation et par transmodulation</u> - (se reporter à la section C-8) - Inclure des exposés relatifs à la possibilité de brouillage par intermodulation et(ou) transmodulation entre stations de radiodiffusion dans la zone et aux mesures correctives à prendre au cas où un tel brouillage se produirait.

2.3.8 <u>Autres renseignements importants</u> - Inclure dans cette section les autres renseignements techniques relatifs au projet. Par exemple, il devra y avoir un énoncé affirmant que l'émetteur a été ou sera homologué. Il y a lieu aussi de faire des observations générales en ce qui concerne l'alimentation en programmes, les opérations de réémission, etc.

2.3.9 <u>Qualification des ingénieurs</u> - Dans cette sous-section, donner la liste des noms et signatures des personnes responsables de la préparation du mémoire technique. Il est important de noter qu'au moins une signature devra être celle d'un ingénieur possédant une vaste expérience dans le domaine de la radiodiffusion AM. Son sceau ou tampon d'ingénieur devrait aussi apparaître dans cette section et sur toutes les cartes de couverture.

2.4 <u>Description de l'antenne</u>

Remplir les formules applicables indiquées dans l'Accord Canada/É.-U., annexe 1, parties I à V. Des renseignements supplémentaires devront être fournis sur le type de chaque élément du système d'antennes (c.-à-d. haubané ou non-haubané, de section triangulaire ou carrée, de section uniforme ou variable, etc.).

2.5 <u>Diagramme d'intensité de champ dans le plan horizontal</u>

2.5.1 Les méthodes à utiliser pour calculer les diagrammes des antennes directives sont détaillées dans l'appendice 3 à l'annexe 2 à l'Accord Canada/É.-U. Cet appendice donne les méthodes à employer pour calculer le diagramme élargi et le diagramme

2.3.6 <u>Image Interference</u> - (Refer to Section C-7) - If it is not possible to meet the criteria of Section C-7, the following additional information is required in support of an exception:

(a) a justification for selection of the frequency proposed;

(b) a map showing the area of overlap of the pertinent contours of both stations;

(c) an estimate of the number of broadcast receivers within the area of overlap;

(d) a commitment that the applicant will investigate complaints of image interference and assume full financial responsibility for the remedial measures.

2.3.7 <u>Intermodulation/Cross-Modulation Interference</u> - (Refer to Section C-8) - Statements shall be included regarding the possibility of interference due to intermodulation/cross-modulation between broadcasting stations in the area and the remedial measures to be taken should such interference result.

2.3.8 <u>Other Significant Information</u> - Other technical information pertinent to the proposal should be included in this section. For example, there shall be a statement that the transmitter will be or has been type approved. General comments should also be made respecting audio feed, rebroadcasting operations, etc.

2.3.9 <u>Qualification of Engineers</u> - This sub-section shall contain a listing of names and signatures of those responsible for the preparation of the engineering brief. It is important to note that one signature at least, shall be that of an engineer with considerable experience in the AM broadcasting field, whose engineering seal or stamp should also appear in this section and on all coverage maps.

2.4 <u>Description of Antenna System and Array</u>

Forms listed in the Canada/USA Agreement, Annex 1, Parts I to V shall be completed as applicable. Additional information shall be given on the type of each element of the array (i.e. guyed or self-supporting, triangular or square, uniform cross-section or tapered etc.).

2.5 <u>Horizontal Field Strength Patterns</u>

2.5.1 The methods to be used in calculating directional antenna patterns are detailed in Annex 2, Appendix 3, of the Canada/USA Agreement, which includes methods to be used in calculating the expanded pattern and the modified pattern as well as criteria modifié, ainsi que les critères relatifs à la réduction des tolérances de conception. Le calcul du diagramme d'intensité de champ dans le plan horizontal pour chaque puissance ou diagramme en question devra mentionner:

(a) l'intensité de champ directive non atténuée à un kilomètre du diagramme élargi ou du diagramme modifié, selon le cas, et l'intensité de champ équidirective non atténuée équivalente (valeur quadratique moyenne) du diagramme théorique à un kilomètre;

(b) le nord géographique indiqué comme azimut zéro;

(c) la direction et la distance de chaque station existante avec laquelle peut se présenter un problème de brouillage.

2.5.2 Mentionner les renseignements concernant toute variation par rapport à la pratique normale, utilisée pour le calcul des diagrammes ci-dessus, comme:

(a) les formules utilisées pour calculer les diagrammes dans le plan horizontal et dans le plan vertical, ainsi qu'un exemple de calcul et leur dérivation;

(b) les hypothèses utilisées et leur fondement, y compris la hauteur électrique, la distribution de courant et le rendement de chaque élément, ainsi que les conductivités du sol.

2.5.3 Utiliser les lignes directrices qui suivent pour tracer les diagrammes d'intensité de champ:

(a) tracer les diagrammes élargis ou modifiés, définis dans l'appendice 3 à l'annexe 2 à l'Accord Canada/É.-U., sur du papier format papier à lettre ordinaire, à coordonnées polaires présentant des marges appropriées,

(b) tracer tous les diagrammes à la plus grande échelle possible sur le papier mentionné en (a) ci-dessus,

(c) indiquer à une échelle agrandie toutes les valeurs d'intensité de champ inférieures à 10 % de la valeur quadratique moyenne de l'intensité de champ du diagramme.

2.6 Formule 16-879 du MDC

Cette formule devra être remplie pour toutes les demandes et l'on devra prendre bien soin de remplir chaque section.

2.7 Tracé du plan de la propriété de la station montrant l'emplacement du pylône et du réseau de terre

Inclure dans le mémoire technique, sur une feuille de papier de format papier à lettre ordinaire, les renseignements suivants:

for reduced design tolerence. The calculation of horizontal field strength pattern for each power or pattern involved shall outline:

(a) unattenuated directional field strength at one kilometre of the expanded or modified pattern as applicable and the equivalent unattenuated non-directional (r.m.s.) field strength of the theoretical pattern at one kilometre;

(b) true north shall be shown at zero azimuth;

(c) direction and distance to each existing station, with which interference may be involved.

2.5.2 Information concerning any variations from the normal practice, used in computing the above patterns shall be included such as:

(a) formulae used for calculating both horizontal and vertical patterns and sample calculations and their derivation;

(b) assumptions made and basis therefore, including electrical height, current distribution and efficiency of each element and ground conductivities.

2.5.3 The following guidelines shall be used in plotting field strength patterns:

(a) the expanded or modified patterns as defined in the Canada/USA Agreement, Annex 2, Appendix 3 shall be plotted on standard letter size polar coordinate paper with adequate margin;

(b) all patterns shall be plotted to the largest scale possible on the paper specified in (a);

(c) all values of field strength less than 10 percent of the r.m.s. field strength of the pattern shall be shown on an enlarged scale.

2.6 Completing of DOC Form 16-879

This Form shall be completed for all applications and extreme care should be exercised in completing each section.

2.7 Plot Plan of Station Property Showing Location of Tower and Ground System

Information is required as follows on one standard letter size sheet in the brief:

1. tracé du plan de la propriété de la station, à une échelle convenable, montrant l'emplacement de l'antenne ainsi que les limites du réseau de terre;

2. carte à l'échelle 1/50 000, montrant l'emplacement de l'émetteur;

3. latitude et longitude du centre du système d'antenne, arrondies à la seconde la plus proche. Si un emplacement n'a pas été choisi au moment de la demande, on pourra désigner un emplacement provisoire en vue de satisfaire aux exigences de la présente procédure de demande étant entendu qu'une soumission distincte sera présentée à une date ultérieure, pour faire approuver par le Ministère l'emplacement définitif, une fois choisi.

Les requérants sont priés de noter qu'ils devraient obtenir une option sur la parcelle de terrain choisie avant de soumettre à l'approbation du Ministère les renseignements portant sur l'emplacement projetté.

2.8 Discussion de tout facteur pouvant provoquer une distorsion des diagrammes d'antenne prévus

Si, pour une raison quelconque, le diagramme calculé dans le plan horizontal ou les diagrammes caractéristiques dans le plan vertical ont peu de probabilité d'être réalisés, à moins que des mesures extraordinaires soient prises, le mémoire technique devra inclure une analyse détaillée de l'anomalie, ainsi qu'un exposé relatif aux mesures correctives qui pourraient être prises pour redonner au diagramme sa forme normale.

2.9 Analyses du brouillage

2.9.1 Analyses de brouillage par onde de sol (de jour et de nuit)

Préparer les analyses du brouillage par onde de sol conformément aux indications de l'ÉCHANTILLON de l'ANNEXE 1. On trouvera les détails portant sur les règles de protection, les courbes de conductivité du sol et les méthodes de calcul à la section C-2, ainsi qu'au chapitre 2 de l'annexe 2 à l'Accord Canada/É.-U.

Une analyse de brouillage nocturne causé par une station fonctionnant sur une voie adjacente pour la région désservie par onde de sol, devra être préparée conformément à la section C-5.

Dans les analyses du brouillage par onde de sol, si le rayonnement dans un secteur particulier approche de la valeur exigée pour protéger une autre assignation, le dégagement devra être confirmé sur un arc. Il faut donc faire une analyse du brouillage par onde de sol pour un certain nombre d'azimuts à partir des stations en cause. Ces points devraient être identifiés par leurs coordonnées géographiques ou dans une partie de carte distincte qui devrait être jointe au mémoire, pour chacun de ces cas. Sur la carte, tracer les contours protégés et

1. a plot plan of suitable scale showing the location of the antenna and limits of ground system marked thereon;

2. a map of scale 1:50,000 on which the transmitting site is shown;

3. latitude and longitude of the centre of the antenna system to the nearest second. If a site has not been selected at the time the application is made a tentative site may be submitted to fill the requirements of this application procedure, with the understanding that negotiations for Departmental approval of the final site, when selected, is made in a separate submission at a later date.

When the proposed site is submitted for approval, applicants are cautioned that an option should be obtained on the selected piece of property before submitting the information thereon to the Department.

2.8 Discussion of Any Factors which Could Distort the Intended Antenna Patterns

If for any reason the calculated horizontal radiation pattern or characteristic vertical patterns are unlikely to be realized, unless extraordinary measures are taken, a detailed analysis of the abnormality shall be included in the engineering brief with a statement relative to any corrective measures which might be undertaken to attempt to achieve the intended shape of the pattern.

2.9 Interference Analyses

2.9.1 Groundwave Interference Analyses (Day and Night)

Groundwave interference analyses are to be prepared according to SAMPLE SHEET of APPENDIX 1. Details such as protection rules, ground conductivity curves and methods of calculation may be found in Section C-2 and also in Annex 2, Chapter 2 of Canada/USA Agreement.

Analysis of night-time interference to the groundwave service area from adjacent channel stations are to be prepared in accordance with Section C-5.

In groundwave analyses, where radiation in a particular sector is approaching the value required to protect another assignment, the clearance shall be confirmed over an arc. This necessitates a groundwave study on a number of bearings from the stations involved. These points should be identified by geographical co-ordinates or in a separate map segment, for each of these cases, should be included in the brief. On this map, the protected and les contours brouilleurs pour montrer le dégagement auquel on s'attend.

Note: Le Ministère fournira des renseignements sur les assignations, y compris sur l'emplacement des contours de protection des stations canadiennes, renseignements qu'il tirera des preuves de performance figurant dans les dossiers du Ministère.

2.9.2 Analyses du brouillage par onde ionosphérique

Préparer les analyses du brouillage par onde ionosphérique conformément à l'ÉCHANTILLON de l'ANNEXE 2. Les détails, tels que les règles de protection, les courbes d'onde ionosphérique et la méthode de calcul se trouvent au chapitre 4 de l'annexe 2 à l'Accord Canada/É.-U. (voir aussi la section C-4).

2.9.3 Calcul de distance et d'azimut

Tous les calculs de distance et d'azimut devront se fonder sur le trajet sur le petit arc du grand cercle, en supposant une Terre sphérique d'un rayon de 6370 km (un degré à la surface de la Terre représentant 111,18 km).

2.10 Cartes montrant les contours pertinents d'intensité de champ

Pour chaque diagramme de rayonnement projeté (c'est-à-dire si les puissances et les diagrammes diffèrent le jour et la nuit), tracer les contours d'intensité de champ qui suivent sur des cartes à jour (se reporter à la section 3 des RÈGLES GÉNÉRALES):

1000, 250, 25, 15, 5 et 0,5 mV/m, E_u et, s'il est compris dans le contour 0,5 mV/m, le contour qui est 20 % de E_u.

2.11 Exigences supplémentaires

Si le projet comporte l'acceptation de brouillage opposable, tel qu'il est défini dans les deux accords, indiquer les zones en question par des hachures sur les cartes de couverture.

2.12 Liste de contrôle du mémoire technique

Remplir un exemplaire de la formule 16-848 de MDC, intitulée "Liste de contrôle du mémoire technique à l'appui d'une demande d'établissement ou de modification d'une installation de radiodiffusion MA", et la joindre en annexe au mémoire technique.

2.13 Engagements

Joindre les engagements qui suivent, concernant la résolution de tout problème possible de brouillage telle qu'exigée par les sections précédentes:

1. brouillage par fréquence image (section B-2.3.6 et section C-7.2);

interfering contours should be drawn to demonstrate the expected clearance.

Note: The Department will make available assignment information, including the location of protected field strength contours of Canadian stations from proofs of performance in Departmental records.

2.9.2 Skywave Interference Analyses

Skywave interference analyses are to be prepared according to the SAMPLE SHEET of APPENDIX 2. Details such as protection rules, skywave curves and method of calculating may be found in Annex 2, Chapter 4, of Canada/USA Agreement (also note Section C-4).

2.9.3 Calculation of Distance and Azimuth

All calculations of distance and azimuth are to be based on the short great-circle path assuming a spherical earth of radius 6370 km (one degree on the surface of the earth equals 111.18 km).

2.10 Maps Showing Pertinent Field Strength Contours

The following field strength contours shall be plotted for each radiation pattern proposed (i.e., if powers and patterns are different day and night), on up-to-date maps (refer to Section 3 of GENERAL RULES):

1000, 250, 25, 15, 5 and 0.5 mV/m, Eu and if within 0.5 mV/m contour, the contour which is 20 % of E_u.

2.11 Additional Requirements

When the proposal involves the acceptance of objectionable interference as defined in both agreements, such areas shall be shown by cross-hatched areas on coverage maps.

2.12 Engineering Brief Check List

The engineering brief check list, DOC Form 16-848 "Technical Brief Checklist in Support of Application for Establishment or Change of AM Broadcast Facilities", shall be completed and included as an appendix in the engineering brief.

2.13 Commitments

The commitments relating to the resolution of any potential interference problems as required in the above Sections, shall be included:

1. image interference (Section B-2.3.6 and Section C-7.2);

2. blocage de la réception ou transmodulation externe (section C-3.3);

3. intermodulation et transmodulation (section C-8.2);

4. maintien des diagrammes directionnels avec tolérances réduites (section B-2.5.1 et addendum B de l'appendice 3 à l'annexe 2 à l'Accord Canada/É.-U.);

5. tout engagement pris pour conclure une entente avec une autre station, en particulier en ce qui a trait au "blocage" (section C-6.2) et aux dérogations aux exigences normales de protection (section C-9).

2. blanketing or external cross-modulation (Section C-3.3);

3. intermodulation and cross-modulation (Section C-8.2);

4. maintenance of reduced tolerance directional patterns (Section B-2.5.1 and Annex 2, Appendix 3, Attachment B of Canada/USA Agreement);

5. any commitment which may have been made in reaching agreement with another station, particularly in relation to "lock-in" (Section C-6.2) and departures from normal protection requirements (Section C-9).

3. PREUVE DE PERFORMANCE FINALE DES ANTENNES DIRECTIVES

Une installation est jugée incomplète jusqu'à ce que la preuve de performance finale de l'antenne directive ait été complétée et approuvée par le Ministère.

3.1 Documentation (en quatre exemplaires)

Lorsque le requérant projette d'exploiter une station avec une antenne directive, soit à temps complet, soit à temps partiel, il est nécessaire qu'il soumette la preuve que le diagramme produit par l'antenne correspond au diagramme prévu et approuvé pour cette station, à la fois en ce qui concerne la forme et les dimensions dans des tolérances acceptables. La limite supérieure normale est celle du diagramme élargi et la limite inférieure normale est 5 % au-dessous du diagramme théorique. Tout écart dépassant cette limite devrait être justifié. De même, si la limite supérieure est dépassée mais que cela ne conduirait pas à du brouillage, le diagramme peut être modifié conformément à l'appendice 3 à l'annexe 2 à l'Accord Canada/É.-U. La limite supérieure ne devra pas être dépassée, s'il en résultait du brouillage. Il est aussi nécessaire que la preuve soit présentée en ce qui concerne la performance réelle des éléments rayonnants, y compris les caractéristiques d'impédance et le rendement de l'antenne.

Les contours d'intensité de champ sont nécessaires pour montrer la couverture réelle de la station, bien que le contour protégé contre le brouillage causé par d'autres stations est celui qui est calculé conformément au chapitre 2 de l'annexe 2 à l'Accord Canada/É.-U., à moins d'un accord spécifique entre les stations en cause.

Les données suivantes devront être présentées dans la preuve de performance, ainsi qu'une description de la procédure à suivre pour obtenir ces données.

3.2 Mesures d'intensité de champ pour établir l'intensité du champ équivalent à un kilomètre

En commençant aussi près que possible de l'antenne, sans inclure le champ d'induction et en tenant compte du fait qu'une antenne de radiodiffusion n'est pas une source de rayonnement ponctuelle, prendre des mesures sur huit lignes radiales ou plus, à intervalles d'environ:

- 200 mètres jusqu'à trois kilomètres de l'antenne;
- un kilomètre, entre trois et 10 kilomètres de l'antenne;
- et trois kilomètres au-delà de 10 kilomètres, s'il y a lieu.

3. FINAL PROOF OF PERFORMANCE FOR DIRECTIONAL ANTENNAS

An installation is deemed to be incomplete until such time as the Final Proof of Performance of the directional antenna system has been submitted to and approved by the Department.

3.1 Documentation (in quadruplicate)

When a station proposes to operate with a directional antenna either full- or part-time, it is necessary that proof be submitted that the pattern produced by the antenna array agrees with the pattern predicted and approved for that station, both as to shape and size within an acceptable tolerance. The normal upper limit is the expanded pattern and the normal lower limit is 5 % below the theoretical pattern. Any deviation beyond these limits should be justified. Also if the upper limit is exceeded but this would not lead to interference, the pattern may be modified in accordance with Annex 2, Appendix 3 of Canada/USA Agreement. The upper limit may not be exceeded if interference would result. It is also necessary that proof be submitted as to the actual performance of the radiating elements, including impedance characteristics and radiation efficiency.

Field strength contours are required to show the actual coverage of the station, although the contour protected against interference from other stations is that calculated, in accordance with Annex 2, Chapter 2 of Canada/USA Agreement, unless there is specific agreement between the stations involved.

Following are the data which shall be submitted in the proof of performance, together with a description of the procedure to be followed in obtaining these data.

3.2 Field Strength Measurements to Establish Effective Field Strength at One Kilometre

Beginning as near to the antenna as possible without including the induction field and to provide for the fact that a broadcast antenna is not a point source of radiation, measurements shall be made on eight or more radials, at intervals of approximately:

- 200 metres up to three kilometres from the antenna;
- one kilometre from three to 10 km from the antenna;
- and three kilometres beyond 10 km as required.

S'il est possible de prendre des mesures non obstruées, prendre 18 ou 20 sur chaque ligne radiale. Toutefois, lorsque les mesures non obstruées sont difficiles à faire, prendre les mesures sur chaque ligne radiale à autant d'emplacements non obstrués que possible, même si les intervalles sont considérablement inférieurs aux intervalles ci-dessus, en particulier dans un rayon de trois kilomètres de l'antenne. Dans les cas où il est impossible d'obtenir des mesures précises à de faibles distances (même à une distance de huit ou 10 kilomètres, à cause de la nature du terrain environnant), prendre à des intervalles plus rapprochés les mesures devant être faites à de plus grandes distances.

Porter ces données sur le papier pour chaque ligne radiale en utilisant du papier à coordonnées logarithmiques, porter l'intensité de champ en ordonnée et la distance en abscisse.

Toutefois, quelle que soit la méthode employée, la courbe à faire passer par les points portés sur le papier devra être déterminée par comparaison avec les courbes théoriques, de la façon suivante:

- tracer les courbes théoriques (se reporter à l'appendice 2 à l'annexe 2 à l'Accord Canada/É.-U.) pour plusieurs valeurs de conductivité approchant de la conductivité indiquée par les mesures sur une autre feuille de papier ayant les mêmes coordonnées;

- placer cette feuille sous la feuille sur laquelle les points réels ont été portés et la faire glisser sur l'autre jusqu'à ce qu'on trouve la courbe qui correspond le mieux aux points tracés;

- tracer ensuite cette courbe sur la feuille qui porte les points trouvés, ainsi que la courbe inversement proportionnelle à la distance qui lui correspond.

Le champ à un kilomètre pour la ligne radiale en question devra être en ordonnée sur la courbe inversement proportionnelle à la distance à un kilomètre.

Quand toutes les lignes radiales ont ainsi fait l'objet d'une analyse, tracer une courbe sur du papier à coordonnées polaires en se servant des intensités de champ inversement proportionnelles à la distance obtenues, ce qui donne le diagramme de champ inversement proportionnel à la distance à un kilomètre. Le rayon d'un cercle, dont l'aire est égale à celle de ce diagramme, est le champ équivalent.

En faisant les mesures d'intensité de champ, maintenir la puissance de sortie de la station à la puissance mentionnée sur le certificat technique, déterminée par la méthode directe. Si l'on utilise une puissance plus faible, les résultats de mesures devront être corrigés en conséquence. À cet effet, il est nécessaire de déterminer de façon aussi précise que possible les

Where unobstructed measurements can be made, there shall be as many as 18 or 20 on each radial. However, where unobstructed measurements are difficult to make, these shall be made on each radial at as many unobstructed locations as possible, even though the intervals are considerably less than stated above, particularly within three kilometres of the antenna. In cases where it is not possible to obtain accurate measurements at the closer distances (even out to eight or 10 kilometres due to the character of the intervening terrain), measurements at greater distances should be made at closer intervals.

These data should be plotted for each radial using log-log co-ordinate paper, plot field strength as ordinate and distance as abscissa.

However, regardless of which of these methods is employed, the proper curve to be drawn through the points plotted shall be determined by comparison with theoretical curves as follows:

- plot theoretical curves (refer Appendix 2 to Annex 2 of the Canada/USA Agreement) for several values of conductivities approximating the conductivity indicated by the measurements on another sheet of the same co-ordinate paper;

- place this sheet under the sheet on which the actual points have been plotted and adjust until the curve most closely matching the points is found;

- draw this curve on the sheet on which the points were plotted, together with the inverse distance curve corresponding to that curve.

  The field at one kilometre for the radial concerned shall be the ordinate on the inverse distance curve at one kilometre.

When all radials have been analyzed in this manner, a curve shall be plotted on polar co-ordinate paper from the inverse distance field strengths obtained, which give the inverse distance field pattern at one kilometre. The radius of a circle, the area of which is equal to the area bounded by this pattern, is the effective field.

While making the field strength measurement, the output power of the station should be maintained at the licensed power as determined by the direct method. If a lower power is used, the results of the measurements should be adjusted appropriately. To do this it is necessary to determine the antenna impedances as impédances d'antenne et de mesurer le courant d'antenne au moyen d'un ampèremètre de précision connue.

Présenter les données complètes obtenues en même temps que les mesures d'intensité de champ, et notamment:

1. tableau donnant chaque point de mesure par ordre numérique, ainsi que l'intensité de champ et la distance par rapport à l'antenne;

2. carte indiquant chaque point de mesure numéroté de façon à concorder avec le tableau exigé dans 1 ci-dessus;

3. courbes tracées pour chaque ligne radiale et le diagramme d'intensité de champ;

4. mesures d'impédance propre et d'impédance d'exploitation de l'antenne;

   (a) impédance d'exploitation (Z = R + jX) de l'antenne à la fréquence de la porteuse et l'impédance propre à la fréquence d'exploitation et à des échelons de 10 kHz sur une gamme de fréquences de ±30 kHz;

   (b) description de la méthode employée;

   (c) tableau de toutes les données;

   (d) courbes montrant l'impédance propre et l'impédance d'exploitation de l'antenne par rapport à la fréquence, sur une gamme de ±30 kHz;

5. courant(s) d'antenne maintenu(s) pendant les mesures d'intensité de champ;

6. tout autre renseignement pertinent.

3.3 <u>Mesures d'intensité de champ pour établir la performance des antennes directives</u>

Pour établir cette performance, faire des mesures conformément à la section 3.2 précédente, sur un nombre de lignes radiales suffisant pour établir le champ équivalent de l'antenne. Dans le cas du diagramme d'une antenne directive relativement simple, environ huit lignes radiales suffisent, en plus des lignes radiales dans les directions de limitation. Toutefois, lorsque des diagrammes plus compliqués sont en jeu, c'est-à-dire des diagrammes ayant plusieurs lobes très déterminés ou des zéros bien marqués, prendre les mesures le long d'autant de lignes radiales additionnelles que nécessaire pour établir le diagramme.

Présenter les renseignements suivants:

accurately as practical and to measure the antenna current by means of an ammeter of known accuracy.

Complete data taken in conjunction with the field strength measurements shall be submitted including the following:

1. tabulation by number of each point of measurement, the field strength and the distance from the antenna;

2. map showing each point of measurement numbered to agree with the tabulation required in 1 above;

3. the curves drawn for each radial and the field strength pattern;

4. antenna self- and operating impedance measurements.

    (a) Antenna operating impedance (Z=R+jX) at carrier and the self-impedance at the operating frequency and at 10 kHz steps over a ±30 kHz range.

    (b) Description of method employed.

    (c) Tabulation of all data.

    (d) Curves showing antenna self- and operating impedance versus frequency over the ±30 kHz range;

5. antenna current or currents maintained during field strength measurements;

6. any other pertinent information.

3.3 <u>Field Strength Measurements to Establish Performance of Directional Antennas</u>

To establish this performance, measurements shall be made in accordance with the preceding Section 3.2 along a sufficient number of radials to establish the effective field from the antenna system. In the case of a relatively simple directional antenna pattern, approximately eight radials in addition to the radials in the directions of limitation are sufficient. However, when more complicated patterns are involved, that is, patterns having several sharp lobes or nulls, measurements shall be taken along as many additional radials as necessary to establish the pattern.

The following information shall be submitted.

3.3.1 Description complète de l'antenne qui devra préciser:

(a) nombre d'éléments;

(b) type de chaque élément (haubané ou non haubané, de section triangulaire ou carrée, de section uniforme ou variable, etc.);

(c) détails relatifs à la charge terminale, le cas échéant;

(d) hauteur totale en mètres de chaque élément au-dessus du niveau du sol;

(e) orientation de l'antenne par rapport au nord géographique;

(f) espacement des éléments (donner cet espacement en mètres ainsi qu'en degrés);

(g) détails du réseau de terre pour chaque élément (longueur et nombre de fils radiaux, dimensions du tapis de sol, le cas échéant, et profondeur d'enfouissement);

(h) courant dans chaque élément (au point où se trouve l'ampèremètre d'antenne), courant et impédance au point d'entrée commun de l'antenne;

(i) lecture de phase (indiquer spécifiquement si elle est en retard ou en avance) et lecture du courant relatif pour chacun des éléments.

3.3.2 Diagramme d'intensité de champ dans le plan horizontal pour chaque puissance en cause:

(a) intensité de champ directive à un kilomètre et intensité du champ équivalent par rapport à l'antenne, déterminée à partir des calculs d'intensité de champ; indiquer ces points sur le diagramme élargi (ou modifié, le cas échant);

(b) indiquer le nord géographique comme l'azimut zéro;

(c) direction et indicatif d'appel de chaque station pour laquelle la protection est nécessaire selon les dispositions de l'Accord régional pour la Région 2 ou de l'Accord Canada/É.-U., et comme l'indique le mémoire technique, ainsi que l'intensité de champ dans chacune de ces directions, comme les mesures l'ont déterminée.

3.3.3 Tout autre renseignement pertinent.

3.3.4 Tracé des diagrammes d'intensité de champ (se reporter à la section B-2.5.3).

3.3.1 A description of the antenna array which shall outline:

(a) number of elements;

(b) type of each element (i.e. guyed or self-supporting, triangular or square, uniform cross-section or tapered, etc);

(c) if top-loaded, give details;

(d) overall height (in metres) of each element above ground level;

(e) orientation of array with respect to true north;

(f) space phasing of elements (space phasing should be given in metres as well as in degrees);

(g) details of ground system for each element (length and number of radials, dimensions of ground screen if used, and depth buried);

(h) current in each element (at point where antenna ammeter is located) and current and impedance at point of common input to the antenna system;

(i) the phase readings (specifying whether leading or lagging) and the relative current readings for each element.

3.3.2 Horizontal field strength patterns for each power involved showing:

(a) directional field strength at one kilometre and effective field strength from the antenna determined from the field strength calculations. These points should be shown on the expanded (or modified if applicable) pattern;

(b) true north shall be shown at zero azimuth;

(c) direction and call sign of each station to which protection is required under the provisions of RAMFBC-R2 or Canada/USA Agreements, and as shown in the engineering brief and the field strength in each such direction as determined from measurements.

3.3.3 Any other pertinent information.

3.3.4 Plotting of field strength patterns (refer to Section B-2.5.3).

3.3.5 Présentation des cartes de contour qui devront figurer:

(a) tracer sur la plus grande échelle possible les contours d'intensité de champ mesurée pour 1000, 250, 25, 15, 5 et 0,5 mV/m, E_u et 20 % de E_u ou l'intensité de champ nominale utilisable (la valeur la plus grande étant retenue);

(b) tableau de toutes les données utilisées pour tracer les diagrammes ci-dessus.

3.4 <u>Instruments de mesure et qualifications</u>

En ce qui a trait aux instruments utilisés et à la surveillance des mesures, les renseignements suivants devront être fournis:

1. description, précision, date d'étalonnage de chaque instrument et le nom de la personne qui l'a étalonné;

2. nom, tampon et signature de l'ingénieur responsable des mesures.

3.3.5 Presentation of contour maps which shall include:

(a) measured field strength contours for 1000, 250, 25, 15, 5 and 0.5 mV/m, E_u and 20 % of the E_u or nominal usable field strength (whichever is greater), shall be plotted on a map or maps having the largest practical scale;

(b) tabulation of all data used in plotting the above patterns.

3.4 Test Equipment and Qualifications

Concerning the test equipment used and supervision of measurements, the following information shall be provided:

1. description, accuracy, date and by whom each instrument was last calibrated;

2. name, stamp and signature of the engineer responsible for the measurements.

4. <u>PREUVE DE PERFORMANCE PRÉLIMINAIRE DES ANTENNES DIRECTIVES</u>

4.1 Le Ministère reconnaît que les études et les calculs nécessaires pour établir une preuve finale de performance peuvent prendre beaucoup de temps, et c'est pourquoi il accepte normalement une preuve préliminaire de performance dans le but uniquement de permettre à la station de commencer son exploitation, à condition que la preuve de performance finale lui soit présentée dans les 90 jours qui suivent.

4.2 La preuve de performance préliminaire (à présenter en 4 exemplaires au moins 5 jours ouvrables avant le début de la diffusion régulière) devra comprendre:

1. la preuve de la forme du diagramme déterminée à partir des mesures d'intensité de champ prises à une distance commode de l'émetteur, à des intervalles d'environ 15°, au moyen du rapport entre l'exploitation avec diagramme directif et avec diagramme équidirectif, ou par toute autre méthode acceptable, comme celle des lignes radiales courtes, si un diagramme équidirectif fiable n'est pas disponible;

2. la preuve des dimensions du diagramme, au moyen d'une série de lectures prises le long d'une ligne radiale dans un lobe principal, jusqu'à une distance d'au moins 16 km. Le champ équivalent approximatif à un kilomètre, la courbe d'atténuation et la conductivité moyenne pour la région devront être déterminés à partir de ces lectures;

3. l'impédance d'exploitation ($Z = R + jX$) de l'antenne à la fréquence de la porteuse et l'impédance propre à la fréquence d'exploitation et à des échelons de 10 kHz sur une gamme de plus ou moins 30 kHz.

4.3 Dans le cas où la protection d'autres stations sur la même voie ou sur une voie adjacente est exigée, on devra effectuer des mesures additionnelles, afin de démontrer qu'il ne résultera aucun brouillage du fonctionnement de la station pour laquelle une preuve de performance est présentée.

4. PRELIMINARY PROOF OF PERFORMANCE FOR DIRECTIONAL ANTENNAS

4.1 It is recognized that the surveys and calculations necessary for a Final Proof of Performance may take considerable time. For this reason the Department normally will accept a Preliminary Proof of Performance for the purpose only of permitting the station to commence operation, provided that the Final Proof of Performance is submitted within 90 days.

4.2 The Preliminary Proof of Performance (to be submitted in quadruplicate at least five working days before commencement of regular broadcasting) shall consist of:

1. proof of the shape of the pattern determined from field strength measurements taken at a convenient distance from the transmitter at approximately 15 degree intervals, by means of ratio between the directional pattern and non-directional operation, or by any other acceptable method such as short radials if a reliable non-directional pattern is not available;

2. proof of the size of the pattern by means of a series of readings along one radial in a major lobe to a distance of at least 16 km. The approximate effective field at one kilometre, the attenuation curve and the mean conductivity for the region, shall be determined from these readings;

3. antenna operating impedances (Z=R+jX) at carrier and the self-impedance at the operating frequency and at 10 kHz steps over a ±30 kHz range.

4.3 Where protection to other stations on the same or adjacent channels is required, additional measurements shall be supplied to show that interference will not result from the operation of the station for which proof of performance is being made.

5. PREUVE DE PERFORMANCE FINALE DES ANTENNES ÉQUIDIRECTIVES

L'installation est jugée incomplète jusqu'à ce que la preuve de performance finale de l'antenne ait été présentée au Ministère et approuvée par lui.

5.1 Documentation (en quatre exemplaires)

Une preuve de performance démontrant les intensités de champ inversement proportionnelle à la distance, en millivolts par mètre à une distance de un kilomètre, est exigée pour toutes les stations de radiodiffusion exploitées avec des antennes équidirectives.

Les contours d'intensité de champ sont nécessaires pour montrer la couverture réelle de la station, bien que le contour protégé, contre le brouillage causé par d'autres stations, est celui qui est calculé conformément au chapitre 2 de l'annexe 2 à l'Accord Canada/É.-U., à moins d'un accord spécifique entre les stations en cause.

Les données suivantes devront être présentées dans la preuve de performance, ainsi qu'une description de la procédure à suivre pour obtenir ces données.

5.2 Mesures d'intensité de champ pour établir l'intensité du champ équivalent à un kilomètre pour les stations de classe A ou B

En commençant aussi près que possible de l'antenne, sans inclure le champ d'induction et en tenant compte du fait qu'une antenne de radiodiffusion n'est pas une source de rayonnement ponctuelle (pas moins d'une longueur d'onde ou cinq fois la hauteur), prendre des mesures sur huit lignes radiales ou plus, à intervalles d'environ:

- 200 mètres jusqu'à trois kilomètres de l'antenne;
- un kilomètre, entre trois et 10 kilomètres de l'antenne;
- et trois kilomètres au-delà de 10 kilomètres, s'il y a lieu.

S'il est possible de prendre des mesures non obstruées, prendre 18 ou 20 sur chaque ligne radiale. Toutefois, lorsque les mesures non obstruées sont difficiles à faire, prendre les mesures sur chaque ligne radiale à autant d'emplacements non obstrués que possible, même si les intervalles sont considérablement inférieurs aux intervalles ci-dessus, en particulier dans un rayon de trois kilomètres de l'antenne. Dans les cas où il est impossible d'obtenir des mesures précises à de faibles distances (même à une distance de huit ou 10 kilomètres, à cause de la nature du terrain environnant), prendre à des intervalles plus rapprochés les mesures devant être faites à de plus grandes distances.

5. FINAL PROOF OF PERFORMANCE FOR NON-DIRECTIONAL ANTENNAS

The installation is deemed to be incomplete until such time as the Final Proof of Performance of the antenna system has been submitted to and approved by the Department.

5.1 Documentation (in quadruplicate)

A proof of performance demonstrating the inverse distance field strength in terms of millivolts per metre at a distance of one kilometre is required of all broadcasting stations operating with non-directional antennas.

Field strength contours are required to show the actual coverage of the station, although the contour protected against interference from other stations is that calculated in accordance with Annex 2, Chapter 2 of Canada/USA Agreement, unless there is specific agreement between the stations involved.

Following are the data which shall be submitted in the proof of performance, together with a description of the procedure to be followed in obtaining these data.

5.2 Field Strength Measurements to Establish the Effective Field Strength at One Kilometre for Class A or B Stations

Beginning as near to the antenna as possible without including the induction field and to provide for the fact that a broadcast antenna is not a point source of radiation (not less than one wavelength or five times the vertical height), measurements shall be made on eight radials at intervals of approximately:

- 200 metres up to three kilometres from the antenna;
- one kilometre from three to 10 km from the antenna;
- and three kilometres beyond 10 km as required.

Where unobstructed measurements can be made, there shall be as many as 18 or 20 on each radial. However, where unobstructed measurements are difficult to make, these shall be made on each radial at as many unobstructed locations as possible, even though the intervals are considerably less than stated above, particularly within three kilometres of the antenna. In cases where it is not possible to obtain accurate measurements at the closer distances (even out to eight or 10 km due to the character of the intervening terrain) the measurements at greater distances should be made at closer intervals.

Porter ces données sur du papier à coordonnées logarithmiques pour chaque ligne radiale, l'intensité de champ en ordonnée et la distance en abscisse.

Déterminer la courbe à faire passer par les points portés sur le papier par comparaison avec les courbes théoriques, de la façon suivante:

- tracer les courbes théoriques (se reporter à l'appendice 2 à l'annexe 2 à l'Accord Canada/É.-U.) pour plusieurs valeurs de conductivité approchant de la conductivité indiquée par les mesures sur une autre feuille de papier ayant les mêmes coordonnées;

- placer cette feuille sous la feuille sur laquelle les points réels ont été portés et la faire glisser sur l'autre jusqu'à ce qu'on trouve la courbe qui correspond le mieux aux points tracés;

- tracer ensuite cette courbe sur la feuille qui porte les points trouvés, ainsi que la courbe inversement proportionnelle à la distance qui lui correspond.

Le champ à un kilomètre pour la ligne radiale en question devra être tracé en ordonnée sur la courbe inversement proportionnelle à la distance à un kilomètre.

Quand toutes les lignes radiales ont ainsi fait l'objet d'une analyse, tracer une courbe sur du papier à coordonnées polaires en se servant des intensités de champ inversement proportionnelle à la distance obtenues, ce qui donne le diagramme de champ inversement proportionnel à la distance à un kilomètre. Le rayon d'un cercle, dont l'aire est égale à celle de ce diagramme, est le champ équivalent mesuré.

En faisant les mesures d'intensité de champ, maintenir la puissance de sortie de la station à la puissance autorisée, déterminée par la méthode directe. Si l'on utilise une puissance plus faible, les résultats des mesures devront être corrigés en conséquence. À cet effet, il est nécessaire de déterminer de façon aussi précise que possible l'impédance d'antenne et de mesurer le courant d'antenne au moyen d'un ampèremètre de précision connue.

Présenter les données complètes obtenues en même temps que les mesures d'intensité de champ, et notamment:

1. tableau donnant chaque point de mesure par ordre numérique, ainsi que l'intensité de champ et la distance par rapport à l'antenne;

2. carte indiquant chaque point de mesure numéroté de façon à concorder avec le tableau exigé dans 1 ci-dessus;

These data should be plotted for each radial using log-log co-ordinate paper with field strength as ordinate and distance as abscissa.

The appropriate curve to be drawn through the points plotted shall be determined by comparison with theoretical curves as follows:

- plot theoretical curves (refer Appendix 2 to Annex 2 of the Canada/USA Agreement) for several values of conductivities approximating the conductivity indicated by the measurements on another sheet of the same co-ordinate paper;

- place this sheet under the sheet on which the actual points have been plotted and adjust until the curve most closely matching the points is found;

- draw this curve on the sheet on which the points were plotted, together with the inverse distance curve corresponding to that curve.

The field at one kilometre for the radial concerned shall be plotted as the ordinate on the inverse distance curve at one kilometre.

When all radials have been analyzed in this manner, a curve shall be plotted on polar co-ordinate paper from the fields obtained, which gives the inverse distance field pattern at one kilometre. The radius of a circle, the area of which is equal to the area bounded by this pattern, is the measured effective field.

While making the field strength survey, the output power of the station should be maintained at the licensed power as determined by the direct method. If a lower power is used, the results of measurements should be adjusted appropriately. To do this it is necessary to determine the antenna impedance as accurately as practical, and to measure the antenna current by means of an ammeter of known accuracy.

Complete data taken in conjunction with the field strength measurements shall be submitted including the following:

1. tabulation by number of each point of measurement, the field strength and the distance from the antenna for each point of measurement;

2. map showing each point of measurement numbered to agree with the tabulation required in 1 above;

3. courbes tracées pour chaque ligne radiale et le diagramme d'intensité de champ;

4. mesures d'impédance de l'antenne:

   (a) impédance de l'antenne ($Z = R + jX$) à la fréquence d'exploitation et à des échelons de 10 kHz sur une gamme de fréquences de ±30 kHz;

   (b) description de la méthode employée;

   (c) tableau de toutes les données;

   (d) courbes montrant la résistance et la réactance de l'antenne par rapport à la fréquence, sur une gamme de ±30 kHz;

5. courant d'antenne (jour et nuit) maintenu pendant les mesures d'intensité de champ;

6. tout autre renseignement pertinent.

5.3 Mesures d'intensité de champ pour établir l'intensité du champ équivalent à un kilomètre pour les stations de classe C

Pour établir l'intensité du champ équivalent à un kilomètre pour les stations de classe C, suivre la même procédure qu'à la section 5.2 ci-dessus, sauf que les mesures n'ont besoin d'être prises que sur deux lignes radiales et qu'elles ne devraient s'étendre au-delà du contour 0,5 mV/m.

5.4 Instruments de mesure et qualifications

En ce qui a trait aux instruments utilisés et à la surveillance des mesures, les renseignements suivants devront être fournis:

1. description, précision, date d'étalonnage de chaque instrument et le nom de la personne qui l'a étalonné;

2. nom, tampon et signature de l'ingénieur responsable des mesures.

5.5 Tracé des contours d'intensité de champ

Les contours d'intensité de champ mesurés 1000, 250, 25, 15, 5 et 0,5 mV/m et les contours E_u et 20 % E_u, ou le champ nominal utilisable (celui qui est le plus grand), devront être tracés sur une carte ayant la plus grande échelle possible.

3. curves drawn for each radial and the field strength pattern;

4. antenna impedance measurements.

   (a) Antenna impedance (Z=R+jX) at the operating frequency and at 10 kHz steps over a ±30 kHz range.

   (b) Description of method employed.

   (c) Tabulation of all data.

   (d) Curves showing antenna resistance and reactance versus frequency over the ±30 kHz range;

5. antenna current (day and night) maintained during field strength measurements;

6. any other pertinent information.

5.3 Field Strength Measurements to Establish the Effective Field Strength at One Kilometre for Class C Stations

The procedure for establishing the effective field strength at one kilometre for Class C stations shall be the same as in Section 5.2 above except that measurements may be made on two radials only, and need not extend beyond the 0.5 mV/m contour.

5.4 Test Equipment and Qualifications

Concerning the test equipment used and supervision of measurements, the following information shall be provided:

1. description, accuracy, date and by whom each instrument was last calibrated;

2. name, stamp and signature of the engineer responsible for the measurements.

5.5 Plot of Field Strength

Measured field strength contours for 1000, 250, 25, 15, 5 and 0.5 mV/m, E_u and 20 % of the E_u or nominal usable field strength (whichever is greater), shall be plotted on a map or maps having the largest practical scale.

6. PREUVE DE PERFORMANCE PRÉLIMINAIRE DES ANTENNES ÉQUIDIRECTIVES

6.1 Le Ministère reconnaît que les études et les calculs nécessaires pour établir une preuve de performance finale peuvent prendre beaucoup de temps. C'est pourquoi il accepte normalement une preuve préliminaire de performance dans le but uniquement de permettre à la station de commencer son exploitation, à condition que la preuve finale de performance lui soit présentée dans les 90 jours qui suivent.

6.2 La preuve de performance préliminaire devra être présentée en quatre exemplaires, au moins trois jours ouvrables avant le début de la diffusion régulière et devra consister en:

1. un tableau donnant chaque point (au moins 10) de mesure d'intensité de champ par ordre numérique, prise le long d'une ligne radiale, pour établir avec une précision raisonnable l'intensité de champ inversement proportionnelle à la distance, en mV/m, à un kilomètre;

2. une liste des distances des points de mesure à l'antenne, numérotés conformément au tableau exigé dans 1. ci-dessus;

3. un tracé des mesures, comme il est exigé à la section B-5.2, avec indication du champ non atténué à un kilomètre.

S'il est le moindrement question de protection d'autres stations sur la même voie ou sur une voie adjacente, des mesures supplémentaires devront être fournies pour montrer qu'il ne résultera pas de brouillage de l'exploitation de la station pour laquelle la preuve de performance est faite.

6. PRELIMINARY PROOF OF PERFORMANCE FOR NON-DIRECTIONAL ANTENNAS

6.1 It is recognized that the surveys and calculations necessary for a Final Proof of Performance may take considerable time. For this reason the Department normally will accept a Preliminary Proof of Performance for the purpose only of permitting the station to commence operation, provided that the Final Proof of Performance is submitted within 90 days.

6.2 The Preliminary Proof of Performance shall be submitted in quadruplicate at least three working days before commencement of regular broadcasting and shall consist of:

1. a tabulation by number (at least 10) of each point of measurement of the field strength taken along one radial to establish with reasonable accuracy the inverse distance field strength in mV/m at one kilometre;

2. distances from the antenna of all measurement points numbered to agree with the tabulation required in 1. above;

3. a plot of the measurements as required in Section B-5.2 with the unattenuated field at one kilometre indicated thereon.

Where protection to other stations on the same or adjacent channels is required, additional measurements shall be supplied to show that interference will not result from the operation of the station for which the proof of performance is being made.

7. PREUVE DE PERFORMANCE SUPPLEMENTAIRE (en quatre exemplaires)

7.1 Introduction

Les stations de radiodiffusion sont tenues en tout temps d'accorder protection aux autres stations, conformément aux stipulations des accords internationaux et des exigences nationales. Par conséquent, il est impératif que l'exploitation des émetteurs de radiodiffusion et de leurs antennes soit vérifiée de temps en temps. Par conséquent, sur la demande du Ministère, une preuve de performance supplémentaire devra être soumise normalement avant chaque renouvellement de CTCF. La preuve de performance supplémentaire n'est pas exigée pour les systèmes d'antenne équidirectifs.

En plus du contrôle normal, les indications qui suivent donnent les exigences relatives à la preuve de performance supplémentaire destinée à démontrer que l'antenne de radiodiffusion continue à fonctionner telle qu'autorisée.

7.2 Mesures

7.2.1 Déterminer la forme du diagramme directif en se servant des mesures d'intensité de champ prises à une distance commode de l'émetteur et à des intervalles d'environ 15°, au moyen du rapport entre le diagramme directif et l'exploitation à diagramme équidirectif, ou par toute autre méthode acceptable, comme des lignes radiales courtes, si un diagramme fiable d'antenne équidirective n'est pas disponible.

7.2.2 Déterminer les dimensions du diagramme au moyen d'une série de mesures d'intensité de champ prises dans un lobe principal le long d'une ligne radiale, à partir d'à peu près 200 mètres de l'antenne jusqu'à une distance de 16 km ou jusqu'au contour 0,5 mV/m, la distance la plus courte étant retenue. Déterminer à partir de ces lectures le champ équivalent à un kilomètre comme l'indique la section B-3.2.

7.2.3 Déterminer par la méthode directe et exprimer sous la forme $Z = R + jX$ les caractéristiques d'impédance des éléments rayonnants et l'impédance d'exploitation au point d'entrée commun.

7.2.4 Pour déterminer l'intensité du champ non atténué à un kilomètre, porter sur du papier à coordonnées logarithmiques les mesures d'intensité de champ en ordonnée et la distance en abscisse. Déterminer la courbe à faire passer par les points portés sur le papier par comparaison avec les courbes théoriques, de la façon suivante:

7. SUPPLEMENTARY PROOF OF PERFORMANCE (In quadruplicate)

7.1 Introduction

Broadcasting stations at all times are required to accord protection to other stations as prescribed by international agreements and domestic requirements. Therefore, it is imperative that the operation of broadcast transmitters and their antenna systems be checked from time to time. Accordingly, a supplementary proof of performance shall be submitted on request by the Department normally before each renewal of the TC & OC. Supplementary proofs of performance are not required for non-directional antenna systems.

In addition to normal monitoring, the following comprise the requirements for a Supplementary Proof of Performance to demonstrate that the broadcast antenna system continues to function as authorized.

7.2 Measurements

7.2.1 The shape of the directional pattern shall be determined from field strength measurements taken at a convenient distance from the transmitter at approximately 15 degree intervals by means of the ratio between the directional pattern and non-directional operation. or by any other acceptable method such as short radials if a reliable non-directional pattern is not available.

7.2.2 The size of the pattern shall be determined by means of a series of field strength measurements taken in a major lobe along one radial from approximately 200 metres from the antenna to a distance of 16 km or to the 0.5 mV/m contour whichever is closer. The effective field at one kilometre shall be determined from these readings as set forth in Section B-3.2.

7.2.3 Impedance characteristics of the radiating elements and the operating impedance at point of common input shall be determined by the direct method and expressed as $Z=R+jX$.

7.2.4 To determine the unattenuated field strength at one kilometre the field strength measurement data should be plotted on log-log co-ordinate paper with field strength as ordinate and distance as abscissa. The appropriate curve to be drawn through the points plotted shall be determined by comparison with theoretical curves as follows:

- tracer les courbes théoriques (se reporter à l'appendice 2 de l'Accord Canada/É.-U.) pour plusieurs valeurs de conductivité approchant de la conductivité indiquée par les mesures sur une autre feuille de papier ayant les mêmes coordonnées;

- placer cette feuille de papier à coordonnées sous la feuille sur laquelle les points de données réelles ont été portés et la faire glisser jusqu'à ce que l'on trouve la courbe correspondant le mieux aux points;

- tracer cette courbe sur la feuille sur laquelle les points ont été portés.

Le champ à un kilomètre pour la ligne radiale devra être tracé en ordonnée sur la courbe inversement proportionnelle à la distance à un kilomètre.

7.2.5 En faisant les mesures d'intensité de champ, maintenir la puissance de sortie de la station à la puissance mentionnée sur la licence, déterminée par la méthode directe. Inscrire soigneusement dans un registre les paramètres de fonctionnement pendant la période de mesures.

7.3 Documents (en quatre exemplaires)

La preuve de performance supplémentaire devra comprendre les documents suivants, préparés ou approuvés par un ingénieur professionnel et présentés sur la foi de sa signature et de son tampon:

1. un exposé des travaux faits, des réglages effectués, des pièces remplacées, des mesures prises et des instructions données au personnel d'exploitation;

2. dans le cas d'une antenne directive, la courbe polaire du diagramme élargi (ou modifié, le cas échéant) de l'antenne directive sur du papier à coordonnées polaires de format papier à lettre ordinaire, d'échelle convenable (avec marges appropriées);

3. le tracé des mesures d'intensité de champ prises le long d'une ligne radiale, ainsi que la courbe inversement proportionnelle à la distance tracée sur papier à coordonnées logarithmiques. Les valeurs de la conductivité du sol et de l'intensité de champ à un kilomètre devront être marquées;

4. des renseignements sur les mesures d'impédance de l'antenne donnant:

   (a) la description des méthodes employées;

   (b) les données de mesure;

- plot theoretical curves (refer to Appendix 2 of the Canada/USA Agreement) for several values of conductivities approximating the conductivity indicated by the measurements on another sheet of the same co-ordinate paper;

- place this sheet under the sheet on which the actual data points have been plotted and adjust until the curve most nearly matching the points is found;

- draw this curve on the sheet on which the points were plotted.

The field at one kilometre for the radial shall be plotted as the ordinate on the inverse distance curve at one kilometre.

7.2.5 While making the field strength measurements the output power of the station should be maintained at the licensed power as determined by the direct method. A careful log shall be taken of the operating parameters during the measurement period.

7.3 Documents (in quadruplicate)

A Supplementary Proof of Performance shall comprise the following, prepared or approved by a professional engineer and submitted over his or her stamp and signature:

1. a statement of the work which was done, adjustments made, components replaced, measurements taken and instructions left with operating staff;

2. where a directional antenna is involved, the polar plot of the expanded (or modified, if applicable) directional antenna pattern shall be provided using a suitable scale on standard letter size polar co-ordinate paper (with adequate margin);

3. a plot of the field strength measurements made along the single radial, together with the inverse distance curve plotted on suitable log-log graph paper. The values of ground conductivity and field strength at one kilometre shall be marked;

4. information on the antenna impedance measurements shall be provided showing:

   (a) description of the methods employed;

   (b) measurement data;

(c) l'impédance de chaque pylône à la fréquence d'exploitation, exprimée sous la forme $Z = R + jX$;

5. un tableau des lectures de courant et de phase de l'émetteur et du système d'antenne après le réglage final et le rendement de la sortie de l'émetteur;

6. si des travaux d'autre nature ont été effectués à l'émetteur, comme le réglage et l'étalonnage du matériel de surveillance, des contrôleurs de fréquence ou de modulation, inclure aussi la documentation convenable y ayant trait.

7.4 Instruments de mesure et qualifications

En ce qui a trait aux instruments utilisés et à la surveillance des mesures, les renseignements suivants devront être fournis:

1. description, précision, date d'étalonnage de chaque instrument et le nom de la personne qui l'a étalonné;

2. nom, tampon et signature de l'ingénieur responsable des mesures.

(c) impedances of each tower at the operating frequency expressed as Z=R+jX;

5. a table of current and phase readings of the transmitter and antenna system as finally adjusted and the transmitter output efficiency;

6. if other work was done at the transmitter, such as adjustment and calibration of supervisory control equipment, frequency or modulation monitors, proper documentation covering this work should also be included.

7.4 Test Equipment and Qualifications

Concerning the test equipment used and supervision of measurements, the following information shall be provided:

1. description, accuracy, date and by whom each instrument was last calibrated;

2. name, stamp and signature of the engineer responsible for the measurements.

8. DEMANDES RELATIVES AUX STATIONS DE FAIBLE PUISSANCE NON PROTÉGÉES ET AUX SYSTÈMES À COURANTS PORTEURS EXPLOITÉS À DES PUISSANCE D'ÉMISSION NE DÉPASSANT PAS 50 W

8.1 Stations de radiodiffusion de faible puissance non protégées

Normalement, une demande relative à une station de radiodiffusion de faible puissance non protégée est techniquement acceptable:

(a) si l'on prévoit que cette station ne causera aucun brouillage à d'autres stations, en utilisant les critères de protection habituels;

(b) si le niveau du signal dans la zone à desservir est suffisant pour assurer des services fiables de jour et de nuit;

(c) si la disparité entre le service de jour et le service de nuit est mineure, c'est-à-dire que le contour E_u devra englober au moins 90 % de la population comprise dans le contour 0,5 mV/m.

L'émetteur devra satisfaire aux exigences du Cahier des charges sur les normes radioélectriques numérc 150. L'utilisation d'un émetteur qui ne répond pas à ces normes pourrait résulter en une qualité de service inadéquate.

8.1.1 Exigences pour une demande

Les documents à présenter pour une demande relative à une station de radiodiffusion de faible puissance sont:

- 2 exemplaires de la formule 16-1 ou 16-4 suivant le cas;
- 2 exemplaires de la formule 16-653;
- 4 exemplaires de la formule 16-879 (à envoyer au bureau régional du MDC approprié);
- 5 exemplaires d'un mémoire technique.

Normalement, il suffit que le mémoire technique décrive seulement l'émetteur et l'emplacement (population à servir, alimentation en programme). Toutefois, si l'analyse du Ministère indique que les exigences de protection de service peuvent ne pas avoir été satisfaites, un mémoire technique détaillé peut être exigé.

8.2 Systèmes à courants porteurs

Normalement, une demande relative à un système à courants porteurs est considérée comme techniquement acceptable si les exigences techniques du Ministère mentionnées ci-après sont satisfaites.

8. APPLICATIONS FOR LOW POWER UNPROTECTED STATIONS AND CARRIER CURRENT SYSTEMS WITH TRANSMITTER POWERS NOT EXCEEDING 50 W.

8.1 Low Power Unprotected Broadcasting Stations

Normally, an application for a low power unprotected broadcasting station is technically acceptable if:

(a) no interference to other stations is predicted, using regular protection criteria;

(b) the signal level within the area to be served is sufficient to provide reliable daytime and night-time services;

(c) the disparity between day and night service is minor, i.e. the E_u contour shall enclose at least 90 % of the population within the 0.5 mV/m contour.

The transmitter should meet Radio Standards Specifications 150. The use of a transmitter which does not meet these standards could result in an inadequate quality of service.

8.1.1 Requirements for an Application

The requirements for an application for a low power broadcasting station are:

- 2 copies of Form 16-1 or 16-4 as applicable;
- 2 copies of Form 16-653;
- 4 copies of Form 16-879 (to be sent to the appropriate DOC Regional office);
- 5 copies of an engineering brief.

Normally, an engineering brief need only describe the transmitting plant and location (population to be served, audio feed). However, if the Department's analysis indicates that protection or service requirements may not have been met, a detailed engineering submission may be requested.

8.2 Carrier Current Systems

Normally, an application for carrier current system is considered technically acceptable if the technical requirements of the Department are met as set forth hereafter.

8.2.1 Exigences

(a) Un mémoire technique contenant les renseignements qui suivent devra être approuvé par le Ministère:

- emplacement de l'émetteur;

- fréquence projetée;

- type du matériel qui sera utilisé (nom du fabricant, numéro de modèle, puissance). Ce matériel devra être approuvé par le ministre des Communications.

(b) L'émetteur et le matériel associé devront être conçus conformément à la dernière édition de la norme ACNOR C22.2 N° 98.

(c) Cet appareil devra fournir au réseau de ligne la puissance radiofréquence minimale nécessaire pour parvenir au but désiré.

(d) Aucun brouillage ne devra être causé à d'autres services radio.

(e) L'émetteur devra satisfaire aux exigences du Cahier des charges sur les normes radioélectriques 158.

8.2.2 Preuve de performance et exigences de certification

Une preuve de performance démontrant que les installations répondent aux exigences mentionnées ci-dessous devra être soumise au Ministère au moins cinq jours ouvrables avant la date désirée d'exploitation régulière.

Le requérant devra fournir la preuve que le champ électromagnétique s'étendant en dehors de la propriété à desservir contenant le circuit de distribution de signal ne dépasse pas 15 uV/m à une distance

$$d = \frac{48\,000}{f}$$

d = distance en mètres

f = fréquence en kHz

de la propriété desservie. Les mesures devront être prises pendant le jour par un ingénieur ou un technicien expérimenté dans ce genre de travail, à l'aide d'un appareil de mesure d'intensité de champ normalisé. Les lectures devront être prises, l'antenne ne se trouvant pas à moins de 50 cm ni à plus de trois mètres au-dessus du sol, en 12 points espacés aussi régulièrement que possible sur un cercle de rayon d autour de la propriété. S'il y a des fils aériens électriques ou autres raccordés à la propriété, faire les lectures avec l'antenne placée directement au-dessous des fils et dans le même plan, à la distance prescrite de la propriété.

8.2.1 Requirements

(a) An engineering brief containing the following data is approved by the Department:

- the location of the transmitter;
- the proposed frequency;
- the type of equipment to be used (manufacturer's name, model number, power). This equipment should be approved by the Minister of Communications.

(b) The transmitter and associated equipment is designed according to the latest issue of the CSA Standards C22.2 No. 98.

(c) Such apparatus will deliver to the line network the minimum radio frequency power necessary to accomplish the desired purpose.

(d) No interference is expected to be caused to other radio services.

(e) The transmitter is to meet Radio Standards Specifications 158.

8.2.2 Proof of Performance and Certification Requirements

A proof of performance demonstrating that the installations meet the requirements mentioned below, shall be submitted to the Department at least five working days before the desired date for regular operation.

The applicant shall provide evidence that the electromagnetic field extending outside the property to be served containing the signal distribution circuit does not exceed 15 uV/m at a distance

$$d = \frac{48,000}{f}$$

d = the distance in metres

f = the frequency in kHz

from the property served. The measurements shall be taken in daylight using a field strength meter operated by an engineer or technician experienced in this work. The readings shall be obtained with the antenna not less than 50 cm nor more than three metres above ground at 12 points spaced as equally as may be practicable around the property at the required distance d. If there are overhead power cables or other wires connected to the property, readings shall be obtained with the antenna directly under and in the same plane as the wires at the prescribed distance from the property.

Note: Théoriquement, pour un rendement de 100 %, le champ créé par une fraction de milliwatt pourrait dépasser la limite 15 uV/m à la distance définie par rapport à la source.

Il incombe au propriétaire et à l'exploitant du système de s'assurer qu'à la distance définie, un signal brouilleur possible provenant du système à courants porteurs ne dépasse pas l'intensité de champ maximale admissible et ne cause pas de brouillage aux services radio autorisés. Dans le cas de brouillage, l'exploitant du système devra immédiatement prendre des mesures pour éliminer le brouillage et les mesures correctives à prendre peuvent aller jusqu'à la cessation de l'exploitation.

Note: Theoretically, at 100 % efficiency, the field from a fraction of a milliwatt could exceed the 15 uV/m limit at the defined distance from the source.

The responsibility for ensuring that at the defined distance a possible interfering signal from the carrier current system does not exceed the maximum permissible field strength and does not cause interference to authorized radio services, lies with the owner and operator of the system. In the event interference is caused, the operator of the system shall promptly take steps to eliminate the interference and remedial measures would have to be taken to the extent of ceasing operation.

9. DEMANDES FONDÉES SUR LA SUPPRESSION D'ASSIGNATIONS DANS LE PLAN

9.1 Suppression ou transfert d'une assignation inutilisée

9.1.1 Étant donné qu'un certain nombre d'assignations canadiennes inutilisées dans le Plan se fondaient sur une estimation d'un besoin dans une zone générale, de telles assignations peuvent être transférées à une autre communauté, si les critères de protection nécessaire sont respectés. Le mémoire devra comprendre une discussion des assignations disponibles dans les deux communautés.

9.1.2 Si une demande se fonde sur la suppression d'une assignation inutilisée, et non sur un transfert, le requérant devra fournir une analyse détaillée démontrant qu'il n'existe pas une autre solution satisfaisante et il devra:

(a) démontrer qu'il existe d'autres assignations appropriées dans le Plan; ou

(b) proposer des modifications au Plan pour remplacer l'assignation supprimée.

9. APPLICATIONS BASED ON DELETION OF ASSIGNMENTS IN THE PLAN

9.1 Deletion or Transfer of an Unused Assignment

9.1.1 Since a number of the unused Canadian assignments in the Plan were based on an estimate of a need in a general area, such assignments may be transfered to an alternate community if the necessary protection criteria are met. The brief shall include a discussion of the assignments available in both communities.

9.1.2 If an application is based on the deletion of an unused assignment, other than a transfer, the applicant shall provide a detailed analysis demonstrating the unavailability of a satisfactory alternative; and

(a) demonstrate that adequate alternate assignments are available in the Plan; or

(b) propose modifications to the Plan to replace the deleted assignment.

SECTION C: **EXIGENCES TECHNIQUES RELATIVES AUX STATIONS DE RADIODIFFUSION AM DANS LA BANDE 535 - 1605 kHz**

La présente section établit les règles techniques à suivre lors de la conception des stations de radiodiffusion AM exploitées avec des puissances supérieures à 50 W dans la bande de fréquences 535-1605 kHz.

1. **ANTENNES ET RÉSEAUX DE TERRE**

La conception d'un système d'antenne relatif à une station devra satisfaire aux exigences suivantes:

1. des éléments rayonnants verticaux devront être utilisés dans la plupart des cas;
2. la hauteur des éléments rayonnants verticaux devra être d'au moins 1/6 de longueur d'onde ou l'équivalent, sans dépasser 5/8 de longueur d'onde;
3. une charge terminale est parfois utilisée au sommet d'un élément rayonnant vertical pour augmenter sa hauteur effective. Toutefois, cette méthode devrait être évitée dans toute la mesure du possible, car elle influe sur les caractéristiques de rayonnement vertical. Si elle est employée, la charge terminale devra être symétrique et ne devra pas dépasser 1/8 de longueur d'onde de hauteur équivalente. Lorsque la charge terminale est obtenue par des ajouts matériels à l'élément rayonnant (plutôt qu'en utilisant les haubans), de tels ajouts devront être pris en considération lors de l'évaluation de la structure;
4. tous les pylônes d'antenne devront faire l'objet d'une attestation quant à leur résistance mécanique (voir RÈGLES GÉNÉRALES, section 1);
5. tous les pylônes d'antenne devront être peints et balisés conformément aux exigences de Transports Canada;
6. tous les pylônes d'antenne, lignes de transmission, etc., qui sont le siège de courants et de tensions radiofréquences dangereux devront être situés et protégés de façon à écarter la possibilité d'un contact accidentel;
7. les réseaux de terre devront comprendre au moins 120 fils radiaux également espacés et disposés en rayons à partir de la base de l'élément rayonnant, à moins que le système d'antenne n'exige une autre configuration. Les fils radiaux ne devront pas être d'un calibre inférieur au N° 10 B & S ni être enfouis à plus de 20 cm dans le sol sur une distance d'au moins 0,25 longueur d'onde de l'antenne;

SECTION C: TECHNICAL REQUIREMENTS FOR AM BROADCASTING STATIONS IN THE 535-1605 kHz BAND

This Section establishes the technical rules to be followed in designing AM broadcasting stations operating with powers greater than 50W in the frequency band 535-1605 kHz.

1. ANTENNAS AND GROUND SYSTEMS

The design of an antenna system for a station shall conform to the following requirements:

1. vertical radiators shall be used under most circumstances;

2. the height of vertical radiators shall be at least 1/6 wavelength or equivalent, but not exceed 5/8 wavelength;

3. top-loading of vertical radiator is sometimes used to increase the effective height. However, this should be avoided whenever possible, since it affects the vertical radiation characteristics. If used, top-loading shall by symetrical and not exceed 1/8 wavelength equivalent height. When top-loading is achieved by physical additions to the radiator (rather than using the guy wires), such additions shall be taken into consideration in assessing the structural adequacy;

4. all antenna towers shall be certified as to structural adequacy (see under GENERAL RULES, Section 1);

5. all antenna towers shall be painted and lighted in accordance with the requirements of Transport Canada;

6. all antenna towers, transmission lines etc., on which dangerous radio frequency voltages and currents exist, shall be so located and protected as to preclude the possibility of accidental contact;

7. ground systems shall consist of at least 120 radial wires evenly spaced and radiating out from the base of the radiating element unless the design of the antenna system is such as to require other configurations. Radial wires shall not be smaller than No. 10 B & S gauge, and buried no deeper than 20 cm in the ground for a distance not less than 0.25 wavelength from the antenna;

8. dans le choix de l'emplacement, il importe de bien étudier la conductivité du sol à l'emplacement, ainsi que les complications qui peuvent découler de l'établissement des réseaux de terre spécifiés dans la présente règle technique. Autant que possible, tout le terrain dans lequel le réseau de terre sera enfoui devrait être raisonablement plat, afin de minimiser les déformations du diagramme de rayonnement.

8. in selecting the site, every consideration should be given to the conductivity of the ground at the site and the complications which may arise in laying the ground systems specified under this technical requirement. Whenever possible, the entire area in which the ground system is to be laid should be reasonably flat, to minimize deformities in the radiation pattern.

2. CONDUCTIVITÉS DU SOL

2.1 Les valeurs officielles de conductivité du sol pour le Canada sont contenues dans la carte du ministère des Communications intitulée "Carte de la conductivité du sol pour radiodiffusion en ondes hectométriques" datée de janvier 1980.

La carte comprend cinq feuilles séparées pour l'Atlantique, le Québec, l'Ontario, les Prairies et la Colombie-Britannique. On peut obtenir les feuilles individuelles ou un ensemble complet auprès de la Direction générale de la règlementation de la radiodiffusion, ministère des Communications, 300, rue Slater, Ottawa, K1A 0C8.

2.2 Dans les régions du Nord, pour lesquelles il n'existe pas de valeurs spécifiques de conductivité, on peut supposer, pour la conception des stations, la même valeur que pour la zone adjacente vers le sud, une valeur fondée sur les données d'intensité de champ mesurée ou une valeur estimée à partir de la composition géologique et(ou) des données sur le terrain.

2.3 Les valeurs officielles de conductivité du sol pour les États-Unis sont contenues dans la carte de la Federal Communications Commission, figure M3, intitulée "Estimated Effective Ground Conductivity in the United States" (valeur estimée de conductivité apparente du sol aux États-Unis).

2.4 Pour les cartes ci-dessus, la frontière internationale est considérée comme une frontière de conductivité.

2.5 Les valeurs de conductivité indiquées par les cartes devront être utilisées pour tous les calculs de couverture et de brouillage, à moins que le requérant ne justifie, conformément aux articles C-2.6 et C-2.7, l'utilisation d'autres valeurs.

2.6 Des valeurs de conductivité autres que les valeurs indiquées par les cartes seront prises en considération dans les cas relatifs au brouillage calculé des services de radiodiffusion existants, si l'on peut démontrer, par suite de nombreuses mesures, qu'il est improbable que le brouillage se produise en pratique. Normalement, les mesures devront être prises à partir de l'emplacement d'antenne projeté, à l'aide d'un émetteur d'essai au besoin. Le contour de protection sera habituellement tiré de la preuve finale de performance de la station touchée. Si la preuve finale de performance n'est pas disponible, le contour de protection sera calculé à l'aide des valeurs de conductivité indiquées par les cartes, à moins que les deux parties n'en conviennent autrement.

2.6.1 Le requérant projetant d'utiliser des valeurs de conductivité autres que celles indiquées par les cartes devra fournir à la station touchée une copie du mémoire technique relatif à son projet, au moment où il déposera ce projet auprès du ministère des Communications.

2. GROUND CONDUCTIVITIES

2.1 The official ground conductivity values for Canada are contained in the issue of the Department of Communications Map entitled "Ground Conductivity Map for MF Broadcasting Band" dated January 1980.

The Map consists of five separate sheets labelled Atlantic Provinces, Quebec, Ontario, Prairie Provinces and British Columbia. Individual sheets or a complete set is available from the Broadcasting Regulation Branch, Department of Communications, 300 Slater Street, Ottawa, K1A 0C8.

2.2 In northern regions lacking specific conductivity values, the design of stations may assume the same value as the adjacent area to the south, a value based on measured field strength data or a value estimated from geological composition and/or terrain information.

2.3 The official ground conductivity values for the USA are contained in the Federal Communications Commission Map Figure M3 entitled "Estimated Effective Ground Conductivity in the United States".

2.4 For the above maps, the international border is considered as a conductivity boundary.

2.5 Conductivity values from the maps shall be used for all coverage and interference calculations, unless the applicant provides a suitable showing in accordance with Sections C-2.6 and C-2.7 to use other values.

2.6 Conductivity values other than map values will be considered in cases involving calculated interference to existing broadcasting services, if it can be demonstrated, as a result of extensive measurements, that interference is unlikely to occur in practice. Normally, measurements shall be made from the proposed antenna site, using a test transmitter if necessary. The location of the protected contour shall normally be derived from the final proof of performance of the affected station. If a final proof is not available, the protected contour location shall be calculated using conductivity values from the map unless otherwise agreed by both parties.

2.6.1 An applicant proposing the use of conductivity values other than map values shall provide the affected station with one copy of the engineering brief outlining his or her proposal at the time of filing the proposal with the Department of Communications.

2.6.2 Sur réception d'une copie du mémoire technique projetant l'utilisation de valeurs de conductivité autres que les valeurs indiquées sur les cartes, la station touchée devra soit accepter les valeurs utilisées, soit y faire objection. Après réception du mémoire technique, le radiodiffuseur de la station touchée a trente jours pour informer par écrit le ministère des Communications et le requérant de son opinion. S'il ne le fait pas, on supposera qu'il accepte le projet du requérant.

2.6.3 Si la station touchée fait objection à l'utilisation des valeurs de conductivité mentionnées dans le mémoire technique, elle sera invitée à participer à un programme de mesures approuvé par le Ministère, au cours duquel les deux parties devraient conclure un accord quant à la valeur de conductivité acceptable et, par conséquant, quant au rayonnement admissible permettant d'assurer la protection de la station touchée. Le programme de mesures devrait être entrepris, aux frais du requérant, par une ou plusieurs firmes techniques choisies d'un commun accord par les deux parties. Dans certains cas, il pourra être nécessaire de répéter les mesures à une autre période de l'année, afin de tenir compte des variations saisonnières de la conductivité. Si les deux parties ne peuvent en venir à une entente, le Ministère évaluera la demande en se fondant sur les mémoires présentés par les deux parties et sur ses propres études.

2.6.4 Dans le cas où une demande a été approuvée en se fondant sur des valeurs autres que les valeurs indiquées sur les cartes, qu'une entente ait été conclue ou non avec la station touchée, et où l'on peut démontrer qu'un brouillage se produit en pratique, la station brouilleuse devra réduire immédiatement le rayonnement en direction de la station touchée. Les valeurs du rayonnement réduit seront déterminées par des calculs se fondant sur les valeurs de conductivité indiquées sur les cartes ou sur des valeurs intermédiaires faisant l'objet d'un accord mutuel entre les deux parties. Si le rayonnement ne peut pas être suffisamment réduit, dans les sept jours, par ajustement du diagramme de directivité, il devra l'être par réduction de puissance.

2.7 Tant qu'une meilleure méthode n'aura pas été mise au point pour tenir compte des variations saisonnières, les mesures devront être répétées dans des conditions représentant au moins deux extrêmes, à moins d'accord du radiodiffuseur touché.

2.6.2 The affected station shall, upon receiving a copy of the engineering brief proposing the use of conductivities other than map values, either accept or object to the values used. The affected broadcaster shall have 30 days from receipt of the engineering brief to advise the Department of Communications and the applicant of his or her opinion in writing. Failure to do so will imply acceptance of the applicant's proposal.

2.6.3 In the event that the affected station objects to the use of the conductivities involved in the engineering brief, the station shall be invited to participate in a measurement program approved by the Department during which the two parties should reach an agreement as to the acceptable conductivity and thus the allowable radiation to provide protection to the affected station. The measurement program should be undertaken at the cost of the applicant by an engineering firm or firms chosen by mutual consent of both parties. In some cases, it may be necessary to repeat the measurements at a different time of year to take seasonal variation of conductivity into account. If agreement cannot be reached, the Department will assess the application on the basis of the submissions by both parties and its own studies.

2.6.4 If an application is approved on the basis of other than map conductivity values, whether or not agreement has been reached with the affected station, if it can be shown that interference occurs in practice, the interfering station shall immediately reduce radiation towards the affected station. The values of reduced radiation will be determined by calculations based on map conductivity values or intermediate values mutually agreed upon by both parties. If the appropriate reduction of radiation cannot be made within seven days by adjustment of a directional pattern, it shall be made by reduction of power.

2.7 Until a better method is developed to allow for seasonal variation, measurements will have to be repeated under conditions representative of at least two extremes, unless there is agreement from the affected broadcaster.

3. INTENSITÉS DE CHAMP MAXIMALE ET MINIMALE POUR UN SERVICE SATISFAISANT DANS LES RÉGIONS MÉTROPOLITAINES

3.1 Exigences

Dans le choix de l'emplacement du système d'émission d'une station de radiodiffusion à modulation d'amplitude, il y a lieu d'assurer un service satisfaisant à un centre de population, habituellement appelé région métropolitaine* (où normalement le studio est situé) et d'assurer un service maximal aux régions voisines avec un minimum de brouillage entre la nouvelle station et les autres usagers du spectre radio. Une intensité de champ minimale de 25 à 50 mV/m est jugée nécessaire pour assurer un service de radiodiffusion suffisant aux régions commerciales et (ou) industrielles de la ville et, si le brouillage industriel et celui causé par des stations de radiodiffusion utilisant la même voie ou des voies adjacentes ne sont pas excessifs, le champ devra avoir une intensité minimale de 5 à 10 mV/m pour une région résidentielle. Par contre, il faut établir une valeur maximale d'intensité de champ à ne pas dépasser, afin d'éviter de bloquer la réception des autres stations et d'empêcher le brouillage résultant de contacts non linéaires entre fils, tuyaux ou autres conducteurs, vétustes ou mal installés.

3.2 Choix de l'emplacement et des paramètres

Le choix de la puissance, de l'antenne, des caractéristiques directionelles et de l'emplacement de l'émetteur de radiodiffusion AM devra répondre aux conditions suivantes:

1. le contour de 25 mV/m et le contour de limitation RSS pour l'exploitation nocturne, lorsqu'il excède 25 mV/m (voir article 3 ci-dessous), devraient englober toute la région métropolitaine.

2. dans le cas de propositions démontrant l'impossibilité de remplir les exigences de l'article 1. ci-dessus, les contours indiqués par cet article devront englober au moins 50 p. 100 de la région métropolitaine. En outre, en ce qui concerne les limitations RSS nocturnes inférieures à 5 mV/m, une intensité de champ minimum de 5 mV/m pour l'exploitation de nuit devra permettre de couvrir la plus grande partie possible de la région à population dense englobée par le contour de 5 mV/m pour l'exploitation diurne.

3. les propositions comportant une limitation RSS pour l'exploitation de nuit supérieure à 25 mV/m devront être pleinement justifiées avant de pouvoir être étudiées comme cas spéciaux.

*Une région métropolitaine s'entend de toute région où se trouvent, de façon raisonnablement continue, des immeubles industriels ou résidentiels sur des parcelles de terrain normalement appelées terrains à bâtir.

3. MAXIMUM AND MINIMUM FIELD STRENGTHS FOR SATISFACTORY SERVICE TO METROPOLITAN AREAS

3.1 Requirements

In the selection of a site for a transmitter system of an AM broadcasting station the objectives are to provide adequate service to a centre of population, usually referred to as a metropolitan area* (in which the studio is normally located), and to give maximum coverage to adjacent areas with a minimum of interference to and from other users of the radio spectrum. It is considered that a minimum field strength of 25 to 50 mV/m is required to provide an adequate broadcast service to the business and/or factory areas of a city and, in the absence of excessive co-channel, adjacent channel and industrial interference, a minimum field strength of 5 to 10 mV/m is required for a residential area. On the other hand, a maximum value of field strength shall be established in order to prevent blanketing of radio receivers as well as to avoid interference arising from non-linear contacts between old or improperly installed wiring, plumbing, or other conductors.

3.2 Selection of Site and Parameters

The power, antenna, directional characteristics and location of an AM broadcast transmitting system shall be selected in compliance with the following:

1. the 25 mV/m contour and the night-time RSS limitation contour, if it exceeds 25 mV/m, Section 3. below, should enclose the whole of the metropolitan area.

2. for proposals in which it is demonstrated that the requirement of 1. above cannot be met, the contours in 1. shall enclose at least 50 % of the metropolitan area. In addition, for night-time RSS limitations less than 5 mV/m, a minimum field strength of 5 mV/m night-time shall be provided over as much of the densely populated area enclosed by the 5 mV/m daytime contour as practicable.

3. proposals accepting night-time RSS limitations greater than 25 mV/m shall be supported by sufficient data to justify consideration as a special case.

* A metropolitan area is considered to be any area where there are located in reasonably continuous fashion, industrial or residential buildings on parcels of ground normally referred to as building lots.

4. la population comprise à l'intérieur du contour de 250 mV/m ne devra pas dépasser un habitant par watt de puissance d'émission. Par exemple, pour une puissance d'émission de 10 000 watts, cette population ne dépassera pas 10 000 habitants.

   En outre, la population englobée par le contour de 250 mV/m ne devra pas excéder un tiers de la population totale du centre principal à desservir.

   Les nouvelles stations devront observer les limites indiquées ci-dessus. Cependant, dans le cas de modification d'une installation, une considération spéciale peut être accordée relativement aux populations situées à l'intérieur du contour de 250 mV/m et excédant les valeurs indiquées ci-dessus sous réserve que:

   (a) une étude soit soumise qui fournisse des indications sur les produits d'intermodulation et la transmodulation par rapport aux autres stations de radiodiffusion de la région et du brouillage possible, compte tenu du nombre de stations situées dans la région et du niveau des signaux dans la zone de recouvrement des contours de 250 mV/m.

   (b) des dispositions soient prises permettant de revenir à l'installation antérieure en cas d'apparition de brouillage grave, et qu'un engagement à cet effet soit pris par le demandeur.

   Cependant, l'expérience a démontré au Canada que des problèmes de brouillage sont apparus quand la population située dans le contour de 250 mV/m atteint des valeurs de 50 p. 100 supérieures à celles du tableau ci-dessus pour les stations les plus puissantes et, de ce fait, le Ministère est peu disposé à prendre en considération de telles propositions même comme cas spéciaux.

5. Le contour de 1 V/m, pour les nouvelles stations et les nouvelles installations d'émission de stations existantes, devrait englober le moins grand nombre possible de constructions. Il appartient au demandeur de fournir des indications relatives au nombre de constructions et à l'importance des populations situées dans le contour de 1 V/m. Des photographies aériennes de cette zone sont souhaitables.

4. the population within the 250 mV/m contour shall not exceed one person per watt of transmitter power. For example for 10,000 watts, this population will not exceed 10,000 persons.

   In addition, the population enclosed by the 250 mV/m contour shall not exceed one-third of the total population within the principal centre to be served.

   New stations shall adhere to the limits outlined above. However, in the case of changes of facilities, special case consideration may be given to populations within the 250 mV/m contours in excess of values given above, provided that:

   (a) a study is submitted, including information on the intermodulation products, and cross-modulation relative to other radio services in the area, and the potential interference situation giving due consideration to the number of stations in the area and the levels of signals in the overlap areas of the 250 mV/m contours.

   (b) arrangements are made so that it would be possible to revert to the previous facilities in the event of serious interference developing, and a commitment to this effect is made by the applicant.

   However, experience in Canada has shown that problems of interference have arisen in cases where populations within the 250 mV/m contour are increased to values approximately 50 % above those tabulated for the higher powered stations, and therefore the Department would be most reluctant to consider such proposals even as special cases.

5. the 1 V/m contour, for new stations and new transmitting site of existing stations, should enclose a minimum number of buildings. The applicant is to provide information as to the number of buildings, and population in the area within the 1 V/m contour. Aerial photographs of the area would be desirable.

3.3 <u>Engagement et responsabilité</u>

Le requérant devra s'engager à prendre, à ses frais, des mesures pour remédier à toute plainte raisonnable provoquée par le bloquage de récepteurs et (ou) par du brouillage de transmodulation externe subi par d'autres utilisateurs du spectre radioélectrique situés dans le contour de 250 mV/m.

Il incombe au requérant d'établir les chiffres de population nécessaires pour se conformer aux règles ci-dessus. Ces chiffres devraient être fournis par une source locale reconnue ou par Statistique Canada.

3.3 Commitment and Responsibility

The applicant shall submit an undertaking that, should blanketing interference to receivers and/or external cross-modulation interference to other users of the radio spectrum result within the station's 250 mV/m contour, he would be prepared to remedy, at his or her own expense, all reasonable complaints of such interference.

The responsibility rests with the applicant to establish the population figures required to comply with the above rules. These figures should be obtained from a recognized local source or from Statistics Canada.

4. EXIGENCES DE PROTECTION CONTRE LE BROUILLAGE PAR ONDE IONOSPHÉRIQUE

4.1 Le chapitre 4 des Actes finals de l'Accord régional pour la Région 2 prescrit les contours de protection pour les stations de classe A, B et C, ainsi que les méthodes à utiliser pour calculer le brouillage par onde de sol et par onde ionosphérique. L'accord bilatéral Canada/É.-U. prescrit les mêmes méthodes au chapitre 4 de l'annexe 2.

4.2 Il est à noter que lorsqu'on protège les assignations au Gröenland, à Saint-Pierre et Miquelon, au Mexique et aux États-Unis, la valeur de tous les signaux brouilleurs par onde ionosphérique vers chacun de ces pays est déterminée en utilisant les courbes d'onde ionosphérique pour 10 % du temps, comme le définit le paragraphe 3.4 de l'Accord régional pour la Région 2. Pour la protection de tous les autres pays, les courbes d'onde ionosphérique pour 50 % du temps devront être utilisées pour tous les calculs de signaux brouilleurs par onde ionosphérique.

4.3 Dans certains cas où l'on considère le brouillage par onde ionosphérique du service par onde de sol, il est probable que la protection contre le brouillage par onde ionosphérique de l'emplacement de l'émetteur assurera automatiquement une protection acceptable au contour de service par onde de sol de nuit, si une marge de protection appropriée est prévue et si la station protégée est à une distance considérable de la nouvelle assignation. Dans le cas contraire, la protection du contour de service réel devra être assurée. Les mémoires techniques se fondant uniquement sur la protection de l'emplacement de l'émetteur, sans tenir compte de la possibilité de brouillage à l'intérieur du contour de service par onde de sol de nuit, seront considérées comme étant techniquement erronés et seront retournés aux fins de correction.

4.4 Le contour E_u et tous les niveaux de brouillage devront être calculés en utilisant les diagrammes élargis (ou modifiés, le cas échéant).

4. SKYWAVE PROTECTION REQUIREMENTS

4.1 Chapter 4 of the Final Acts of the RAMFBC-R2 prescribes the protected contours for Classes A, B and C stations and the methods to be used in calculating the skywave interference to skywave and groundwave service contours. The Canada/USA bilateral agreement prescribes the same methods in Annex 2, Chapter 4.

4.2 It should be noted that when protecting assignments in Greenland, Saint Pierre et Miquelon, Mexico and United States the value of all interfering skywave signals to any of these countries is determined using the 10 % skywave curves as defined in paragraph 3.4 of the RAMFBC-R2. When protection to all other countries is determined, 50 % skywave curves are to be used for all calculations of skywave interfering signals.

4.3 In certain instances where skywave interference to groundwave service is being considered, if adequate margin of protection is allowed, and if the protected station is at a considerable distance from the new assignment, it is probable that skywave protection of the transmitter site would automatically provide acceptable protection to the night-time groundwave service contour. Where this is not the case, protection shall be provided to the actual service contour. Technical submissions, predicated upon transmitter site protection only without due consideration being given to possible interference occurring within the night-time groundwave service contour, will be considered to be technically in error and returned for correction.

4.4 The E_u, and all interference levels shall be calculated using expanded (or modified, if applicable) patterns.

5. PROTECTION DE NUIT DE LA ZONE DE SERVICE PAR ONDE DE SOL DES STATIONS CONTRE LE BROUILLAGE CAUSÉ PAR DES STATIONS EXPLOITÉES SUR UNE VOIE ADJACENTE

5.1 Protection

5.1.1 Les chapitres 4 de l'Accord régional pour la Région 2 et de l'Accord Canada/É.-U. exigent la protection contre le brouillage de voie adjacente de la zone de service par onde de sol de nuit jusqu'au contour 0,5 mV/m. Étant donné l'encombrement actuel de la bande AM et, comme il n'est pas jugé nécessaire d'offrir un plus grand degré de protection contre le brouillage de la voie adjacent que contre le brouillage sur la même voie, une règle assouplie a été adoptée à l'usage national seulement. Cette règle assouplit les critères de protection contre le brouillage de la voie adjacente de nuit, le cas échéant, en prenant en considération le brouillage dans la même voie.

5.2 Contour de protection de nuit

5.2.1 Aux fins du calcul du signal de brouillage admissible provenant d'une voie adjacente, le contour de protection d'onde de sol de nuit est déterminé comme suit:

(a) pour les stations de classe A, le contour de protection d'onde de sol de nuit est le contour 0,5 mV/m;

(b) pour les stations des classes B et C, le contour de protection d'onde de sol de nuit de toutes les stations canadiennes est le contour 0,5 mV/m ou le contour correspondant à 20 % du champ utilisable, le contour retenu étant celui qui englobe la superficie la plus faible.

5.3 Niveau de brouillage admissible

5.3.1 Le niveau maximal du signal de brouillage par onde de sol du contour de protection d'onde de sol de nuit d'une station est le suivant:

Séparation en fréquence entre les stations	Niveau maximale du signal de brouillage par onde de sol
10 kHz	0,5 mV/m
20 kHz	15,0 mV/m

5. NIGHT-TIME PROTECTION OF THE GROUNDWAVE SERVICE AREA OF ALL STATIONS AGAINST INTERFERENCE FROM ADJACENT CHANNEL STATIONS

5.1 Protection

5.1.1 Chapter 4 of both the RAMFBC-R2 and the Canada/USA Agreement requires adjacent channel groundwave protection of the night-time service area to the 0.5 mV/m contour. Because of the present congestion in the AM band, and since it is not considered necessary to offer a greater degree of protection from interference by adjacent channel stations than that from co-channel stations, a relaxed rule has been adopted for domestic use only. This rule relaxes the night-time protection criteria of the adjacent channel where appropriate, taking into consideration the co-channel interference.

5.2 Night-time Protected Contour

5.2.1 For the purpose of calculating the allowable interference signal from an adjacent channel, the night-time protected groundwave contour is determined as follows:

(a) for Class A stations, the night-time protected groundwave contour is the 0.5 mV/m contour;

(b) for Class B and Class C stations the night-time protected groundwave contour of all domestic stations is the 0.5 mV/m contour or the contour corresponding to 20 % of the E_u, whichever encloses the smaller area.

5.3 Permissible Interference Level

5.3.1 The maximum level of interfering groundwave signal on the night-time protected groundwave contour of a station is as follows:

Frequency separation between stations	Maximum level of interfering groundwave signal
10 kHz	0.5 mV/m
20 kHz	15.0 mV/m

6. "BLOCAGE" DE LA ZONE DE SERVICE PAR ONDE DE SOL DES STATIONS ÉMETTANT SUR LA VOIE DEUXIÈME-ADJACENTE

6.1 Protection de la zone de service par onde de sol des stations émettant sur la voie deuxième-adjacente

6.1.1 Les critères de protection de la zone de service par onde de sol contre le brouillage provenant des stations émettant sur la voie deuxième-adjacente sont indiqués dans les chapitres 4 de l'Accord régional pour la Région 2 et de l'Accord Canada/É.-U. Pour les stations de radiodiffusion pour lesquelles l'une serait la voie deuxième-adjacente pour l'autre, le rapport exigé du signal d'onde de sol désiré sur le signal d'onde de sol brouilleur est 1/30. Par conséquent, le signal de brouillage admissible pour protéger le contour 0,5 mV/m d'une station est 15 mV/m. L'expérience a montré qu'en appliquant ces critères, on obtient une protection mutuelle des zones de service des deux stations. Toutefois, selon certains facteurs comme la puissance d'une station projetée ou la conductivité locale du sol, il est possible que le contour 15 mV/m d'une station existante soit intersecté ou complètement encerclé par le contour 0,5 mV/m d'une station projetée. Étant donné que le contour 0,5 mV/m devient le contour protégé, la station existante devient "bloquée" et est sérieusement gênée ou empêchée de changer ses installations, à moins que la station change de fréquence (ce qui n'est pas toujours possible) ou que les deux stations puissent en arriver à une entente. La présente règle a pour but de permettre à la station "bloquée" de changer ses installations sur sa fréquence actuelle, quand un tel changement résulterait en un meilleur service.

6.2 Traitement des demandes

Voici les étapes à suivre pour la demande présentée relativement à une station projetée ou à un changement d'installations d'une station existante, lorsque le contour 0,5 mV/m du projet coupe ou encercle le contour 15 mV/m d'une autre station exploitée sur une fréquence espacée de 20 kHz.

1. Le requérant devra envoyer une copie du mémoire technique et une lettre d'accompagnement, par courrier recommandé, au titulaire de la licence de la station touchée, au plus tard à la date de dépôt de la demande. Une copie de la lettre devra également être envoyée au Ministère.

2. Lorsqu'un accord protégeant le droit de la station "bloquée" de modifier ultérieurement ses installations a été convenu entre les parties intéressées, avant le dépôt de la demande, des copies de l'accord devront être présentées avec le mémoire technique, comme faisant partie de la demande de certificat technique de construction et de fonctionnement. la demande est ensuite traitée par le Ministère de la manière habituelle, mais l'évaluation technique comprend une évaluation des contraintes en cause et de l'acceptabilité de l'accord.

6. "LOCK-IN" OF THE GROUNDWAVE SERVICE AREA OF SECOND ADJACENT CHANNEL STATIONS

6.1 Protection of the Groundwave Service Area of Second Adjacent Channel Stations

6.1.1 The criteria for adjacent channel protection of the groundwave service is outlined in Chapter 4 of the RAMFBC-R2 and the Canada/USA Agreements. For broadcasting stations with a second adjacent channel relationship, the required ratio of desired groundwave signal to interfering groundwave signal is 1:30. Therefore, the allowable interfering signal to protect the 0.5 mV/m contour of a station is 15 mV/m. Past experience has shown that applying this criterion will result in mutual protection for the service areas of the two stations. However, depending upon certain factors such as the power of a proposed station or local ground conductivity, it is possible for the 15 mV/m contour of an existing station to be intersected or completely encircled by the 0.5 mV/m contour of a proposed station. Because the 0.5 mV/m contour becomes the protected contour, the existing station becomes "locked-in" and is seriously inhibited or prevented from changing its facilities unless the station changes frequency (which is not always possible) or an understanding can be arrived at between the two stations. The purpose of this present rule is to permit the "locked-in" station to change its facilities on its present frequency when such change would result in providing a better service.

6.2 Application Process

The following are the steps to be taken in the application process when an application is submitted for a proposed station or a change in facilities of an existing station and the 0.5 mV/m contour of the proposal intersects or encircles the 15 mV/m contour of another station separated by 20 kHz.

1. The applicant shall send a copy of the engineering brief and a covering letter, by registered mail, to the licensee of the station affected no later than the date of filing an application. A copy of the letter shall also be sent to the Department.

2. Where an agreement protecting the right of the "locked-in" station to make future changes of facilities has been reached between the involved parties prior to filing the application, copies of the agreement shall be submitted with the engineering brief as part of the application for a TC & OC. The application is then processed by the Department in the normal manner but the technical evaluation would include an assessment of the constraints involved and the acceptability of the agreement.

Ou

3. Lorsqu'aucun accord n'a été conclu entre les parties, avant le dépôt de la demande, le Ministère traitera la demande comme en 2. ci-dessus, mais lorsqu'il enverra la demande au CRTC, le Ministère fournira une évaluation des contraintes en cause et avisera le CRTC que la station touchée est au courant de la situation. Dans le cas où aucun accord n'a été conclu, le Ministère peut imposer des conditions qui protégeraient la station "bloquée".

Or

3. Where no agreement has been reached between the parties prior to filing the application, the Department would process the application as in 2. above but in referring the application to the CRTC, the Department would provide an assessment of the constraints involved and would advise that the affected station is aware of the situation. In cases where no agreement has been reached, the Department may impose conditions which would protect the locked-in station.

7. BROUILLAGE PAR FRÉQUENCE IMAGE

7.1 Introduction

Lorsque deux stations d'émission situées dans la même région fonctionnent à des fréquences qui diffèrent entre elles d'une valeur égale au double de la fréquence intermédiaire (FI) des récepteurs de radiodiffusion, la réception de la station fonctionnant à la fréquence la plus basse peut être brouillée par une fréquence image. Comme la fréquence intermédiaire nominale des récepteurs utilisés au Canada est 455 kHz, avec une déviation normale de 4 kHz, la réception de toute station fonctionnant entre 540 et 700 kHz peut être brouillée par une station dont la fréquence est de 900 à 920 kHz plus élevée, c'est-à-dire, comprise entre 1 440 et 1 600 kHz. On a trouvé que le niveau de brouillage était opposable pour une proportion importante des récepteurs de radiodiffusion lorsque le rapport d'intensité de champ du signal à la fréquence la plus élevée et du signal à la fréquence la plus basse était supérieur à 30. Bien qu'il soit parfois possible de remédier au brouillage en modifiant la fréquence intermédiaire des récepteurs, cette méthode n'est pas pratique. Par conséquent, pour éviter ces situations de brouillage opposable par fréquence image, il ne devrait pas y avoir de chevauchement entre le contour 0,5 mV/m de la station fonctionnant sur la fréquence basse et le contour 15 mV/m de la station sur la fréquence élevée.

7.2 Projets basés sur un rapport de fréquence image

Par suite du grand nombre de stations dans certaines régions, il peut être presque impossible d'éviter le brouillage par fréquence image dans le choix d'une fréquence. Le Ministère serait prêt à considérer un projet basés sur un rapport de fréquence image à condition que la région où le rapport d'intensités de champ est supérieur à 30, soit petite et à population clairsemée de sorte que les récepteurs brouillés étant peu nombreux, un programme efficace de modification de la fréquence intermédiaire de ces récepteurs pourrait être mise en oeuvre avec succès. La responsabilité technique et financière incombe à la station dont la date de notification est la plus récente. Cela s'applique à une nouvelle station ou à une station existante qui présente une demande en vue de la modification de ses installations, sauf dans les circonstances suivantes:

1. lorsqu'il existe déjà un espacement de fréquence de 900 kHz entre les stations;

2. lorsque la station fonctionnant sur la fréquence la plus basse a accepté l'existance d'une région où le rapport d'intensités de champ est supérieur à 30, au moment de la notification de son exploitation actuelle.

7. IMAGE INTERFERENCE

7.1 Introduction

When two transmitting stations in the same area operate on frequencies which differ by a value equal to twice the intermediate frequency (IF) of broadcast receivers, image interference may occur to the reception of the station on the lower frequency. Since the nominal IF of receivers used in Canada is 455 kHz with a standard deviation of 4 kHz, interference may be caused to the reception of any station in the range 540 to 700 kHz by a station whose frequency is 900 to 920 kHz higher, that is, in the range 1440 to 1600 kHz. The interference level has been found to be objectionable to a significant proportion of broadcast receivers where the field strength ratio of the high frequency to the low frequency station signals is greater than 30:1. Although the interference can be remedied sometimes by the adjustment of receiver IF's, this has been found to be impractical. Therefore, to avoid objectionable image interference situations, there should be no overlap of the 0.5 mV/m contour of the station on the lower frequency by the 15 mV/m contour of the station on the higher frequency.

7.2 Proposals Predicated on Image Relationship

Due to the congestion of stations in some areas, it may not be possible to avoid an image relationship in the selection of a frequency. The Department would be prepared to consider a proposal predicated on an image relationship provided that the area where the 30:1 field strength ratio is exceeded is small and sparcely populated so that the receivers affected would be few in number and an effective programme of adjustment of receiver intermediate frequencies could be successfully carried out. The burden of technical and financial responsibility lies with the applicant of the incoming station having the most recent Notification Date. This applies to a new station or an existing station applying for a change in facilities, except as follows:

1. where a 900 kHz frequency separation already exists between stations;

2. where the station on the lower frequency accepted an area where the 30:1 field strength ratio is exceeded at the time of notification of its present operation.

Dans ces derniers cas, la responsabilité de la station fonctionnant sur la fréquence la plus élevée est limitée aux récepteurs englobés dans le contour 250 mV/m, conformément à l'engagement général figurant sur la formule de demande.

In the latter cases, the responsibility of the station on the higher frequency is limited to receivers within the 250 mV/m contour under the general commitment in the application form.

8. BROUILLAGE PAR INTERMODULATION ET TRANSMODULATION

8.1 Lorsque des stations d'émission fonctionnent très près l'une de l'autre, il y a possibilité de brouillage causé par intermodulation et(ou) transmodulation aux installations émettrices. Lors du choix de l'emplacement d'une station, toutes les précautions devront être prises pour éviter de placer l'émetteur à l'intérieur des contours 250 mV/m d'une autre station émettrice. Bien qu'il soit possible de concevoir des installations qui tolèrent une forte intensité de champ provenant de stations rapprochées, dans la pratique, ces cas deviendraient des cas spéciaux.

8.2 Lorsque le contour 250 mV/m d'une station projetée, ou d'une station existante qui désire apporter des changements à ses installations, englobe l'emplacement de l'émetteur d'une autre station, le Ministère exige que le requérant de l'exploitation faisant l'objet de la dernière notification s'engage par écrit à demander à son ingénieur-conseil en radiodiffusion d'étudier la possibilité de brouillage et, au besoin, de calculer et d'installer des filtres à toutes les stations en cause, afin de réduire le brouillage à un niveau qui ne soit pas opposable, et à payer toutes les dépenses, y compris les dépenses afférentes à une perte de recettes que pourrait subir une station obligée de suspendre son exploitation pendant qu'on remédie à la situation.

8. INTERMODULATION AND CROSS-MODULATION INTERFERENCE

8.1 When transmitting stations operate in close proximity to each other, there is a possibility of interference resulting from intermodulation and/or cross-modulation at transmitting installations. In selecting a site for a station every precaution should be taken to avoid locating any transmitter within the 250 mV/m contours of another transmitter. Although it is possible to design installations to tolerate high field strengths from nearby stations, in practice these would become special cases.

8.2 When the 250 mV/m contour of a proposed station, or change in facilities of an existing station, encloses the transmitting site of another station, the Department requires of the applicant for the latest notified operation, a written commitment concerning this. This commitment shall be to the effect that the applicant will have his broadcast engineering consultant study the potential interference situation, and if necessary, design and install filters at all stations involved to reduce the interference to a non-objectionable level, and that the applicant will bear all expenses including those due to a loss of revenue resulting from a station having to suspend operation while remedial action is being taken.

9. **DÉROGATION À L'ACCORD RÉGIONAL POUR LA RÉGION 2 ET À L'ACCORD CANADA/É.-U. POUR UTILISATION À L'INTÉRIEUR DU CANADA**

Pour certains projets de stations de radiodiffusion, la conception des installations d'émission est conforme aux principes fondamentaux de l'Accord régional pour la Région 2 et de l'Accord Canada/É.-U. mais, suivant une stricte interprétation des procédures et règles, cette conception dépend d'une dérogation aux critères acceptés. C'est le cas, par exemple, d'un contour de service de protection qui couvre une étendue d'eau ou une région isolée et non habitée, et où la présence d'un signal brouilleur dont l'intensité dépasse la limite spécifiée ne serait pas préjudiciable au service. La protection de telles régions peut exiger des installations complexes très coûteuses et si cette protection était impossible, il en résulterait, pour les stations canadiennes, une perte de spectre utilisable ou une perte de couverture.

Par conséquent, le Ministère serait disposé à étudier de tels projets, mais seulement lorsque la protection de stations canadiennes est en cause et à condition que le mémoire technique présente des justifications adéquates et qu'il comprenne:

1. une analyse détaillée démontrant qu'il n'existe pas de solution de rechange satisfaisante;

2. des preuves documentaires concernant le chiffre de la population qui habite la région dans laquelle on prévoit du brouillage;

3. une liste des stations normalement captées dans la région atteinte;

4. une analyse détaillée de la dérogation aux conditions restrictives concernant les frontières;

5. une déclaration du titulaire de la licence de toute station atteinte, attestant qu'il accepte les conditions de brouillage comme le décrit le paragraphe 2 ci-dessus.

Toutefois, il faudra examiner très soigneusement toute dérogation aux exigences techniques reconnues, ainsi que son effet sur les stations existantes, afin de determiner si la demande sera acceptable aux fins de traitement.

Le Directeur général de la
Réglementation de la radiodiffusion

G.R. Begley

9. DEPARTURES FROM THE RAMFBC-R2 AND THE CANADA/USA AGREEMENTS FOR DOMESTIC USE IN CANADA

In certain proposals for broadcasting stations, the design of the transmitting facilities is in accordance with the underlying principles of the RAMFBC-R2 and the Canada/USA Agreements but, under a strict interpretation of the procedures and rules, it depends upon a departure from the accepted criteria. An example is the case of a protected service contour extending over a body of water, or outlying terrain with no resident population, where the presence of an interfering signal greater than the specified limit would not be detrimental to service. Protection of such areas may require high cost complex installations and where such may not be feasible a loss of usable spectrum or coverage for Canadian stations may result.

Therefore the Department would be prepared to consider such proposals but only where protection to Canadian stations is involved and provided that the engineering brief presents adequate justification including the following:

1. a detailed analysis demonstrating unavailability of satisfactory alternative;

2. a documentary evidence as to the extent of resident population within the area of proposed interference;

3. a list of stations normally received in the affected area;

4. a detailed analysis concerning the departure from the limiting boundery conditions;

5. a statement from the licensee of any station affected agreeing to the interfering condition as described under 2 above.

However, the departure from recognized technical requirements, and its effect on existing stations, would have to be examined most carefully to determine whether the application would be acceptable for processing.

G.R. Begley
Director General
Broadcasting Regulation Branch

ANNEXE 1

ÉCHANTILLON

ANALYSE DE BROUILLAGE DE JOUR POUR LA STATION XXXA, VILLE 1, PROVINCE   PUISSANCE: 5kW   FREQ. 1,000 kHz   CLASSE B

STATION PROTÉGÉE					STATION PROTÉGÉE VERS POINT PROTÉGÉ						STATION BROUILLEUSE VERS POINT PROTÉGÉ					
IND. D'APPEL	FRÉQ (kHz)	CLA	PUIS (kW)	EMPLACEMENT	PT	CONT. (mV/m)	RAYON (mV/m)	AZ. (deg)	DIST. (km)	ANALYSE DU TRAJET	RAYON (mV/m)	AZ. (deg)	DIST. (km)	ANALYSE DU TRAJET	SIGN. ADM. (mV/m)	SIGN. BROUIL (mV/m)
XXXB	1000	B	1	Ville 2, Prov/État	A	0.5	391	71.5	136.7	8/136.7	738.5	230	391	6/128.7 2/16.5 10/22.5 8/77	.025	.0174
					B	0.5	379.7	52.5	135.1	8/135.1	782.1	236.5	381.3	6/143 2/149.6 10/16.1 8/77	.025	.0176
					C	0.5	373.3	45	134.3	8/134.3	723.9	239	381.3	6/146.4 2/151 10/27.3 8/72.4	.025	.0208
					D	0.5	368.5	38.5	133.5	8/133.5	727.3	241.5	389.4	6/154 2/112.6 10/49.9 8/72.4	.025	.0221
					E	0.5	362	30	131.9	8/131.9	728.9	243.5	399	8/153 2/115.8 10/54.7 8/75.6	.025	.0149
XXXC	1000	B	10	Ville 8, Prov/État	A	0.5	1568.8	14.5	232	15/29 10/203	748.2	165	358.8	6/75.6 2/278.3 10/4.8	.025	.0163
					B	0.5	1562.8	5.5	230	15/32 10/198	764.3	172.5	354	6/77.2 2/197.9 10/77.2	.025	.0204
					C	0.5	1383.7	353.3	220	15/32 10/188	778.7	181	358.8	6/48.3 2/181.8 10/53 4/11.3	.025	.0213
					D	0.5	1142.4	343	206	15/37 10/169	785.2	187.5	360.4	6/53.1 2/173.8 10/175.4	.025	.0224
					E	0.5	828.6	328	186	15/37 10/149	788.4	191.5	436	6/53.1 1/172.2 10/175.4	.025	.0122

SAMPLE SHEET

GROUNDWAVE INTERFERENCE ANALYSIS FOR XXXA, CITY 1, PROVINCE   POWER: 5kW   FREQ 1000 kHz   CLASS B

PROTECTED STATION					PROTECTED STATION TO PROTECTED POINT						INTERFERING STATION TO PROTECTED POINT					
CALL	FREQ (kHz)	CLA	PWR (kW)	LOCATION	PT	CONT. mV/m	RADN mV/m	BRG (deg)	DIST Km	PATH ANALYSIS (Cond/dist.)	RADN mV/m	ERG DEG	DIST Km	PATH ANALYSIS (Cond/dist.)	PERM SIG mV/m	INT SIG mV/m
XXXB	1000	B	1	City 2, Prov/State	A	0.5	391	71.5	136.7	8/136.7	738.5	230	391	6/128.7 2/16.5 10/22.5 8/77	.025	.0174
					B	0.5	379.7	52.5	135.1	8/135.1	782.1	236.5	381.3	6/143 2/149.6 10/16.1 8/77	.025	.0176
					C	0.5	373.3	45	134.3	8/134.3	723.9	239	381.3	6/146.4 2/151 10/27.3 8/72.4	.025	.0208
					D	0.5	368.5	38.5	133.5	8/133.5	727.3	241.5	389.4	6/154 2/112.6 10/49.9 8/72.4	.025	.0221
					E	0.5	362	30	131.9	8/131.9	728.9	243.5	399	8/153 2/115.8 10/54.7 8/75.6	.025	.0149
XXXC	1000	B	10	City 8, Prov/State	A	0.5	1568.8	14.5	232	15/29 10/203	748.2	165	358.8	6/75.6 2/278.3 10/4.8	.025	.0163
					B	0.5	1562.8	5.5	230	15/32 10/198	764.3	172.5	354	6/77.2 2/197.9 10/77.2	.025	.0204
					C	0.5	1383.7	353.3	220	15/32 10/188	778.7	181	358.8	6/48.3 2/181.8 10/53 4/11.3	.025	.0213
					D	0.5	1142.4	343	206	15/37 10/169	785.2	187.5	360.4	6/53.1 2/173.8 10/175.4	.025	.0224
					E	0.5	828.6	328	186	15/37 10/149	788.4	191.5	436	6/53.1 1/172.2 10/175.4	.025	.0122

ÉCHANTILLON

ANALYSE DE BROUILLAGE DE NUIT POUR LA STATION XXX4, VILLE 1, PROV.

VERS: STATION PROTÉGÉE				PROVENANT DE: STATION BROUILLEUSE								BROUILLAGE (mV/m)			
IND. D'APPEL	CLA	PUISS. (kW)	EMPLACEMENT	IND. D'APPEL	CLA	PUISS. (kW)	EMPLACEMENT	DIST (km)	AZ. (Deg)	'O' (Deg)	RAYONN. (mV/m)	BROUILL. (10%)	E_u	RAYONN. PROJ.	BROUILL. PROJ.
XXXX	B	2.5	VILLE 2, Prov/État	XXXB	B	1	VILLE 2, Prov/État	878.5	304.5	10.4	342.7	4.9	13.2	371.8	
				XXXC	B	5	VILLE 3, Prov/État	1227.7	104.5	6.1	555.1	4.55			
				XXXD	B	1	VILLE 4, Prov/État	1755.4	328	2.3	307.3	.96			
				XXXE	B	5	VILLE 5, Prov/État	1108.6	354	7.3	1312.9	13.2*	13.2		
				XXXF	B	50	VILLE 6, Prov/État	2429.6	48	0	2558.3	3.21			
				XXXA	B	10	VILLE 1, Prov/État	1166.5	282.5	7.0	489.9	4.48		371.8	3.4
XXX1	B	50	VILLE 13, Prov/État	XXXB	B	1	VILLE 2, Prov/État	1327.6	101	5.3	90.1	.626			
				XXXC	B	1	VILLE 8, Prov/État	810.9	89.5	16.1	18.5	.288			
				XXXH	B	.5	VILLE 9, Prov/État	381.3	83	25.9	52.6	1.484*	2.43		
				XXXI	B	50	VILLE 10, Prov/État	978.3	39	8.9	156.7	1.918*			
				XXXJ	B	1	VILLE 11, Prov/État	1255	56	6.0	104.1	.79			
				XXXA	B	10	VILLE 1, Prov/État	1041	127	8.0	16.1	.18		93.3	1.044

* Contribuent à la valeur calculée de E_u.

SAMPLE SHEET

APPENDIX 2

SKYWAVE INTERFERENCE ANALYSIS FOR STATION XXXA, CITY 1, PROV

TO: PROTECTED STATION				FROM: INTERFERING STATION								INTERFERENCE (mV/m)			
CALL	CLA	PWR (kW)	LOCATION	CALL	CLA	PWR (kW)	LOCATION	DIST (km)	BRG (Deg)	'O' (Deg)	RADN (mV/m)	INT (10%)	E_u	PROP RADN	PROP INT
XXXX	B	2.5	CITY 2, Prov/State	XXXB	B	1	CITY 2, Prov/State	878.5	304.5	10.4	342.7	4.9			
				XXXC	B	5	CITY 3, Prov/State	1227.7	104.5	6.1	555.1	4.55			
				XXXD	B	1	CITY 4, Prov/State	1755.4	328	2.3	307.3	.96			
				XXXE	B	5	CITY 5, Prov/State	1108.6	354	7.3	1312.9	13.2*	13.2		
				XXXF	B	50	CITY 6, Prov/State	2429.6	48	0	2558.3	3.21			
				XXXA	B	10	CITY 1, Prov	1166.5	282.5	7.0	489.9	4.48		371.8	3.4
XXX1	B	50	CITY 13, Prov/State	XXXB	B	1	CITY 2, Prov/State	1327.6	101	5.3	90.1	.626			
				XXXC	B	1	CITY 8, Prov/State	810.9	89.5	16.1	18.5	.288			
				XXXH	B	.5	CITY 9, Prov/State	381.3	83	25.9	52.6	1.484*	2.43		
				XXXI	B	50	CITY 10, Prov/State	976.3	39	8.9	156.7	1.918*			
				XXXJ	B	1	CITY 11, Prov/State	1255	56	6.0	104.1	.79			
				XXXA	B	10	CITY 1, Prov	1041	127	8.0	16.1	.18		93.3	1.044

* Contribute to the calculated value of E_u

PERMISSIBLE POWERS FOR AM STATIONS ON LOCAL AND REGIONAL CHANNELS

1. Canada ratified the North American Regional Broadcasting Agreement with the following reservation:

> "Notwithstanding the maximum power limits specified for regional and local stations, Canada reserves the right to make use of powers in excess of those limits on local and regional channels, provided that in all cases the resulting interference to other stations on the same and adjacent channels will not exceed the values specified in the Agreement as resulting from the operation at or below the specified limits."

2. In the light of this reservation, the Department accepts applications for powers in excess of 5 Kw on regional channels and 250 watts on local channels, provided the following protection requirements are met:

(1) Stations assigned to regional channels with power in excess of 5 kilowatts: Day-time protection would be afforded co-channel and adjacent channel stations and Night-time protection would be afforded co-channel stations in accordance with the engineering standards of the North American Regional Broadcasting Agreement, Washington, D.C., 1950.

(2) Stations assigned to local channels with powers in excess of 250 watts:

(a) Day-time protection is to be afforded other stations in accordance with the engineering standards of the 1950 NARBA, provided that the geographical separations resulting between the station operating with a directional antenna and utilizing more than 250 watts, and other stations on the same or on adjacent channels shall be no less than those which would be necessary to afford this degree of protection with 250 watts omnidirectional operation (95 Mv/m in the horizontal plane).

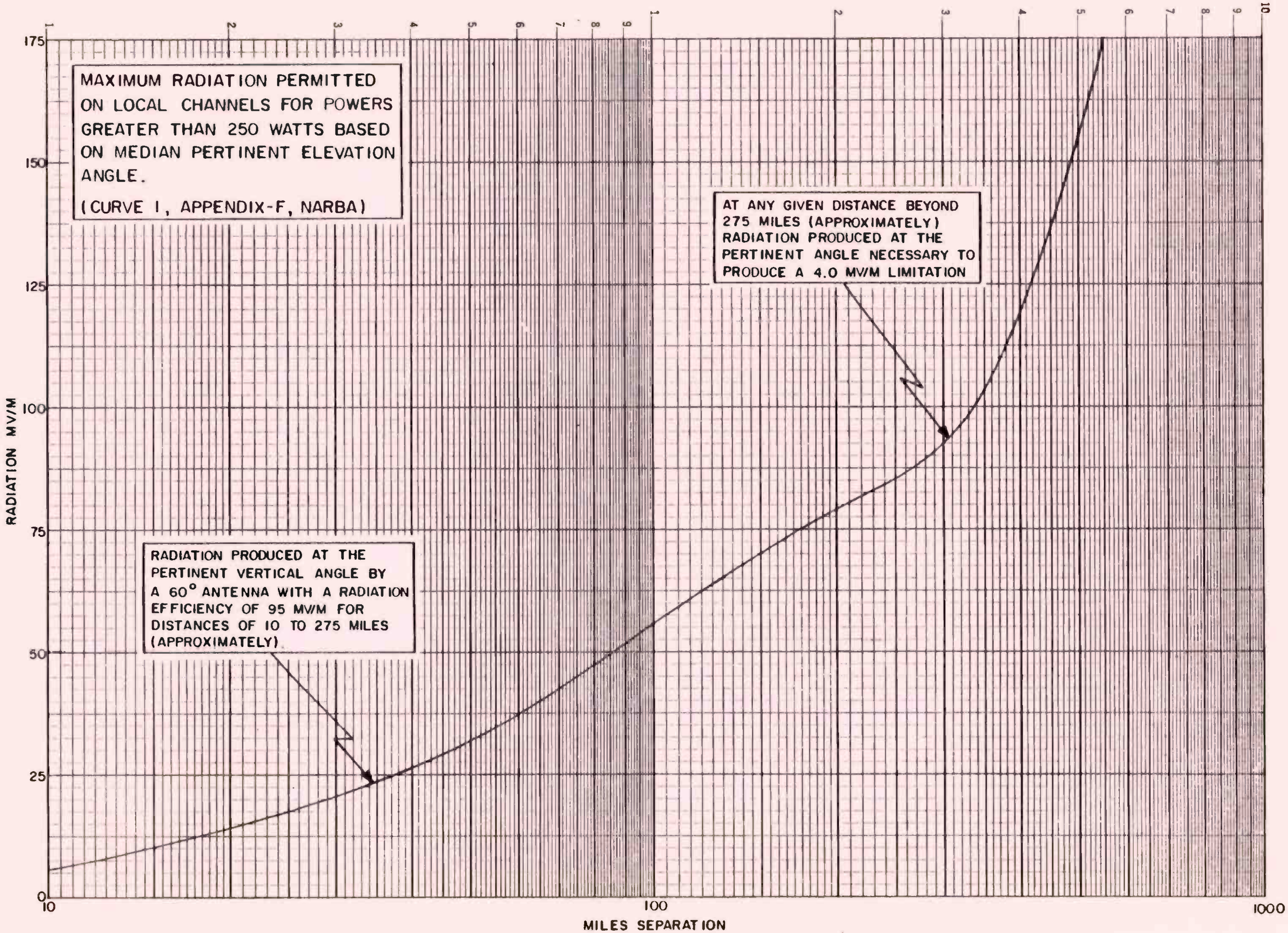
(b) Night-time radiation towards any other co-channel stations shall not exceed the values defined by the attached curve for the distance between the stations involved. This curve is constructed on the following basis:

... 2

(i) 10-275 miles (approximately) - Radiation at the pertinent angle (as determined from Curve 1, Appendix F, of the 1950 NARBA) from a vertical antenna with an electrical height of 60 degrees, producing an unattenuated field at 1 mile of 95 Mv/m for a power of 250 watts.

(ii) 275 miles (approximately) and thereafter, the radiation at the pertinent angle which will produce a single limitation of 4 Mv/m at any given distance.

To demonstrate this, technical briefs must include Night-time radiation patterns in the vertical plane, involving vertical sections in the direction of all stations likely to be affected, or, alternatively, conical sections sufficient for the purpose.


MAXIMUM RADIATION PERMITTED ON LOCAL CHANNELS FOR POWERS GREATER THAN 250 WATTS BASED ON MEDIAN PERTINENT ELEVATION ANGLE.
(CURVE I, APPENDIX-F, NARBA)
AT ANY GIVEN DISTANCE BEYOND 275 MILES (APPROXIMATELY) RADIATION PRODUCED AT THE PERTINENT ANGLE NECESSARY TO PRODUCE A 4.0 MV/M LIMITATION
RADIATION PRODUCED AT THE PERTINENT VERTICAL ANGLE BY A 60° ANTENNA WITH A RADIATION EFFICIENCY OF 95 MV/M FOR DISTANCES OF 10 TO 275 MILES (APPROXIMATELY)
RADIATION MV/M
0
25
50
75
100
125
150
175
MILES SEPARATION
10
100
1000

PROVISIONAL

Broadcast Procedure 1
Rule 16
Issue 1 Provisional
Effective Date: JUL 15 1977
Release Date: JUL 15 1977

DESIGN TOLERANCE FOR DIRECTIONAL

ANTENNA RADIATION PATTERNS FOR AM STATIONS

1. Introduction

1.1 There are 107 channels in the AM band accommodating approximately 6,000 stations in the North American Region. With this congestion, proposals for new stations, or for increases in power for existing stations, frequently require highly complex multi-tower directional antenna arrays to meet service and protection requirements. In the light of past experience, it is apparent that the operation of such arrays would not conform strictly to the theoretical design criteria. This raises the question of providing adequate protection to existing stations, particularly when such requirements impose high constraints on the proposed operations, and call for deep nulls and wide angles of suppression in the radiation pattern.

1.2 The Carl E. Smith method outlined in the National Association of Broadcaster's Handbook has been used for many years to derive the theoretical pattern of an array. If the array is not too complex, the theoretical pattern will serve as a good approximation of the actual radiation for an operating array and the pattern may be maintained with regular monitoring equipment and operating procedures. If the array is a complex one, certain operating variations which cannot always be predicted mathematically become more pronounced resulting in a pattern which may be at some variance with that designed theoretically. Furthermore, if protection and service constraints are critical, interference to an existing service may result.

1.3 To take this situation into account, a requirement for the addition of a design tolerance to the theoretical pattern has been adopted. If it is necessary for an array to operate with a tolerance less than these values, stringent precautions will be required to ensure satisfactory operation of the array.

1.4 This procedure supersedes Notice to Broadcast Consultants No. 29, issued on January 24, 1969 and Notice to Broadcast Consultants No. 39 issued on October 23, 1970.

2. Design Tolerance

2.1 All applications proposing new or changed directional antenna patterns including power increase shall have a design tolerance consisting of two components and calculated as follows:

a) An orthogonal component which is 2.5% of the root-sum-square (RSS) of the fields of the array elements multiplied by the vertical field distribution factor for the shortest tower in the array and added to the theoretical pattern radiation on any specific azimuth plus,

b) A linear component equal to 5% of the resulting sum of the theoretical radiation and the orthogonal component on the same azimuth.

2.1.1 The theoretical pattern plus the design tolerance required can be expressed by the following formula:

$$E\,(\phi,\theta)_a = 1.05\,\sqrt{E(\phi,\theta)_t^2 + Q^2}$$

where:

$E\,(\phi,\theta)_a$ is the magnitude of the theoretical pattern plus the design tolerance required in the horizontal and vertical planes.

$E(\phi,\theta)_t$ is the expression which represents the theoretical pattern inverse distance fields for the given azimuth and elevation.

Q is the orthogonal component and is equal to:

$$0.025\ f\,(\theta)\ E_{rss}$$

E_{rss} is the root-sum-square of the amplitudes of the inverse fields of the elements in the array in the horizontal plane, as used in the expression for $E(\phi,\theta)_t$.

$f(\theta)$ is the vertical distribution factor for the shortest tower in the array.

for a typical vertical antenna with sinusoidal current distribution:

$$f(\theta) = \frac{\cos\,(G \sin\theta) - \cos G}{(1-\cos G)\cos\theta}$$

where G is the electrical tower height and θ is the vertical elevation angle measured from the horizontal plane ($0 \leq \theta \leq 90^{\circ}$).

For G greater than 0.5 wavelength, the vertical distribution factor $g(\theta)$ shall be computed as follows:

$$g(\theta) = \sqrt{\frac{(f(\theta))^2 + 0.0625}{1.030776}}$$

2.2 The theoretical pattern(s) shall be plotted and the tolerance values tabulated for all directions in which protection is required.

3. <u>Determination of Service Contours and Protection Constraints</u>

3.1 The theoretical pattern shall be used for predicting the location of ground wave service contours and protected contours where these have not been measured, for determination of RSS night-time limitation values and for notification purposes.

3.2 The theoretical pattern plus the design tolerance shall be used as a maximum allowable radiation value in proving-in the directional pattern, and to determine compliance with the protection requirements for both ground wave and sky wave signals towards existing stations.

4. <u>Criteria for Reduced Design Tolerance</u>

4.1 Applications proposing radiation fields not providing the required tolerance will be acted upon favourably only where the applicant can clearly demonstrate that the proposed operation is the most satisfactory technical alternative, is achievable in practice, and is maintainable over the long term.

4.2 A showing must be presented which takes into account the complexity of the array, the width of the arc of suppression and the minimum fields, proposed, and would include the following:

a) A demonstration that the proposed antenna site is suitable in all respects for establishment of the antenna system, and that scattering or residual re-radiation from structures on or near the site would be of insufficient magnitude to preclude the adjustment of the measured fields within the proposed tolerance.

This would include:

- a description of all metal structures, towers, transmitting facilities, power lines, railroad tracks, etc. within 2 km of the site preferably accompanied by an appended map or aerial photograph; on highly directional arrays, distances beyond the 2 km should be considered;

- the details of all proposed detuning procedures;

- a projection of future development of the surrounding area together with supporting documentation;

- a detailed description of the physical terrain, including soil test data if available.

b) An analysis to demonstrate that the electrical and physical design of the array would be such as to ensure stable operation. Such designs would require specialized equipments and components. Moreover, the design should avoid electrical parameters known to present instability problems, for example:

- operating resistances between -5 and +5 ohms;

- sectionalized or special feed antennas;

- towers spacings less than 70 degrees;

- field ratios from adjacent towers greater than 3:1;

- top loading;

The description of the array design would include tower specifications, phasing equipment, ground system and transmission lines. This must include major components and equipment layouts.

The description of the ground system would detail all proposed extensions together with the method of burial. Detail with respect to special features such as counterpoises would also be supplied.

A description of the method of temperature stabilization for all critical components throughout the system would be required.

c) A description of the proposed current and phase monitoring system, including the electrical components and physical design details with a specific evaluation of the ultimate accuracy of the system in detecting changes in current amplitudes or phase relationships, specifically, that the phase/current sampling lines for the antenna current and phase monitor have identical physical and electrical characteristics, a low temperature/phase coefficient and have equal lengths subject to the same environmental conditions.

d) An analysis to determine what levels of system deviation would cause objectionable interference to other stations. The monitoring system described in c) must be capable of detecting system deviations of 1/2 the tolerance limits or less.

e) An analysis to demonstrate that the effect of climatic changes would not affect the array parameters as defined in d). Measurement data should be provided if available.

f) A description of the proposed procedure of monitoring the radiation pattern in the field, including the location of the monitoring points, the frequency of the readings and the method of measurement. The monitoring points should be located so as to insure maintenance of the pattern within the tolerance required.

g) A commitment that any deviation outside of the tolerance limit referred to in d) above, will be corrected under the direction of a broadcast consulting engineer.

4.3 Depending upon the substance of the showing in 4.2 above, the value of Q as defined in 2.1.1 may be re-defined as a lower fraction of $f(\theta)\ E_{rss}$

4.4 To obtain authorization for technical operation of a station accepted under this special criteria, the applicant must submit a final proof-of-performance. A preliminary proof-of-performance is not considered adequate.

5. <u>Changes in Operation by Existing Stations</u>

An existing station proposing a major change in its operation, must comply with this rule. However, such a station is not required to provide a greater degree of protection to existing stations as calculated in accordance with this rule, than is provided by its present authorized operation.

Government of Canada
Department of Communications

Gouvernement du Canada
Ministère des Communications

RSS - 150
ISSUE 2
PROVISIONAL

RADIO STANDARDS SPECIFICATION

AM BROADCASTING TRANSMITTERS OPERATING IN THE 535-1705 kHz FREQUENCY BAND AT 10 kHz SPACING

EFFECTIVE DATE: JULY 27, 1985

TELECOMMUNICATION REGULATORY SERVICE

CNR - 150
2e ÉDITION
PROVISOIRE

CAHIER DES CHARGES SUR LES NORMES RADIOÉLECTRIQUES

ÉMETTEURS DE RADIODIFFUSION AM FONCTIONNANT DANS LA BANDE DE FRÉQUENCES DE 535 À 1705 kHz AVEC ESPACEMENT ENTRE VOIES DE 10 kHz

MISE EN VIGUEUR: 27 JUILLET 1985

SERVICE DE LA REGLÉMENTATION DES TÉLÉCOMMUNICATIONS

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CNR 150
2^e^ édition
Provoire

ÉMETTEURS DE RADIODIFFUSION AM
FONCTIONNANT DANS LA BANDE DE FRÉQUENCES DE 535 À 1705 kHz
AVEC ESPACEMENT ENTRE VOIES DE 10 kHz

1. OBJET

1.1 Le présent cahier des charges expose les normes minimales requises pour l'homologation des émetteurs de radiodiffusion AM désignés dans le titre du présent cahier. Les émetteurs dont l'homologation est fondée sur le présent cahier des charges sont considérés comme techniquement acceptables pour les entreprises de radiodiffusion pour lesquelles un Certificat technique de construction et de fonctionnement est exigé conformément aux dispositions de Loi sur la radio.

2. GÉNÉRALITÉS

2.1 Les personnes désireuses d'obtenir l'homologation de matériel fondée sur le présent cahier des charges devront, à leur frais, démontrer au Ministère que ce matériel répond réellement aux prescriptions du présent cahier.

2.2 Le Ministère se réserve le droit d'exiger des mises au point à tout matériel qui produit du brouillage aux termes de la Loi sur la radio, même si ce matériel répond aux prescriptions du présent cahier des charges.

2.3 Le Ministère se réserve le droit de réviser le présent cahier des charges.

2.4 Le présent cahier des charges s'applique à l'émetteur proprement dit: notamment des bornes d'entrée audio aux bornes de sortie, y compris les amplificateurs RF et les filtres.

2.5 Dans le cas où le matériel ne fonctionnerait pas pendant les essais d'homologation se fondant sur le présent cahier des charges, tous les essais touchés par la défaillance devront être répétés une fois le défaut corrigé.

AM BROADCASTING TRANSMITTERS
OPERATING IN THE 535 - 1705 kHz FREQUENCY BAND
AT 10 kHz CHANNEL SPACING

1. INTENT

1.1 This Specification sets forth the minimum standards required for the type-approval of AM broadcasting transmitters described by the above specification title. Transmitters type-approved under this Specification are considered technically suitable for broadcasting undertakings for which a Technical Construction and Operating Certificate is required in accordance with the provisions of the Radio Act.

2. GENERAL

2.1 Those seeking type-approval of equipment under this Specification shall satisfy the Department at their own expense that the equipment actually meets this Specification.

2.2 Notwithstanding the fact that a particular piece of equipment meets this Specification, the Department reserves the right to require that adjustments be made to that equipment wherever it causes interference within the meaning of the Radio Act.

2.3 The Department reserves the right to revise this Specification.

2.4 This Specification covers the transmitter proper: namely from audio input terminals to the output terminals including the r.f. amplifiers and filters.

2.5 In the event that the equipment fails to function during type-approval tests under this Specification, all tests affected by the failure shall be repeated after the trouble has been corrected.

2.6 L'émetteur devra pouvoir satisfaire aux normes du présent cahier des charges sur n'importe quelle voie et à la puissance de sortie nominale pour laquelle son exploitation est prévue.

3. CAHIERS DES CHARGES ET PROCÉDURES CONNEXES

3.1 Procédure n° 100 concernant les normes radioélectriques - Procédure de certification.

3.2 Procédure n° 2 concernant la radiodiffusion - Préparation des documents techniques à présenter à l'appui des demandes d'autorisation d'exploiter des stations commerciales privées de radiodiffusion utilisant des systèmes d'antennes omnidirectionnelles.

3.3 Cahier des charges n° 1 sur la radiodiffusion - Données à fournir dans les demandes de stations de radiodiffusion comportant l'utilisation de systèmes d'antenne directive dans la bande comprise entre 535 et 1605 kHz.

4. CONDITIONS NORMALES D'ESSAI

4.1 Définition - Les conditions normales d'essai sont les conditions dans lesquelles l'émetteur devra fonctionner lorsqu'il est soumis à un essai relatif aux exigences minimales. Ces conditions sont toujours applicables, sauf indication contraire. Lorsqu'aucune condition spéciale n'est mentionnée dans les essais, les conditions devront être celles qui sont spécifiées par le fabricant pour l'exploitation normale et elles devront être mentionnées dans le rapport d'essai.

4.2 Tension normale d'essai - Ce devra être l'une des tensions d'alimentation nominales précisées par le fabricant.

4.3 Température normale - Elle devra être de 20 degrés centigrade plus ou moins 5 degrés centigrade. La température réelle devra être consignée dans le rapport d'essai.

4.4 Charge normale d'essai - Elle devra avoir une caractéristique d'impédance résistive et pouvoir dissiper la puissance de sortie de l'émetteur. A la fréquence d'essai, la composante résistive de la charge d'essai devra être égale, à 5 pour cent près, à l'impédance de la charge avec laquelle l'émetteur a été conçu pour fonctionner. La composante réactive de la charge d'essai ne devra pas dépasser la composante résistive de plus de 5 pour cent dans la gamme de ± 10 kHz par rapport à la fréquence d'essai.

2.6 The transmitter shall be capable of meeting the standards in this Specification on any channel and at the rated power output for which it is designed to operate.

3. RELATED SPECIFICATIONS AND PROCEDURES

3.1 Radio Standards Procedure Number 100 - Certification Procedure.

3.2 Broadcast Procedure Number 2 - Preparation of technical submissions required with applications for private commercial broadcasting stations using omnidirectional antenna systems.

3.3 Broadcast Specification Number 1 - Data required with applications for broadcasting stations involving directional antenna systems to operate in the band 535 to 1605 kHz.

4. STANDARD TEST CONDITIONS

4.1 Definition - Standard test conditions are those conditions which shall apply to a transmitter while it is being tested for minimum requirements. These conditions apply unless otherwise specified. Where no special conditions are called for in the tests, the conditions shall be those specified by the manufacturer for normal operation, and these shall be stated in the test report.

4.2 Standard Test Voltage - Shall be one of the rated power supply voltages specified by the manufacturer.

4.3 Standard Temperature - Shall be 20 degrees C plus or minus 5 degrees C. Actual temperature shall be recorded in the test report.

4.4 Standard Test Load - Shall have a resistive impedance characteristic and be capable of dissipating the output power of the transmitter. At the test frequency, the resistive component of the test load shall be within 5 percent of the load impedance into which the transmitter was designed to operate. The reactive component of the test load shall not be greater than 5 percent of the resistive component over the range of ± 10 kHz from the test frequency.

4.5 Fréquence normales d'essai - La fréquence normale d'essai devra être la fréquence porteuse de la voie dans laquelle l'émetteur est conçu pour fonctionner. Pour les émetteurs pouvant fonctionner sur n'importe quelle voie de la bande de 535 à 1705 kHz, les essais se feront sur deux voies, près de chaque extrémité de la bande. Les fréquences d'essai devront être précisées dans le rapport d'essai.

4.6 Signal normal d'entrée d'essai - Le signal audio normal d'essai devra être une onde sinusoidale de 400 Hz.

4.7 Matériel normal d'essai - Toutes les mesures devront être faites avec des instruments ayant une précision suffisante pour garantir qu'aucune erreur appréciable ne se produit à cause du matériel d'essai, dans les mesures de l'émetteur soumis aux essais.

4.8 Montage normal d'essai - A moins d'indication contraire, tous les essais devront être faits sur la porteuse à la puissance nominale de sortie, modulée par le signal normal d'entrée d'essai.

4.9 Durée de préchauffage - L'émetteur et le matériel d'essai devront être mis sous tension au moins 30 minutes avant le début de tout essais, à moins d'indication contraire.

5. NORMES APPLICABLES A L'ÉMMETEUR

5.1 Système d'émission - Un émetteur de radiodiffusion AM comprend tous les appareils nécessaires pour convertir le signal d'entrée audio en une porteuse RF modulée en amplitude, sur une voie de la bande de fréquences de 535 à 1705 kHz.

5.2 Type d'émission - La désignation de la modulation et de l'émission indique la manière selon laquelle la porteuse est modulée et émise. L'émetteur devra produire une émission A3EGN.

5.3 Réglage de la fréquence porteuse - L'émetteur devra pouvoir fonctionner conformément aux présentes normes, sur n'importe quelle voie de la gamme de fréquences porteuses spécifiée, sans changement de construction autre que le changement des composants déterminant la fréquence. Des dispositifs devront permettre de ramener la fréquence porteuse à la fréquence assignée dans les conditions normales d'exploitation.

5.4 Alimentation nominale - La tension d'entrée c.a. devra être une tension monophasée ou triphasée, à une fréquence de 60 Hz. La tension, la fréquence et la valeur maximale en kVA devront être indiquées sur l'émetteur.

4.5 Standard Test Frequencies - Shall be the carrier frequency of the channel for which the transmitter is designed to operate. For transmitters capable of operating on any one channel in the 535-1705 kHz band, tests shall be made on two channels, one near each end of the band. The test frequencies shall be specified in the test report.

4.6 Standard Test Input Signal - The standard audio test signal shall be a 400 Hz sine wave.

4.7 Standard Test Equipment - All measurements shall be made with instruments having sufficient accuracy to ensure that no appreciable error occurs due to test equipment in the measurements of the transmitter under test.

4.8 Standard Test Set-up - Unless otherwise specified, all tests shall be made with the carrier at rated power output and modulated with the standard test input signal.

4.9 Warm-up Time - The transmitter and test equipment shall be switched on at least 30 minutes before any test is started, unless otherwise stated.

5. TRANSMITTER STANDARDS

5.1 Transmission System - An AM broadcasting transmitter consists of all the apparatus necessary to convert the audio input signal to an amplitude modulated r.f. carrier at a channel frequency in the 535 to 1705 kHz frequency band.

5.2 Type of Emission - The designation of modulation and emission refers to the manner in which the carrier is modulated and transmitted. The transmitter shall produce A3EGN emission.

5.3 Carrier Frequency Adjustment - The transmitter shall be capable of operation in accordance with these standards on any channel in the specified carrier frequency range without change in construction other than changing frequency determining components. Provision shall be made for trimming the carrier frequency to the assigned frequency under normal operating conditions.

5.4 Power Supply Rating - The AC voltage input shall be single phase or three phase, at a frequency of 60 Hz. Voltage, frequency and maximum kVA requirement shall be indicated on the transmitter.

5.5 Charge de phase en phase - Si sa valeur nominale est supérieure à 10 kVA, l'émetteur devra présenter une charge équilibrée au secteur c.a., de telle sorte que le courant dans chaque phase soit égal, à dix pour cent près, à la moyenne des trois courants.

6. NORMES MINIMALES DE PERFORMANCE RF

6.1 Puissance nominale de sortie

6.1.1 Définition - La puissance nominale de sortie d'un émetteur est la puissance de la porteuse à laquelle on peut faire fonctionner l'émetteur dans la charge d'essai.

6.1.2 Méthode de mesure - La porteuse devra être modulée continuellement par le signal normal d'entrée d'essai à un niveau produisant une modulation de 50 pour cent pendant une période de 3 heures, suivie immédiatement par une période de 5 minutes à 95% de modulation. La sortie devra être raccordée à la charge normale d'essai. La puissance de sortie de la porteuse devra être mesurée à l'aide d'un dispositif de mesure de puissance approprié. La méthode devra être décrite dans le rapport d'essai.

6.1.3 Norme - La puissance nominale normale de sortie de l'émetteur devra être telle qu'elle est spécifiée par le fabricant. L'émetteur devra pouvoir fournir la puissance nominale normale plus 10 pour cent, pour les émetteurs de moins de 10 kW, ou la puissance nominale normale plus 6 pour cent pour les émetteurs de 10 kW ou plus. L'émetteur devra pouvoir être réglé de manière à délivrer la puissance nominale de sortie lorsque la tension d'entrée c.a. est à 5 pour cent au-dessus ou au-dessous de la valeur nominale.

6.1.3.1 Le rapport d'essai devra mentionner les limites de la puissance de sortie pour lesquelles l'émetteur satisfait au présent cahier des charges.

6.2 Capacité de modulation

6.2.1 Définition - La capacité de modulation est la capacité d'un émetteur à être modulé.

6.2.2 Méthode de mesure - La capacité de modulation devra être mesurée à l'aide d'un oscilloscope, d'un analyseur de spectre, d'un moniteur de modulation ou par toute autre méthode convenable. La méthode devra être décrite dans le rapport d'essai.

6.2.3 Norme minimale - L'émetteur devra pouvoir être modulé à 95% sur les crêtes positives et négatives de toute fréquence porteuse de la bande de radiodiffusion.

5.5 Phase-to-Phase Loading - The transmitter, if rated above 10 kVA input, shall present a balanced load to the AC mains such that the current in each phase shall be within ten percent of the average of the three currents.

6. MINIMUM RF PERFORMANCE STANDARDS

6.1 Power Output Rating

6.1.1 Definition - The power output rating of a transmitter is the carrier power at which the transmitter may be operated into the test load.

6.1.2 Method of Measurement - The carrier shall be continuously modulated with the standard test input signal at a level producing 50 percent modulation for a period of 3 hours followed immediately by 95% modulation for a period of 5 minutes. The output shall be connected to the standard test load. The output power of the carrier shall be measured by using a suitable power measuring device. The method shall be described in the test report.

6.1.3 Standard - The standard rating of power output for the transmitter shall be as specified by the individual manufacturer. The transmitter shall be capable of delivering the standard output rating plus 10 percent for transmitters rated below 10 kW or the standard output rating plus 6 percent for transmitters rated 10 kW or above. The transmitter shall be capable of being adjusted to deliver the rated power output when the AC input voltage is 5 percent above or below rated value.

6.1.3.1 The test report shall state the power output limits over which the transmitter complies with this specification.

6.2 Modulation Capability

6.2.1 Definition - Modulation capability is the extent to which the carrier can be modulated.

6.2.2 Method of Measurement - Using an oscilloscope, spectrum analyser, modulation monitor, or any other suitable method, the modulation capability shall be measured. The method shall be described in the test report.

6.2.3 Minimum Standard - The transmitter shall be capable of modulation to 95% on positive and negative peaks at any carrier frequency within the broadcast band.

6.3 Stabilité de fréquence de la porteuse

6.3.1 Définition - La stabilité de fréquence de la porteuse est la capacité de l'émetteur à maintenir une fréquence moyenne normale d'essai.

6.3.2 Méthode de mesure - Après une durée de préchauffage d'une heure à la tension nominale d'alimentation c.a., mesurer la fréquence de la porteuse à intervalles d'une minute pendant une période de quinze minutes. Déterminer, à partir de ces mesures, la fréquence moyenne d'essai de la porteuse. Puis, à des températures de 5 degrés centigrade et de 45 degrés centigrade, mesurer la fréquence de fonctionnement pour des tensions d'alimentation de 85, 100 et 115 pour cent. Avant d'effectuer les mesures, laisser l'émetteur soumis aux essais se stabiliser en température pendant 30 minutes.

Lorsqu'il n'est pas pratique de soumettre l'émetteur complet aux conditions d'essais spécifiées, il est permis d'isoler les éléments déterminant la fréquence de l'émetteur, et d'en mesurer séparément la stabilité, dans les conditions spécifiées.

6.3.3 Norme minimale - La fréquence de la porteuse devra rester égale à la fréquence moyenne d'essai, à 10 Hz près.

6.4 Changement de niveau de la porteuse

6.4.1 Définition - Le changement de niveau de la porteuse est la variation, exprimée en pourcentage, de l'amplitude moyenne du signal pendant la modulation.

6.4.2 Méthode de mesure - Le changement de niveau de la porteuse devra être mesuré à l'aide d'un moniteur de modulation approprié.

6.4.3 Norme minimale - Le changement de niveau de la porteuse ne devra pas dépasser 5% pour une modulation de 95%.

6.5 Rayonnements non essentiels

6.5.1 Définition - Les rayonnements non essentiels sont les signaux radiofréquence apparaissant aux bornes de sortie de l'émetteur sur des fréquences autres que la fréquence porteuse précisée et les produits de modulation.

6.5.2 Méthode de mesure - Faire fonctionner l'émetteur dans la charge normale d'essai, à la puissance nominale. Moduler la porteuse avec le signal normal d'entrée d'essai, pour une modulation de 95%. A l'aide d'un dispositif d'échantillonnage, mesurer tous les rayonnements non essentiels jusqu'à la troisième harmonique de la fréquence porteuse. Mesurer l'intensité du rayonnement à l'aide d'un instrument sélectif en fréquence. Les caractéristiques d'atténuation en fonction de la fréquence du dispositif d'échantillonnage de puissance et de la charge utilisés pour cet essai doivent être connues pour toute la gamme de fréquences en question. Consigner les rayonnements non essentiels en dB par rapport à la puissance nominale, à l'exception des rayonnements se trouvant à plus de 20 dB au-dessous des valeurs mentionnées en 6.5.3.

6.3 Carrier Frequency Stability

6.3.1 Definition - The carrier frequency stability is the ability of the transmitter to maintain a mean standard test frequency.

6.3.2 Method of Measurement - After a warm-up period of one hour at rated a.c. input voltage, measure the frequency of the carrier at one minute intervals during a period of fifteen minutes. From those measurements determine the mean test frequency for the carrier. Then at temperatures of 5 degrees C and 45 degrees C measure the operating frequency at supply voltages of 85, 100 and 115 percent. A period of 30 minutes should be allowed to enable the unit under test to achieve temperature stability before performing the measurements.

Where it is not practical to subject the complete transmitter to the specified test conditions, it is permissible to isolate and separately measure the stability of the frequency-determining elements of the transmitter under the specified conditions.

6.3.3 Minimum Standard - The frequency stability of the carrier shall remain within 10 Hz of the mean test frequency.

6.4 Carrier Level Shift

6.4.1 Definition - The carrier level shift is the change in average carrier amplitude during modulation expressed as a percentage.

6.4.2 Method of Measurement - Carrier level shift shall be measured by a suitable modulation monitor.

6.4.3 Minimum Standard - The carrier level shift for 95% modulation shall not exceed 5%.

6.5 Spurious Emissions

6.5.1 Definition - Spurious emissions are radio frequency signals appearing at the transmitter output terminals on frequencies other than the specified carrier frequency and modulation products.

6.5.2 Method of Measurement - The transmitter shall be operated into the standard test load at rated power. The carrier shall be modulated with the standard test input signal at 95% modulation. Using a sampling device measure all spurious emissions up to the third harmonic of the carrier frequency. The voltage of the emission shall be measured with a frequency selective instrument. The attenuation versus frequency characteristics of the power sampling device and the load used in this test shall be known over the range of frequencies involved. Record all spurious outputs in dB relative to rated power except those more than 20 dB below the values in 6.5.3.

6.5.3 Norme minimale - Les rayonnements non essentiels de l'émetteur ne devront pas dépasser les valeurs données dans le tableau suivant:

Rayonnements non essentiels	Valeur maximale
a) de 15 kHz à 30 kHz à partir de la fréquence porteuse	-25 dB*
b) à plus de 30 kHz de la fréquence porteuse et jusqu'à 75 kHz compris	-35 dB*
c) à plus de 75 kHz de la fréquence porteuse	-(43 + 10 log P)* ou -80 dB*, la valeur la plus élevée étant seule retenue P = puissance en watts

* Par rapport au niveau de puissance de la porteuse non modulée.

En outre, lorsque le cristal de l'oscillateur est enlevé ou mis hors circuit, les rayonnements non essentiels à toute fréquence, y compris la fréquence de la porteuse assignée, ne devront pas être supérieurs à la valeur indiquée en (c) ci-dessus.

6.6 Rayonnement du meuble

6.6.1 Définition - Le rayonnement du meuble comprend toute émission provenant de l'enveloppe de l'émetteur, autre que celle qui provient de ses bornes normales de sortie.

6.6.2 Méthode de mesure - Faire fonctionner l'émetteur à la puissance nominale. Raccorder à un mesureur d'intensité de champ ou à un voltmètre sélectif en fréquence étalonné une antenne de réception placée en alternance à une distance connue se trouvant entre trois et dix mètres d'au moins trois des côtés de l'émetteur (c.-à-d. avant, arrière, côté droit ou gauche). Faire les mesures d'intensité de champ de toutes les émissions (y compris la fréquence fondamentale de la porteuse et ses harmoniques) jusqu'à la troisième harmonique de la fréquence porteuse. Pour la mesure, faire tourner l'antenne de réception dans les trois plans et noter le champ maximal reçu (tenir compte du facteur d'antenne et des pertes de ligne de transmission du matériel de mesure). En utilisant la formule ci-dessous valable en espace libre, calculer l'intensité de champ de référence.

$$E = 7 \sqrt{P}/r \text{ volts par mètre}$$

P étant la puissance nominale de sortie en watts et r étant la distance en mètres.

6.6.3 Norme minimale - Les émissions à n'importe quelle fréquence devront être au moins à 54 dB au-dessous du niveau de référence d'intensité de champ calculé. Il est inutile de consigner tout rayonnement se trouvant à plus de 70 dB au-dessous du niveau de référence.

6.5.3 Minimum Standard - Spurious emissions of the transmitter shall not exceed the values given in the following table:

Spurious Emission	Maximum Value
a) between 15 kHz and 30 kHz from the carrier frequency	-25 dB*
b) more than 30 kHz and up to and including 75 kHz from the carrier frequency	-35 dB*
c) more than 75 kHz from the carrier frequency	-(43 + 10 log P)* or -80 dB* whichever is the higher signal level P = power in watts

* Referred to the power level of the unmodulated carrier.

In addition, when the oscillator crystal is removed or deactivated, spurious radiation at any frequency including the assigned carrier frequency shall be no greater than the value specified in (C) above.

6.6 Cabinet Radiation

6.6.1 Definition - Cabinet radiation is any emission from the transmitter housing or enclosure from sources other than a normal output port.

6.6.2 Method of Measurement - The transmitter shall be operated at rated power output. A receiving antenna, located alternately at a known distance between three and ten metres from at least three sides of the transmitter (i.e. front, back, left or right hand side), shall be connected to a calibrated field strength meter or frequency selective voltmeter. Field strength measurements shall be made of all emissions (including the fundamental and harmonics of the carrier frequency) up the third harmonic of the carrier frequency. For the measurement, the receiving antenna shall be rotated in all three planes and the maximum received field shall be noted (allowance shall be made for antenna factor and transmission line loss of the measuring equipment). Using the free space formula below, calculate the reference field strength.

$$E = 7\sqrt{P}/r \text{ volts per metre}$$

where P is the rated output power in watts and r is the distance in metres.

6.6.3 Minimum Standard - Emissions at any frequency shall be at least 54 dB below the calculated field strength reference level. Any radiation weaker than 70 dB below the reference level need not be recorded.

7. NORMES MINIMALES DE PERFORMANCE AUDIO

7.1 Impédance d'entrée audio

7.1.1 Norme - L'impédance d'entrée audio devra être une impédance nominale de 600 ohms, équilibrée par rapport à la masse, pour toutes les audiofréquences. Des impédances nominales additionnelles peuvent aussi être utilisées selon les spécifications du fabricant.

7.2 Niveau d'entrée audio pour une modulation de 95 pour cent

7.2.1 Définition - Le niveau d'entrée audio pour une modulation de 95 pour cent est le niveau audio, exprimé en dBm (0 dBm = 1 mW), nécessaire pour obtenir une modulation de 95 pour cent de la porteuse, tant sur les crêtes positives que sur les crêtes négatives.

7.2.2 Méthode de mesure - Le signal normal d'essai devra être réglé de manière à produire une modulation de 95 pour cent et son niveau devra être consigné.

7.2.3 Norme - Le niveau d'entrée audio normal pour une modulation de 95 pour cent devra être plus 10 dBm ± 2 dBm.

7.3 Réponse audiofréquence

7.3.1 Définition - La réponse audiofréquence est le rapport des tensions d'entrée et de la tension à 400 Hz, exprimé en dB, nécessaire pour maintenir un pourcentage constant de modulation sur toute la gamme des audiofréquences.

7.3.2 Méthode de mesure - Utiliser le montage normal d'essai. Déterminer le niveau d'entrée audio pour maintenir les niveaux de modulation constants de 25, 50 et 85 pour cent, à un nombre suffisant de points sur la gamme de fréquences 50 Hz - 10 kHz, pour pouvoir tracer une courbe pour chaque niveau de modulation.

7.3.3 Norme minimale - La courbe de réponse en audiofréquence devra être entièrement dans la zone non ombrée des limites de l'annexe A pour chaque niveau de modulation.

7.4 Distorsion harmonique en audiofréquence

7.4.1 Définition - La distorsion harmonique en audiofréquence est le contenu harmonique du signal audio contribué par l'émetteur.

7.4.2 Méthode de mesure - Mesurer la distorsion hamonique en audiofréquence en démodulant un échantillon de la sortie RF de l'émetteur et en l'appliquant à un analyseur d'onde ou à un distorsiomètre. Si l'on utilise un instrument de moyenne, il sera nécessaire de tenir compte des erreurs possibles dues aux relations de phase des harmoniques. Mesurer la distorsion en audiofréquence à 50, 100, 400, 1000, 2500, 5000, 7500 et 10 000 Hz et à 25, 50 et 85 pour cent de modulation pour chacune de ces fréquences.

7. MINIMUM AUDIO PERFORMANCE STANDARDS

7.1 Audio Input Impedance

7.1.1 Standard - The audio input impedance shall be a nominal 600 ohms balanced to ground, at all audio frequencies. Additional nominal impedances may also be used as specified by the manufacturer.

7.2 Audio Input Level for 95 Percent Modulation

7.2.1 Definition - The audio input level for 95 percent modulation is the audio input, expressed in dBm (0 dBm = 1 mW), necessary to obtain 95 percent modulation of the carrier, on both positive and negative peaks.

7.2.2 Method of Measurement - The standard test signal shall be adjusted to produce 95 percent modulation and this level shall be recorded.

7.2.3 Standard - The standard audio input level for 95 percent modulation shall be plus 10 dBm ± 2 dBm.

7.3 Audio Frequency Response

7.3.1 Definition - The audio frequency response is the ratio of input voltages relative to the voltage at 400 Hz, expressed in dB, required to maintain a constant percentage of modulation across the audio frequency range.

7.3.2 Method of Measurement - The standard test set up shall be used. The audio input to maintain constant modulation levels of 25, 50 and 85 percent shall be determined at a sufficient number of points over the frequency range 50 Hz to 10 kHz to enable a curve to be plotted for each modulation level.

7.3.3 Minimum Standard - The audio frequency response curve shall be entirely within the unshaded area of the limits in Appendix A for each modulation level.

7.4 Audio Frequency Harmonic Distortion

7.4.1 Definition - The audio frequency harmonic distortion is the harmonic content of the audio signal contributed by the transmitter.

7.4.2 Method of Measurement - The audio frequency harmonic distortion shall be measured by demodulating a sample of the r.f. output of the transmitter and feeding this to a wave analyzer or distortion meter. If an average-reading instrument is used, it will be necessary to take into account possible errors due to the relative phase relations of the harmonics. The audio frequency distortion shall be measured at 50, 100, 400, 1000, 2500, 5000, 7500 and 10 000 Hz and at 25, 50 and 85 percent modulation respectively.

7.4.3 Norme minimale - La distorsion en audiofréquence, y compris toutes les harmoniques jsuqu'à 24 kHz, ne devra pas dépasser 3%, de 50 Hz à 10 000 Hz.

7.5 Distorsion d'intermodulation en audiofréquence

7.5.1 Définition - La distorsion d'intermodulation en audiofréquence est le signal non linéaire contribué par l'émetteur et résultant en composantes de modulation égales à la somme et à la différence des multiples entiers d'un signal d'entrée audio complexe.

7.5.2 Méthode de mesure - Appliquer aux bornes d'entrée audio de l'émetteur un signal d'essai constitué d'une onde sinusoidale de 60 Hz et d'une onde sinusoidale de 7 kHz ayant entre elles un rapport d'amplitude de 4/1. La distorsion d'intermodulation en audiofréquence doit être mesurée en démodulant un échantillon de la sortie RF de l'émetteur et en l'appliquant à un analyseur d'onde ou à un distorsiomètre approprié. La distorsion doit être mesurée pour une modulation de 25, 50 et 85 pour cent.

7.5.3 Norme minimale - La distorsion efficace d'intermodulation en audiofréquence ne devra pas dépasser 4 pour cent, en prenant comme référence le plus grand des deux signaux d'essai.

7.6 Ronflement et bruit de la porteuse

7.6.1 Définition - Le niveau de ronflement et de bruit de la porteuse est le rapport, exprimé en dB, entre la valeur de la composante de modulation d'amplitude correspondant à une modulation de 100% de l'enveloppe de la porteuse et la valeur de la composante de modulation d'amplitude résiduelle lorsque la porteuse n'est pas modulée.

7.6.2 Méthode de mesure - Pour mesurer le ronflement et le bruit de la porteuse, utiliser un détecteur AM couplé à la sortie de l'émetteur. La sortie du détecteur devra être appliquée par l'intermédiaire d'un filtre passe-bas à un mesureur de distorsion et de bruit. Relever les lectures de la sortie avec une modulation normale d'essai de 95 pour cent et sans modulation, l'entrée audio étant raccordée à une résistance égale à l'impédance d'entrée audio.

7.6.3 Norme minimale - Le niveau mesuré de toutes les composantes de bruit et de ronflement apparaissant comme modulation sur la porteuse devra être au moins à 55 dB au-dessous du niveau correspondant à la modulation à 100 pour cent.

7.4.3 Minimum Standard - The audio frequency distortion, including all harmonics up to 24 kHz shall not exceed 3% from 50 Hz to 10 000 Hz.

7.5 Audio Frequency Intermodulation Distortion

7.5.1 Definition - The audio frequency intermodulation distortion is the nonlinear signal contributed by the transmitter resulting in modulation components equal to the sums and differences of integral multiples of a complex audio input signal.

7.5.2 Method of Measurement - A test signal consisting of a 60 Hz and a 7 kHz sine wave with a relative amplitude ratio of 4:1 respectively shall be applied to the transmitter audio input terminals. The audio frequency intermodulation distortion shall be measured by demodulating a sample of the RF output of the transmitter and feeding this to a wave analyzer or suitable distortion meter. The distortion shall be measured at 25, 50 and 85 percent modulation.

7.5.3 Minimum Standard - The rms audio frequency intermodulation distortion shall not exceed 4 percent referenced to the larger of the two test signals.

7.6 Carrier Hum and Noise

7.6.1 Definition - The carrier hum and noise level is the ratio, expressed in dB, of the value of the amplitude modulation component at 100% modulation of the carrier envelope to the value of residual amplitude modulation component when the carrier is unmodulated.

7.6.2 Method of Measurement - Measurement of the carrier hum and noise level may be made by the use of an AM detector coupled to the output of the transmitter. The output of the detector shall be fed through a 10 kHz low pass filter to a distortion and noise meter. Readings shall be made of the output with standard test modulation of 95 percent and without modulation but with the audio input terminated with a resistance equal to the audio input impedance.

7.6.3 Minimum Standard - The measured level of all hum and noise components appearing as modulation on the carrier shall be at least 55 dB below 100 percent modulation.

8. EXIGENCES RELATIVES AU MATÉRIEL

8.1 Conception - Les émetteurs devront être conçus selon la bonne technique courante.

8.2 Plaque d'identification - Une plaque d'identification sur laquelle devront être inscrits d'une façon permanente le numéro d'homologation, le nom du fabricant, le nom et la puissance nominale de l'unité ainsi que son numéro de série, de même que tout autre renseignement servant à identifier complètement l'unité, devra être fixée solidement et bien en évidence sur l'extérieur de l'émetteur. Toutes les autres unités connexes devront être convenablement identifiées.

8.3 Protection du personnel - L'émetteur devra être construit de manière que tous les éléments dangereux soient contenus dans des espaces entièrement clos ou de façon que le personnel soit protégé contre tout contact accidentel. L'enceinte de l'émetteur devra être suffisante pour assurer la sécurité du personnel pendant l'exploitation.

8.4 Changements et modifications du matériel - Tout changement important de conception ou de matériel, autre que le remplacement des pièces défectueuses par des pièces équivalentes, effectué sur un matériel homologué, entraînera l'annulation de l'homologation, à moins qu'il n'ait été notifié au Ministère et approuvé par ce dernier. La notification doit donner des renseignements démontrant que la modification donne une performance égale ou améliorée de l'émetteur.

Publication autorisée par le
ministre des Communications

Le Directeur
Direction de la réglementation
de la radiodiffusion
Service de la réglementation
des télécommunications

8. EQUIPMENT REQUIREMENTS

8.1 Design - Transmitters shall be designed according to good current engineering practice.

8.2 Nameplate - There shall be securely fastened to each transmitter in a conspicuous external location, a nameplate having permanently marked thereon, the type-approval number, the manufacturer's name, name and rating of the unit and serial number, together with sufficient other information to identify the unit completely. All other units associated with it shall be suitably identified.

8.3 Protection of Personnel - The transmitter shall be so constructed that all hazardous components are totally enclosed, or protected from accidental contact by personnel. The transmitter enclosure shall be sufficient to provide adequate personnel safety during operation.

8.4 Equipment Changes and Modifications - Any major design or equipment changes outside the replacement of defective components by equivalent parts made to an approved equipment will void the approval unless notified to and approved by the Department. The notification must provide information demonstrating that the modification provides equal or improved transmitter performance.

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Broadcasting Regulation Branch
Telecommunication Regulatory
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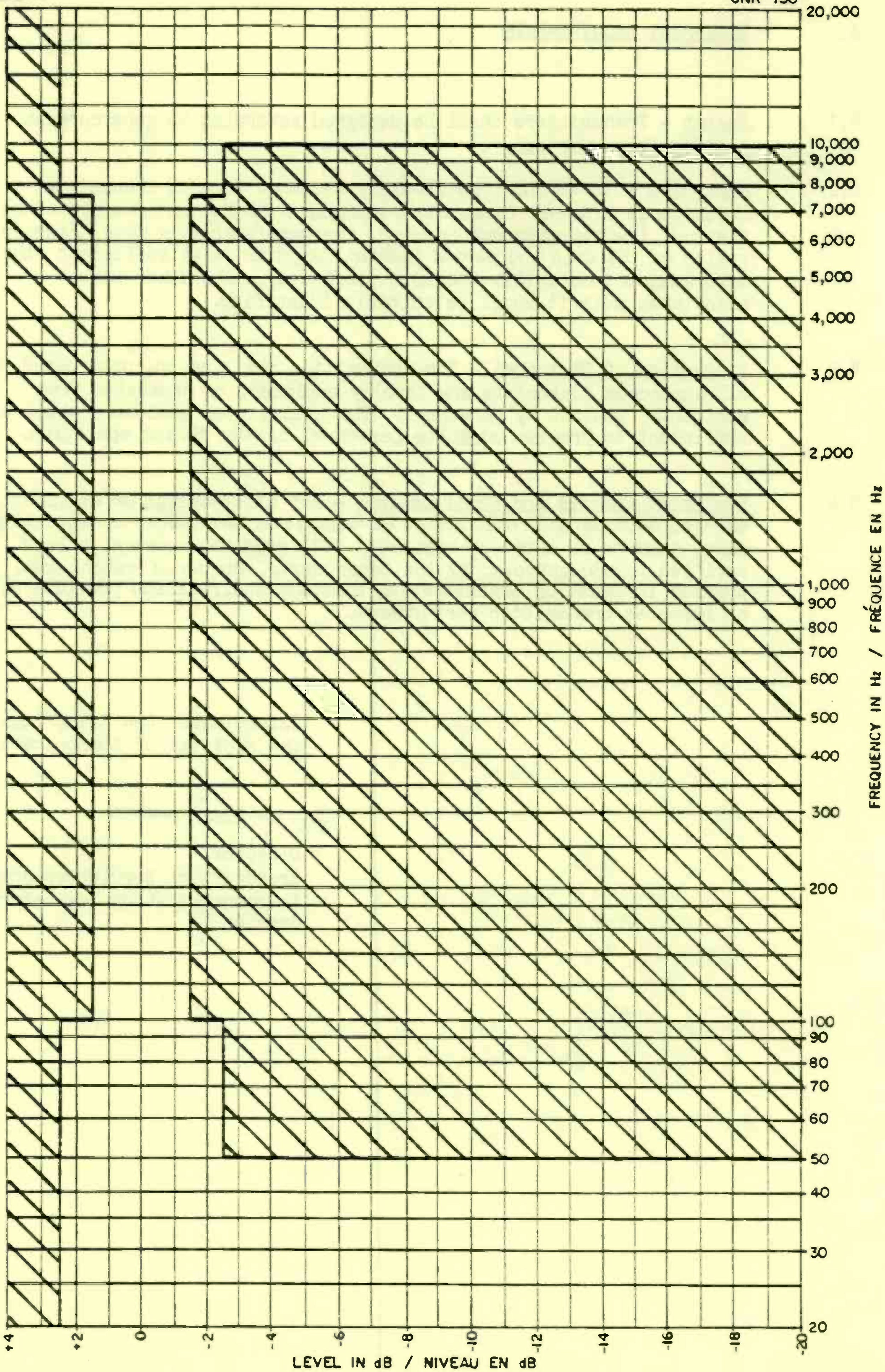


AUDIO FREQUENCY RESPONSE LIMITS
LIMITES DE LA RÉPONSE AUDIOFRÉQUENCE

Communications
Canada

BTS 1-2
ISSUE 1
DRAFT

BROADCAST TRANSMISSION STANDARD

AM BROADCASTING

RF EMISSION LIMITS

EFFECTIVE DATE :

JULY 16, 1988

BROADCASTING REGULATION BRANCH

NER 1-2
1 ère ÉDITION
BROUILLON

NORME SUR LES ÉMISSIONS DE RADIODIFFUSION

RADIODIFFUSION AM

LIMITES D'ÉMISSION RF

MISE EN VIGUEUR :

16 JUILLET 1988

DIRECTION GÉNÉRALE DE LA RÉGLEMENTATION DE LA RADIODIFFUSION

TABLE OF CONTENTS

Broadcasting Transmission Standard
AM Broadcasting
RF Emission Limits

1. General.

1.1 This standard specifies the RF emission limits for AM broadcasting stations in Canada. The standard applies to both AM monophonic and AM stereophonic operation.

1.2 The emission standard consists of two limits; a maximum limit applicable for station operation when the input signal is normal program material (plus ancillary and/or data inputs) and a test limit applicable for station operation when the input signal is the standard noise test signal (see section A4). The test limit and its measurement is included as a control standard which may be used by transmitter manufacturers and broadcasters to provide results that may be directly correlated with each other.

2. RF Emission Limits.

2.1 Purpose. - The purpose of the emission standard is to control the maximum RF emissions of AM broadcast stations and thereby limit possible interference.

2.2 Maximum Limits. The maximum RF emission limits are the peak values of the radiated emissions and include all spectral components caused by programming as well as all ancillary or data inputs. AM broadcast station emissions shall not exceed the maximum limits given in Table 1 and Figure 1 within the frequency ranges specified.

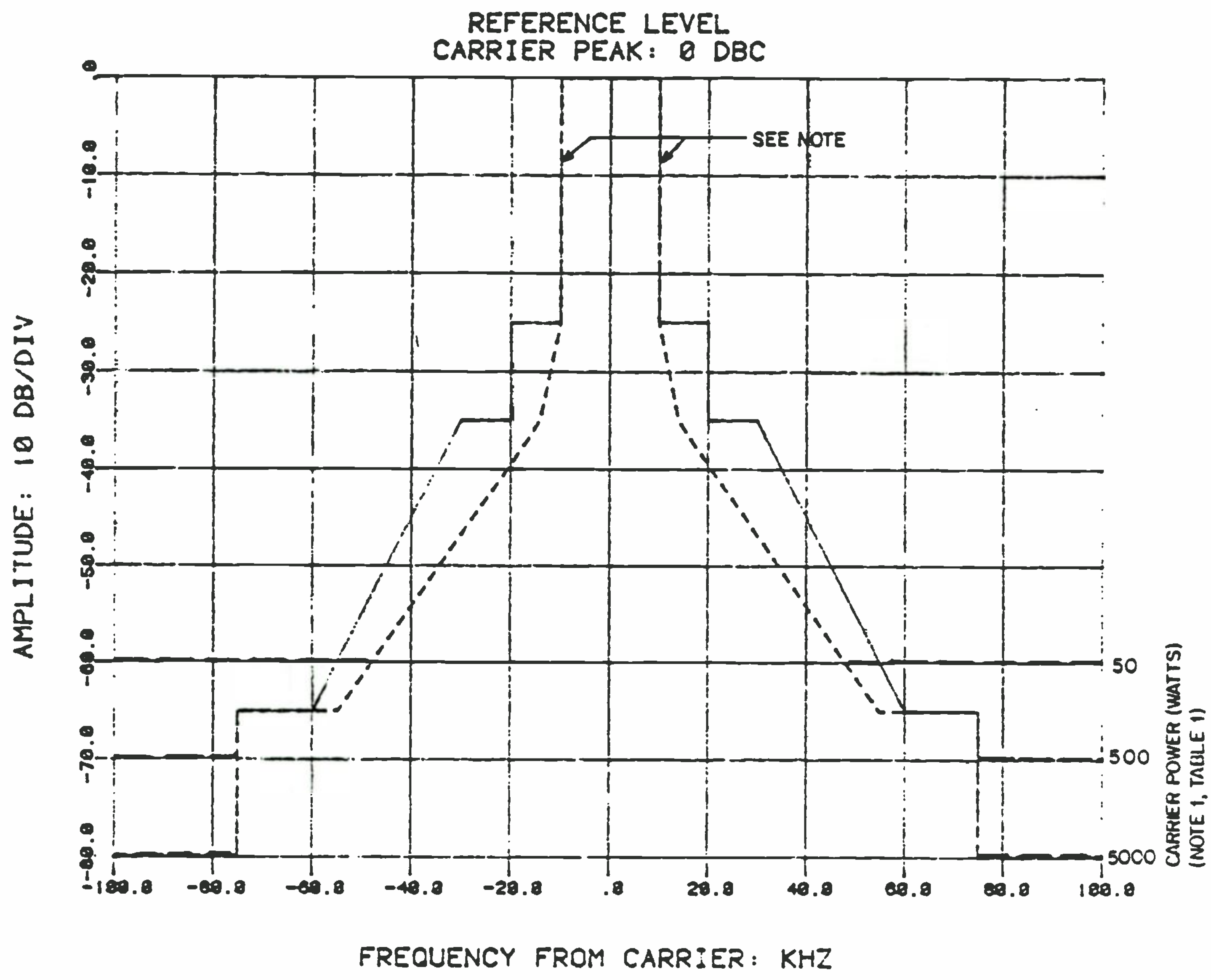
Table 1 Maximum Limits

Frequency Relative to Carrier (+/- kHz)	Amplitude Relative to Carrier (dB)
0 to 10	0
10 to 20	-25
20 to 30	-35
30 to 60	-(5 + 1 dB/kHz from carrier) Note 1
60 to 75	-65 Note 1
above 75	-80 Note 1

Note 1. For carrier power levels between 50 and 5000 watts, the maximum limit shall be -(43 + 10 log P (carrier power in watts)) dB or as indicated in Table 1/Figure 1.

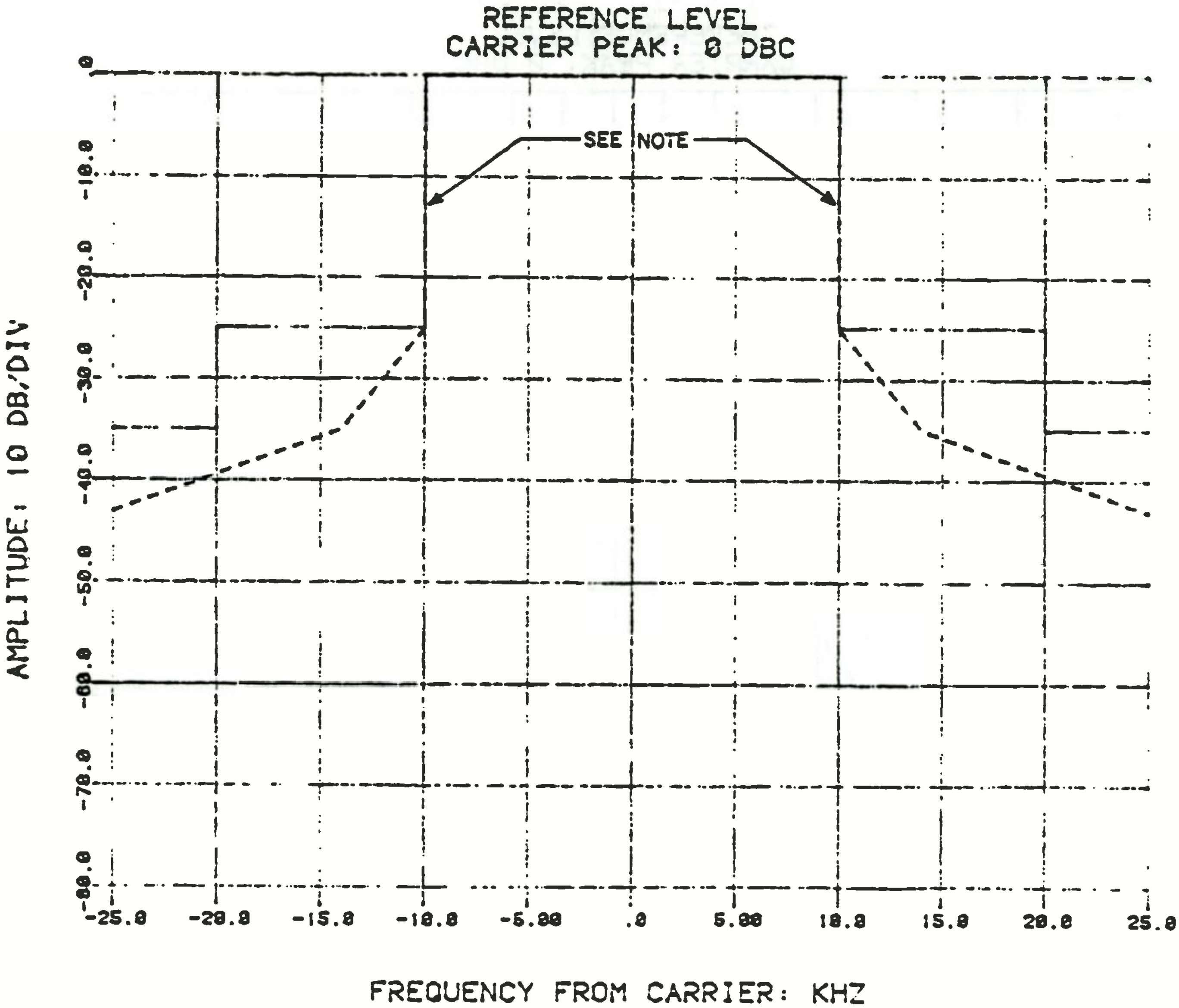
FIGURE 1

AM BROADCAST
RF EMISSION LIMITS



NOTE: TOLERANCE FOR TRANSITION REGION IS A SLOPE FROM 0 DB AT ±10 KHZ TO -25 DB AT ±11 KHZ

FIGURE 1A
(EXPANDED SCALE)
AM BROADCAST
RF EMISSION LIMITS



NOTE: TOLERANCE FOR TRANSITION REGION IS A SLOPE FROM 0 DB AT ±10 KHZ TO -25 DB AT ±11 KHZ

2.3 Test Limits. The RF emission test limits are the peak values of the radiated emissions and include all spectral components caused by the standard noise test signal (see section A4). AM broadcast station emissions shall not exceed the test limits shown in Figure 1 when measured with the standard noise test signal applied.

3.0 Measurement of Emission Limits

3.1 Maximum Limits Measurement

3.1.1 When evaluating for maximum limits, the measurement of AM station spectrum emissions shall be conducted using normal program material (plus ancillary and/or data inputs if present) under normal operating conditions using the measurement procedure given in section A.1 of Appendix A.

3.2 Test Limits Measurement

3.2.1 When evaluating for test limits, the measurement of AM station spectrum emissions shall be conducted using the standard noise test signal and the measurement procedure of section A.2 of Appendix A.

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the Minister of Communications

G.R. Begley
Director General
Broadcasting Regulation Branch

APPENDIX A

Measurement Procedures
AM Broadcasting
RF Emission Limits

A.1 Measurement Procedure: Maximum Limits

A.1.1 Use of Normal Program Material. Measurements of AM station spectrum emissions shall be conducted using normal program material. All audio processing used in the AM station shall be in normal operating modes.

A.1.2 Use of Audio Input Characteristics. Measurements will be taken using the station's usual audio input configuration. It is recommended that the audio signal input to the AM transmitter conforms to the audio input characteristics given in section A.3.

A.1.3 Use of Audio Tones. Sweeping a transmission system with audio tones is a widely accepted and respected method for gauging spectrum emission limits and for troubleshooting and adjusting AM transmission systems and is useful for this purpose. However, compliance with the maximum emission limits may only be determined using dynamic conditions with actual program signals.

A.1.4 Measurement Location. The measurement should be taken at a suitable off-air receiving location in order that the antenna system be included in the measurement. Alternatively, the measurement may be taken at an RF probe in the antenna transmission line.

A.1.5 Use of Spectrum Analyzer. A suitable swept-frequency RF spectrum analyzer may be used to measure compliance with the maximum limits of RF spectrum emissions. The spectrum analyzer setup shall consist of

a. 300 Hz resolution bandwidth
b. 5, 10 or 20 KHz/horizontal division (as appropriate)
c. 10 dB/vertical division
d. Reference: carrier peak
e. Peak Hold: 10 minute duration

A.1.6 Use of Splatter Monitor. A recently developed splatter monitor device may be used to measure compliance with the maximum limits of RF spectrum emissions. A measurement method will be specified following evaluation and correlation of field results from this device.

A.2 **Measurement Procedure : Test Limits.**

A.2.1 Standard Noise Test. Measurements of AM station spectrum emissions shall be conducted using a standard noise test signal described in Section A.4. All audio processing used in the AM station shall be in normal operating modes.

A.2.1.1 Monophonic Conditions. The noise source is unmodified.

A.2.1.2 Stereophonic Conditions. Two independent but equivalently designed USASI - weighted noise sources are employed. Pulsing of the sources is controlled by a single control signal. The pulsed output of one noise generator is defined as L + R (mono, sum information) where the other is attenuated by 3 dB to provide L-R (stereo, difference information). The signals are then matrixed to provide left and right channel information to be applied to the audio input terminals of the stereophonic audio processor employed.

A.2.2 Use of Audio Input Characteristics. Measurements will be taken using the station's usual audio input configuration. If the station's input configuration does not limit the input bandwidth to 10 kHz or less, a low pass filter with attenuation characteristics similar to those specified in section A.3.2 must be inserted between the noise signal source and the audio input. It is recommended that the audio signal input to the AM transmitter conforms to the audio input characteristics given in section A.3.

A.2.3 Measurement Location. The measurement should be taken at a suitable off-air receiving location in order that the antenna system be included in the measurement. Alternatively, the measurement may be taken at an RF probe in the antenna transmission line.

A.2.4 Use of Spectrum Analyzer. A suitable swept-frequency RF spectrum analyzer shall be used to measure compliance with the RF emission test limits. The analyzer's setup shall consist of:

a. 300 Hz resolution bandwidth
b. 5, 10 or 20 KHz/horizontal division (as appropriate)
c. 10 dB/vertical division
d. Reference: carrier peak
e. Peak Hold: 10 minute duration

A.2.5 Use of Splatter Monitor. A recently developed splatter monitor device may be used to measure compliance with the RF emission test limits. A measurement method will be specified following evaluation and correlation of field results from this device.

A.3 Audio Input Characteristics

A.3.1 Purpose. The purpose of standard audio input characteristics is to establish uniform audio input bandwidth and preemphasis which serves to control the RF emissions of AM stations and promote complementary receiver designs.

A.3.2 Audio Input Bandwidth. The audio input bandwidth response shall conform to the following specifications. The reference level is 1 dB above a 200 Hz sine wave at 90 % negative modulation. The relative amplitude of the audio envelope input spectrum to the AM transmitter shall be -15 dB at 10 kHz, smoothly decreasing to -30 dB at 10.5 kHz, then remaining at -30 dB from 10.5 kHz until 11.0 kHz. At 11.0 kHz, the relative amplitude shall step decrease to -40 dB, then smoothly decrease to -50 dB at 15 kHz. Above 15 kHz, the relative amplitude shall remain at least -50 dB. These specifications are presented in graphical form in figure A1. Appropriate and carefully designed audio low-pass filters as the final filtering prior to modulation can be used to implement this specification.

A.3.3 Audio Input Preemphasis. The audio preemphasis curve is a modified 75 us curve. It has a single zero with the break frequency of 2122 Hz and to reduce peak boost at high frequency a single pole with a break frequency of 8700 Hz. The curve is shown graphically in Figure A2 and technical information is presented in Table A1. AM broadcast stations broadcasting with the standard preemphasis given above shall have an audio response which remains within ±1 dB of the curve for audio frequencies up to 10 kHz.

FIGURE A1

AUDIO INPUT BANDWIDTH STANDARD

STOPBAND SPECIFICATION

(AUDIO ENVELOPE INPUT SPECTRUM TO AM TRANSMITTER)

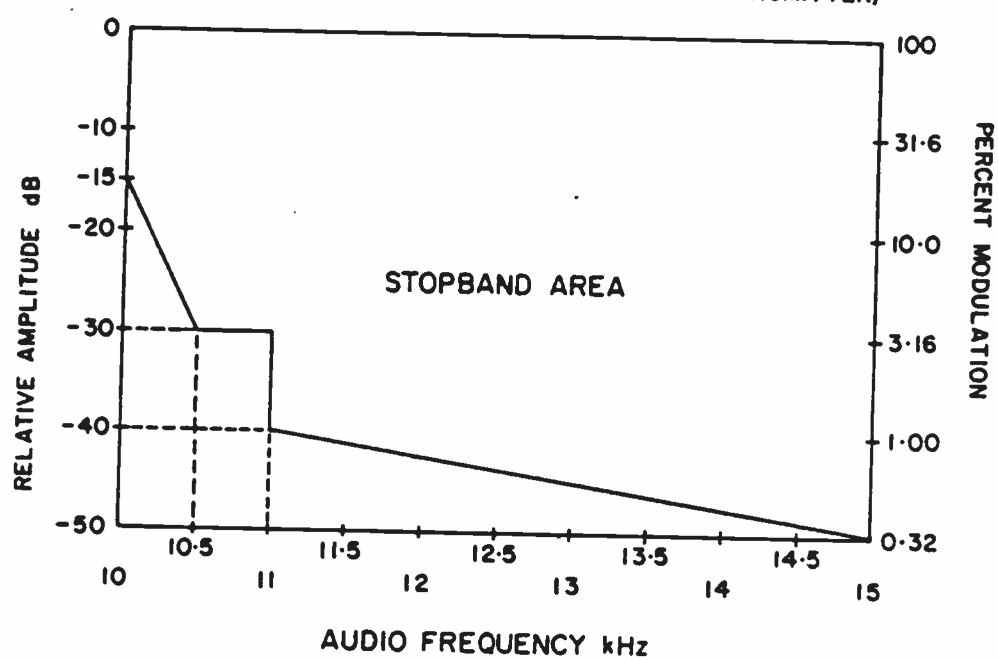
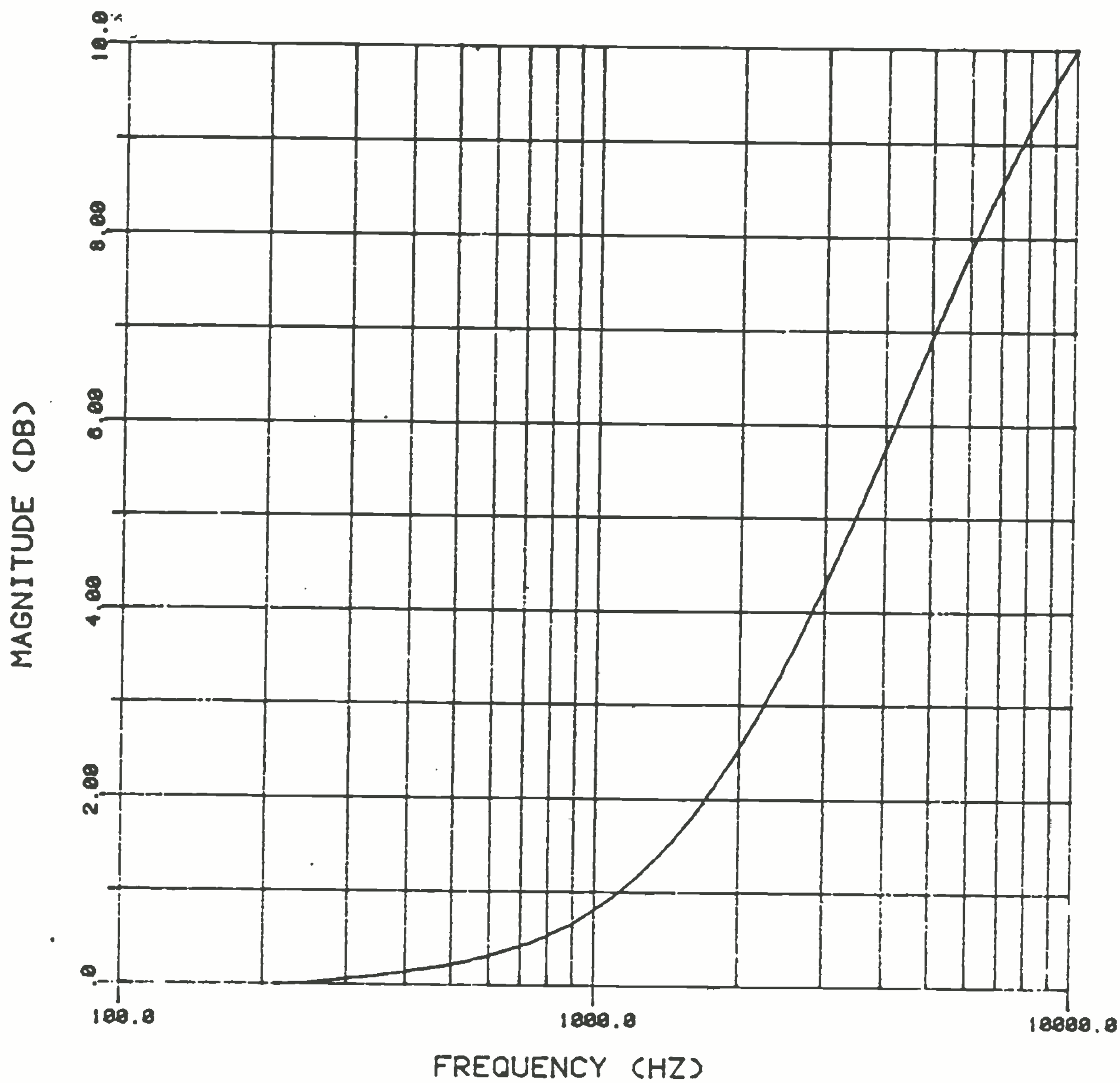


FIGURE A2

AM BROADCAST
AUDIO INPUT PREEMPHASIS



MODIFIED 75 MICROSEC
AUDIO INPUT PREEMPHASIS CURVE

TABLE A1

Audio Input Preemphasis

Technical Information

Frequency	Magnitude (dB)	Phase (deg)	Group Delay (sec)
50	0.00	1.0	-5.6669E-005
100	0.01	2.0	-5.6547E-005
400	0.14	8.0	-5.4175E-005
700	0.42	13.7	-4.9467E-005
1000	0.81	18.7	-4.3318E-005
1500	1.63	25.5	-3.2247E-005
2000	2.54	30.4	-2.2343E-005
2500	3.44	33.6	-1.4509E-005
3000	4.28	35.7	-8.6612E-006
3500	5.05	36.9	-4.4133E-006
4000	5.75	37.4	-1.3702E-006
4500	6.37	37.4	7.8900E-007
5000	6.92	37.1	2.3048E-006
5500	7.41	36.6	3.3525E-006
6000	7.85	35.9	4.0592E-006
6500	8.24	35.2	4.5169E-006
7000	8.58	34.3	4.7926E-006
7500	8.89	33.4	4.9357E-006
8000	9.16	32.5	4.9823E-006
8500	9.41	31.6	4.9595E-006
9000	9.62	30.8	4.8871E-006
9500	9.82	29.9	4.7801E-006
10000	10.00	29.0	4.6495E-006

A.3.4 Measurement Procedure·Audio Input Bandwidth

A.3.4.1 Use of Standard Noise Test Signal. Measurement of an AM station's input bandwidth shall be conducted using the standard noise test signal described in Section A4. Audio bandwidth measurements shall be obtained between the audio input terminals of the audio processing equipment and the audio input terminals of the AM transmitter. For AM stereo stations, audio bandwidth shall be measured at the L+R audio input terminals to the RF modulator.

A.3.4.2 Use of Spectrum Analyzer. A suitable swept-frequency or FFT (Fast Fourier Transform) spectrum analyzer shall be used to measure compliance with the bandwidth specification (see section A.3.2).

(a) Spectrum Analyzer Setup When a swept-frequency audio spectrum analyzer is used to measure compliance with the bandwidth specification, the analyzer's setup shall consist of:

a. 300 Hz resolution bandwidth
b. 2 kHz/horizontal division
c. 10 dB/vertical division
d. Reference: 1 dB above 200 Hz (sine wave) 90% negative modulation
e. Display: maximum peak hold (or equivalent function).

(b) Fast Fourier Transform Analyzer When a FFT analyser is used to measure compliance with the bandwidth specification, the analyzer's setup shall consist of:

a. Reference: 1 dB above 200 Hz (sine wave) 90% negative modulation
b. Window: Hanning
c. Horiz. span: 20 kHz
d. Dynamic range: 80 dB or available range
e. Display: Maximum peak hold (or equivalent function).

A.3.5 Measurement Procedure Audio Input Preemphasis.

A.3.5.1 Method of Determining Performance. The audio preemphasis curve is a static curve and cannot be measured dynamically. Studies have shown that the dynamic and non-linear functions performed by most AM station audio processors will modify any given preemphasis curve. The dynamic functions of the AM station's processor, but not the frequency shaping circuits, must be inactive (i.e. in "proof" mode).

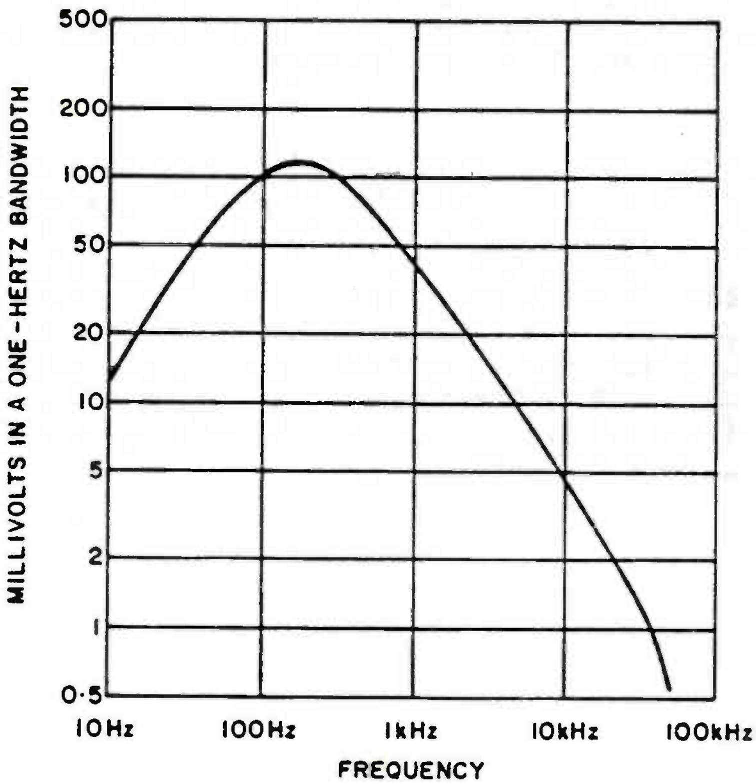
A.3.5.2 Use of Audio Tones. Compliance with the pre-emphasis curve shall be measured by sweeping the station's transmission system with audio tones. The net transmission system audio response is best measured by detecting the over-the-air signal using an AM modulation monitor. This will ensure that the AM transmitter and antenna combination is faithfully reproducing the preemphasized audio. Alternatively, if the transmitter and antenna is broadband, performance can be determined by static measurement of the audio signal prior to modulation.

A.4 Standard Noise Test Signal.

A.4.1 Purpose. The purpose of the standard noise test signal is to provide a repeatable analytical test signal which is representative of actual programme material used on AM broadcast stations. The test signal has spectral characteristics simulating typical music programming in average level and in percussive beats.

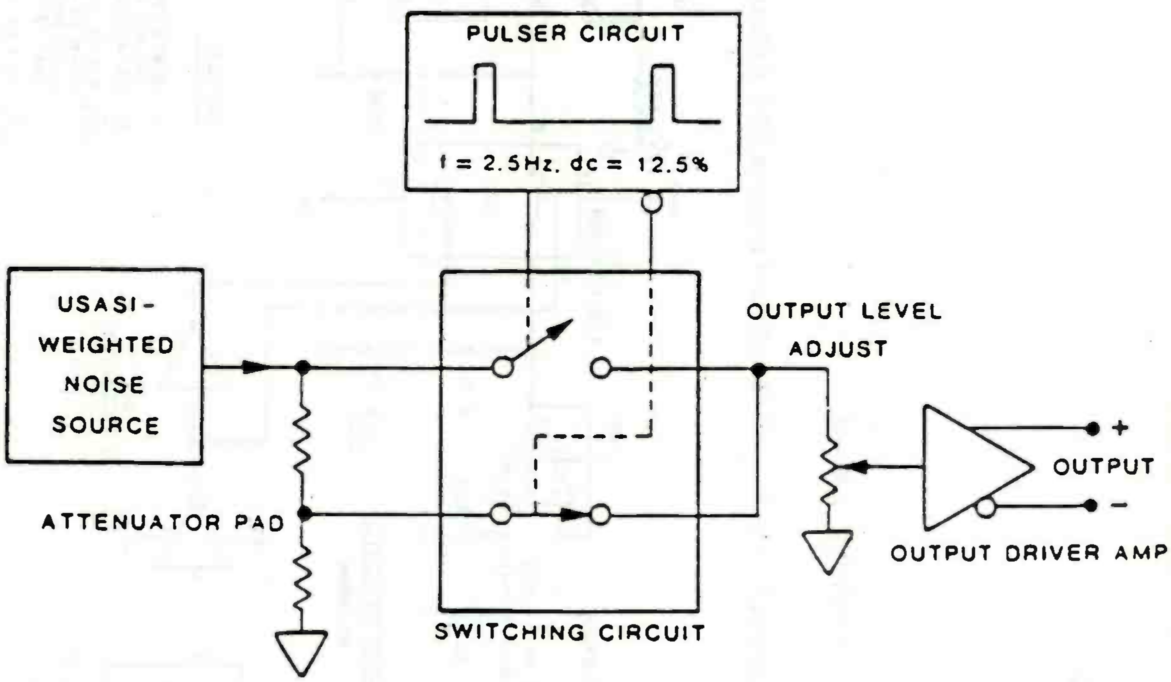
A.4.2 Description. The test signal shall consist of a white noise source with USASI (United States of America Standards Institute) weighting. The weighting is produced by filtering white noise with (1) a 100 Hz, 6 dB per octave high pass network and (2) a 320 Hz, 6 dB per octave low pass network. (See Figure A3). The USASI noise signal is then passed through a pulser circuit wherein the ratio of the peak to average amplitude of the noise signal is set to 20 dB at the output of the pulser. A pulsed USASI noise generator is shown in figures A4-A and A4-B.

FIGURE A3



SPECTRA OF USASI NOISE

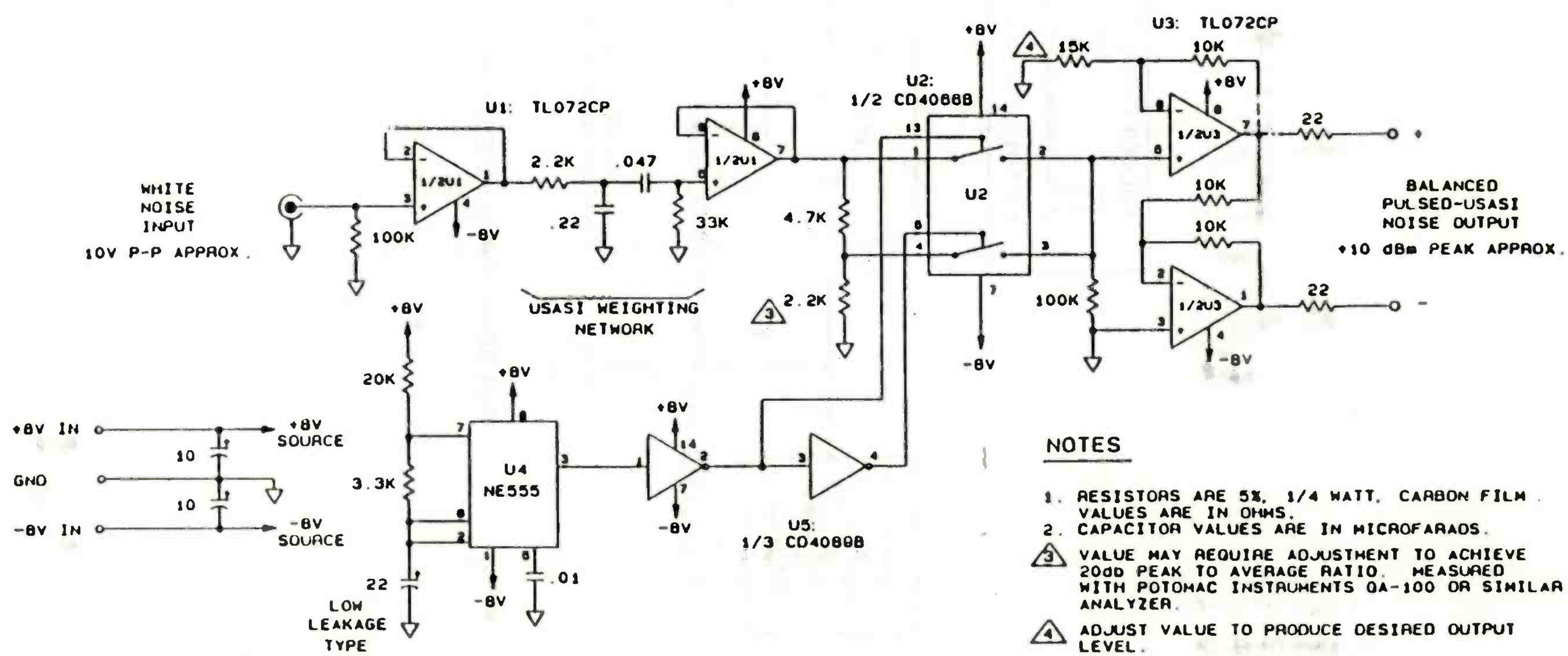
FIGURE A4-A



PULSED-USASI NOISE GENERATOR

FIGURE A4-B

APPLICATION CIRCUIT: USASI NOISE WEIGHTING/PULSER CIRCUIT



NOTES

1. RESISTORS ARE 5%, 1/4 WATT, CARBON FILM. VALUES ARE IN OHMS.
2. CAPACITOR VALUES ARE IN MICROFARADS.

△3 VALUE MAY REQUIRE ADJUSTMENT TO ACHIEVE 20dB PEAK TO AVERAGE RATIO. MEASURED WITH POTOMAC INSTRUMENTS QA-100 OR SIMILAR ANALYZER.

△4 ADJUST VALUE TO PRODUCE DESIRED OUTPUT LEVEL.

Basics of Directional Patterns

by Paul K. Hart*

As the population increases in the United States and Canada, more media services of all types are required. This includes medium wave broadcasting where greater choice of programming material is available and as a consequence more stations can be supported by advertising revenue. All stations legally transmitting in the U.S. and Canada are licensed by the F.C.C. in Washington or the D.O.T. in Ottawa, in keeping with the international treaty obligations contained in the North American Regional Broadcasting Agreement (N.A.R.B.A.). A more detailed discussion of the relationship between channel allocations and the N.A.R.B.A. will be found elsewhere in this book.

With more than 5,000 stations in the U.S. and Canada operating on only 107 channels, many stations have been forced to make use of directional transmitting antennas to reduce interference to an acceptable level. Many stations now operate with highly sophisticated directional antennas in order to meet the strict interference criteria contained in the F.C.C. and D.O.T. rules and regulations.

It is important to realize that the formal interference criteria established by the licensing agencies are based upon the ordinary home-type broadcast receiver. DXers with highly sophisticated receiving equipment are often able to hear distant stations even though the listener is located in a null of the transmitter antenna pattern. When reporting reception to these highly directional stations it is therefore most important to stress in your reception report that you are a DXer and not a regular listener with "ordinary" receiving equipment.

The allocation of frequencies by the F.C.C. and D.O.T. involves specification of a signal intensity contour of the station coverage area which must be protected from objectionable interference from other licensed stations. This contour level varies with the class of the station on the channel (i.e., Clear, Regional, or Local).

The primary service area of a station is the region where the ground-wave signal is free from objectionable interference from other licensed stations. The secondary coverage area is the region covered by the sky-wave signal; while the secondary coverage area may be protected from interference from other stations by F.C.C./D.O.T. rules and regulations, fading and other propagation effects may prove important in actual practice.

During the daylight hours the sky-wave signal is almost totally absorbed in the lower ionosphere at broadcast band frequencies; thus secondary coverage of any particular station exists only at night. There is also an intermittent coverage area located just on the edge of the ground-wave daytime service area; this area is outside the regular primary service area and is often subject to extreme fading and distortion as the result of destructive interference between the station's own sky-wave and ground-wave signals.

Directional antenna systems are used to provide primary and secondary coverage without interference to existing stations on the same and nearby frequencies. The problem of satisfying all of the interference criteria specified by the licensing agency can be very complex in actual practice, often necessitating elaborate engineering studies and costly directional antenna arrays.

Suppose a new station is proposed to operate on 1420 with 1,000 watts day and night.

In another town 25 miles away there is a station operating on 1430 with 500 watts non-directional daytime. The new facility must provide protection to the existing coverage of the second station. Since the second station does not operate at night, secondary protection is not required. However, other stations operating on 1420 will suffer interference unless radiation is limited towards them at night. This may require 4, 5, 6 or even more towers in the transmitting array.

In this case the station might require two different patterns, one for daytime and one for night. The exact values for these antenna fields are set forth in the rules and regulations in accordance with the interference criteria. Care must be taken in designing directional patterns so they not only protect the required stations but provide adequate coverage throughout the primary coverage area.

A common tactic near coastlines is to locate the transmitter inland so the peak of the pattern covers the city of interest and then goes out to sea; while fine for foreign DXers, this common approach often results in very weak radiation in the direction of the opposite coast. Similiar tactics are often used by stations close to the borders. Many stations reduce power at night in conjunction with pattern changes to limit the interference to the required level. In recent years more stations have been using separate transmitter sites for day and night operation.

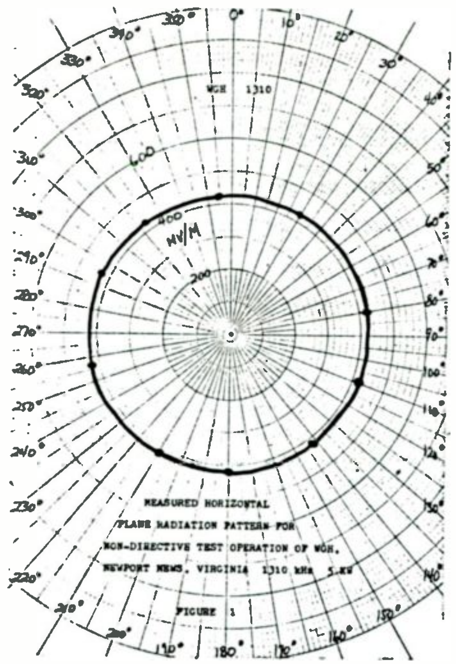
Bear in mind that the pattern is a graphical representation of field intensity generated by the combination of the transmitter and antenna system. All of the patterns shown in this volume are polar plot patterns showing field intensity at one mile from the antenna as measured at ground level (0 degrees elevation). This style of presentation is used because it is the form in which data must be supplied to the licensing agencies; additional discussion of the relationship between pattern size, field strength, and S-units will be found elsewhere in this volume.

Were a station to test with 50,000 watts into a dummy load antenna, the field strength at one mile might well be unmeasurable - this is the extreme case of an inefficient antenna! The same station with identical power loaded properly into an efficient antenna would produce a very high field strength at one mile. The less efficient the antenna, the weaker the field strength produced by a particular transmitter power. This illustrates a basic fact: transmitter output power alone is not the only factor which determines station coverage - antenna efficiency and directionality must also be considered if actual receptions are to make any sense at all.

Figure 1 is the non-directional daytime pattern for WGH, Newport News, Virginia on 1310 kHz. This pattern is unusual because it is almost perfectly non-directional in practice as well as theory. The bearings around the outside indicate the compass heading FROM THE ANTENNA referred to TRUE NORTH corresponding to 0 degrees (or 360 degrees) at the top of the plot. The distance from the center of the pattern to the curve in any direction is proportional to the signal intensity in millivolts per meter (mV/m), the standard measure of field strength, as measured one mile from the antenna. Figure 1 shows that the 5,000 watt WGH transmitter generates a field of 420 mV/m in all directions. Were the transmitter power reduced to 1,000 watts, this field drops to 188 mV/m - or a bit less than half the 5,000 watt coverage (remember that the field strength varies as the square of the power). If WGH wanted to increase the field from 420 mV/m to 840 mV/m (~~twice the coverage~~), they would have to increase transmitter power to 20,000 watts.

Another concept essential to any discussion of directional patterns is the RMS field. The RMS field shown on the patterns in this article is the field strength a station would generate

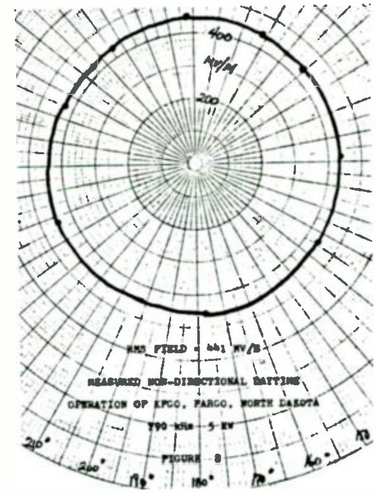
* condensed and abridged from the original article in DX NEWS by permission of the author by Wes Boyd and Gordon Nelson.

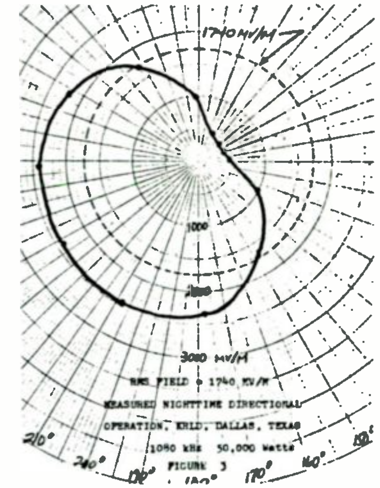


if all of the station's power were radiated in a PERFECT CIRCLE. The non-directional pattern of WGH is almost a perfect circle so the RMS will be very close to 420 mV/m.

Figure 2 is the non-directional daytime pattern of KFGO, Fargo, N.D. on 790 kHz. Note that even tough this station has but a single tower and is therefore supposedly non-directional, the coverage is not actually uniform in all directions. This is caused by factors such as non-uniform ground conductivity and such terrain features as buildings, power lines, and other structures. Since the pattern is not perfectly circular, a separate RMS value is given, 441 mV/m. Notice that WGH's RMS is only 420 mV/m compared with KFGO's 441 mV/m while both use the same transmitter power. This indicates that KFGO is using its transmitter power more effectively and more of it is being translated into field strength. For the most part the RMS is a useful indicator of the efficiency of the transmitter/antenna combination.

The F.C.C. and D.O.T. require that certain minimum values of field strength be generated with assigned powers for all stations. These minimum fields vary with the power and class of the station. The stations which are required to have the most efficient antennas are the Class I (Clear Channel) stations; this explains why these stations have huge antennas and vast coverage areas. The least strict requirements are for Local and daytime stations, although in no case will the F.C.C. permit new construction of an antenna less than 150 feet in height.



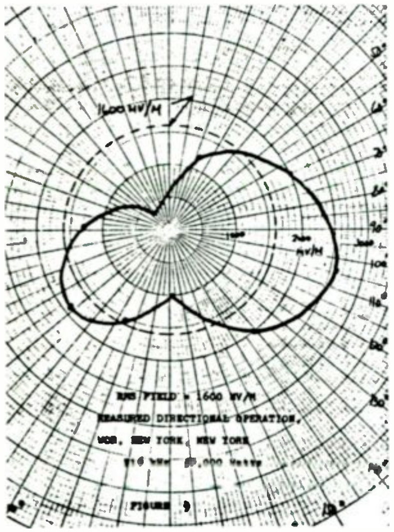


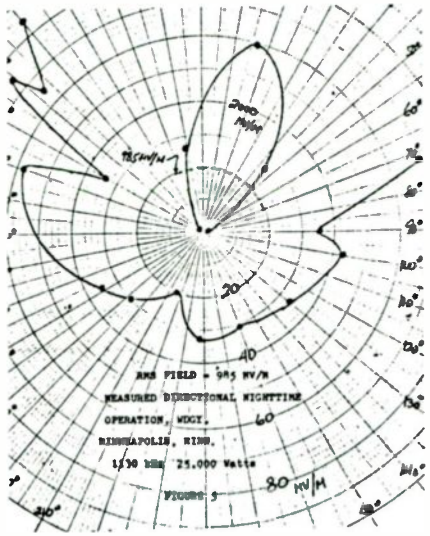
Directional patterns on the broadcast band are produced by employing multiple vertical towers and driving each tower with a definitely established and carefully maintained fraction of the total transmitter output power. As a result of tower spacing and electrical tuning networks, the radiated power is altered in amplitude and phase as required to produce cancellation or reinforcement effects which create the pattern. The design and construction of directional patterns is a very complex business and beyond the scope of this article. One simple rule-of-thumb of value to DXers is that the number of nulls in the pattern is equal to the number of towers in the directional array. This is not always the case but it holds often enough to be useful. In the remainder of this article we will deal with the final measured patterns without going too deeply into the details of the antennas themselves. DXers interested in more details are referred to the numerous articles which have appeared in DX NEWS and which are available as reprints from NRC headquarters.

The polar plot patterns shown here are of some stations selected to illustrate typical situations for discussion. The original sheets have details including tower location, phasing, spacing, height, and orientation which are not included in the interest of simplicity.

Figure 3 shows 50,000 watt KRLD in Dallas on 1080 kHz. This pattern is typical of the simplest types using two towers aligned along a line of peak and null. The RMS value of 1740 mV/m indicates a very good antenna efficiency. This pattern protects WTIC, Hartford, Conn., and WTIC mutually protects KRLD. Notice the direction of the very broad peak in the pattern. All of West and South Texas (along with most of the Southwest) lies in the KRLD secondary coverage area, thus guaranteeing interference-free reception over a wide area at night.

Figure 4 is WOR, New York City, on 710 kHz. This is a non-symmetrical pattern produce produced by a three tower array in a triangular layout. There are many other fulltime stations on 710 but they have patterns which protect WOR and are located a good distance from New York City. The main lobe covers N.Y.C., Long Island, and most of New England. Wor's southwest lobe covers New Jersey and a large portion of Pennsylvania. The RMS value of 1,600 mV/m indicates good antenna efficiency; it is lower than some other 50,000 watt stations however. This is because as antenna arrays become increasingly complex, the RMS produced for the same power input usually drops because of the power losses in the associated power lines and tuning





networks.

Figure 5 is WDGY, Minneapolis, Minn. on 1130 kHz. This pattern was achieved with 25,000 watts and a complex 9 tower system. In this pattern the nulls off the back of the array are so deep that a separate expanded scale is necessary to plot them. It is a safe bet that WDGY's transmitter is located to the south or southwest of Minneapolis-St. Paul area. His signal in these cities and to the north must be fantastic, but the signal must drop off quite rapidly to the south of the transmitter site.

On 1130 the primary stations are KWKH Shreveport, La., WNEW New York City, and CKWX Vancouver, B.C. All 3 stations operate with 50,000 watts full time; however the location of the 3 leaves a "dead spot" on 1130 in the mid-west. In this "dead spot" the trio of WCAR Detroit, Mich., WISN Milwaukee, Wis., and WDGY Minneapolis, Minn. operate with powers ranging from 10,000 to 50,000 watts. All 3 of these "secondary" stations operate under very strict rules so that none of them interfere with each other or any of the primary stations. Due to the relatively close geographical spacing of these "secondary" stations (all with high power) very sophisticated patterns are required. All three stations operate with patterns that are very similar.

Looking back at KRLD's night pattern you will notice that the pattern crosses the RMS field at 150 and 330 degrees. If you lived along either of these bearings the power from KRLD is 50,000 watts whether the pattern is used or not. If you lived in the "back" of the pattern the signal would be less than 50,000 watts. Along the bearing of 60 degrees the power at night is about 3,000 watts. For those in Arizona wondering why KRLD is so powerful for 50,000 watts, the power at a bearing of 260 degrees is almost 100,000 watts.

In the case of the WDGY pattern the power along a bearing of 17 degrees is almost 300,000 watts. At the same time WDGY's power at 180 degrees is less than 50 watts. The peak value of the curve on a bearing of 17 degrees for WDGY is almost 3,000 mV/m. This is more than KRLD achieves (2450 mV/m maximum) and KRLD has a more efficient antenna system! Considering that WDGY's pattern uses 1/4 wavelength towers while KRLD uses 1/2 wavelength towers the power from WDGY's narrow high intensity beam is fantastic.

NARBA ALLOCATIONS AND PRIORITY COUNTRIES

Here is a breakdown of the broadcast band frequencies and priorities as set by the N.A.R.B.A. To make this useful as possible we have omitted all regional and local channels.

540	Canada I-A, Mexico I-A	1010	Canada I-A
640	USA I-A, Canada I-B	1020	USA I-A
650	USA I-A	1030	USA I-A
660	USA I-A	1040	USA I-A
670	USA I-A	1050	Mexico I-A
680	USA I-B	1060	Mexico and USA I-B
690	Canada I-A, Mexico I-B	1070	Canada and USA I-B
700	USA I-A	1080	USA I-B
710	USA I-B	1090	Mexico and USA I-B
720	USA I-A	1100	USA I-A
730	Mexico I-A	1110	USA I-B
740	Canada I-A, Mexico I-D	1120	USA I-A
750	USA I-A	1130	USA and Canada I-B
760	USA I-A	1140	Mexico and USA I-B
770	USA I-A	1160	USA I-A
780	USA I-A	1170	USA I-B
800	Mexico I-A	1180	USA I-A
810	USA I-B	1190	Mexico and USA I-B
820	USA I-A	1200	USA I-A
830	USA I-A	1210	USA I-A
840	USA I-A	1220	Mexico I-A
850	USA and Mexico I-B	1500	USA I-B
860	Canada I-A	1510	USA I-B
870	USA I-A	1520	USA I-B
880	USA I-A	1530	USA I-B
890	USA I-A	1540	Bahamas I-A, USA I-B
900	Mexico I-A	1550	Canada and Mexico I-B
940	Canada and Mexico I-B	1560	USA I-B
990	Canada I-A	1570	Mexico I-A
1000	Mexico and USA I-B	1580	Canada I-A

Abbreviations

CLASS OF OPERATION:

DA-1	Unlimited hours of operation; same pattern day and night
DA-2	Unlimited hours; different patterns day and night
DA-N	Unlimited hours of operation; directional nights only
ND	Nondirectional

MISCELLANEOUS:

CP	Construction Permit
mV/m	millivolts per meter
kw	kilowatt
kHz	kiloherts
NARBA	North American Regional Broadcast Agreement
FCC	Federal Communications Commission
DOT	Department of Transport (Canada)
RMS	Root mean square

SITING OF DIRECTIONAL MW STATIONS
*Wes Boyd

In construction of directional antenna systems, several factors must be considered. #1. Protection to existing stations on the same or on adjacent frequencies. #2. Providing maximum coverage of the city of license. #3. The expense of land in locations that could be used. #4. Coverage of adjacent communities if desired or necessary.

These requirements make transmitter site placement very unique. As an example, we shall look at some typical class IV installations. Normally these operate with 1,000 watts daytime, 250 watts night non directional. Most such stations have towers of 150 feet or a bit taller.

Several stations operating on these frequencies will use excellent antenna systems to obtain maximum coverage. In most cases this also involves coverage to a larger adjacent city. With careful transmitter placement, they can obtain coverage in cities several miles away that normally wouldn't be covered.

EXAMPLES::::

WENZ 1450 Highland Springs (Richmond), Virginia; the city of license is about 5 miles east of Richmond. By locating the transmitter about 1 1/2 miles to the west of Highland Springs, that city receives excellent coverage. This also places the transmitter about 3 1/2 miles east of Richmond and also provides rather good coverage of that city.

WEXL 1340 Royal Oak, Michigan, is some 5 miles north of Detroit. As with WENZ transmitter placement allows coverage of the larger city. In this case, the transmitter is 1 1/2 miles south of Royal Oak. Such a location offers excellent coverage of both the city of license and Detroit.

WVON 1450 Cicero, Illinois, and WOPA 1490 Oak Park, Ill., both are located in areas that provide excellent coverage of Chicago. These communities are adjacent to Chicago on the city's west side. From here, transmitter sites on top of buildings in the area will have great coverage.

Such rooftop installations are not always used to provide maximum coverage. If properly used, they can increase or decrease coverage. Location of antennas of one-quarter wavelength on buildings of the same height will reduce coverage. A shorter building would provide more coverage; however, not as much as one over one-quarter wavelength tall would.

Among other stations using transmitter placement to serve communities other than the city of license: WNIA 1230 New York; WJMO 1490 Ohio; WLPM 1450 Virginia; WSMY 1400 N.C.; WFOM 1230 Georgia; WXVW 1450 Indiana.

Several years ago the F.C.C. made an attempt to limit the number of radio stations in larger communities. At the time, many stations were licensed to these cities and used the F.C.C.'s ruling to become licensed fulltime. If the city had adequate service, they wouldn't license any more fulltime stations for it. This allowed daytimers to relicense the stations to suburban cities without (in the F.C.C.'s terms) local service.

These stations would become licensed for fulltime operation. Then with careful transmitter placement, be able to serve the larger community anyhow. The coverage was not as good as it could be (or should be) to serve these larger cities. However, poor night coverage is better than signing off the air. Some of these included WCUE 1150, Akron, Ohio; WVOL 1470 Nashville, Tenn., and KUDL 1380, Kansas City.

During this same era, other stations went on the air as daytimers licensed to suburban cities. Then after several years, finally were given permission to operate fulltime. In both cases, the stations placed transmitters so they would provide coverage of the larger communities. These include WHOT 1330, WPAT 930, KDAY 1580, KQRS 1440, WYOO 980, etc.

In most cases, the area to be served determines the shape of the pattern more than the protection to existing stations does. Many stations could have lower power or less complicated patterns if the extra communities were not wanted in the coverage area.

KFXD 580 Nampa, Idaho, wouldn't require such a night pattern if coverage of Boise, Idaho, wasn't wanted. On such a lower frequency, the coverage is tremendous even at lower power levels. The large west lobe has enough signal to let the transmitter be several miles from Nampa. Since Boise is about 10 miles east of Nampa, the transmitter could be midway between them. Such a location allows the front lobe to serve the city of license while the lobe to the northeast will provide a very good signal in Boise.

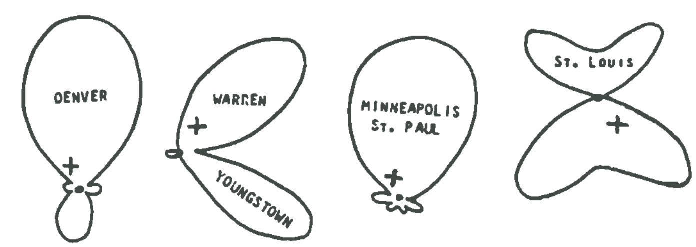
Similar transmitter placement was used by WSAR 1480 Fall River, Mass. With a location west of Fall River, the east lobe covers the city of license. At the same time, the secondary lobe north/northwest covers Providence, R.I.

WTSN 1270 Dover, N.H., has a location just west of Dover. This allows Dover to be in the main lobe east. The back lobe provides coverage of Rochester, N.H., for a secondary coverage. At the same time, the front lobe is powerful enough to provide a good signal in Portsmouth.

WIBX 950 and WRUN 1150 Utica, New York, use transmitter placement to provide coverage of Rome, New York, (10 miles away) but both used different systems. WIBX 950 has a location to the west of Utica so it lies in the east lobe. This allows Rome to be covered by the lobe to the North. WRUN 1150 is located to the northwest of Utica so it lies in the southeast lobe. The lobe to the northwest then covers Rome.

Dallas/Fort Worth, Texas, provides similar problems in transmitter placement. Of the stations here, KLIF 1190 is the most unique. Protection to WOAI 1200, KVOO 1170 and other 1190 stations are required. The pattern used offers this protection but makes coverage of both cities difficult. Transmitter location near Irving, Texas, (northwest of Dallas) allows Dallas to be served with the lobe to the southeast. Then the main lobe southwest will cover Fort Worth with signals of excellent quality. With this pattern coverage of both cities is impossible unless the transmitter is in this area.

In coastal areas (New York City and Los Angeles are excellent examples), the stations have transmitters several miles inland. If stations in this area had moderate power and patterns aimed at the larger city, they would be almost as strong as stations licensed there. Others are licensed to communities surrounded by larger cities. They place the transmitter 10 miles away from the larger city and with power lobes cover both cities to serve the city of license. KDAY 1580 and KROQ 1500 in California are great examples of this.



KLAK 1600 — WHHH 1440 — WYOO 980 — WIBV 1260

SOME QUANTITATIVE ASPECTS OF VERTICAL PATTERNS
*Chris Lucas

The NRC Night Pattern Book has been a great aid to DXers. A glance is all it takes to see if a station nulls toward you or has a lobe in your direction. If you have compared the patterns shown with actual listening experiences, you will note some stations which should be heard are not while some with nulls in your direction are quite audible. This article will explain why this is so and should help you obtain more information from the pattern book.

The patterns shown in the pattern book indicate the electrical field strength in different directions from the transmitter due to radiation in the horizontal or ground plane. When considering nighttime skywave we must deal with radio waves leaving the antenna system at some angle above ground. This angle of elevation will be referred to as angle B in the following discussion. Radio waves at broadcast band frequencies normally propagate at night by reflection off the E layer of the ionosphere. The shorter the distance from the transmitter the greater the elevation of angle B. For single hop transmission beyond 700 miles, angle B is quite small. In this case the pattern book gives a good idea of how a station will be received. However, at distances progressively less than 700 miles, angle B becomes progressively larger and the pattern becomes considerably altered from the groundwave pattern indicated in the pattern book. However, only a certain type of pattern is applicable.

We will ignore for now that radio waves radiate preferentially in a ground plane. An antenna system composed of two or more towers located along a straight line produces a pattern with a special kind of symmetry. The pattern in three dimensions is symmetrical about a line connecting the bases of the towers. From here on this will be referred to as the "axis of symmetry". For the ground plane patterns shown in the pattern book, the two-dimensional pattern produced is symmetrical about an axis of symmetry.

EXAMPLES: WROW 590's pattern is symmetrical about an axis running almost N & S. That of WICC 600 is symmetrical about an NW-SE axis, as is WTOR 610. WVNJ 620 has an axis of symmetry running more or less N & S. WINR 680's axis goes NE-SW, while WELM 1410 is nearly N & S.

The results of this article can not be applied unless you know which axis of symmetry corresponds to the line in which the towers lie. Also it is not necessary to have in-line towers to produce a symmetrical pattern. Four towers located at the corners of a square will also produce a symmetrical pattern. Any calculations based on this article are accurate only if the towers are actually along a line.

At this point we will introduce another angle which we will call angle A. This is an acute angle between the axis of symmetry and a line from the transmitter to the receiver. A definition of this angle is shown in Figure #1.

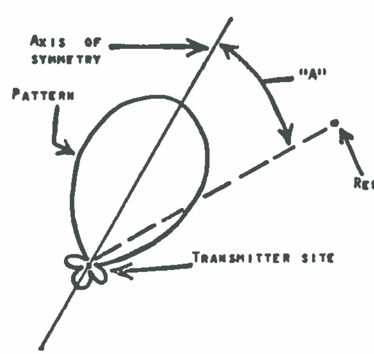


FIGURE I
Definition of angle A.

Angle B has been defined as the elevation angle, and it varies with the transmitter-receiver separation. This separation is always measured along the great circle paths. Some trigonometry gives the following expression for the cosine of angle B.

$$\cos B = \frac{(3960 + H)\ \sin\left(\frac{D}{7920}\right)}{\sqrt{(31{,}363{,}200 + 7920\,H)\left(1 - \cos\frac{D}{7920}\right) + H^2}}$$

In this expression the arguments of the sine and cosine are in radians, and measured in miles. H is the reflection height and D is the transmitter-to-receiver distance along the surface of the earth. For distances under 700 miles and an assumed reflection height of 65 miles, this expression simplifies to:

$$\cos B = \frac{(0.508)\ D}{\sqrt{0.254\ D^2 + 4225}}$$

This expression will provide an answer with less than 1% error. Figure II is a graph of cosine B versus the transmitter-receiver distance D.

In determining the radiation pattern at angle B, we must look at the point on radiation pattern given in the pattern book and not at angle A. In reality, we should look at angle C which is obtained from the equation:

$$\cos C = (\cos A)\cdot(\cos B)$$
$$C = \arccos\ (\cos A)\cdot(\cos B)$$

In effect for skywave we must look at the pattern more broadside to the axis of symmetry than we would for groundwave. A few examples will help to make this clear.

Let's evaluate the signal WHOT 1330 has towards Flint, Michigan, where another station operates on the same frequency. Figure III shows the pertinent angles. In this example D is 210 miles and A is 56 degrees. A look at figure II shows that cos B is 0.858 for the distance of 210 miles. Cos A is 0.559 thus cos C = cos A · cos B = (0.559) · (0.858) = 0.480. This then makes the magnitude of angle C 61.3 degrees, and corresponds to a field strength of about 100 mv/m instead of the approximately 150 mv/m measured at angle A. It becomes apparent that this null near angle C was designed to protect the Flint, Michigan, station.

Example #2: Here we will evaluate the signal that WHOT 1330 directs towards Erie, Pa., where another station operates on 1330 kHz. The pattern might indicate to you that WHOT doesn't protect this station at all, but this is not the case. Using figure III again we find the angles of interest, A* and C*. The * being used to distinguish these angles from those used in connection with the station in Flint, Michigan. For this example, D = 74 miles and A = 11 degrees. Figure III tells us the value of cos B in this case is 0.502 and cos A is 0.982. Thus cos C = cos A · cos B = (0.982) · (0.502) = 0.493. This makes the magnitude of angle C 60.5 degrees, and this corresponds to a field strength of 120 mv/m at one mile towards Erie and lies quite close to the null. The groundwave radiation towards Erie is much higher (at angle A) at about 640 mv/m at one mile. This is a prime example of where a location seems to be in a lobe while it is really in a null as far as skywave is concerned. There is considerable error possible in these examples mostly due to the small size of the patterns in the pattern book and the slight errors that inevitably occurred in the drawing of these patterns. If we had the exact pattern of WHOT and knew the exact bearing of the axis of symmetry we may have found that Erie and Flint lie directly in the null instead of within a few degrees of the null.

Example #3: In this example, we will evaluate the signal received at Ithaca, New York, from WPTR 1540 Albany, New York. Figure IV shows the angles involved. For this example we have D = 142 miles and the corresponding cos B = 0.746 (Figure II) thus A = 29 degrees and cos A = 0.875.

Therefore cos C = cos A · cos B = (0.875) · (0.746) = 0.652 hence C = 49.3

FIGURE II: COSINE θ AS A FUNCTION OF DISTANCE, D.

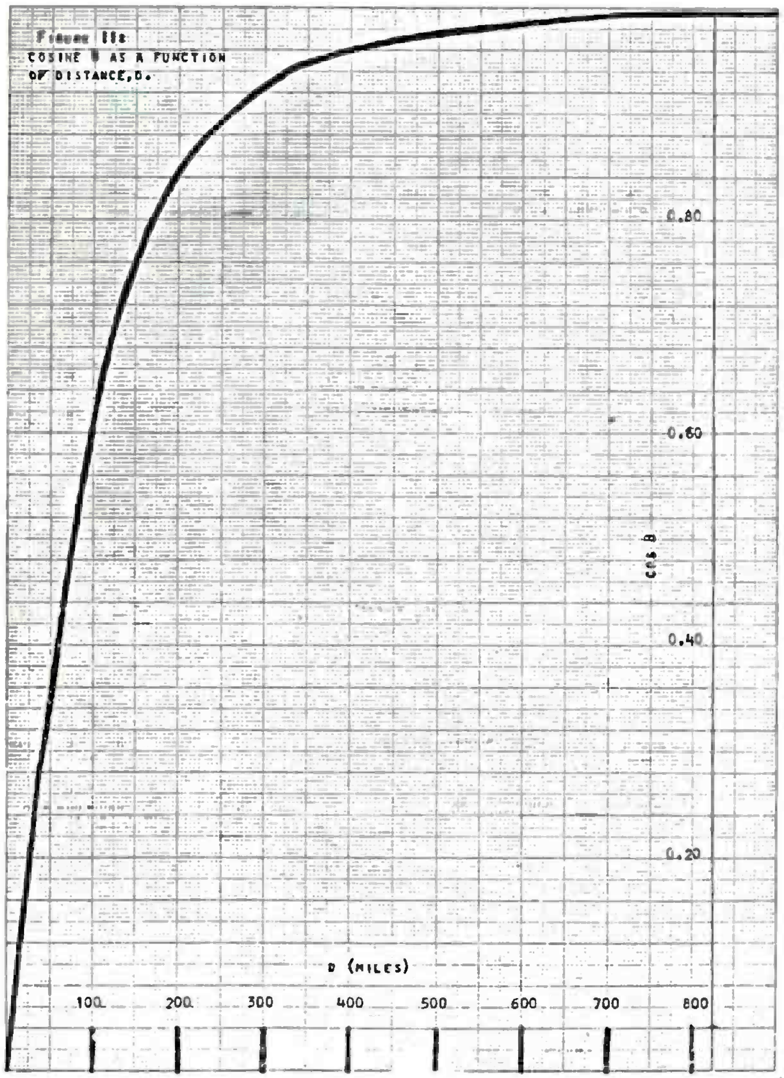
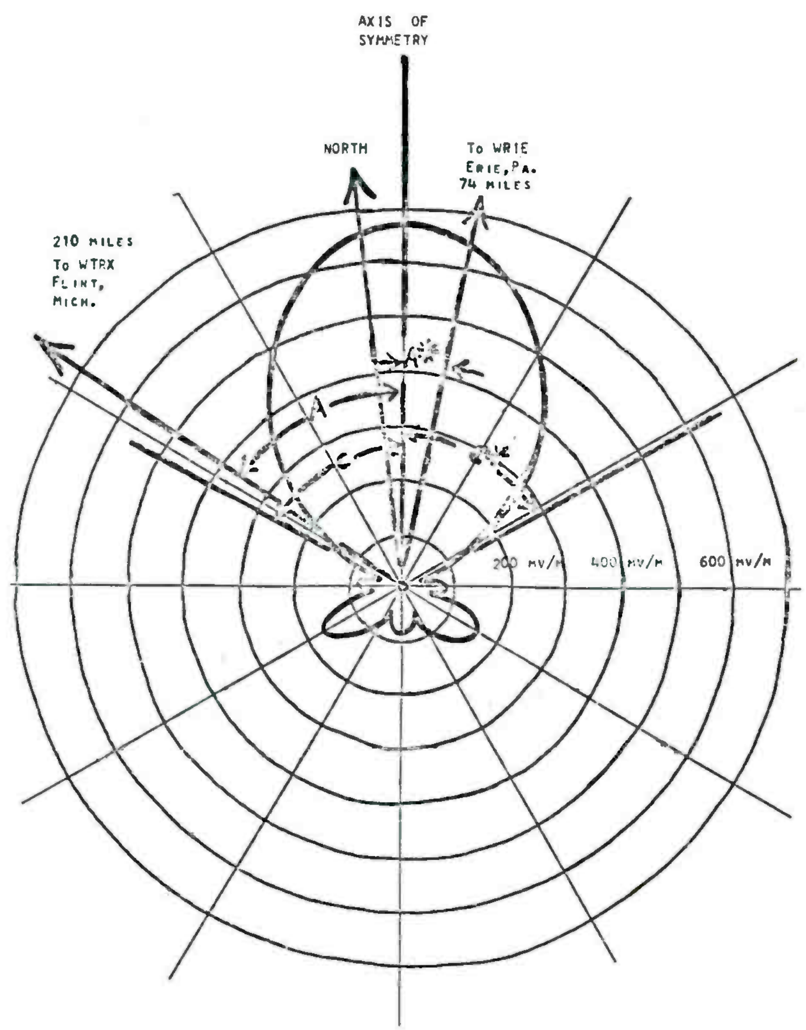


FIGURE III: PATTERN OF WHOT CAMPBELL, OHIO AND THE ANGLES USED IN CALCULATING SKYWAVE RADIATION TOWARDS ERIE, PA. AND FLINT, MICHIGAN.



degrees. This angle is very close to the null and it is difficult to get a value for the field strength at one mile. However, this should be a field of about 100 mv/m. It should be pointed out that the radial at angle C is on the other side of the null from the radial towards Ithaca at angle A. Ground-wave signal towards Ithaca is approximately 300 mv/m at one mile at angle A.

Example #4: Instead of calculating the field at one point, we can calculate the entire pattern corresponding to radiation at a certain elevation angle (B). If we continue the case just considered, we can calculate the entire pattern. First we evaluate the pattern at an elevation angle of 41.75 degrees corresponding to the transmitter-receiver distance of 142 miles (cos B = 0.746). Several representative points can be taken and the resulting angle C and field strength evaluated. This has been done but to save space, the calculations won't be shown, rather the resulting pattern is shown in figure V. The pattern shows that if you were to circle the transmitter at a distance of 142 miles, you would get the strongest field in approximately North and East directions, 49.5 degrees from the axis of symmetry. These locations are a few miles west of Plattsburgh, New York, and the southern part of Boston, Mass. The weakest signals lie across the axis of symmetry to the southwest of Albany, 10 miles west of Scranton, Pa. We note the rear lobe has disappeared and that the pattern itself is somewhat smoother. This smoothness at high radiation angles is a general result.

You will remember that we assumed that transmitter towers radiate equally well at all angles above the horizon; this is just not true. However, the effect is the same whether a station is nondirectional (single tower) or directional (multiple towers). As angle B increases, the strength of radiation generally decreases. Extremely tall towers have peculiar variations in field strength with increasing B. Figure VI shows the relative radiation at various elevation angles B compared to radiation in the horizontal plane. It is plotted in cos B since we have been working directly with this quality in this article. Note that of cos B of about 0.80 the radiation drops to zero for a 5/8 wavelength antenna. This value of cos B corresponds to a transmitter-receiver distance of about 168 miles (see figure II). At this distance from a station using a 5/8 wavelength antenna, virtually no skywave will be received. It should be noted that the taller towers radiate a stronger signal in the ground plane than the shorter towers do. A radio station using a 5/8 wavelength tower has a ground plane field strength of almost double that of a station using a 1/4 wavelength antenna on the same frequency.

The pattern obtained for WPTR is not correct in magnitude although it is correct in shape (figure V). We would have to know the height of WPTR's towers if we were to get the correct magnitude of the pattern. If they were 1/2 wavelength tall, figure VI shows the field strength is 34% of that in the groundplane (B = 41.75 degrees, cos B = 0.746). Should these towers be 5/8 wavelength tall, then the appropriate factor is 12%.

Local WTKO 1470 recently began nighttime operation from four in-line towers on the south end of Ithaca. These towers seem to be 5/8 wavelength tall which means it should be difficult to receive them 165 to 170 miles from the transmitter. Reception would be difficult in Toronto, Ontario; Punxsutawney, Penna.; or Plainfield, New Jersey.

If a station uses towers of two or more different heights, as is often done, the results of calculations shown in this article will not be accurate even though the towers do lie in a straight line.

We should mention that the radiation pattern at some elevation angles can be different from the ground plane pattern shown in the pattern book. Especially for large angles which correspond to transmitter-receiver distances of less than 150 miles. If you are broadside to a station's antenna system, the pattern stays the same in your direction. Regardless of the distance, a null remains a null and a lobe remains a lobe.

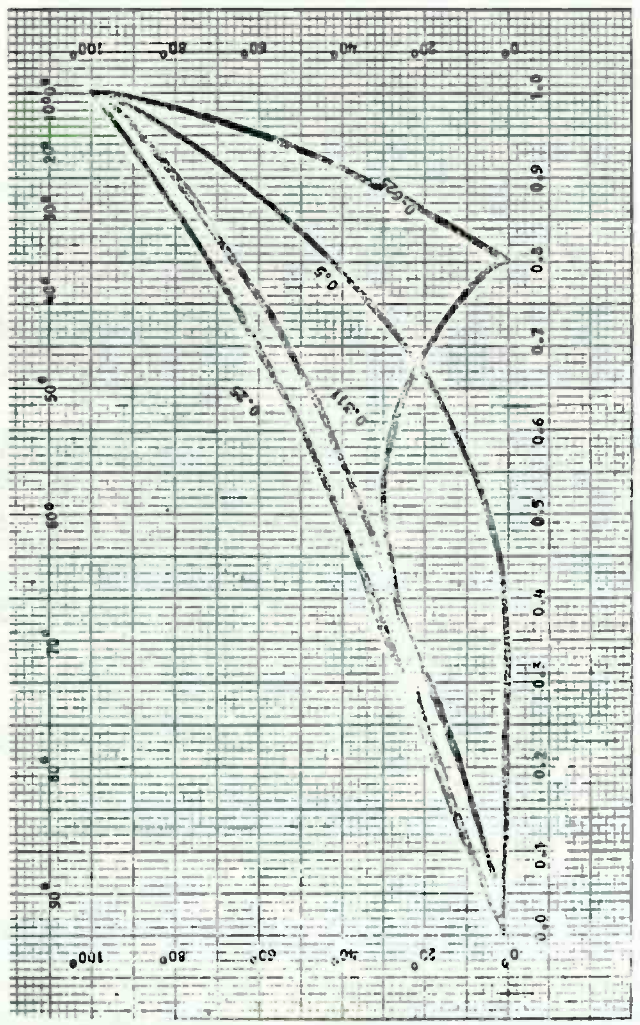


Fig. VI

FIGURE IV: PATTERN OF WPTR ALBANY, N.Y. AND ANGLES USED IN CALCULATING THE SKYWAVE RADIATION TOWARD ITHACA, N.Y.

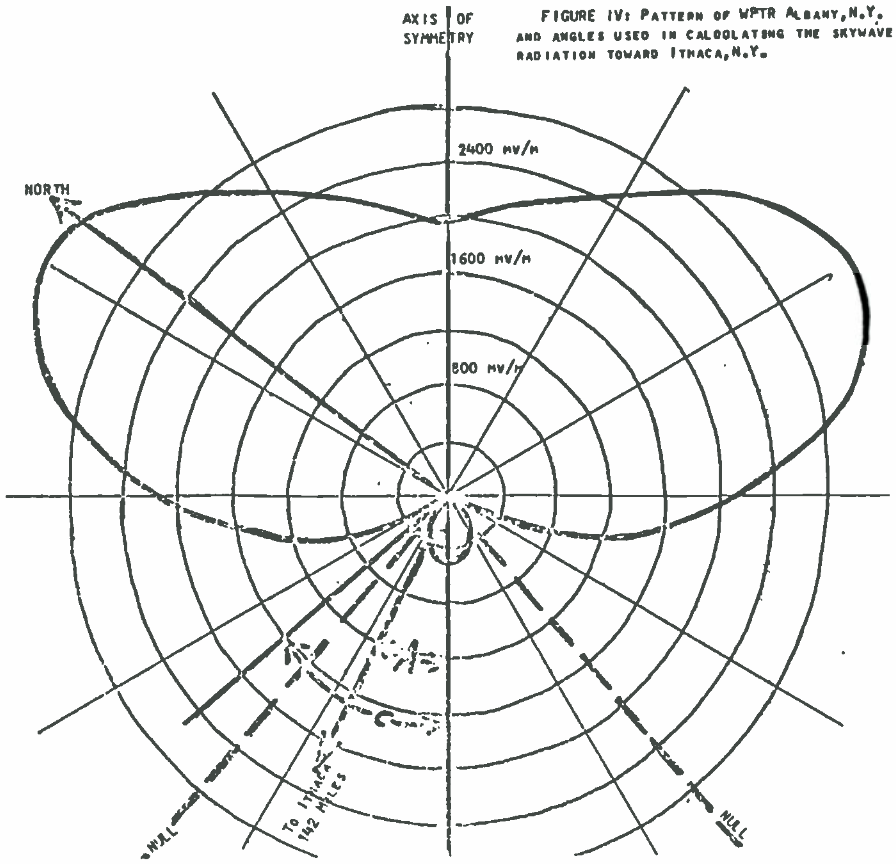
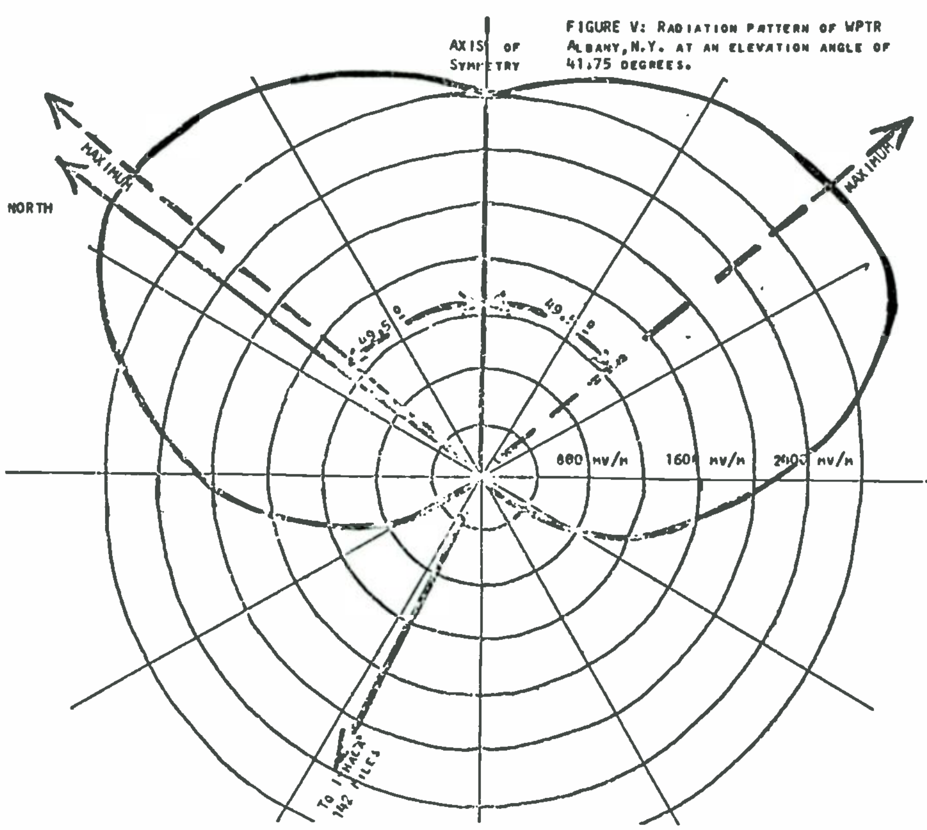


FIGURE V: RADIATION PATTERN OF WPTR ALBANY, N.Y. AT AN ELEVATION ANGLE OF 41.75 DEGREES.



M7

PATTERNS

Paul Hart

Why is KYW-1060 so strong in the Chicago area at night - and how can WNOE operate on the same frequency at night with 5 KW in New Orleans? Why is WWL-870 heard very well all over the United States? Why didn't Richard Wood log WBAL-1090 in Hawaii, even when WCBS, WNBC and WBZ were very strong? And how did I know that he probably would not be able to do it?

If you know what patterns these stations use, can determine a bearing and make a few calculations, these questions are easily and accurately answered.

INTRODUCTION

Patterns are used because they fundamentally affect reception and interference conditions on the broadcast band. This article will describe antenna patterns in detail, and propose the use of antenna pattern information to predict and explain relative signal strengths. Much of the information used is taken from the FCC Rules, Volume III, Part 73 - Radio Broadcast Services. The pattern information is contained in the Cooper-Trent files or is in the station proposals at the Commission in Washington.

As population increases in the United States, more and more services of all types are required. This includes broadcasting, where more choices of program material and consequently more radio stations can be supported by advertising revenue. All stations legally transmitting within the United States are licensed by the Federal Communications Commission in Washington, D.C. When patterns are used, it is almost always because they are required to enable station to operate without interfering with each other. Many stations now operate very sophisticated patterns as the complexity of controlling interference increases. The interference criteria are contained in the FCC Rules, and it is important to remember that they are based on results normally obtainable with home-type broadcast receivers.

Directional receiving antennas, high-gain receivers and unusual propagation effects are not considered. (Normal day-night propagation changes and their seasonal variations are considered). The fact that we take advantage of all of these things in conjunction with the Commission's allocations and rules is what makes unusual DX "catches" possible.

GENERAL DISCUSSION

If a person or company wants to put a new station on the air, or substantially change the operation of one already on the air, a proposal must be made to the FCC which describes all of the details concerning the proposed operation. In addition to all of the details of ownership, financial and legal aspects, the technical details must be completely described. Within the technical portion of the proposal, two primary factors of interest to us are presented:

1. The submission must give evidence that the proposed station's primary coverage area will be covered by a very strong signal, providing a broadcast service. (Some stations have secondary and intermittent coverage areas - see Note 1).
2. The proposed operation must not interfere with other stations within the limits of the FCC Rules, Part 73.

For purposes of understanding patterns, the second point is the one we must examine most closely, because it is the primary reason for the existence of patterns. There are two basic conditions under which Point 2 above, or lack of interference, must be maintained; day and night. (See Note 2). Both day and night, two fundamental possibilities exist for station-to-station interference:

1. Stations on the same frequency may interfere. (SC or same channel).
2. Stations on different frequencies, but located geographically close together may interfere. (AC or adjacent channel).

Note 1. In order to clarify the terms used, following are the FCC definitions for the three service areas:

A. Primary service area - The area in which the ground wave is not subject to objectionable interference or objectionable fading.

B. Secondary service area - The area served by the skywave and not subject to objectionable interference. The signal is subject to intermittent variations in intensity.

C. Intermittent service area - The area receiving service from the groundwave but beyond the primary service area and subject to some interference and fading.

Note 2. A third class of conditions exists, sunrise and sunset. Some station licenses provide for specialized operation at these times with pre-sunrise authority or "PSA" and critical hours or "CH" requirements. For the sake of simplicity, we will refer here only to day and night conditions.

The problem of satisfying all of the conditions can be and often is very complex. Presented below is an over-simplified situation to illustrate:

Suppose new station B is proposed to operate on 1420 kHz, day and night at 1 KW, to be licensed to a specified small city. Station A is already assigned to 1430 kHz, broadcasting with 500 watts, non-directional, daytime only, 25 miles from proposed station A's location. The new station B must propose to protect station A from adjacent channel interference by limiting its radiation in that direction by use of a daytime pattern. The exact values required will come from calculations so as to conform with the FCC requirements.

At nightfall, station A leaves the air, and station B's daytime protection is not required. However, other stations operating on 1420 kHz will be interfered with by skip from station B unless radiation is limited toward them at night. This may include 4, 5, 6 or even more stations.

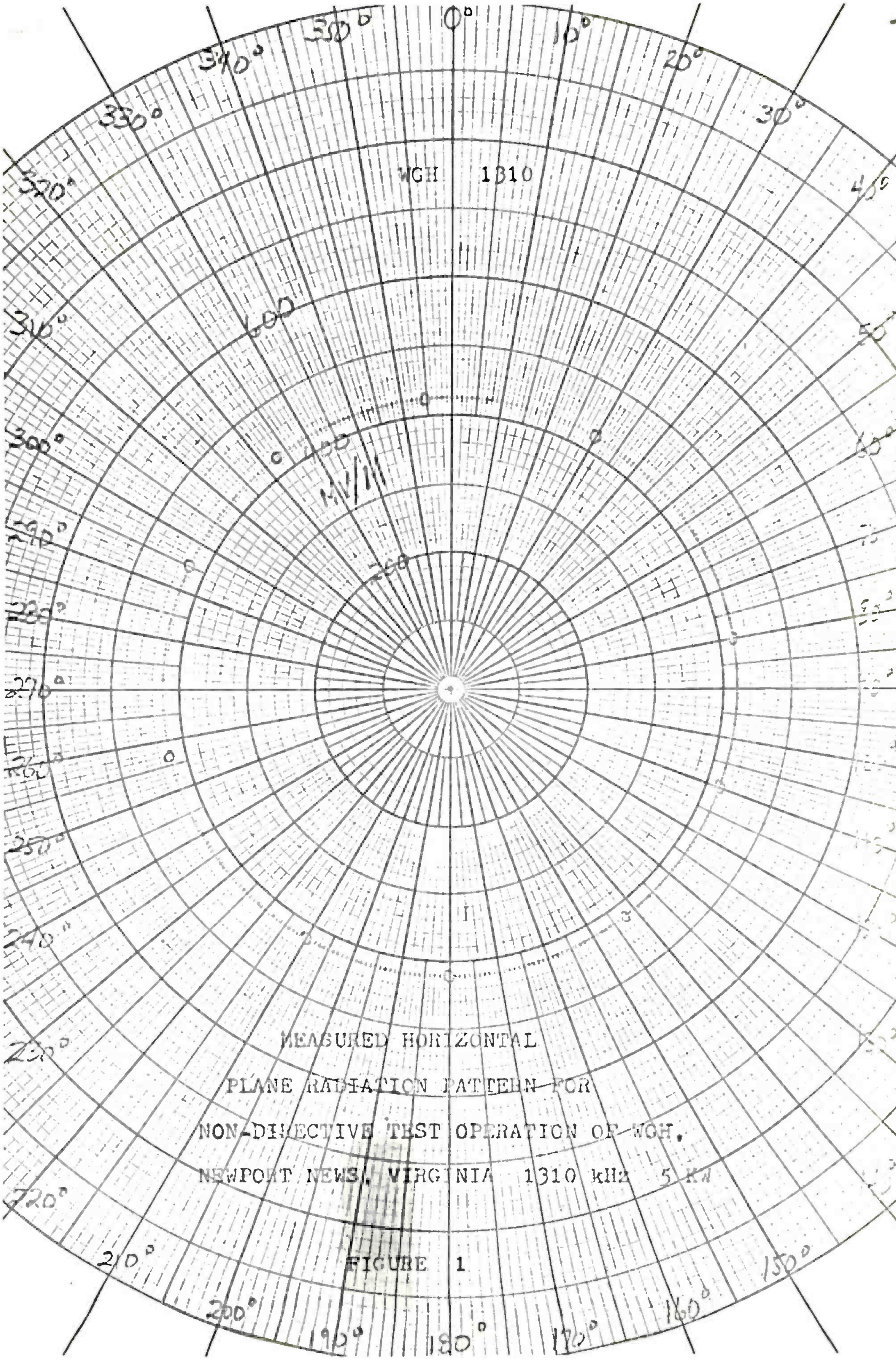
Another different pattern is therefore required for nighttime operation so as to limit station B's interference with these other stations. Again, the exact values required for the pattern will come from calculations in accordance with the interference criteria in Part 73. Care must be taken in proposing the patterns so as not to have a major null in either pattern fall over the primary coverage area, or service to the local audience may be unsatisfactory.

A common tactic near coastlines and borders is to locate the station's transmitter inland, so that the peak of the pattern faces toward the town, and then out to sea or across the border. In this way, the chances of interference are greatly reduced. This explains why many coastline stations are difficult to log outside their immediate coverage areas, since only a series of deep nulls faces inland.

Many stations also lower power at night in conjunction with a pattern change to limit interference to the levels required. Most proposals for new broadcast stations are now so complex that they are prepared and submitted by consulting engineering firms specializing in this type of project. Even so, the FCC denies many proposals and some take years for all of the amendments and exceptions to be resolved.

INITIAL PATTERN CONSIDERATIONS

It is essential to keep in mind that a pattern is a graphical representation of a radio signal field intensity generated by a transmitter and antenna combination. In order to facilitate furthur discussion and illustrate the terms we must use, please refer to Figure 1, the non-directional pattern for WGH-1310. This and all of the patterns in this group are polar plots showing field intensity at 1 mile from the antenna, measured at 0° elevation, or ground level. This form of presentation is used for convenience because this is the form in which data must be submitted to the FCC. Actual values (data points) are shown by the small circles.



MEASURED HORIZONTAL PLANE RADIATION PATTERN FOR NON-DIRECTIVE TEST OPERATION OF WGH, NEWPORT NEWS, VIRGINIA 1310 kHz 5 KW

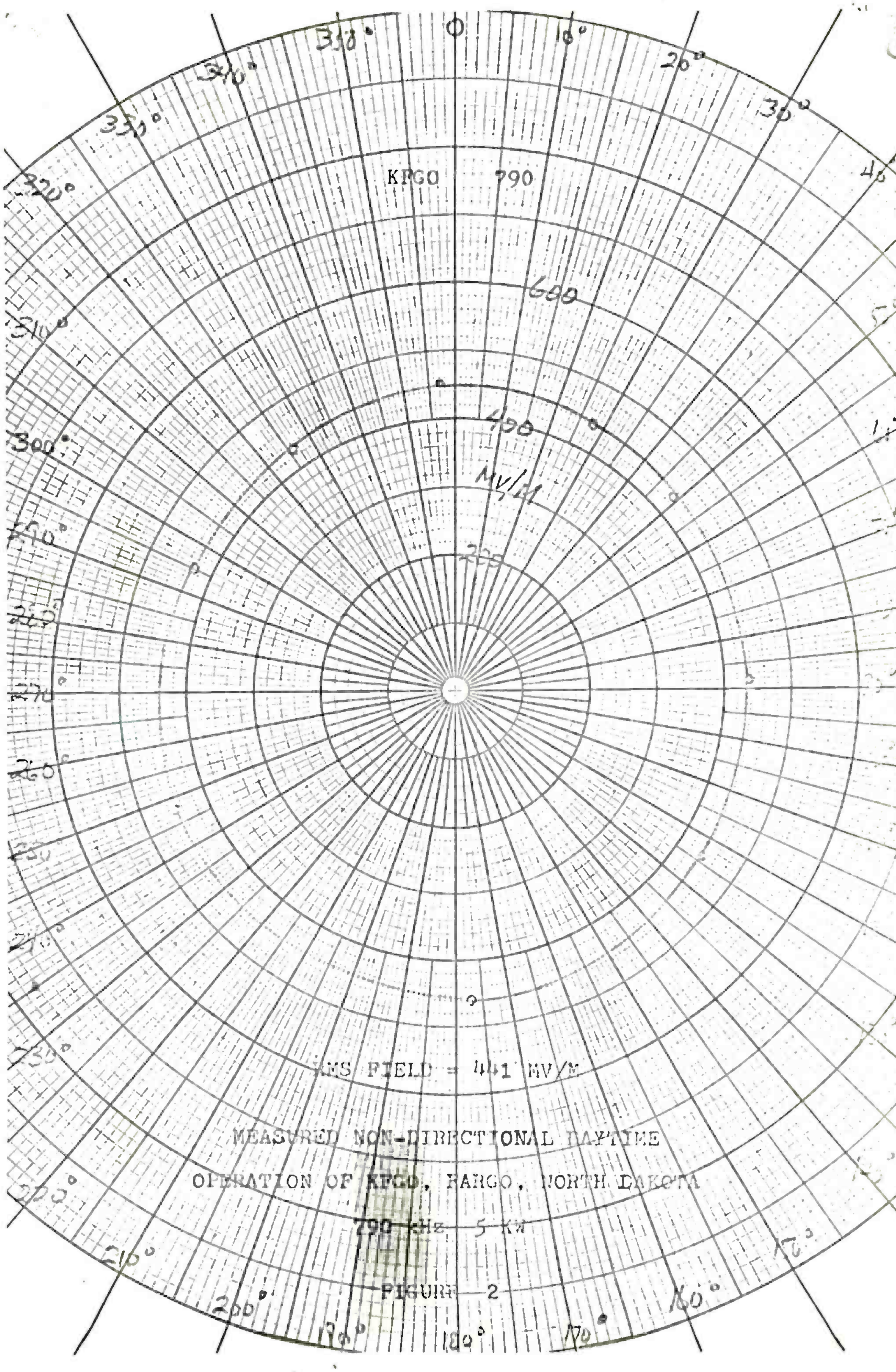
FIGURE 1

WGH's pattern is very unusual in that it is perfectly non-directional for all of the data points obtained. Consider that the antenna is a point source of radiation located at the center of the chart. The bearings around the outside indicate the compass heading from the antenna referred to true North, represented by 0^o (or 360^o) at the top of the chart. The curve drawn connects the data points plotted on the chart, measured at or normalized to 1 mile values. This curve is the pattern, indicating the intensity of radiation at any bearing the observer wishes to read from the curve. The radial value of measurement is in MV/M, the abbreviation for millivolts per meter, the standard unit for measurement and expression of field strength.

If a station were to test with 50 KW operating into a dummy load, the field strength generated at 1 mile might be unmeasurable, the extreme case of a poor antenna. Obviously, if the 50 KW were to be loaded properly to a very efficient antenna, the field strength would be very high. If a less efficient antenna were used, less field strength would be generated. All of these conditions assume the same 50 KW output from the transmitter. This illustrates the fact that transmitter power output is not the only factor that determines the strength of a station's radiation. The intensity of the field generated by any broadcast station is determined by the transmitter power, the antenna type and efficiency and the coupling circuitry.

Figure 1 indicates that the field strength generated by WGH is 420 MV/M in any direction with 5 KW driving the antenna. Given this information, it is possible to predict what the radiation level would be in any direction if the transmitter power was to change to any other figure. This is possible only because we are still using the same antenna, the only variable is the transmitter power output.

If the original power for which the antenna performance in millivolts per meter (AP) is known is P_1 and the new power is P_2, the resulting field strength with the new power is $\sqrt{\frac{P_2}{P_1}}(AP)$. To illustrate, suppose we want to know what WGH's field intensity would be if the transmitter power was reduced to 1 KW from the 5 KW for which our curve is plotted. The solution is $\sqrt{\frac{1}{5}}\,(420) = \sqrt{.2}\,(420) = (.447)(420) = 188$ MV/M. Conversely, if we wanted to double the field strength to 840 MV/M from the original 420 MV/M, we must quadruple the power input to the antenna. If 420 MV/M is FS_1 (field strength value 1), 840 MV/M is FS_2 (field strength 2 or the new field strength value) and 5 KW is the specified power (SP) for which FS_1 is measured, the new power required to generate this new field strength is $\left(\frac{FS_2}{FS_1}\right)^2$ (SP). In this case, $\left(\frac{840}{420}\right)^2(5) = (2)^2(5) = 20$KW. These scaling relationships will be used again later, so try to understand them clearly now.



MEASURED NON-DIRECTIONAL DAYTIME
OPERATION OF KFGO, FARGO, NORTH DAKOTA
790 kHz 5 KW

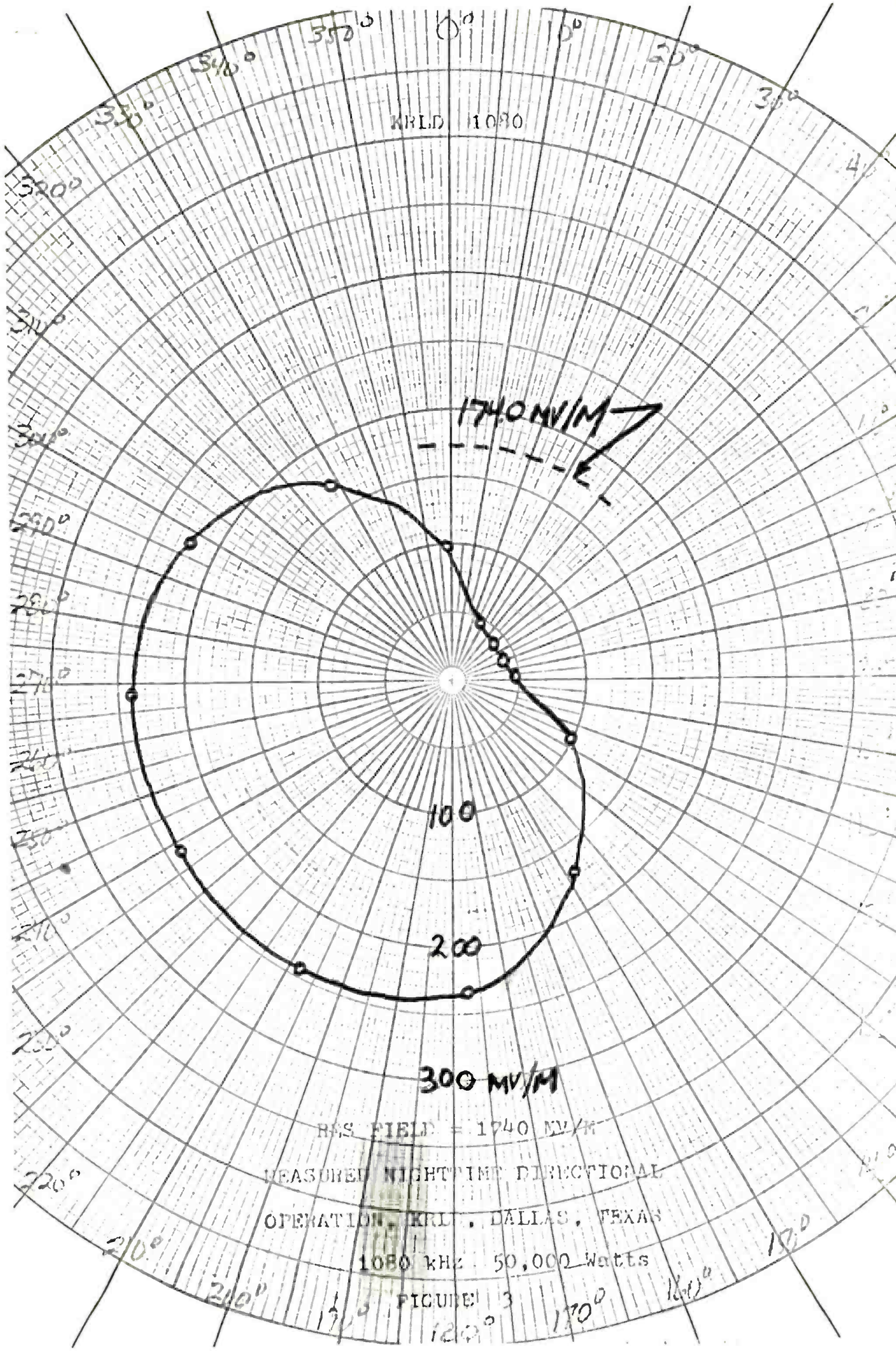
FIGURE 2

Another concept essential to furthur discussion of the patterns is the RMS field. The RMS field shown on the pattern is the field strength value that a station would generate in a perfect circle <u>if</u> all of the station's energy were radiated in a perfect circle. In the case of Figure 1, the non-directional pattern is already a perfect circle, so the RMS field is 420 MV/M, the constant radial field strength value of the pattern. Figure 2 is a non-directional survey of KFGO-790. Note that even though this plot is for non-directional operation, the field strength is not perfectly uniform. This is caused by variations in ground conductivity, terrain features, and other factors such as buildings, power lines, and other structures. Because the pattern is not perfectly circular, a separate RMS field value is given, 441 MV/M. Notice that WGH's RMS field is 420 MV/M and KFGO's is 441 MV/M, but both are using 5 KW transmitter power. This indicates that KFGO is using its transmitter power more effectively; more of it is being translated into field strength. This is the reason for obtaining an RMS field value for each antenna for which a curve is given, it serves as a measure of antenna efficiency. This is very important, as the FCC requires certain minimum values of RMS field strength to be generated with assigned powers for all radio stations. The requirements are different for different classes of stations. Not surprisingly, the stations that must have the best efficiencies are class I's, which explains the huge antennas used by these stations. The least strict requirements are for the locals and daytimers, although the FCC does not allow new construction of any radio transmitting antenna tower less than 150 feet in height.

PATTERNS ON PURPOSE

Broadcast band transmitting patterns are generated by utilizing more than one tower, driving each tower with a definitely established and carefully measured portion of the transmitter's output. As a result of tower spacing and electrical tuning networks, the power used is also altered in phase as required to achieve the needed reinforcement and cancellation effects which create the pattern. The actual design of an antenna to give a required pattern is very complex and outside the scope of this discussion. We will deal with the actual measured performance of operating transmitter-antenna combinations without going too deeply into the details of the antenna itself.

Figures 3, 4 and 5 are patterns of some stations selected to illustrate typical situations for discussion. The original sheets have details included concerning the number of towers used, their phasing, field ratios, spacing, height, and orientation. That information is not included on these sheets in the interest of uniformity and simplicity.



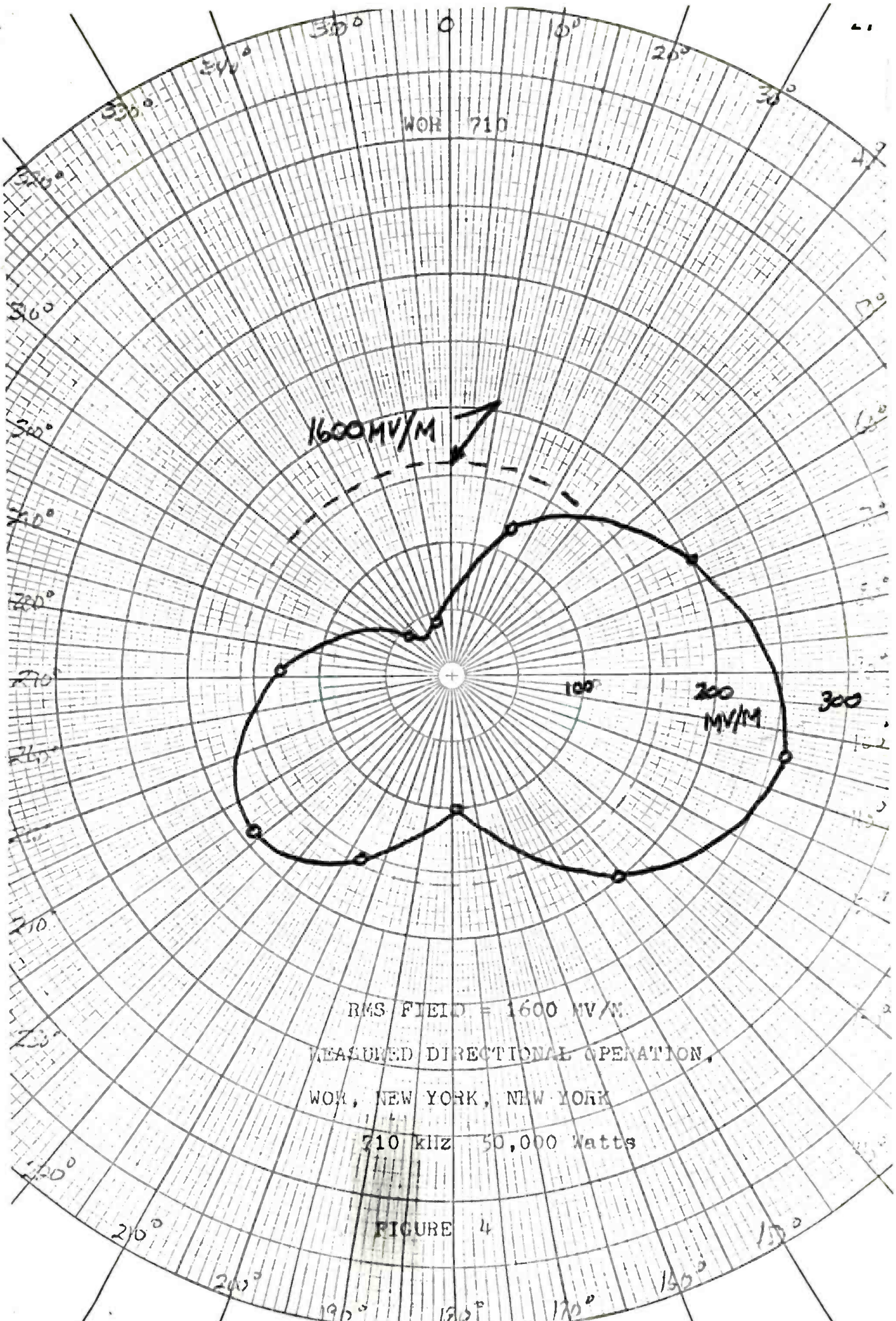
RES FIELD = 1740 MV/M

MEASURED NIGHTTIME DIRECTIONAL

OPERATION, KRLD, DALLAS, TEXAS

1080 kHz 50,000 Watts

FIGURE 3



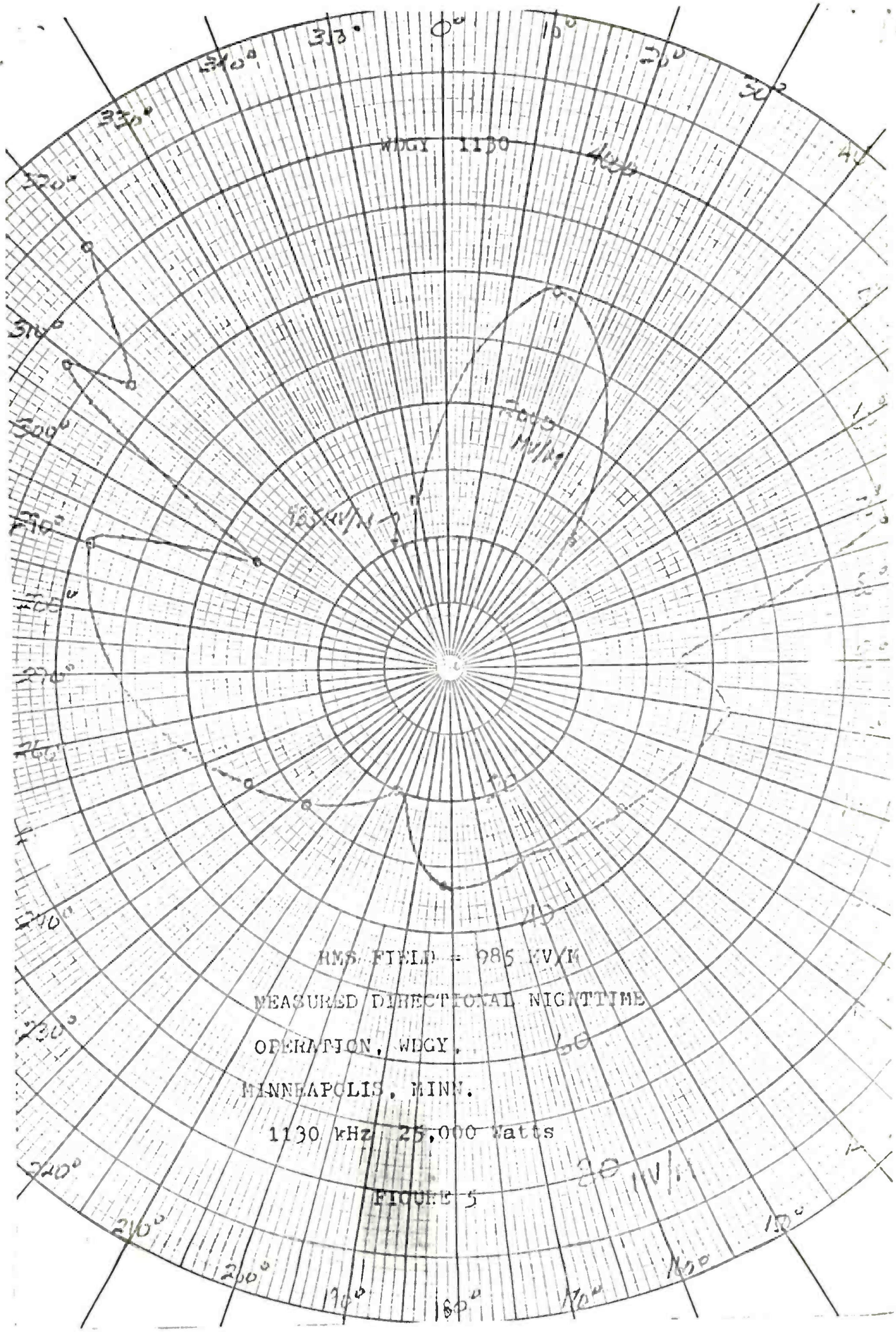
RMS FIELD = 1600 MV/M

MEASURED DIRECTIONAL OPERATION,

WOR, NEW YORK, NEW YORK

710 kHz 50,000 Watts

FIGURE 4



WDGY 1130
RMS FIELD = 985 MV/M
MEASURED DIRECTIONAL NIGHTTIME
OPERATION, WDGY,
MINNEAPOLIS, MINN.
1130 kHz 25,000 Watts
FIGURE 5

Figure 3 is the nighttime pattern for KRLD in Dallas. This pattern is typical of the simplest type, using two towers aligned along the line of the null and peak. The RMS field value of 1740 MV/M indicates good antenna efficiency. This pattern protects WTIC in Hartford and WTIC mutually protects KRLD. Notice the direction of the very broad peak. Just about all of west and south Texas and much of the Southwest is in KRLD's secondary service area, guaranteeing KRLD protection from interference within that area. Knowing the status of KRLD on this channel, it can be presumed that KSCO and KWJJ both null very deeply in KRLD's direction, which is in fact true. In order to place the nighttime peak across the metropolitan Dallas-Ft. Worth area, the transmitter is located northeast of Dallas in Garland, Texas. It is possible to obtain patterns very much unlike this one with two towers by use of different electrical drive conditions.

Figure 4 is WOR's full-time pattern, a non-symmetrical pattern generated by a 3 tower array placed in a triangular layout. (A symmetrical pattern would be generated if the towers were placed in a straight line). From the log, it can be seen that a flock of other stations are assigned to 710, but they also protect WOR with nulls and all are a good distance from New York. WOR's nulls are designed to protect KIRO and CKVM to the Northwest and North and WGBS, Cuba and Puerto Rico to the South. The transmitter location in New Jersey allows the main lobe to cover New York with practically all of Long Island and New England in the primary and secondary coverage areas. The southwest lobe covers much of New Jersey and Pennsylvania. The RMS field value of 1600 MV/M is reasonably good antenna efficiency but somewhat less than that attained by many other 50 KW stations. As antennas become more complex, the RMS field for the same power input usually drops because the additional tuning networks and lines required result in significant power losses. It may be interesting to many of you that this pattern is relatively new, this data being taken in September 1968. A different pattern was used before then.

Figure 5 is WDGY's present 25 KW nighttime pattern in Minneapolis, a very complex antenna using 9 towers. Notice that the nulls off the "back" of the pattern are so deep that a separate expanded scale is necessary in order to plot them. This technique of presenting two scales on the same sheet is a widely used method of providing maximum information on a single sheet. It is a safe bet that the transmitter is located south or southwest of the Minneapolis-St. Paul area. WDGY's signal in those cities must be fantastic, but a little to the south of the antenna, WDGY must fade very rapidly. On 1130, the primary stations are WNEW, KWKH and CKWX. All of these three stations use patterns at night to protect each other. This results in a "dead spot" on 1130 in the Midwest. The trio WCAR-WISN-WDGY all operate in this area under very strict circumstances so that none of these secondary stations interfere with each other or any of the primary stations. All of them operate with high power, and with the relatively close geographical spacing of these 3 stations, very sophisticated patterns are required. As of this writing, all 3 operate 9 tower arrays with pattern results that are very similar.

WDGY's RMS field is 985 MV/M for 25 KW. If we want to relate this to 50 KW in order to judge WDGY against WOR and KRLD, we can compute the RMS field for a hypothetical 50 KW; $\sqrt{\frac{50}{25}}(985) = (1.414)(985) = 1393$ MV/M, considerably less than either of these others. Much of the reason for this is that WDGY's array uses towers $\frac{1}{4}$ wavelength high, and the others use towers $\frac{1}{2}$ wavelength tall. More about that in Part 2.

USE OF THE PATTERNS

As an experienced DX'er with a station log showing assignments and powers, what does 420 MV/M mean to you? Probably not much - you don't have any way to relate that number to your experience. You probably classify a station in terms of power rating, 50 KW, 10 KW, etc.

Let's refer to Figure 3 again. The RMS field circle represents the field that would be generated if all of the available energy at KRLD were radiated non-directionally. For KRLD, 50 KW is worth 1740 MV/M. Notice that at 148° and 326°, the pattern curve crosses the RMS field circle. If you lived on either of these bearings from KRLD, their signal strength would be the same whether they were using their pattern or not. If you lived on the "back" of the pattern, KRLD would appear to be less powerful than 50 KW; if you lived in the "front", KRLD would have to look like more than 50 KW. But how much less - and how much more?

If you live in New Jersey and are listening for KRLD, the knowledge that they are radiating 400 MV/M toward you doesn't help much. But let's say that KRLD is radiating $\left(\frac{400}{1740}\right)^2(50) = (.23)^2(50) = (.053)(50) = 2.7$ KW towards your location. This means that from your location, KRLD appears to generate the same signal strength that it would if their operation were non-directional and their power were reduced to 2.7 KW. That means something, and you now have a "feel" for KRLD's signal.

If you happen to live in Tucson, Arizona and wonder why KRLD is such a pest, a calculation from your location will tell you why. $\left(\frac{2400}{1740}\right)^2(50) = 95$ KW. To you, KRLD is equivalent to a non-directional station running 95 KW.

Take the case of WDGY's pattern again, Figure 5. Look at the peak value of the curve on a bearing of 17°, 2950 MV/M. This is more than KRLD achieves (2450 MV/M maximum), and KRLD has a more efficient antenna, and runs 50 KW. WDGY's radical pattern is squeezing it's power into a very narrow, high intensity beam. The apparent power of WDGY on the 17° radial would then be given by $\left(\frac{2950}{985}\right)^2(25) = 279$ KW! That tells you all you need to know about WDGY's signal if you happen to live in their front lobe. Note that the lobe doesn't cover much in angle, whereas KRLD's front lobe covers a very wide

area. Due South of WDGY, (180°) the equivalent power would be $\left(\frac{33}{985}\right)^2(25{,}000) = .001(25{,}000) = 25$ watts. For reasons that will be fully explained in Part 2, we will accept no more radical reduction in power than 500:1, so for this bearing, the power rating for WDGY will be taken as 25,000/500 = 50 watts.

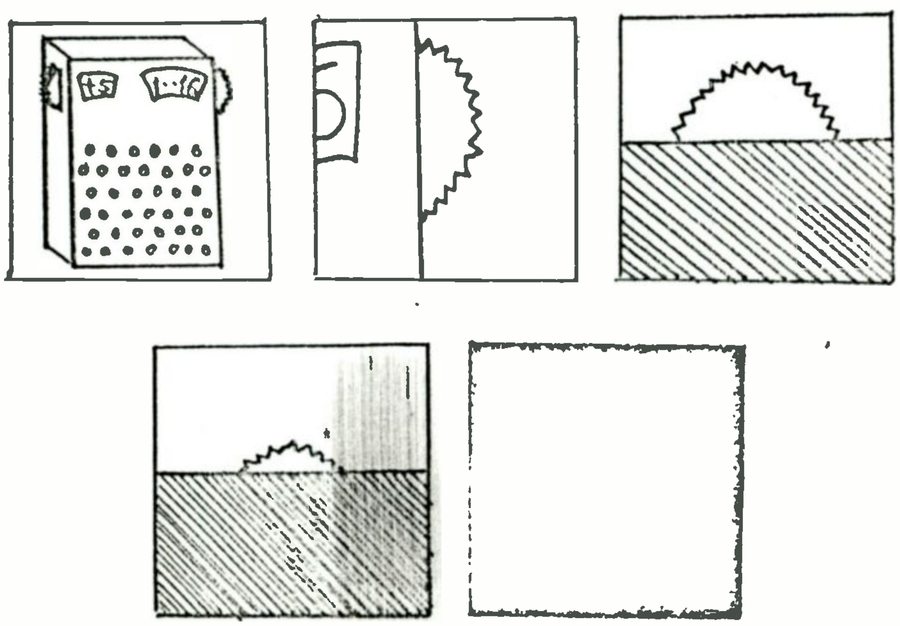
SUMMATION

These few sample calculations give a good idea of how radically a station's pattern can affect reception of that station in different directions. With patterns like these all over the United States and Canada, it seems that many mysteries of strong reception or very poor or non-existent results could never be satisfactorily explained without pattern information. Take Figure 4, WOR's pattern, and see if it doesn't explain some of your experiences.

The results of these calculations from antenna pattern information will be called EQP or equivalent powers. This expresses the radiation of a station using a pattern as a power in watts on a bearing from the station. In order to make these calculations, you need to know the bearing from the station to your location, and have the pattern available. A station operating non-directionally has an EQP rating equal to its power rating on any bearing from the antenna.

Part 3 will present the method by which this information may be made available to DX'ers, but Part 2 must come first. Many of you will immediately be suspicious that it just can't be that simple. Some will have specific objections. Part 2 will examine in detail the objections to the EQP calculation and show that in the vast majority of cases, the calculations are accurate and useful for prediction of signal strengths.

ADVENTURES OF "HARRIET" IN PARIS PART I



PATTERNS

PART II-A, by PAUL HART

In Part 1, a simple method for calculation of EQP's from antenna patterns was presented and illustrated. No consideration was given to the errors that might affect the accuracy of these calculations.

Part 2A will present the first half of the discussion of the specific factors that affect these calculations. It must be kept in mind that the EQP values are used to compare the performance of stations using patterns to those transmitting non-directionally.

The EQP proposition will be defended by attempting to prove the following:

1. A more accurate picture of a given station's expected strength will be obtained if the EQP figure is used instead of the carrier rated power. Specific restrictions may be applied to assure this condition.
2. The errors in using EQP values are consistent with the errors now accepted in using power ratings from the log.
3. Where objectionable errors are encountered, they occur so rarely and are so unlikely to affect practical results that they may be disregarded. (These errors must be fully evaluated and understood, however).

This discussion will present supporting information from the FCC view, that is, in accordance with the engineering specifications in Part 73. This should not imply that the FCC provisions are being represented as above challenge - some informed experts disagree with the FCC Rules in some areas.

In order to present the possible objections in the most direct fashion, questions or statements will be made, followed by the explanation:

1. The calculations may be subject to large errors, as in most cases, DX'ers are hearing skip coming from the antenna at high angles, and the pattern indicates signal intensities at ground level only.

This is the most telling argument against the use of patterns because within some definite areas of experience, the calculations are subject to significant errors. This question is so complex that Part 2B is devoted to an in-depth discussion of it. The detailed discussion required cannot be given without development of much information that will come from answering the other questions first, so let's look at them now:

2. In Part 1, the statement was made that power alone is not enough to characterize a station's output, but then a calculation is made that results in an EQP figure in watts. How can this contradiction be explained?

Another question is implied here, so it will also be asked:

3. Different stations have different antenna types and efficiencies. Won't that distort the calculations comparing one station to another?

A value directly from the pattern in MV/M is undeniably more accurate than the EQP calculation. The EQP calculation is useful, however, because it is subject to no more serious error than the DX'er accepts every time he rates a station by the power figure given in the log book. In addition, the EQP figure is one that has immediate meaning to every DX'er, and is therefore much more useful from the practical standpoint.

The FCC requires certain minimum values of antenna efficiency as discussed in Part 1. The requirement is stated in MV/M/KW. This means that for each kilowatt of transmitter output, the station must generate a certain minimum level of field intensity at 1 mile on the ground. These regulations apply to non-directional and directional antennas alike. For directional antennas, the efficiency value is obtained from the RMS field, scaling if necessary to obtain the 1 KW value.

The minimum requirements from Part 73, 73.189 are as follows:

(i) Class IV stations, 150 MV/M/KW.
(ii) Class II and III stations, 175 MV/M/KW.
(iii) Class I stations, 225 MV/M/KW.

Class IV stations are almost exclusively assigned to local channels. Those very few on regional channels meet (except in one marginal case) the minimum for class II and III stations. Nighttime patterns are not used in the United States on local channels (at least not yet) so the minimum FCC-allowable antenna efficiency that will appear in the EQP calculations or in comparative non-directional stations is 175 MV/M/KW.

Stations usually have the option of building antennas of much higher efficiency than the minimum requirements. Some stations have built very large antennas to get the last drop of radiation possible out of their assigned power. As a matter of interest, the most efficient antennas now operating in the United States are as follows: *

1. WNBF-1290 324 MV/M/KW (daytime non-dir. only)
2. KSTP-1500 318 MV/M/KW (daytime non-dir. only)
3. KELO-1320 312 MV/M/KW (daytime non-dir. only)
4. KDKA-1020 297 MV/M/KW
5. WHO-1040 293 MV/M/KW

* These values were determined from the NAHSA list dated June 24, 1970.

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Checking through the NARBA list, with very few exceptions, the maximum antenna efficiency encountered is about 270 MV/M/KW. For all practical purposes, then, the lowest and highest efficiencies we will encounter in pattern calculations are 175 and 270 MV/M/KW. The maximum possible error in power relationship is then $\left(\frac{270}{175}\right)^2 = 2.38$. This seems to be serious, but don't forget, exactly the same numerical error prevails using non-directional power ratings. The 175 and 270 MV/M/KW numbers used, after all, are efficiencies of non-directional antennas. Stations using patterns fall within these same brackets.**

Did you notice the seeming inconsistency in Part 1? The non-directional antenna measurement for WGH-1310 was 420 MV/M using 5 KW. KRLD's strength to New Jersey was calculated as 2.7 KW with 400 MV/M radiated. Let's assume WGH's power now becomes whatever is necessary to generate 400 MV/M, $\left(\frac{400}{420}\right)^2(5) =$ $(.905)(5) = 4.5$ KW. Both radiation levels are the same, but the power ratings are not. The ratio between them is $\frac{4.5}{2.7} = 1.67$, below the 2.38 maximum obtained above. The point is that errors of this type do exist, but they are in line with what we have been accepting all along. Maybe we just weren't quite so aware of it - hardly a good reason for judging the pattern calculations invalid. KRLD radiates a lot less than 50 KW toward New Jersey, and the number 2.7 KW is much more accurate than counting KRLD as a straight 50 KW.

VERTICAL PATTERNS

To set the stage for further discussion of the first question, we must consider the vertical patterns of non-directional radiators. Please refer to Figure 6a, which is a re-plot of the vertical patterns for antennas of ½ and ¼ wavelength from Part 73, 73.190. These curves are dated May 4, 1938, but hopefully these antennas behave in 1970 the same as they did in 1938. The curves represent typically attained efficiencies on any bearing from the antenna, as a single element vertical radiator should generate an omni-directional field.

The vertical angle markings are in degrees on the left. The horizontal scale is in MV/M/KW at 1 mile. This chart compares two typical antennas each being driven with 1 KW. For both antennas shown in 6a, the maximum radiation level attained is at ground level, and as the angle increases toward 90°, the field decreases to zero (directly over the antenna). It is essential that the reader understand these curves and how to read them. The following examples are presented to illustrate:

** With one exception, WKYC-1100. WKYC's antenna pattern efficiency (related from the RMS field) is 283 MV/M/KW. For stations with patterns, this one is in a class by itself.

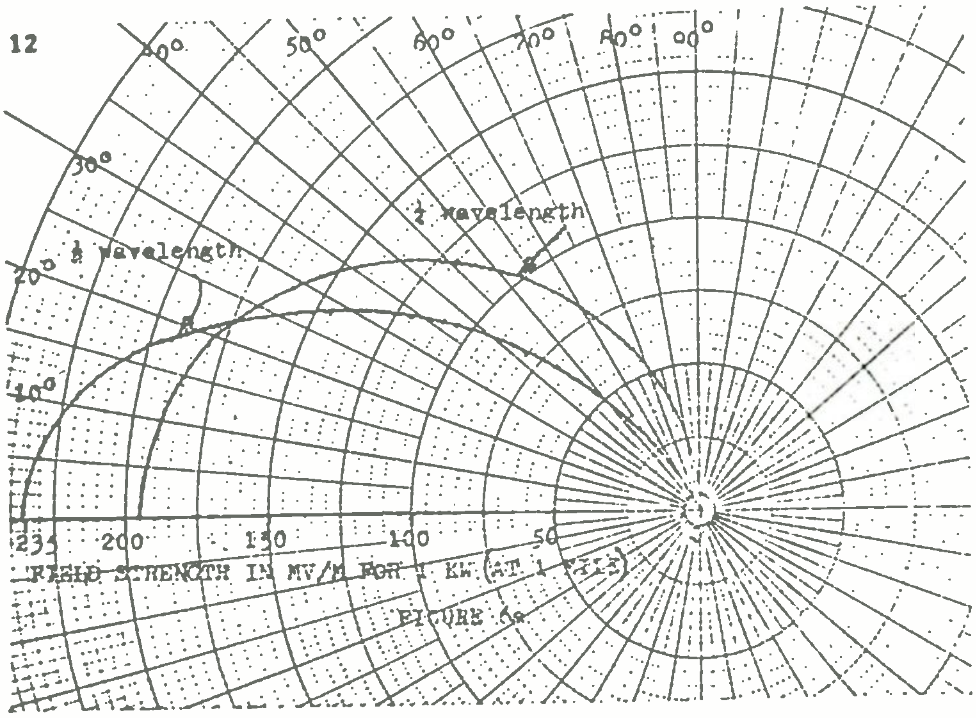


FIGURE 6a

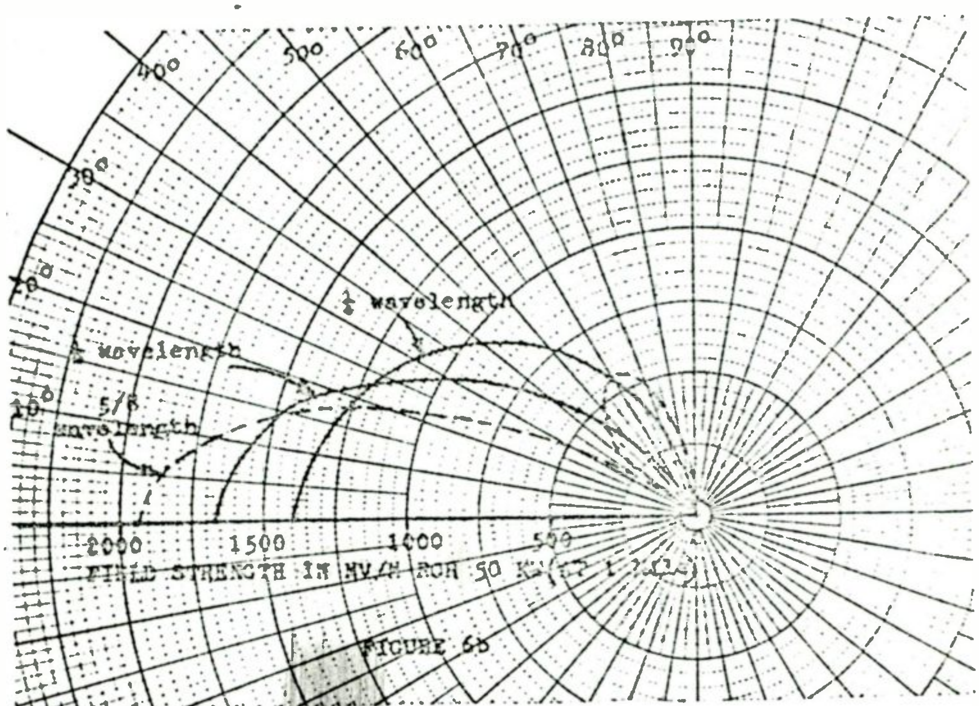


FIGURE 6b

A. For the quarter wavelength antenna shown on 6a, what is the expected radiation level encountered 40° above the horizon, 1 mile from the antenna?
   Find the 40° elevation line at the upper left, and follow it down to the $\frac{1}{4}$ wavelength curve. At the point of intersection (the 40° line with the $\frac{1}{4}$ wavelength curve), follow the radial field strength line down to the horizontal axis and read 135 MV/M.

B. If a $\frac{1}{2}$ wavelength antenna radiates 236 MV/M at 1 mile for 1 kilowatt input, at what vertical angle will the 1 mile value be reduced to 200 MV/M?
   Find 200 MV/M on the horizontal axis and follow it up to the $\frac{1}{2}$ wavelength curve. Follow the angle out to the scale markings and read 17°.

Figure 6b shows the curves of 6a scaled to 50 KW of transmitter output. The scaling factor is $\sqrt{\frac{50}{1}} = 7.07$ to get to 50 KW from 1 KW. An additional curve for a 5/8 wavelength antenna is included dotted so as not to be confused with the other two. Antennas taller than $\frac{1}{2}$ wave are primarily used by the 50 KW "clears", but some other stations do use them, as seen by the list of most efficient stations presented earlier.

Looking at these curves, it becomes obvious why the taller towers have higher rated efficiencies; they get more of their radiation "down on the ground". For revenue purposes, this is where the station wants it, but tall antennas are expensive to erect and maintain. Notice that a 50 KW transmitter driving a typical $\frac{1}{4}$ wavelength antenna will generate a field of about 1400 MV/M at 1 mile, whereas the same 50 KW driving a typical 5/8 wavelength antenna will generate 1930 MV/M at the same 1 mile distance. The primary difference is in the amount of radiation at higher angles.

It can also be seen that as the antenna height increases over $\frac{1}{2}$ wavelength, small secondary lobes begin to appear at high angles. These lobes can be a problem and are definitely undesirable. Practically all directional antennas in the United States use $\frac{1}{2}$, $\frac{1}{4}$ or shorter antennas. (Some stations use odd lengths between these limits). The majority of stations use $\frac{1}{4}$ wavelength antennas.

PROPAGATION

In order to pursue the factors in DX reception even furthur, we must take a step into the world of propagation. The primary purpose of this article is to discuss patterns, but some propagation discussion is necessary to evaluate skip behavior.*** Figure 7 is a chart showing single-hop skip distances vs. angles of departure and arrival for the E and F_2 layers. The inset is an illustration of the geometry involved.

*** Propagation is a very complex subject because of the many variables at work. Detailed articles on this subject are planned for publication in DX NEWS.

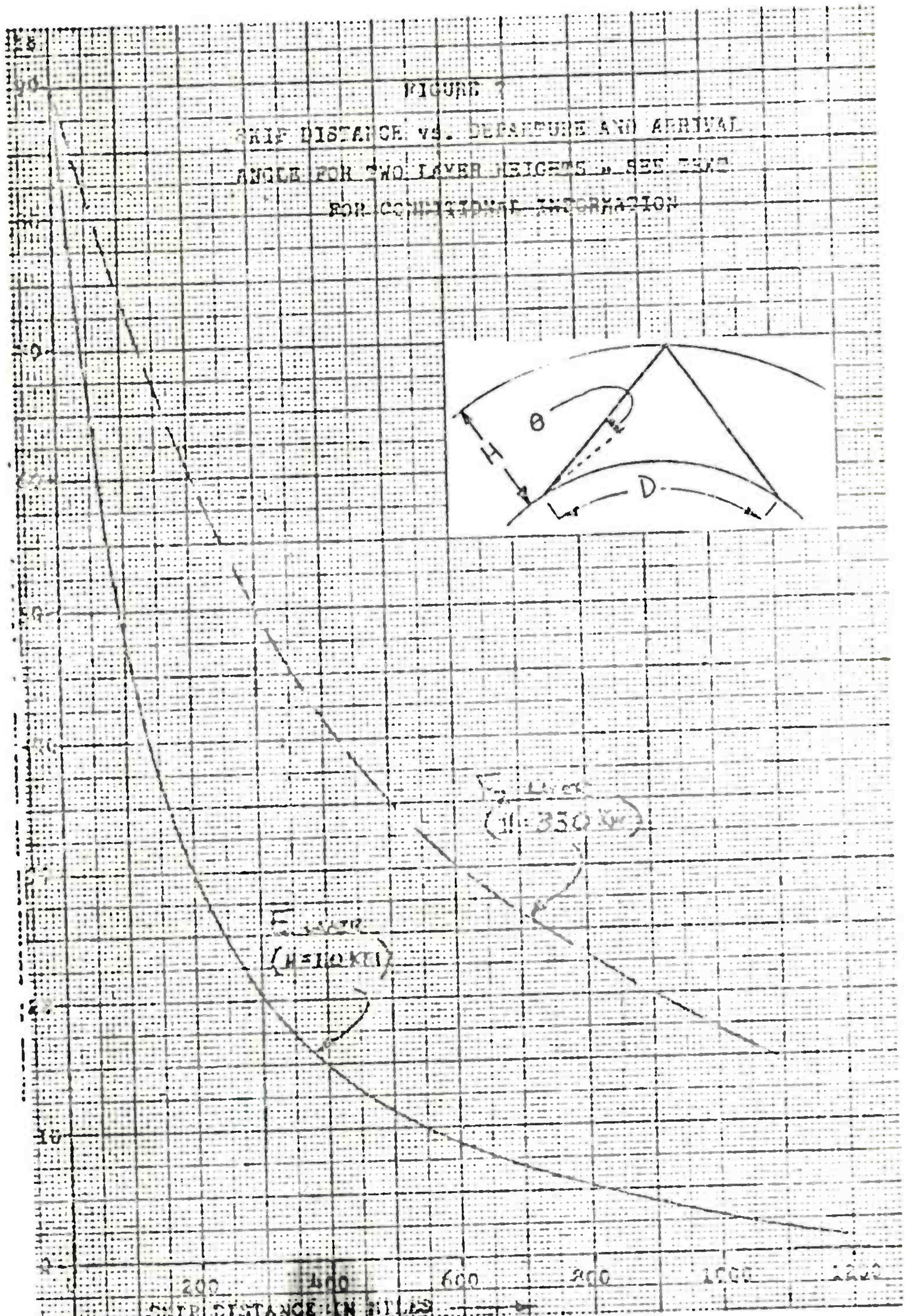


FIGURE
SKIP DISTANCE vs. DEPARTURE AND ARRIVAL
ANGLE FOR TWO LAYER HEIGHTS - SEE TEXT
FOR ADDITIONAL INFORMATION
θ
H
D
(H=350 KM)
(H=100 KM)
10
200
400
600
800
1000
SKIP DISTANCE IN MILES

The dotted line in the inset is an extension of the horizon line, and the angle θ is the elevation at which the signal arrives. The "E layer" curve is taken from the FCC Rules, 73.190 Figure 6a, Curve 1. This is the chart the FCC specifies for calculation of interference signals; they consider E as the dominant mode of propagation. The "F_2 layer" curve is taken from THE ARRL ANTENNA BOOK (1968). For purposes of this discussion, we are concerned with behavior at relatively short distances (600 miles and less) and for this purpose, E layer propagation will be assumed. The F_2 curve is included for the benefit of those who believe that F_2 propagation is dominant.

Looking back at Figure 6b, notice that the crossover point between the ½ wavelength and ¼ wavelength curves is 23°. For 23° on the E curve of Figure 7, read 270 miles as the skip distance. This means that comparing equivalent antennas driven with the same power, the ¼ wavelength antenna will skip more energy back down at distances under 270 miles. For distances over 270 miles, the ½ wavelength antenna will skip in more energy. The longer the skip distance, the lower the angles of departure become, and the greater is the advantage of the taller antenna. Now it is obvious why the little lobe on the 5/8 wavelength antenna is so undesirable, it peaks at 60°. From Figure 7, 60° corresponds to a distance of about 60 miles. This is well inside the groundwave coverage area for most stations using antennas of this height. At night, the skip-in of this skywave signal can cause severe selective fading. Stations using tall antennas try to suppress these minor lobes as much as possible for this reason.

We have considered the vertical patterns for typical non-directional antennas operating on the broadcast band. The next step is to determine whether or not the vertical patterns of stations using horizontal patterns behave like the vertical patterns of non-directional antennas. Part 2B will examine this question with exhibits of the vertical patterns for WGXR's nighttime antenna, and the fantastic 25 KW 12 tower nighttime proposal for WISN in Milwaukee. To complete this section, let's present the remaining questions.

MORE QUESTIONS

4. Patterns change, it is impossible to maintain the original performance. At any given time, won't the actual radiation be different from information shown on the chart?

The originally specified pattern must be maintained if a station is to keep its license. The following paragraphs are from the FCC Rules in Part 73:

73.52(b) "In addition to maintaining the operating power within the above limitations, stations employing directional antenna systems shall maintain the ratio of the antenna currents in the elements of the system within 5 percent of that specified by the terms of the license or other instrument of authorization."

73.67(6) "The indications at the transmitter, if a directional antenna station, of the common point current, base currents, phase monitor sample loop currents and phase indications shall be read and entered in the operating log once each day for each pattern. These readings must be made within two hours after the commencement of operation of each pattern".

Patterns do vary slightly with time, but the errors encountered are not usually serious. The FCC's requirements for complete re-characterization of patterns varies widely from station to station. A provision that is developed in Part 2B is not to accept any more than a 500:1 reduction in power relative to the station's rating. This also helps here to insure that errors are not made as a result of changes in very deep patterns.

5. Even though the FCC record is public domain, the cost of obtaining the patterns from Cooper-Trent makes them unavailable to the individual DX'er as a practical matter.

6. If the bearings determined from a station to the listener are in error by more than about 3°, serious errors may be encountered in the EQP calculation. Determination of bearing angles over moderate or long distances to this accuracy is difficult and time-consuming.

Part 3 will present the proposal for providing DX'ers with pattern information, which answers questions 5 and 6. Once the remaining problem (vertical behavior) with patterns has been examined in Part 2B, we will be able to proceed.

Exporting sound

TEEN IDOL Tony Prince signals his engineer as he spins rock records over popular and profitable Radio Luxembourg. Foreign firms sponsor the broadcasts on the privately owned station, which boasts a wide audience throughout Europe, a continent served largely by government networks.

Radio Luxembourg, the noisiest, brassiest radio station in all Europe, and a strangely incongruous phenomenon to find thriving in so quiet a country. It broadcasts in 11 different languages, on AM, FM, shortwave, long wave, and medium wave. Its main transmitter, 600,000 watts strong, carries its cheerful voice throughout Europe and North Africa, and deep into the Communist bloc. Its English-language disc jockeys call it "Radio-Lucky-Luxembourg"; its staple is rock music.

It was not always so cheerful. During the dark years of World War II, the Nazis seized Radio Luxembourg and used it for propaganda. One of its best remembered and most hated programs was that of a renegade English-language broadcaster named William Joyce, better known as Lord Haw Haw. His commentaries were among the most vicious poured out by the Nazi war machine. After the war Joyce was arrested, taken to London, convicted of treason, and hanged

reprinted from National Geographic


WTAR - NORFOLK, VIRGINIA
NIGHTTIME 2.5 MV/M COVERAGE CONTOUR
JANUARY 1958
ROBERT M. SILLIMAN
WTAR SITE
2.5 MV/M
KENT
NANSEMOND
NORFOLK
PERQUIMANS
HAMPTON
WARWICK
ATLANTIC
SOUND

PATTERNS

Part 2b, by PAUL HART

As developed in Part 2A, the question under examination in this section concerns the vertical behavior of stations using horizontal patterns. In order to place the FCC's attitude in perspective, the following paragraphs are quoted from Part 73:

73.150 Data required with applications for directional antenna systems.

(3) "Calculated field intensity vs. azimuth patterns for every 5 degrees of elevation through 60 degrees in those instances where radiation at angles above the horizontal plane is a pertinent factor in station allocation.* These patterns may be plotted in polar or rectangular coordinates but shall be submitted one to a page. Minor lobe and null detail occurring between the 5 degree intervals need not be submitted."

73.151 Field intensity measurements to establish performance of directional antennas.

(1) "Horizontal field intensity pattern(s) showing the inverse field intensity at 1 mile and effective field intensity (RMS) as determined from field intensity measurements taken and analyzed in accordance with 73.186 in at least the following directions:

(i) Those specified in the instrument of authorization.

(ii) In major lobes. Generally at least three radials are necessary to establish a major lobe; however, additional radials may be required.

(iii) .....However, when more complicated patterns are involved, that is, patterns having several or sharp lobes or nulls, measurements shall be taken along as many radials as may be necessary, to definitely establish the pattern(s)."

The most significant information in these quotes relates to what the FCC does not require:

1. No vertical radiation information is required for any antenna above 60 degrees.
2. For many stations, the vertical pattern is not required by the FCC.
3. Only the horizontal pattern (at 0°) is verified by measurement after the station begins transmitting.

These things, in turn, result in the following situations confronting anyone interested in working with vertical patterns:

A. Vertical patterns are relatively hard to obtain - most do not exist. Even the ones that have been calculated and submitted in the original station proposal are not carried in the Cooper-Trent file.

---

*Underlined emphasis added.

B. The vertical performance of an antenna is rarely if ever checked by actual measurement. The best information we will ever have is the calculated performance contained in the FCC-accepted proposal.

WQXR - FIRST EXHIBIT

Figure 8 is the measured nighttime directional pattern for WQXR in New York. Information is given that three towers in a row are used, spaced 90° electrically, and all three are 0.475 wavelength in height.

Figures 9a and 9b are vertical plots of WQXR on the two bearings shown. On all of these charts, the "base start value" is the actual field strength value in MV/M on the ground at which the curve starts at the left. The estimate of the pattern vertical behavior is shown as a solid line, and an ideal ½ wave curve is shown as a dashed line.

The ideal curve is developed by referring back to Figure 6a in Part 2A. The base start value for the ½ wavelength curve in Figure 6a is 236 MV/M. By taking a straight ratio, all of the values on the ideal curve for Figure 9a will be $\frac{2700}{236} = 11.44$ times the point values for the ½ wave curve of Figure 6a.

To construct a point on the ideal curve on 9a, read the 30° value for the ½ wavelength curve on 6a as 135 MV/M. The value on the ideal curve at 30° will then be (11.44)(135) = 1544 MV/M. By figuring as many points as desired in this manner, the ideal curve is defined. The dashed line is then drawn to connect the data points. The two curves can be easily compared to gauge the vertical behavior of the pattern for the bearing shown.

For Figures 9a and 9b, the estimated curve bulges slightly above the ideal curve. But WQXR's towers are not quite ½ wave tall, and from 6a, you can see that as the antenna height decreases, the upward bulge increases. WQXR's vertical pattern certainly behaves very well on these two bearings, and the EQP values would be accurate without question. To my knowledge, no engineering estimate has been made for any other bearings, but it seems that any deviations from ideal vertical behavior would be insignificant for this pattern.

You may notice that the base start values in 9a and 9b do not agree exactly with the measured pattern of Figure 8. This is because the vertical patterns are estimated from the proposal, and Figure 8 is taken from the actual measurements made on the completed and operating antenna.

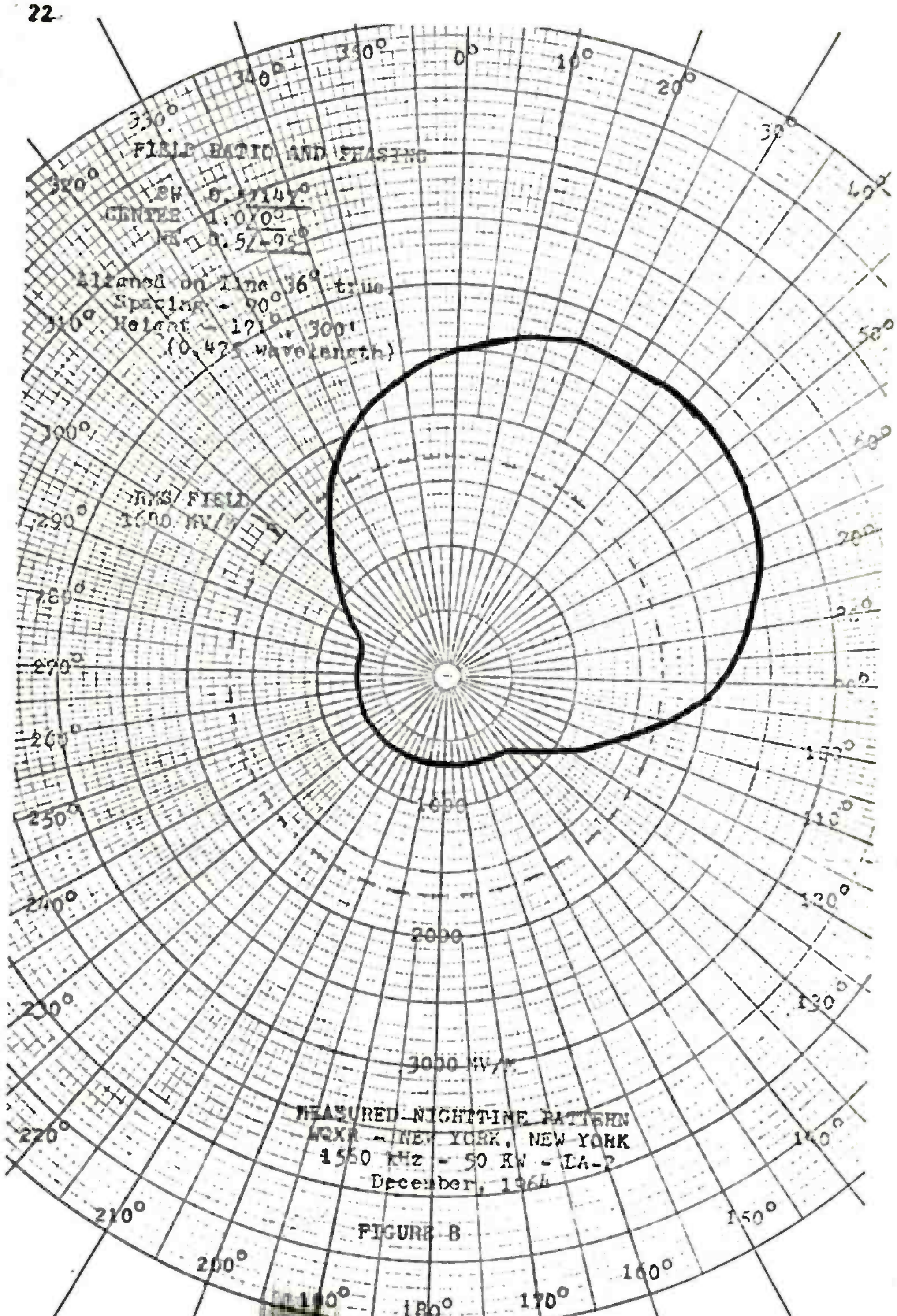

FIELD RATIO AND PHASING
CENTER 1.0/0°
Aligned on Line 36° true
Spacing - 90°
Height - 171°, 300'
(0.475 wavelength)
3000 MV/M
MEASURED NIGHTTIME PATTERN
WQXR - NEW YORK, NEW YORK
1560 kHz - 50 KW - DA-2
December, 1964

FIGURE B

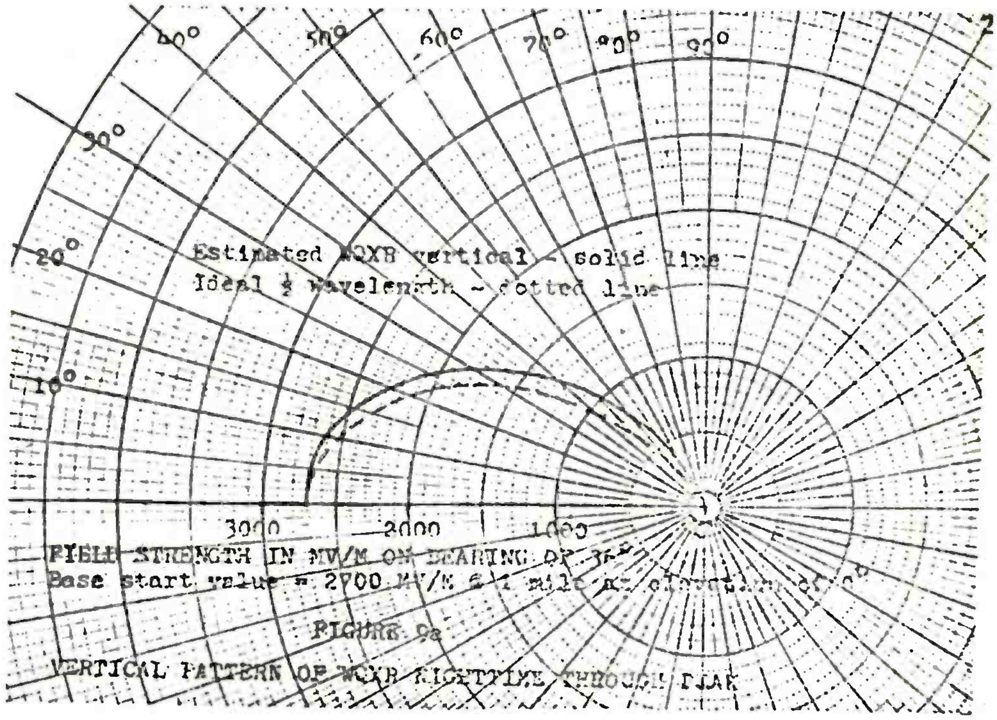


FIGURE 9a

VERTICAL PATTERN OF WQXR NIGHTTIME THROUGH

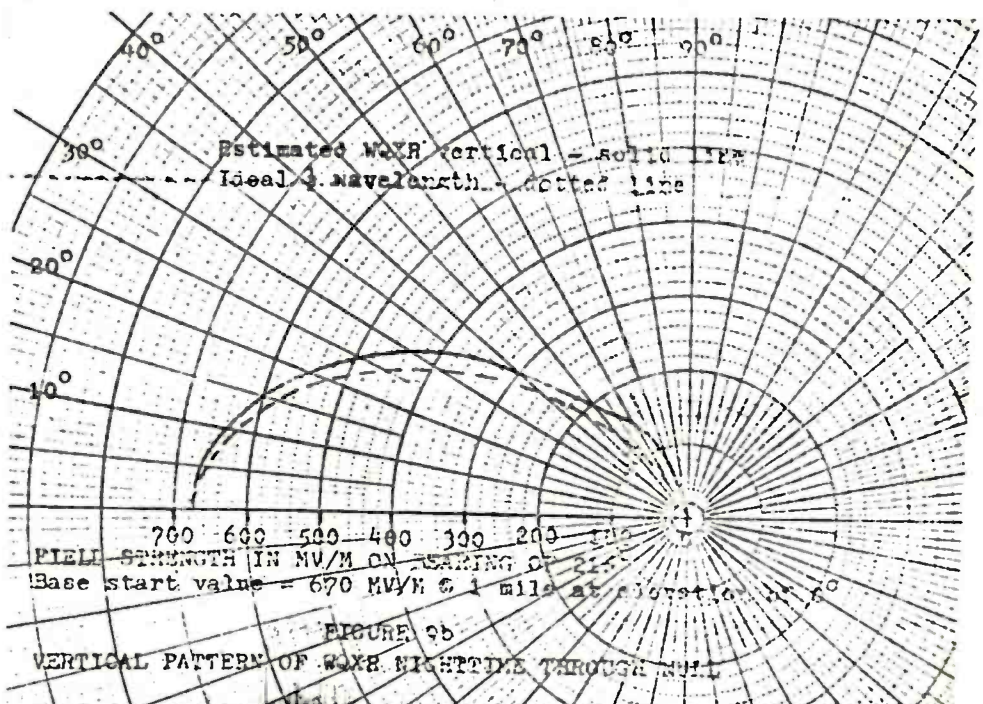


FIGURE 9b

VERTICAL PATTERN OF WQXR NIGHTTIME THROUGH

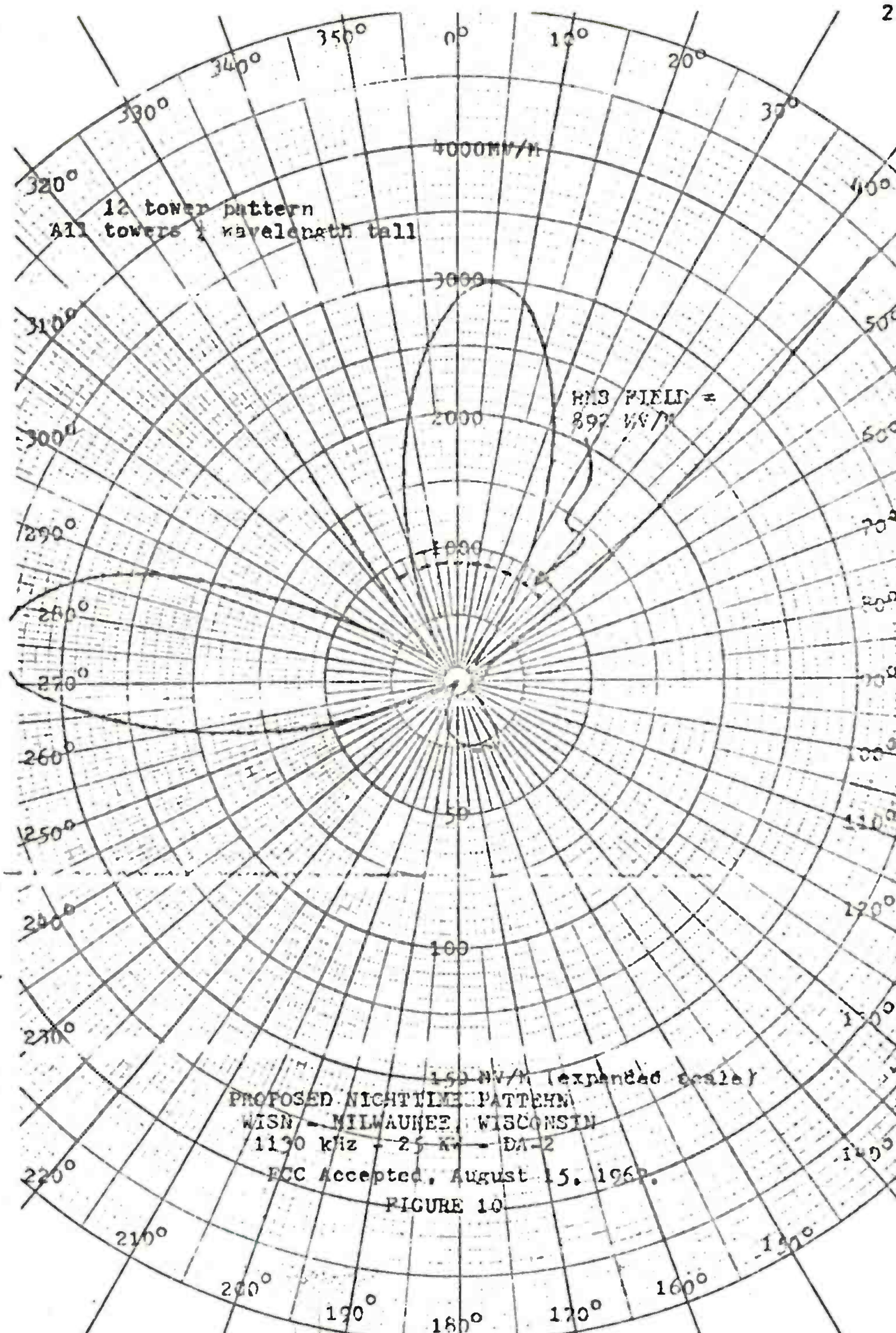
WISN - SECOND EXHIBIT

Figure 10 is the proposed horizontal pattern for WISN in Milwaukee for nighttime operation with 25 KW, using a 12 tower array. Remember that WISN's present operation is 10 KW night with a 9 tower antenna setup. All tower heights are given as 90°, or $\frac{1}{4}$ wavelength, and the RMS field is 892 MV/M.

The complete vertical readout of this pattern is available, with a total of 936 data points. The radials for which Figures 11a, 11b, 12a, and 12b are plotted were deliberately chosen to show the worst vertical behavior to be found on this pattern. On most bearings, the vertical behavior was quite reasonable. Keep in mind that the curves shown are the worst cases obtainable on one of the most radical antennas either proposed or operating.

A quick look at the solid line in Figure 11a shows that WISN's vertical pattern on a bearing of 225° is much unlike the ideal $\frac{1}{4}$ wavelength curve in Figure 6a. If we were to calculate WISN's EQP on this bearing, using the base start of 1 MV/M and the RMS field of 892 MV/M, the EQP value would be $\left(\frac{1}{892}\right)^2(25{,}000) = .031$ watt! Ridiculous as this sounds, the calculation might well be accurate on the ground, but it certainly won't do as an accurate estimate for skywave reception.. (Surely the actually measured value on this bearing will exceed 1 MV/M). Let's impose an arbitrary restriction, and say that we will not accept as valid, any calculation that yields a power less than a 500:1 ratio of the station's rating. We can figure the relation backwards to see what the field value for WISN would be for the 500:1 power. The power would be 25,000/500 = 50 watts. The field necessary to yield an EQP of 50 watts would then be $\left(\frac{x}{892}\right)^2(25{,}000) = 50$. $x = \frac{892}{22.4} = 40$ MV/M. Let's then draw on Figure 11a a dashed line representing an ideal $\frac{1}{4}$ wavelength antenna with a base start value of 40 MV/M. Observe that the ideal and estimated curves cross at 42°. From Figure 7 (Part 2A) on the E curve, 42° corresponds to 125 miles. This means that if you accept 50 watts as an estimate of WISN's signal strength and you live 125 miles from the antenna, your estimate is going to be just right. Farther away, the energy received will be less that predicted by the 50 watt value, but the estimate of 50 watts is still much more accurate than 25 KW.

Take the behavior on the bearing of [illegible]. The base start value is 71 MV/M, so the EQP calculation would yield $\left(\frac{71}{892}\right)^2(25{,}000) = 160$ watts. This value is above our 500:1 value of 50 watts, and would be accepted as a valid calculation. The dashed curve on 11b is the ideal $\frac{1}{4}$ wavelength curve with a base start of 71 MV/M. Notice that the ideal and estimated start off together, but the estimate rapidly drops below the ideal curve until the crossover is reached at 55°. From Figure 7, this is 75 miles. Even with this less-than-ideal behavior, the 160 watt EQP value is always equal to or higher than the estimated curve. It certainly is a much more accurate indication of WISN's signal on this bearing than the 25 KW log power rating.



PROPOSED NIGHTTIME PATTERN
WISN - MILWAUKEE, WISCONSIN
1130 kHz - 25 KW - DA-2
FCC Accepted, August 15, 196[illegible].
FIGURE 10

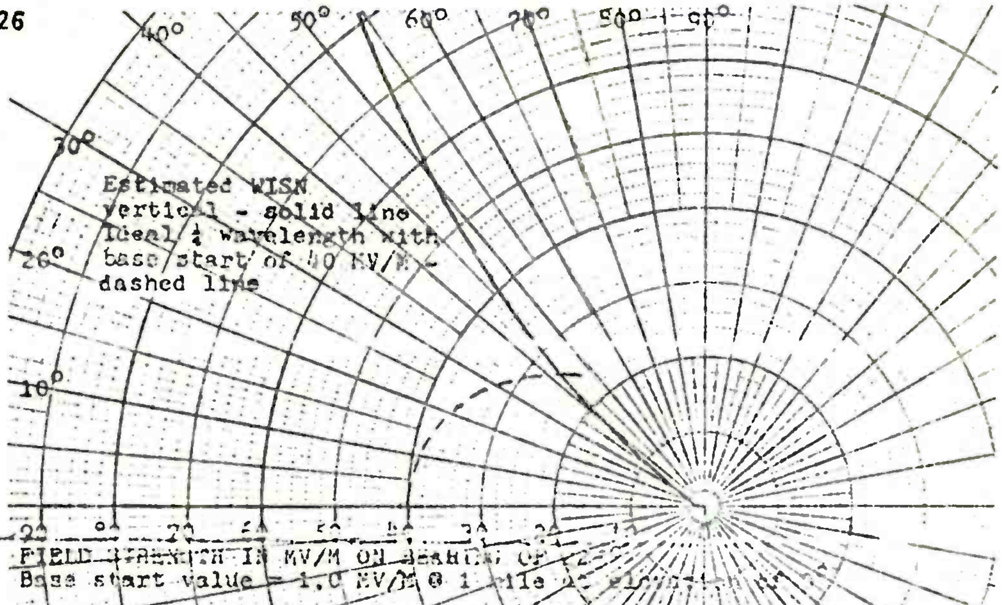


FIGURE 11a

VERTICAL PATTERN OF WISN PROPOSAL THROUGH DEEP NULL

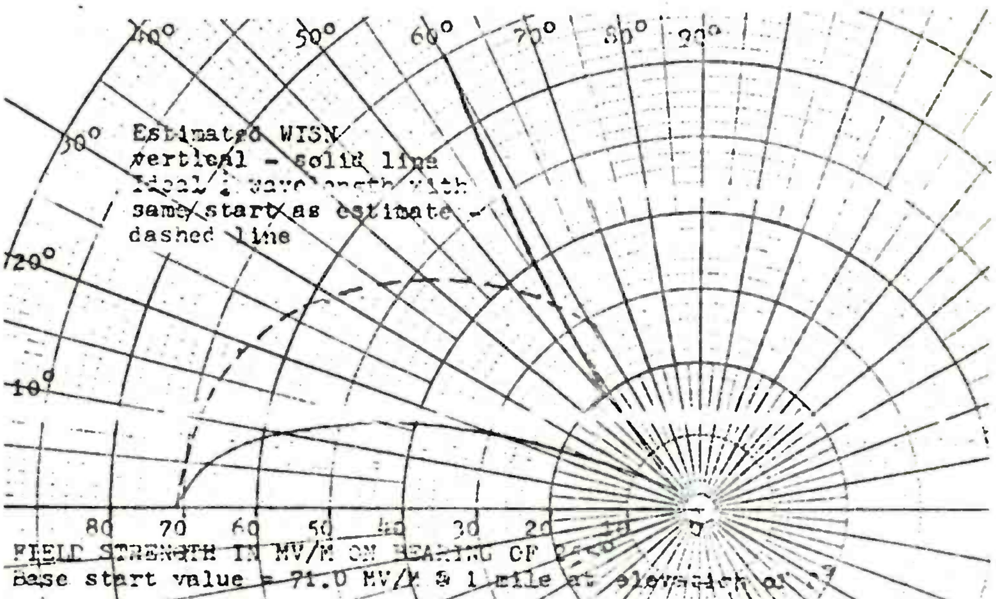


FIGURE 11b

VERTICAL PATTERN OF WISN PROPOSAL THROUGH SELECTED NULL

The only real options we have is to accept and use the EQP ratings as they are or tb reject them. For reasons stated earlier, it is impossible to obtain vertical as well as horizontal plots for all stations using patterns. In order to keep things in line, let's assume that we use the restrictions stated below in regard to EQP values:

1. Restrict power reduction to 500:1 relative to rated carrier power. This is a good rule to observe under any circumstances.
2. The listener should be 200 miles or more from the station. This limitation is subject to modification in light of the individual case. For example, if the reception is daytime groundwave, the EQP calculation is valid regardless of distance. If the pattern is known to be very stable, no restriction as to distance need be imposed, even at night. If the pattern is known to be very unstable, maybe more than 200 miles should be used. The 200 mile figure is intended as a guide for nighttime use if no other specific information is available.

Even these restrictions don't fix everything all the time, as can be seen from Figures 12a and 12b.

Figure 12a is the vertical plot for the WISN proposal on a bearing of 30°. The EQP calculation would be $\left(\frac{1143}{892}\right)^2 (25) = 41$ KW, and would certainly be considered valid. Note that the estimated curve is above the ideal ¼ wavelength curve all the way to 60° and some distance beyond. If we go back to the 200 mile rule, and plot another ideal curve designed to cross the estimate at 30°, we can then see where it would intersect the base line and determine the base start value for this new ideal curve. That curve is shown dashed with circle data points on 12a. The new base start is 1600 MV/M which means that if we want the estimated radiation to be accurate or less than the EQP value for all distances of 200 miles and more, the EQP rating would have to be $\left(\frac{1600}{892}\right)^2 (25) = 80$ KW. This error is significant, but some things must be kept in mind:

1. This behavior only occurs over a very small portion of WISN's curve.
2. The most valuable information from patterns concerns nulls and their magnitude. This is a bearing on the curve where a strong signal would be expected whether you accepted the 41 KW figure or insisted on the 80 KW value.
3. As the distance increases beyond the 200 mile limit, the error rapidly diminishes in magnitude.

Figure 12b is the worst case of all. The base start value of 22.6 MV/M would yield an EQP value of 275 watts, a figure that would be accepted by the 500:1 restriction. The vertical curve increases in value rapidly after the base start, and would result in significant errors. As before, another ideal curve has been constructed on 12b using a 30° crossover to determine what the base start value would have to be. In this case, the value is [illegible] MV/M, which would result in an EQP value of

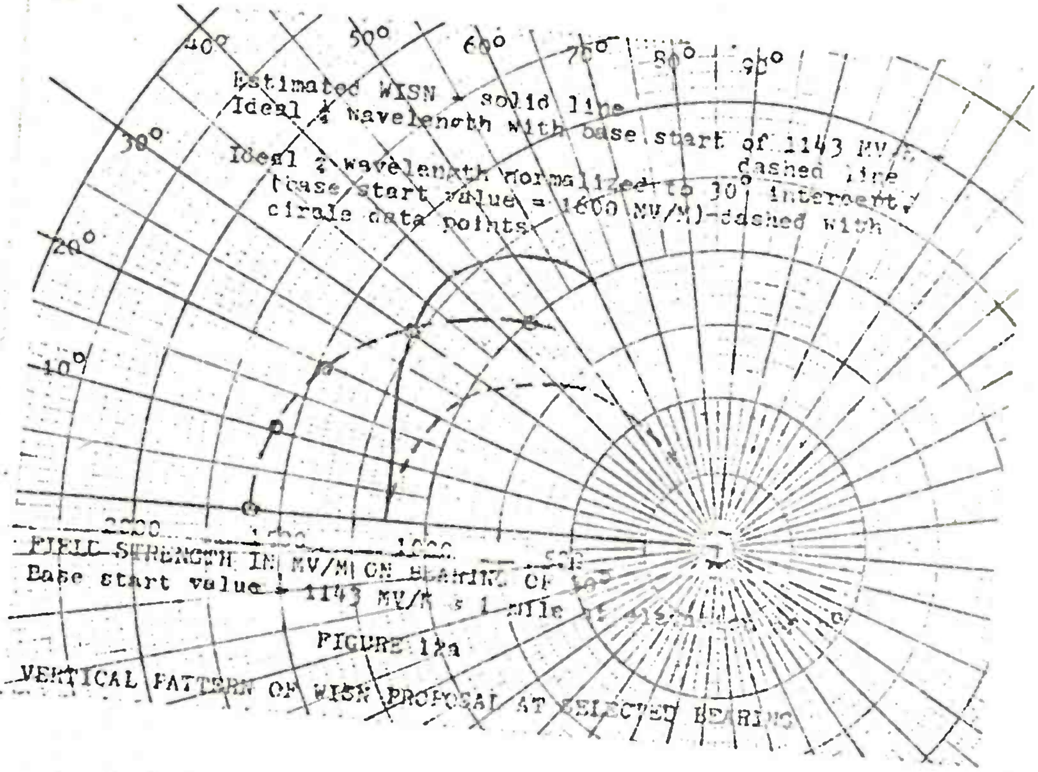


FIGURE 12a

VERTICAL PATTERN OF WISN PROPOSAL AT SELECTED BEARING

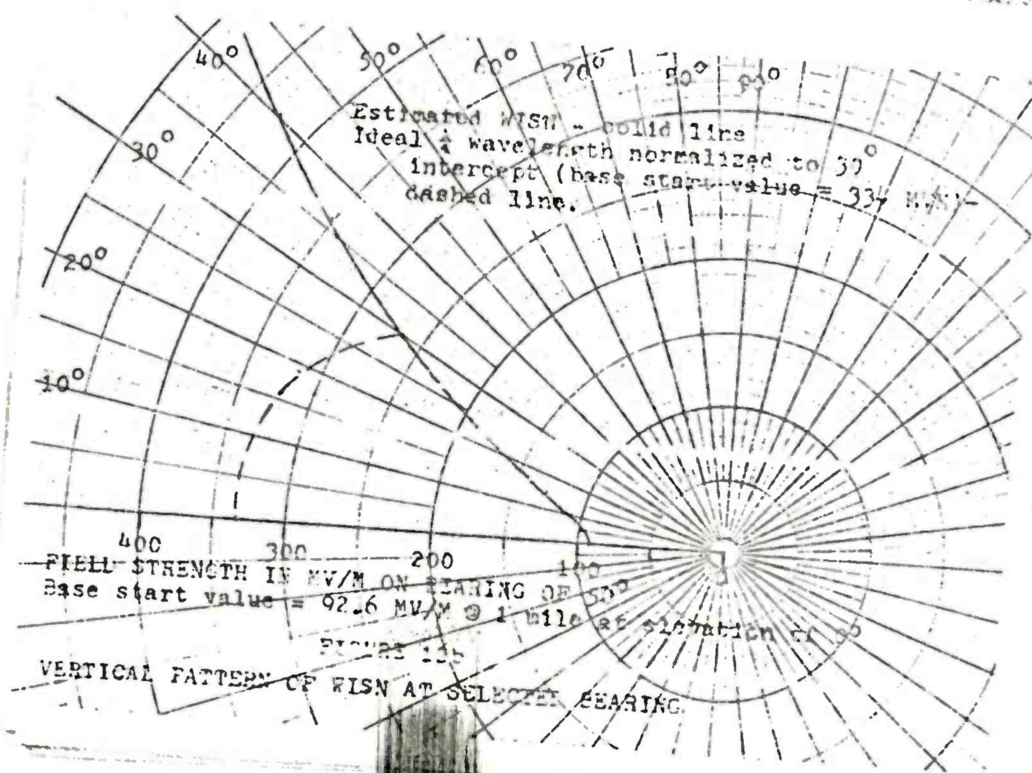


FIGURE 12b

VERTICAL PATTERN OF WISN AT SELECTED BEARING

$\left(\frac{334}{992}\right)^2(25{,}000) = 3500$ watts. No two ways about it, this is gross error, but again, remember the following:

1. This severe a problem only occurs over a small portion of even this radical curve.
2. As the distance increases beyond 200 miles, the error decreases rapidly. For an intercept of 20° or 300 miles, the required EQP prediction to maintain the estimated curve even with or below the ideal curve would be 1 KW.*
3. Using the most gross reasoning, 275 watts is still a better indication of WJSN's radiation than 25 KW, even knowing that if you are 200 miles away, 3.5 KW is the proper value.

SUMMARY

This information has been presented to allow the reader to examine the question of EQP validity for himself and make an intelligent decision. The following proposal is submitted for the reader's consideration:

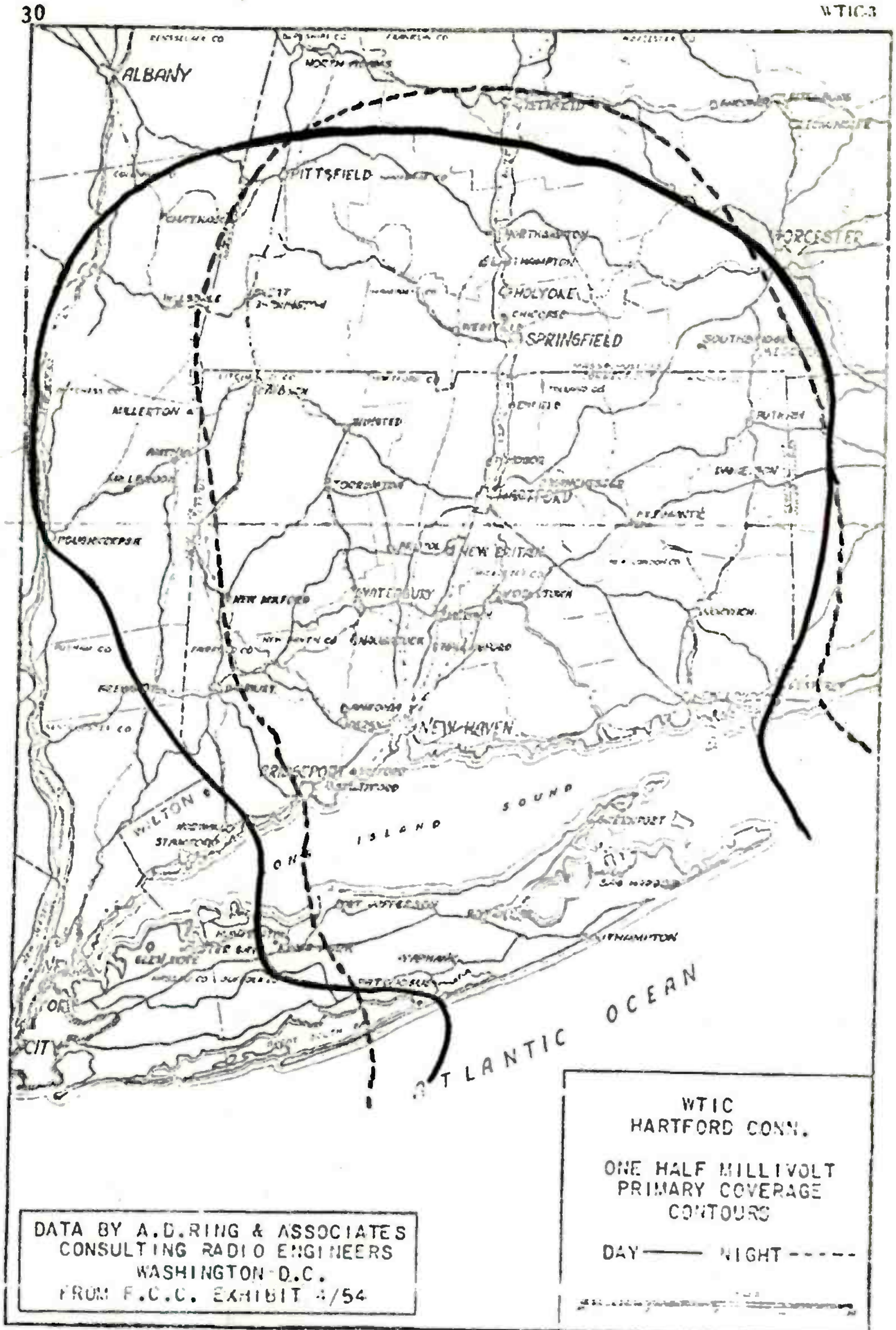
Use the EQP ratings as described, using the 500:1 power restriction, and distance restrictions as seem prudent under the circumstances. If no indication of the probable vertical behavior is available, use the 200 mile rule for night conditions.

The compactly stated reasons for this recommendation are given below:

1. The erratic plots shown for WJSN are worst cases for an extremely radical antenna. Even in the worst cases, the EQP value is more accurate than the station's assigned power.
2. In Part 3, the presentation of the pattern information will give the user an indication as to what distance restrictions may be appropriate.
3. The benefits of using pattern information are enormous in enabling the user to predict probable reception results. The validity of these calculations has been confirmed in practice during 2 years of observations from different locations.

Investigation into these problems will continue, and any new information of significance will be submitted to DX NEWS.

* It would be an interesting exercise for the reader to verify this calculation.


ALBANY
NORTH ADAMS
PITTSFIELD
NORTHAMPTON
HOLYOKE
SPRINGFIELD
WORCESTER
MILLERTON
WINSTED
TORRINGTON
HARTFORD
NEW BRITAIN
WATERBURY
NEW MILFORD
NEW HAVEN
BRIDGEPORT
WILTON
LONG ISLAND SOUND
ATLANTIC OCEAN
WTIC
HARTFORD CONN.
ONE HALF MILLIVOLT
PRIMARY COVERAGE
CONTOURS
DAY —— NIGHT - - - - -
DATA BY A.D.RING & ASSOCIATES
CONSULTING RADIO ENGINEERS
WASHINGTON D.C.
FROM F.C.C. EXHIBIT 4/54

Patterns, Part III fish<>hart

There are two basic methods for obtaining the bearing of a DXer's location as measured at the transmitting site of a broadcast band station, viz.: (a) to calculate the bearing by solving the necessary trigonometric equations based on spherical earth and (b) to measure the angle directly from a map correct for this purpose. Method (a) has been written to at some length in previous issues of DX NEWS and the interested reader is refferred to these Reprints and Monographs.** Method (b) will be discussed here.

The local azimuth bearing of the DXer as measured at the station transmitting antenna site will be henceforth termed the "back bearing" (BB) and is measured on the local azimuth compass at the station's antenna with the following (standard) conventions consistant with the plot of antenna patterns: 0^{o} is True (Geographic) North and is the direction of the North Geographic Pole as measured along the great circle of longitude passing through the antenna site; 90^{o} denotes East; 180^{o} denotes South; 270^{o} denotes West and 360^{o} denotes North (also 0^{o}) etc.

Accuracy is of paramount importance as has been indicated herefore in this series of articles. Specifically, accuracy within 3^{o} of the true value of BB has been called for. However, Method (a) will give exact values of BB provided geographical coordinates are completely specified and correctly accurate trigonometric tables are employed. Method (b) must be somewhat less accurate because of the graphical techniques used and because of the very interesting and formally difficult problem of cartography in projecting a region of the surface area of a sphere onto a plane (a map). Accuracy for the USA using Method (b) can consistantly achieve values within 1^{o} of the true value of BB if the correct graphical constructions are used with a proper map.

To obtain the BB from a map of the USA requires that the map have certain properties which relate to the measurement of azimuth angles. The type of projection, i.e., the manner in which the USA, as it appears on the globe, is projected onto another surface which is eventually converted into a plane (a map), should have the property that no matter which two points on it are selected, the bearing of one as measured at the other by correct graphical procedures will render an azimuth angle sufficinetly accurate for the purpose at hand.

There are several projections which are well suited for BB determination between any two points: viz., Gnomonic, Azimuthal Conformal, Lambert Conformal Conic with two Standard Parallels and the Albers Equal Area Conic with two Standard Parallels. Others less suitable are the Polyconic and Lambert Zenithal. Others which are inappropriate (the errors increase rapidly with increasing distance in most directions) are of the cylindrical class to which the popular Mercator types belong. The specific problem at hand is that of obtaining a map presently published which will be readily available and at reasonable cost. The two projections which are most correct for BB determination and which areavailable with reasonable cost are the Lambert Conformal Conic with two Standard Parallels (best) and the Albers Equal Area Conic with two Standard Parallels(next best). With these projections used, BB values within 1^{o} of the true value can be obtained. Ther errors in these projections are effectively restricted to the expansion and contraction of the paper on which they are printed. The largest errors will occur along the East and West Coasts of the USA so that when determining BB to or from these areas care should be taken to reduce the error inherent in the process of reading angles to as small a value as possible. There are several sources for such maps to be used in conjunction with the graphical prodecures described below to determine azimuth BB required for our objectives. ***

It is necessary that the map have longitude parallels spaced at leaset every two degrees. A map without these parallels is effectively worthless for BB evaluation. A protractor and straightedge are needed to effect the BB measurement. The straightedge should be at most as long as the longest diagonal of the map used and the protractor size is related to the area of the map. It is suggested that no map smaller than 2' x 3' or so be used for accuracy of the graphical technique diminishes with decreasing map size (area). For maps, say, 2' x 3' or larger, the following protractors are reccommended: Keuffel & Esser #1274-8 (8" diameter) or #1274-10 (10" diameter). Each of these instruments is constructed of transparant plastic and scaled 0-180° in 0.5° increments. To determine the BB of point A (the DXer location) as measured at point B (the location of the antenna for the station of interest), follow this procedure:

- (a) lay or mount the map absolutely flat so that measurements will not be distorted;
- (b) using the straightedge draw a line between point A and point B;
- (c) center the protractor on point B and place the base line of the protractor (determined by markings for 0° and 180° and the protractor center) PARALLEL to the nearest line of longitude on the map; (This alignment with the longitude parallel is MOST important!!)
- (d) read the angle at which the line form A to B crosses the protractor scale as follows--
  - (i) all angles are measured clockwise from True North or True South (determined by the base line of the protractor being parallel with the nearest longitude parallel on the map!!!);
  - (ii) if A has longitude East of B, then BB equals the value of the angle as measured from True North;
  - (iii) if A has longitude West of B, then read the angle clockwise from True South at B, call this angle D. Then BB equals D plus 180°.

A few notes are appropriate: In item(a), the entire line between A and B need not be drawn unless a determination of distance (separation between A and B) is desired. Maps of the Lambert Conformal or Albers Equal Area type are also well suited for the determination of great circle distances--just scale off the line from A to B using the scale of distance provided on the map. If the distance from A to B is not desired, then only a portion of the line from A to B need be drawn--a line segment ("mark") long enough in length to allow the angle to be read from the protractor.

Figures (I) and (II) depict the general procedure. After the value of BB has been determined, it is then a relatively simple matter to obtain the EQP radiated in the direction of the DXer provided a plot of the appropriate antenna pattern is on hand. The value of BB is located on the antenna pattern plot and the field value in mv/m @ 1 mile is then scaled or read from that graph and EQP calculations follow directly. -------de Fish, Ph. Dx ©

**--"On the Derivation of those Spherical Trigonometric Relationships Required for the Computation of Great Circle Distances (GCD) and Great Circle Bearings (GCB) with several Algorithms in FFORTRAN IV for Execution on a Digital Computer" --de Fish (NRC Monograph)

--"An Algorithm for Great Circle Computations of Bearings and Distances Between Two Points on the Earth's Surface" --de Fish, DX NEWS, Vol. 39,#8 November 27, 1971 (NRC Reprint)

***--a map which will suffice is obtainable from Rand McNally, Box 7600, Chicago, Ill., 60680 for approximately $4: Stanford's General Map of the USA, 1971. Albers Equal Area Conic Projection with two Standard Parallels, approx., 2' x 3', 2° coordinate increments with 1" equal to 80 miles.

FIGURE I
(A East of B)

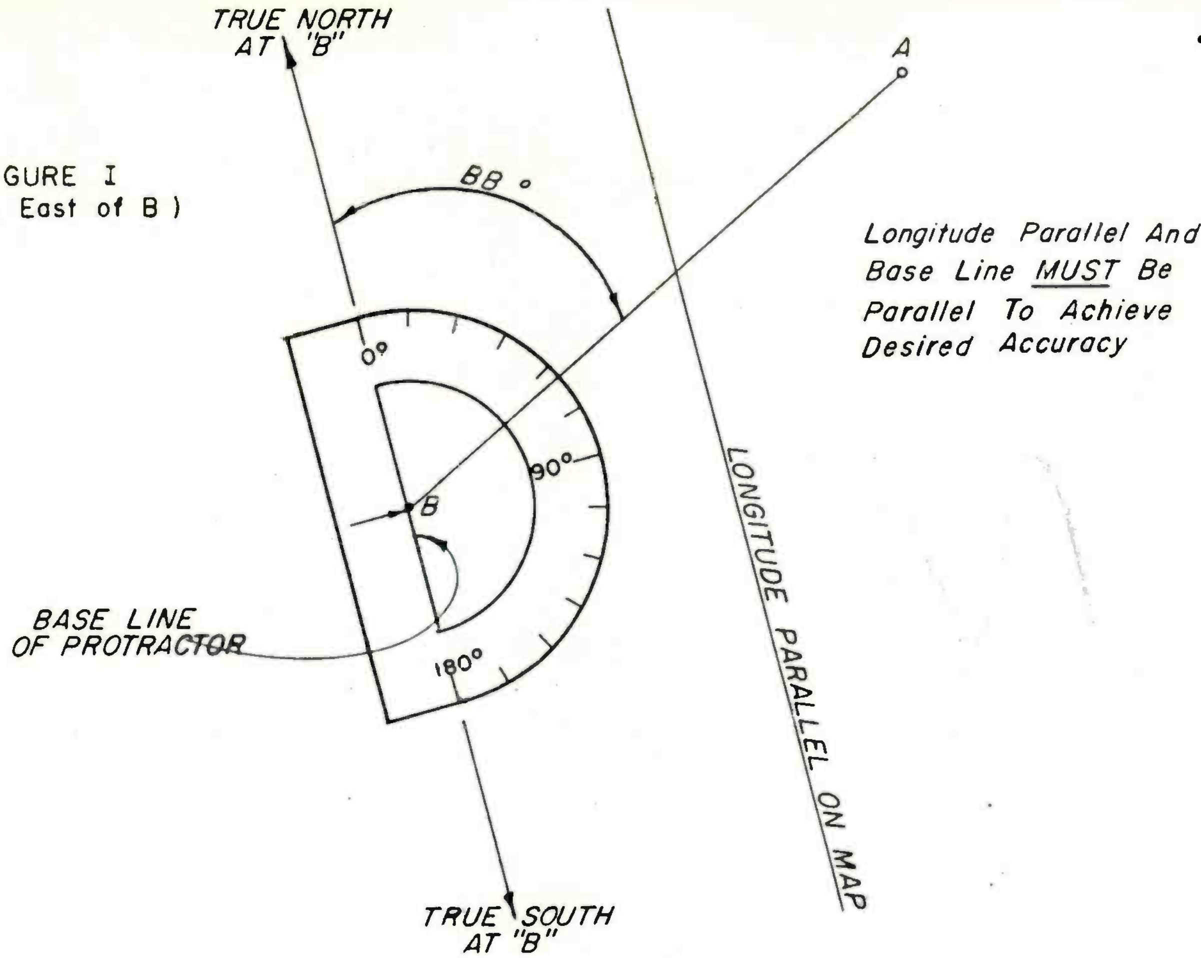
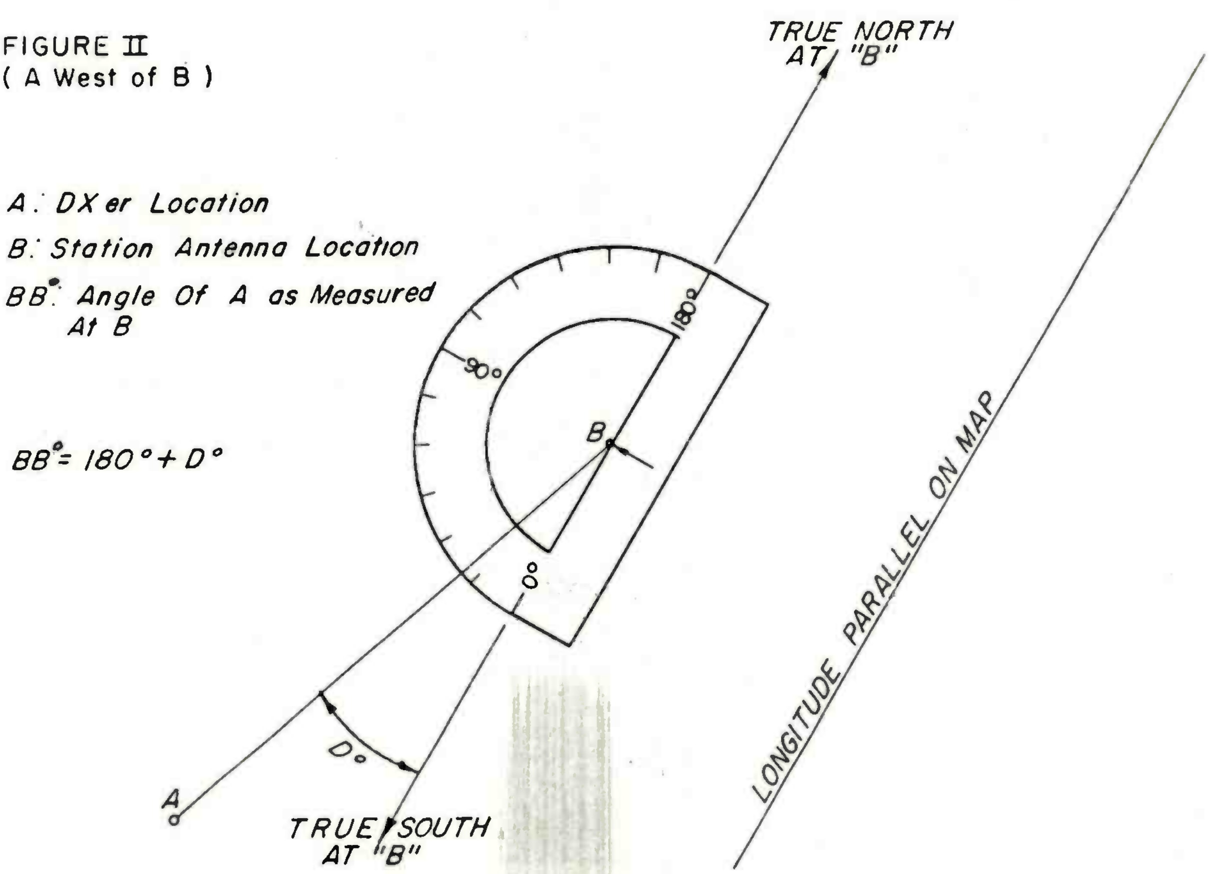


FIGURE II
(A West of B)



M-9

MORE ON HOW DIRECTIONAL PATTERNS ARE PRODUCED

H.W. BOYD

Since the first NRC NIGHT PATTERN BOOK was printed there have been many questions as to just how these patterns are produced. Shortly after the first book came out, I did an article explaining the basics of how such patterns are formed. At the time, that article seemed to answer most questions about such patterns.

The NRC NIGHT PATTERN BOOK is now in its second printing and my article on directional basics is part of it. But there has been more interest in how these patterns are formed than I expected. In the original article I didn't go much beyond the most basic of basics, mostly in the fear that it might go over the head of most members. Mail of late indicates quite an interest in these patterns so this time we'll go a bit deeper!

Below is a chart copied from the NAB Engineering Handbook (one of 4 Or 5 actually) on such patterns. This chart shpws how different patterns can be formed with different antenna spacing and phasing. Going down the left hand side we see different spacings and across are different phasings.

Our earlier example stated: "moving tower #2 to a location 180° north of tower #1, we develop a figure 8 pattern if both towers have equal power and magnitude". Looking down the left hand portion of the chart we find 180°, and since the first column is 0° phasing (equal power and magnitude) there is our pattern. Earlier examples also stated: "an additional phase shift of 90° on tower #2 will create a basic cardioid pattern". Again we look down the left column to find 180°, then across the top to find 90°. The pattern shown where these lines cross is the basic cardioid pattern.

"TOP"

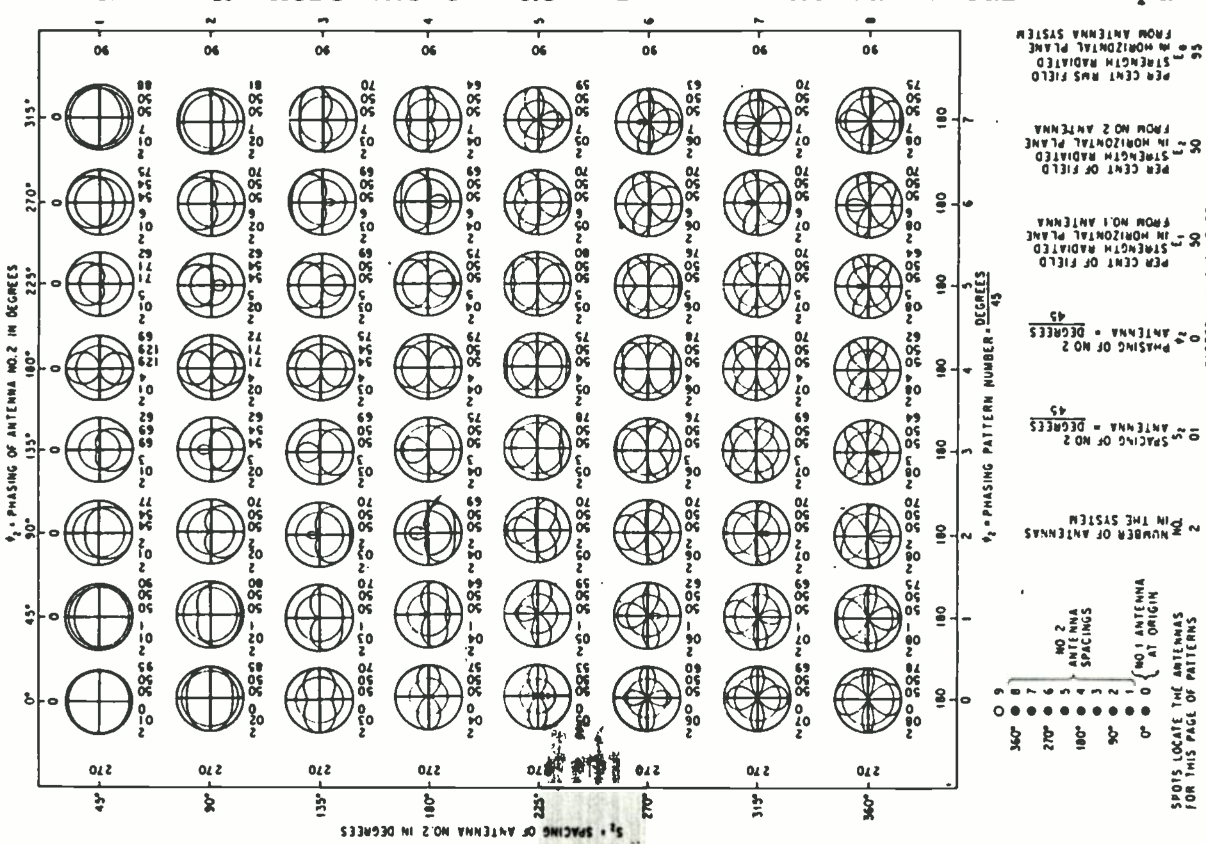


Fig. B-3 Systematization of two-tower patterns

Remember that the pattern developed is the result of phase and spacing. The left side of the graph indicates spacing only while the top is phase. Almost all questions on how such patterns are formed can be answered by the use of the graph and common sense. For more detailed patterns consult the NAB Engineering Handbook or others on the subject at your library.

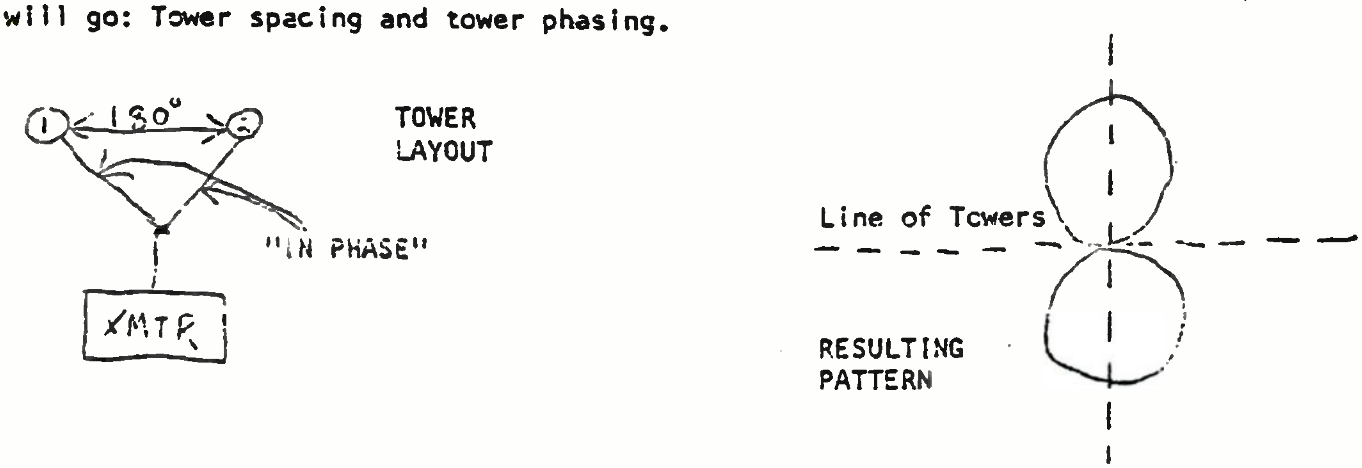
T19-1-1

DIRECTIONAL ANTENNA PATTERNS

Few DXers realize the extent to which directional antennas are used by BCB ations in the U.S.; some of us may not even be aware of them. The fact remains nat over 1,200 stations are now using Directional Antenna (DA) during at least part of their broadcast day, including the vast majority of fulltime regionals and clears. Whether we know it or not, DA's are responsible for bringing us at least a few of our prized catches, and, in much more numerous instances, are to blame for denying us our most sought-after stations.

Why use DA? There are two main reasons: 1) A few of the nationally cleared Class I stations have constructed arrays which provide a "gain" (effective power greater than the input) over most of the U.S. Continent, while reducing power which was formerly wasted over the ocean or a foreign country. WBZ in Boston, for example, beams west in such a way that they enjoy an effective power greater than 50kw over the entire U.S., except for the small areas lying east of the transmitter. 2) A much more common use of DA's is for mutual protection of the service areas of stations which operate on the same or adjacent frequencies.

How do DA's operate? While some of the more intimate mathematics behind DA operation is reputed to be rather involved, the basic theory is quite simple and logical. All directional arrays (DA can mean this also) consist of two or more vertical radiators (towers). Two factors determine where the transmitter's power will go: Tower spacing and tower phasing.



Referring to the diagrams above, it should be noticed that in either of the two directions which are in line with the towers, the r.f. sine wave from one tower will have travelled 180 electrical degrees (one-half of the station's wavelength) farther than that of the other, making the sine waves out-of-phase. Thus, assuming the r.f. amplitude in Tower 1 to be equal to that in Tower 2, the r.f. energy is effectively cancelled to zero in these directions. In the two directions which are broadside to thearray, the r.f. sine waves will add in a similar manner. The familiar "figure 8" pattern has now been formed. Cardioids (patterns having only one null), "four-leaf-clovers", and other even more complex patterns are common.

In the example shown, phase relationships have been achieved wholly by means of tower spacing. In actual practice, a combination of tower spacing and artificial variable r.f. delay networks interposed between transmitter and towers is employed. Use of the delay network (called a phasing unit) carries two big advantages: It can artificially compensate for less controllable variables (such as a necessary change in xmission line lengths), and, more importantly, it permits more complex patterns using a minimum number of towers. The phasing unit's usual place in a broadcast station is right next to the transmitter. Once its controls have been set for the desired pattern, they are strictly taboo to meddlers. This is one of the best reasons why a directional radio station may not be legally operated unless a First Class FCC Broadcast license holder is on the premises!

--Jim Korn

T20-2-1

HOW TO READ DIRECTIONAL PATTERNS

This is probably as good a place as any to mention that a DA pattern and a coverage map are not the same thing. The purpose of the former is to provide a proof of the directionality of a station's transmitting array, while that of the latter is to show the effect of this radiation, i.e. to portray the geographical area which would enjoy a usable signal. Although in pure theory a station's pattern and CM would look identical, they never do in practice due to variations in terrain, QRM, etc.

The FCC requires that all DA patterns be filed as a polar graph of the variations in the station's field intensity (measured in millivolts per meter -- mv/m) as a monitoring instrument is brought around the array in a circle whose radius is fixed at ONE MILE. Of course, it's impossible to measure this intensity at <u>all</u> points which are one mile away; in reality only a few points are selected, the remainder being filled in by interpolation. No pattern is ever graphed in terms of Effective Radiated Power (ERP) in watts as DXers would probably prefer.

An obvious question might be: "Wouldn't such-and-such a field intensity induced at one mile be the result of a specific ERP in watts being radiated in that direction?" Generally speaking (there are some minor complications!), the answer is "yes", and this is the key to interpreting patterns as far as DXers are concerned. The table below can be used to convert from mv/m/one mile to ERP in watts. It should be cautioned that the figures have been rounded off slightly from the true values.

MV/M @ 1 mile	ERP (watts)	MV/M @ 1 mile	ERP (watts)
4500	500,000	200	1000
3450	300,000	140	500
2800	200,000	100	250
2000	100,000	63	100
1400	50,000	45	50
900	20,000	20	10
630	10,000	14	5
450	5,000	6.3	1

You may notice that the inverse-square law is in force here.

Turning to the KRDS (formerly KZON) pattern which follows this article, it becomes apparent that -- with some modifications -- it is the "figure 8" described earlier. In order to check yourself out on the table above, find the pattern's maximum and minimum values of 180 and 6.0 mv/m respectively -- they represent an ERP variation of about 900 watts to 1 watt! In addition to the pattern graph itself, this particular sheet includes a tower layout plan at the upper left, showing tower separation and orientation, as well as tower height ("G" = ht.). The field ratio between towers (ratio of antenna currents in amps) is 0.915 : 1. The power phase relationship is given as "0 deg. - 0 deg." (i.e. radiators are "in phase"). On all DA patterns, one tower will be assigned a field value of unity and a phase angle of zero degrees, to serve as a reference tower. Most of the other markings on this pattern should be self-explanatory.

Although the FCC has on file every current or proposed pattern in existence, they do not have the facilities for making copies of their patterns. Instead, they've contracted Cooper-Trent, Inc., a Washington, D.C. blueprinting firm, to make copies of the FCC patterns for interested individuals. This company is the only dependable source of patterns that I know of; patterns are generally not available from radio stations. Anyone interested in placing orders with this company is invited to write me (or Cooper-Trent) for their fees and other ordering details. Any other queries pertaining to this article are likewise invited.

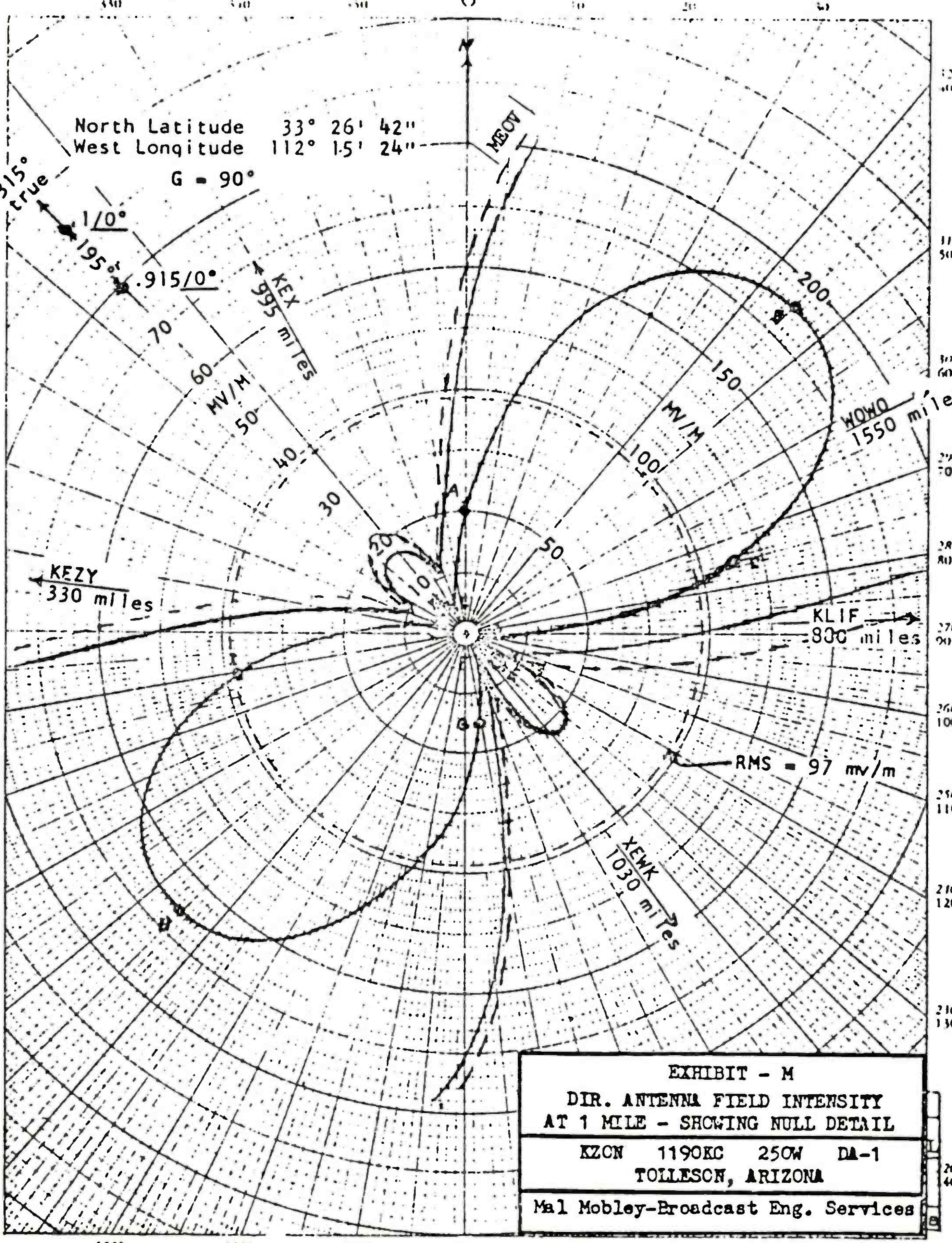
--Jim Korn

T20-2

MEASURED DAY & NIGHT (1-17-61g)

Station KZON Tolleson, Arizona

250w, DA-1,U 1190 KC



FCC File No. BL-8182
Accepted 12-21-60

KZON
Tolleson, Arizona

1190 KC

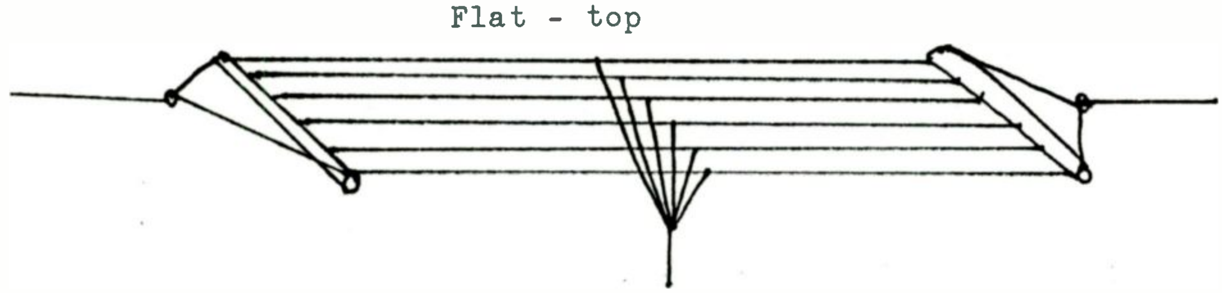
ANTENNAS FOR A.M. BROADCASTING

STEVE KENNEDY NRC REPRINTS A-33

The Antenna is probably one of the most important components of any radio system. A MW DX'er uses an efficient antenna for the DX receiver... loop, beverage, or even a longwire with a tuner. A good antenna is no less important for the station.

In the early days of AM broadcasting, up to the late 1920's; many stations used antennas unlike those in use today. Most stations were using transmitter powers of 100-200 watts... even the big city stations. Often the antenna was simple wire strung between 2 masts on top of the building where the station was located. Almost anything that was tall and offered good support was used to hang the antenna on... even a water tower!!

Most of these longwire antennas were in reality several wires errected so that it looked like a clothes line... 6 wires parallel to each other with a wooden spreader. The antenna was often fed at the center with a single lead which connected to the transmitter. Possibly the reader has seen old pictures of this type of antenna; here is a sketch of what one might have looked like:



The horizontal parallel wires tended to act as a capacitor, which helped to 'load' the antenna for a better match into the transmitter. How well did this type of antenna work? For skywave radiation it worked pretty good, but it was a poor antenna for groundwave reception. It would not radiate a decent signal to overcome dead sports from large buildings and overhead utility wires.

The early engineers of most of these small stations were great experimenters; and often tried almost everything to get a strong signal out to listeners... even using railroad tracks as a ground! In fact, by 1922 or 23, many stations installed an additional wire which ran below the radiating antenna called a counter-poise which was actually part of the ground circuit of the transmitter-antenna. The counterpoise wire helped improve the efficency of the antenna, but until someone finally put in a radial ground which really made a big difference.

The first real significant improvement in AM antennas was in the late 1920's, sometime about the time of the start of the Depression, when the idea came of using a vertical tower. Some of the earliest vertical antennas were tall wooden masts with a simple wire ran up the tower! These early antennas resembled oil derricks!

As the years of the Depression wore on into the Administration of FDR, steel towers were built. Probably one of the most famous is the 831 foot monster built for WLW. Those of us in the MW DX hobby who have a QSL from the mid-60's of WLW, can see the Blaw-Knox tower with it's famous diamond shape and the letters W-L-W across it's 40 foot wide middle!!

This huge affair weighs over 200 tons with all the weight supported on a glass insulator which is 6 feet high!

Almost every 1-A clear channel station had a tall half-wave tower to put out a powerful groundwave signal. It should be interesting to note that a tall tower radiates a better groundwave signal than a short one of quarter wave. But a quarter wave has a higher angle of departure for a better skywave. No wonder class 4 graveyard stations are heard so well!!

Almost all modern AM stations use a vertical antenna. There are a few left who errected a vertical tower on top of a building many years ago. This type of antenna is not efficent, but because of economic reasons its the only thing which could be put up. The reason for poor efficency is a lack of a good ground system.

Let us look into modern AM antennas now, and se how much a good antenna can affect a station's coverage. A large majority of most stations use quarter-wave or half-wave towers. There are a few which employ 5/8 wave (.625) towers.

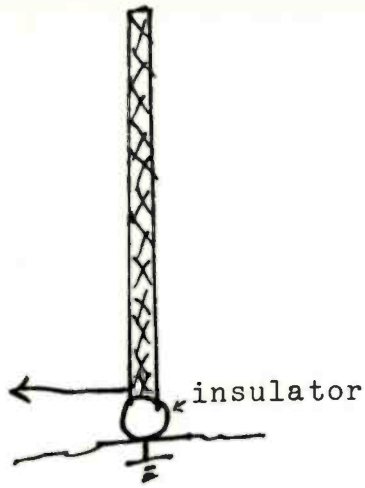
The actual height of an AM tower is dictated by the class of station which will use it. For example, a 1 Kw class 4 graveyard station is required to have a minimum signal of 150 mv/m at 1 mile. FCC rules permit class 4's to use 150 foot towers as minimum heights to meet this requirement. At 1230 KHz, a 190 foot tower would be needed to have a .25-wave antenna. However, a .25-wave antenna is quite efficent - about 182 mv/m at 1 mile with 1 Kw of power. This is actually more signal that is needed to satisfy the 150 mv/m requirement. The FCC intentually imposed the shorter antenna requirement to restrict the groundwave coverage of class 4's. So in reality, most class 4 stations are using antennas shorter than quarter-wave to permit more class 4's to be allocated to the graveyard channels. An interesting fact is in areas where class 4s are close spaced; many will use the short stick and actually radiate a potent skywave signal. There are several 4's built many years ago which use half-wave antennas which can really get out.

Class 3 stations must have a minimum of 175 mv/m at 1 mile, and usually employ a quarter-wave tower in smaller stations, or if a directional array is used, Quarter-wave towers require less space to erect, and much easier to phase properly with spacing of .5 to .25 -wave. Some North Dakota class 3's use half-wave towers.

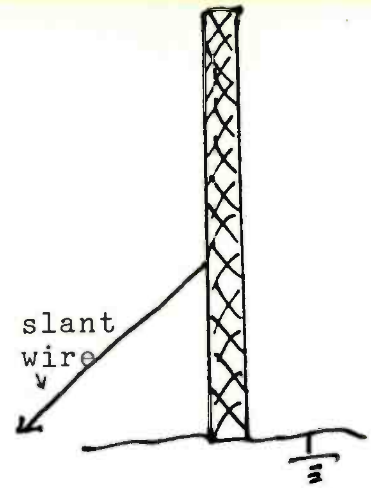
Like class 3 stations, class 2 stations generally are mixed with tower heights. A number of daytime-only class II-D's use quarter-wave towers.... especially when on a low dial position. Some mid-dial II-D's use half-wave towers, but a majority of them use quarter-wave setups.

The largest users of the tall half-wave and a few users of the 5/8ths wave towers are the class 1-As and 1-Bs. The 5/8ths-wave tower is the most efficent vertical antenna design. When coupled with an excellent ground system, this is the best single element antenna which could be employed at an AM transmitter. The power lobe of a 5/8ths-wave antenna is kept close to ground level... and will produce a very potent ground wave. At 540 Khz, a 5/8-wave tower is 1082.5 feet tall!!!

Antennas for AM broadcasting come in several designs. The two most popular types are insulated base-fed series fed towers; and the grounded shunt fed types.



Insulated Base-fed
series fed tower

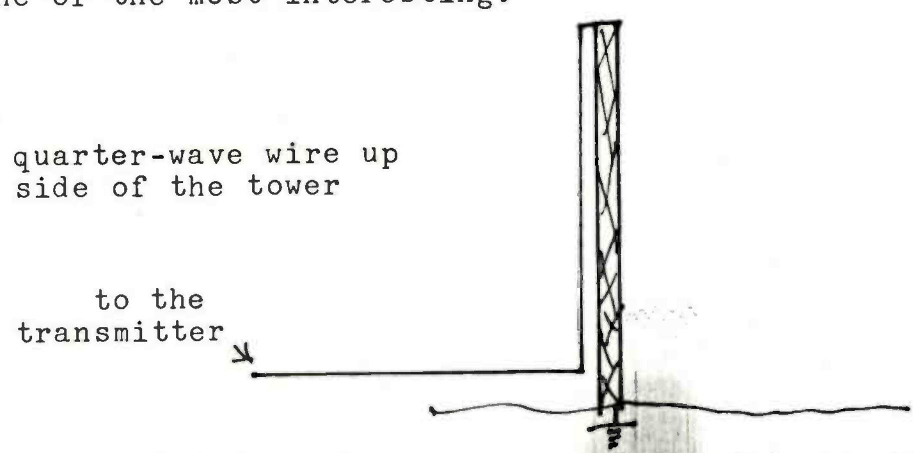


grounded shunt fed
tower

The insulated base-fed series fed tower is the most common type in use. The antennas impedence or resistance will vary from a low 20 ohms to as high as 80-90 ohms. Most are simple to match to a coaxial 50 ohm line, by using a simple L or T tuner at the tower base. This type of tower is RF hot at the base with high current.

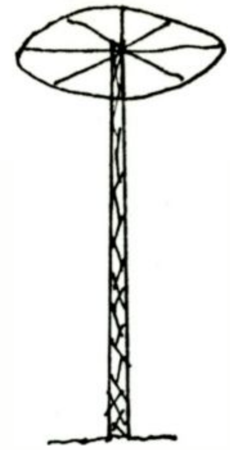
The shunt type is usually a grounded type of tower often used when the station has both AM and FM facilities at the same site, and wish to use the same tower for both stations. It has a high impedence, and the transmitter is connected via a 'slant-wire' which is connected about .25 or up to .35 the height of the tower. The slant wire may be connected to a tuner.... or in some instances directly to the transmitter tank circuit. This type of antenna takes more care in design than the simple base fed tower because the feed point for the slant wire is quite critical; and is often a 'cut and dry' proposition. There are few slant-wire systems being erected today. It is used in cases when more common series fed towers are impractical.

There are a few other interesting antenna designs which are used in AM stations. One of the most unusual is the 'voltage fed monopole'...which is one of the most interesting.



The Voltage Fed Monopole is a simple grounded quarter-wave tower with a wire which runs to the top and is connected to the tower. The parallel wire is usually a cable which is insulated from the tower itself with standoff insulators. Although only quarter-wave high... this antenna acts like a half-wave antenna.

(this is somewhat exxaggerated to show detail. In reality, top-hat is usually 6 feet in diameter in most tower installations.)



Some AM towers have a small metal projection at the top which looks like an old wagon wheel. This is a capacity hat which is sometimes a capacity hat in the middle of the tower to keep it out of the RF field of the FM antenna at the top.

Finally, an important consideration for any AM broadcast tower is it's ground system. Not only does the ground drain off static from lightning, and offers protection from a direct strike. But the ground offers the other half of the antenna circuit for the transmitter. A good ground is so important, that wihtout it, the signal of the station may be reduced back to nearly half of what could be expected with a food ground. Most AM antennas use about 120 quarter-wave radials, spaced about 3° like the spokes of a wheel, with the tower in the center. If the tower is erected on swampy-marshy land, the ground connection could be just about the best which could be had. This is what is done when WOR-710 built it's new plant several years ago in the marshlands of the New Jersey shore across from New York City.

The ultimate AM site is directly on top of sea-water. The European 'pop' pirates of the mid '60's really knew what sea water could do with an AM signal. A 10 Kw rig in the middle of the English Channel could get out as well as a 100 Kw rig on land!! Salt water is the best propogator of AM groundwave signals.

WRHC-1550 Miami has it's AM transmitter offshore about 3 miles from the studio. It has one of the most potent ground-wave signals of any station on the high end of the dial. WQAM-560 Miami has only a quarter-wave antenna at the water's edge on Biscayne Bay... but it's groundwave is heard clearly all the way to Cape Hatteras, NC!....WWL-870 booms into the writer's home at midday....thanks to the Gulf of Mexico. Until Radio Guama took over 1030, KCTA was heard daily at noon in Sarasota, Fl.

If the reader is interested in more information about AM antennas and AM station signal strength; it is reccomended to study the charts and graphs in the FCC rules pertaining to AM stations. There are instructions included to permit the reader to use the charts for signal prediction for almost any type of antenna used in AM radio.

Like the antenna on your receiver, the modern AM station needs an efficent antenna to cover it's primary and secondary coverage area... and to become your next DX catch!!

SUNRISE - SUNSET TIMES

These tables will permit the DX'er to determine the exact time of sunrise or sunset for any station in the world within an accuracy of about 1 minute; they have been prepared by the U.S. Naval Observatory. Sunrise is defined as the instant that the first part of the solar disc rises above the horizon; sunset as the time the last part of the disc disappears.

EXAMPLE: Wish to know sunrise time of a station at 42°30' N, 123° W (About Eureka, California) on April 29th:

Looking in the sunrise table for that date, we find that the local mean time for that latitude is midway between the values for 40° and 45° or about 0457½. To convert the local mean time there to EST, make use of the fact that each degree of longitude west of the Prime Meridian (0°) is equal to 4 minutes of time:

123° x 4 minutes = 492 minutes = 8 hours and 12 minutes;

this means that mean local time at the station is 8 hours and 12 minutes earlier than GMT; 0457½ plus 8 hours and 12 minutes = 1309½ GMT. This is the sunrise time expressed in GMT; since GMT is 5 hours ahead of EST, just subtract off 5 hours to get 0809½ which is the sunrise time at the desired point in EST.

EX 'LE: Wish to know sunset time at a point 35° S, 150° E (about Canberra, Australia) on April 23rd. Since this is in the Southern Hemisphere, we must first look in the small table at the bottom of the page for the equivalent Northern Hemisphere time (since the table is so constructed). The sub-table shows that the sunrise time for our Australian location is the same as for October 31st plus an additional 14 minutes. Looking in the table under October 31st, we find that sunset at 35° is at 1707 mean local time. But we must add the 14 minute correction factor from the sub-table; actual sunset time is then 1721 mean local time. We must now convert mean local time at that point into EST; again we'll first go to GMT for the sake of clarity (it's useful to look at a map while you're doing this). The time difference between 150° East and GMT is

150° x 4 minutes = 600 minutes = 10 hours exactly.

This means that sunset in Australia happens 10 hours before it does in GMT; 1721 less exactly 10 hours is 0721. Sunset at the desired point thus occurs at 0721 GMT or, subtracting 5 hours, at 0221 EST.

HINTS: Use a map along with the table at first so that you can get a feel for what's actually being done. If the station is located south of the Equator, use the small sub-table first to find the equivalent* date, look up the equivalent date in the table, and add the correction. Then convert to GMT and subtract 5 hours to get EST. The only tricky part is the direction of the time correction for longitude; that's when a map is useful. Remember that the shadow boundary moves from East to West on the surface of the earth and that it gets earlier as you go West.

* the small correction is for the fact that the earth's orbit is not circular but elliptical.

GPN

SUNRISE AND TWILIGHT

LOCAL MEAN TIME OF SUNRISE AND BEGINNING OF ASTRONOMICAL TWILIGHT—MERIDIAN OF GREENWICH

SUNRISE (UPPER LIMB)

Date \ Lat.		0°	+10°	+20°	+30°	+35°	+40°	+45°	+50°	+52°	+54°	+56°	+58°	+60°
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Jan.	0	5 59	6 16	6 35	6 55	7 08	7 22	7 38	7 59	8 08	8 19	8 32	8 46	9 03
	5	6 01	6 18	6 36	6 57	7 09	7 22	7 38	7 58	8 08	8 18	8 30	8 44	9 01
	10	6 04	6 20	6 37	6 57	7 09	7 22	7 37	7 56	8 05	8 16	8 27	8 40	8 56
	15	6 06	6 21	6 38	6 57	7 08	7 20	7 35	7 53	8 02	8 12	8 22	8 35	8 49
	20	6 07	6 22	6 38	6 56	7 06	7 18	7 32	7 49	7 57	8 06	8 16	8 28	8 41
	25	6 09	6 23	6 37	6 54	7 04	7 15	7 28	7 44	7 51	8 00	8 09	8 19	8 31
	30	6 10	6 23	6 37	6 52	7 01	7 11	7 23	7 38	7 45	7 52	8 00	8 10	8 21
Feb.	4	6 10	6 22	6 35	6 49	6 57	7 07	7 18	7 31	7 37	7 44	7 51	7 59	8 09
	9	6 11	6 21	6 33	6 46	6 53	7 01	7 11	7 23	7 28	7 34	7 41	7 48	7 57
	14	6 11	6 20	6 30	6 42	6 48	6 56	7 04	7 14	7 19	7 24	7 30	7 36	7 44
	19	6 11	6 19	6 27	6 37	6 43	6 49	6 56	7 05	7 09	7 13	7 18	7 24	7 30
	24	6 10	6 17	6 24	6 32	6 37	6 42	6 48	6 56	6 59	7 02	7 06	7 11	7 16
	29	6 09	6 15	6 21	6 27	6 31	6 35	6 40	6 46	6 48	6 51	6 54	6 58	7 01
Mar.	5	6 08	6 12	6 17	6 22	6 24	6 27	6 31	6 35	6 37	6 39	6 41	6 44	6 47
	10	6 07	6 10	6 13	6 16	6 18	6 20	6 22	6 25	6 26	6 27	6 28	6 30	6 32
	15	6 06	6 07	6 09	6 10	6 11	6 12	6 13	6 14	6 14	6 15	6 16	6 16	6 17
	20	6 04	6 04	6 04	6 04	6 04	6 04	6 03	6 03	6 03	6 03	6 02	6 02	6 02
	25	6 03	6 01	6 00	5 58	5 57	5 56	5 54	5 52	5 51	5 50	5 49	5 48	5 47
	30	6 01	5 58	5 55	5 52	5 50	5 47	5 45	5 41	5 40	5 38	5 36	5 34	5 31
Apr.	4	6 00	5 56	5 51	5 46	5 43	5 39	5 35	5 30	5 28	5 26	5 23	5 20	5 16

BEGINNING OF ASTRONOMICAL TWILIGHT

Date \ Lat.		0°	+10°	+20°	+30°	+35°	+40°	+45°	+50°	+52°	+54°	+56°	+58°	+60°
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Jan.	0	4 44	5 01	5 15	5 30	5 36	5 43	5 51	6 00	6 02	6 06	6 10	6 14	6 18
	5	4 46	5 03	5 18	5 31	5 38	5 45	5 52	6 00	6 03	6 07	6 10	6 14	6 18
	10	4 49	5 05	5 19	5 32	5 39	5 45	5 53	5 59	6 02	6 05	6 09	6 12	6 16
	15	4 51	5 07	5 20	5 33	5 39	5 45	5 51	5 58	6 01	6 04	6 06	6 09	6 13
	20	4 54	5 08	5 21	5 32	5 38	5 44	5 49	5 55	5 57	5 59	6 03	6 05	6 08
	25	4 55	5 10	5 21	5 32	5 37	5 42	5 46	5 51	5 54	5 55	5 58	5 59	6 01
	30	4 58	5 10	5 21	5 31	5 35	5 39	5 42	5 46	5 48	5 50	5 51	5 53	5 54
Feb.	4	4 58	5 10	5 20	5 28	5 31	5 35	5 38	5 41	5 41	5 43	5 44	5 45	5 46
	9	5 00	5 10	5 18	5 25	5 28	5 31	5 32	5 34	5 35	5 35	5 35	5 36	5 35
	14	5 00	5 10	5 17	5 22	5 24	5 26	5 27	5 27	5 27	5 26	5 26	5 26	5 24
	19	5 01	5 08	5 14	5 18	5 19	5 19	5 20	5 19	5 18	5 17	5 16	5 14	5 13
	24	5 00	5 07	5 11	5 13	5 14	5 14	5 12	5 09	5 08	5 07	5 05	5 02	5 00
	29	5 00	5 05	5 08	5 08	5 08	5 06	5 04	5 00	4 58	4 55	4 53	4 49	4 45
Mar.	5	4 59	5 03	5 05	5 04	5 02	4 59	4 55	4 49	4 46	4 44	4 40	4 36	4 30
	10	4 58	5 00	5 01	4 58	4 55	4 51	4 46	4 39	4 35	4 31	4 26	4 21	4 14
	15	4 57	4 58	4 56	4 51	4 48	4 43	4 37	4 27	4 23	4 17	4 12	4 05	3 57
	20	4 56	4 55	4 52	4 45	4 40	4 34	4 26	4 15	4 10	4 04	3 57	3 49	3 39
	25	4 54	4 52	4 48	4 39	4 33	4 26	4 16	4 03	3 57	3 50	3 41	3 31	3 20
	30	4 53	4 49	4 42	4 32	4 25	4 17	4 05	3 50	3 43	3 34	3 25	3 13	2 58
Apr.	4	4 51	4 46	4 38	4 26	4 17	4 08	3 54	3 36	3 28	3 18	3 06	2 53	2 36

SOUTHERN LATITUDES (July to October)

For dates on first line *below*, enter tables above with dates on second line, and apply the correction (in minutes) given on the third line.

Date	July 1	6	11	16	22	27	Aug. 1	Aug. 7	12	17	22	26	Sept. 2	Sept. 7	12	17	22	27	Oct. 3	Oct. 8
Use	Jan. 0	5	10	15	20	25	Jan. 30	Feb. 4	9	14	19	24	Feb. 29	Mar. 5	10	15	20	25	Mar. 30	Apr. 4
Apply	+1	0	−2	−3	−4	−6	−7	−8	−9	−10	−11	−12	−13	−14	−14	−14	−15	−15	−15	−15

LOCAL MEAN TIME OF SUNSET AND END OF ASTRONOMICAL TWILIGHT—MERIDIAN OF GREENWICH

SUNSET (UPPER LIMB)

Date		0°	+10°	+20°	+30°	+35°	+40°	+45°	+50°	+52°	+54°	+56°	+58°	+60°
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Jan.	0	18 07	17 49	17 31	17 10	16 58	16 44	16 27	16 07	15 57	15 46	15 34	15 20	15 03
	5	18 09	17 52	17 34	17 14	17 02	16 48	16 32	16 12	16 03	15 52	15 40	15 26	15 10
	10	18 11	17 55	17 37	17 18	17 06	16 53	16 37	16 18	16 09	15 59	15 48	15 35	15 19
	15	18 13	17 57	17 41	17 22	17 11	16 58	16 43	16 25	16 17	16 07	15 56	15 44	15 30
	20	18 15	18 00	17 44	17 26	17 16	17 04	16 50	16 33	16 25	16 16	16 06	15 55	15 41
	25	18 16	18 02	17 47	17 30	17 21	17 10	16 57	16 41	16 34	16 25	16 16	16 06	15 54
	30	18 17	18 04	17 50	17 35	17 26	17 16	17 04	16 49	16 42	16 35	16 27	16 17	16 07
Feb.	4	18 17	18 06	17 53	17 39	17 31	17 22	17 11	16 58	16 52	16 45	16 38	16 29	16 20
	9	18 18	18 07	17 56	17 43	17 36	17 28	17 18	17 06	17 01	16 55	16 49	16 41	16 33
	14	18 18	18 08	17 58	17 47	17 41	17 34	17 25	17 15	17 10	17 05	17 00	16 53	16 46
	19	18 17	18 09	18 01	17 51	17 46	17 39	17 32	17 24	17 20	17 15	17 11	17 05	16 59
	24	18 17	18 10	18 03	17 55	17 50	17 45	17 39	17 32	17 29	17 25	17 21	17 17	17 12
	29	18 16	18 11	18 05	17 58	17 55	17 51	17 46	17 41	17 38	17 35	17 32	17 29	17 25
Mar.	5	18 15	18 11	18 07	18 02	17 59	17 56	17 53	17 49	17 47	17 45	17 43	17 40	17 38
	10	18 14	18 11	18 08	18 05	18 04	18 02	17 59	17 57	17 56	17 54	17 53	17 52	17 50
	15	18 12	18 11	18 10	18 08	18 08	18 07	18 06	18 05	18 05	18 04	18 04	18 03	18 02
	20	18 11	18 11	18 11	18 11	18 12	18 12	18 12	18 13	18 13	18 13	18 14	18 14	18 15
	25	18 09	18 11	18 12	18 15	18 16	18 17	18 19	18 21	18 22	18 23	18 24	18 25	18 27
	30	18 08	18 11	18 14	18 18	18 20	18 22	18 25	18 29	18 30	18 32	18 34	18 37	18 39
Apr.	4	18 06	18 11	18 15	18 21	18 24	18 27	18 32	18 37	18 39	18 42	18 44	18 48	18 51

END OF ASTRONOMICAL TWILIGHT

Date		0°	+10°	+20°	+30°	+35°	+40°	+45°	+50°	+52°	+54°	+56°	+58°	+60°
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Jan.	0	19 22	19 04	18 50	18 35	18 29	18 21	18 13	18 06	18 02	17 59	17 56	17 52	17 48
	5	19 24	19 07	18 52	18 39	18 32	18 25	18 18	18 10	18 08	18 04	18 00	17 56	17 53
	10	19 25	19 10	18 55	18 43	18 36	18 29	18 22	18 15	18 12	18 10	18 07	18 03	17 59
	15	19 27	19 11	18 58	18 46	18 40	18 34	18 27	18 21	18 19	18 16	18 13	18 10	18 07
	20	19 28	19 14	19 01	18 49	18 44	18 39	18 33	18 28	18 26	18 23	18 21	18 19	18 15
	25	19 29	19 15	19 03	18 53	18 49	18 44	18 39	18 35	18 33	18 30	18 29	18 27	18 25
	30	19 29	19 17	19 06	18 57	18 53	18 49	18 45	18 41	18 40	18 39	18 38	18 36	18 35
Feb.	4	19 29	19 18	19 08	19 01	18 57	18 55	18 52	18 49	18 48	18 47	18 47	18 46	18 46
	9	19 29	19 19	19 11	19 04	19 02	19 00	18 58	18 56	18 56	18 56	18 56	18 56	18 56
	14	19 29	19 19	19 12	19 08	19 06	19 05	19 04	19 04	19 04	19 05	19 06	19 06	19 08
	19	19 27	19 20	19 15	19 11	19 11	19 10	19 10	19 12	19 13	19 14	19 16	19 17	19 19
	24	19 27	19 20	19 17	19 15	19 14	19 15	19 17	19 20	19 22	19 23	19 25	19 28	19 31
	29	19 25	19 21	19 18	19 18	19 19	19 21	19 24	19 29	19 30	19 33	19 36	19 40	19 44
Mar.	5	19 24	19 21	19 20	19 21	19 23	19 26	19 31	19 37	19 40	19 43	19 47	19 52	19 58
	10	19 23	19 21	19 21	19 24	19 28	19 32	19 37	19 45	19 49	19 53	19 58	20 05	20 11
	15	19 21	19 21	19 23	19 28	19 32	19 37	19 44	19 54	19 59	20 04	20 10	20 17	20 25
	20	19 20	19 21	19 24	19 31	19 37	19 43	19 51	20 03	20 08	20 15	20 23	20 31	20 41
	25	19 18	19 21	19 26	19 35	19 41	19 49	19 59	20 12	20 19	20 27	20 35	20 45	20 58
	30	19 17	19 21	19 28	19 39	19 46	19 55	20 06	20 23	20 30	20 39	20 49	21 02	21 16
Apr.	4	19 15	19 21	19 29	19 42	19 51	20 01	20 15	20 33	20 42	20 52	21 04	21 19	21 36

SOUTHERN LATITUDES (July to October)

For dates on first line *below*, enter tables above with dates on second line, and apply the correction (in minutes) given on the third line.

Date	July 1	6	11	16	22	27	Aug. 1	7	12	17	22	28	Sept. 2	7	12	17	22	27	Oct. 3	8
Use	Jan. 0	5	10	15	20	25	30	Feb. 4	9	14	19	24	29	Mar. 5	10	15	20	25	30	Apr. 4
Apply	+1	0	−2	−3	−4	−6	−7	−8	−9	−10	−11	−12	−13	−14	−14	−14	−15	−15	−15	−15

LOCAL MEAN TIME OF SUNRISE AND BEGINNING OF ASTRONOMICAL TWILIGHT—MERIDIAN OF GREENWICH

SUNRISE (UPPER LIMB)

Date		0°	+10°	+20°	+30°	+35°	+40°	+45°	+50°	+52°	+54°	+56°	+58°	+60°
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Apr.	4	6 00	5 56	5 51	5 46	5 43	5 39	5 35	5 30	5 28	5 26	5 23	5 20	5 16
	9	5 58	5 53	5 47	5 40	5 36	5 32	5 26	5 20	5 17	5 14	5 10	5 06	5 01
	14	5 57	5 50	5 43	5 34	5 29	5 24	5 17	5 09	5 06	5 02	4 57	4 52	4 46
	19	5 56	5 48	5 39	5 29	5 23	5 16	5 09	4 59	4 55	4 50	4 45	4 39	4 32
	24	5 55	5 45	5 35	5 24	5 17	5 09	5 00	4 49	4 44	4 39	4 32	4 25	4 17
	29	5 54	5 43	5 32	5 19	5 11	5 03	4 52	4 40	4 34	4 28	4 21	4 13	4 03
May	4	5 53	5 42	5 29	5 15	5 06	4 57	4 45	4 31	4 25	4 18	4 09	4 00	3 50
	9	5 53	5 40	5 27	5 11	5 01	4 51	4 38	4 23	4 16	4 08	3 59	3 49	3 37
	14	5 53	5 39	5 24	5 07	4 57	4 46	4 32	4 16	4 08	3 59	3 49	3 38	3 25
	19	5 53	5 38	5 23	5 04	4 54	4 41	4 27	4 09	4 00	3 51	3 40	3 28	3 13
	24	5 53	5 38	5 21	5 02	4 51	4 38	4 22	4 03	3 54	3 44	3 32	3 19	3 03
	29	5 54	5 38	5 20	5 00	4 48	4 35	4 18	3 58	3 48	3 38	3 25	3 11	2 54
June	3	5 54	5 38	5 20	4 59	4 47	4 32	4 15	3 54	3 44	3 33	3 20	3 05	2 46
	8	5 55	5 38	5 20	4 58	4 46	4 31	4 14	3 52	3 41	3 29	3 16	3 00	2 41
	13	5 56	5 39	5 20	4 58	4 45	4 30	4 13	3 50	3 40	3 27	3 13	2 57	2 37
	18	5 57	5 40	5 21	4 59	4 46	4 31	4 13	3 50	3 39	3 27	3 13	2 56	2 35
	23	5 58	5 41	5 22	5 00	4 47	4 32	4 14	3 51	3 40	3 28	3 13	2 57	2 36
	28	6 00	5 42	5 23	5 01	4 48	4 33	4 15	3 53	3 42	3 30	3 16	2 59	2 39
July	3	6 00	5 43	5 25	5 03	4 50	4 36	4 18	3 56	3 46	3 34	3 20	3 04	2 44
	8	6 01	5 45	5 26	5 05	4 53	4 39	4 21	4 00	3 50	3 38	3 25	3 10	2 51

BEGINNING OF ASTRONOMICAL TWILIGHT

Date		0°	+10°	+20°	+30°	+35°	+40°	+45°	+50°	+52°	+54°	+56°	+58°	+60°
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Apr.	4	4 51	4 46	4 38	4 26	4 17	4 08	3 54	3 36	3 28	3 18	3 06	2 53	2 36
	9	4 50	4 42	4 33	4 19	4 09	3 58	3 43	3 24	3 13	3 02	2 48	2 32	2 10
	14	4 47	4 40	4 29	4 12	4 02	3 49	3 32	3 09	2 58	2 45	2 29	2 08	1 39
	19	4 46	4 36	4 24	4 06	3 54	3 40	3 20	2 55	2 42	2 26	2 06	1 39	0 58
	24	4 44	4 34	4 19	4 00	3 47	3 31	3 10	2 40	2 25	2 06	1 42	1 03	
	29	4 43	4 31	4 16	3 54	3 39	3 22	2 58	2 25	2 07	1 44	1 11		
May	4	4 42	4 29	4 12	3 47	3 32	3 13	2 48	2 10	1 49	1 19	0 15		
	9	4 41	4 26	4 08	3 42	3 25	3 05	2 37	1 54	1 28	0 44			
	14	4 40	4 24	4 05	3 38	3 20	2 57	2 25	1 37	1 02				
	19	4 40	4 23	4 02	3 33	3 14	2 49	2 16	1 18	0 26				
	24	4 39	4 22	3 59	3 29	3 09	2 43	2 06	0 58					
	29	4 40	4 22	3 58	3 26	3 06	2 38	1 58	0 32					
June	3	4 40	4 21	3 57	3 24	3 02	2 33	1 51						
	8	4 40	4 21	3 56	3 22	3 00	2 30	1 45						
	13	4 41	4 22	3 56	3 22	2 58	2 27	1 41						
	18	4 42	4 22	3 57	3 22	2 59	2 28	1 40						
	23	4 43	4 22	3 57	3 22	2 59	2 28	1 40						
	28	4 44	4 24	3 59	3 25	3 01	2 30	1 43						
July	3	4 45	4 26	4 00	3 27	3 04	2 33	1 47						
	8	4 46	4 27	4 03	3 30	3 07	2 38	1 54						

When no times are given, twilight lasts all night.

SOUTHERN LATITUDES (October to January)

For dates on first line *below*, enter tables above with dates on second line, and appiy the correction (in minutes) given on the third line.

Date	Oct. 8	12	17	22	27	Nov. 1	Nov. 6	11	16	20	25	30	Dec. 5	9	14	19	23	28	Jan. 2	Jan. 7
Use	Apr. 4	9	14	19	24	Apr. 29	May 4	9	14	19	24	29	June 3	8	13	18	23	28	July 3	July 8
Apply	−15	−15	−15	−15	−14	−14	−13	−12	−12	−11	−10	−9	−7	−7	−5	−4	−3	−2	0	+1

LOCAL MEAN TIME OF SUNSET AND END OF ASTRONOMICAL TWILIGHT—MERIDIAN OF GREENWICH

Date \ Lat.		0°	+10°	+20°	+30°	+35°	+40°	+45°	+50°	+52°	+54°	+56°	+58°	+60°
SUNSET (UPPER LIMB)														
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Apr.	4	18 06	18 11	18 15	18 21	18 24	18 27	18 32	18 37	18 39	18 42	18 44	18 48	18 51
	9	18 05	18 11	18 17	18 24	18 28	18 32	18 38	18 44	18 47	18 51	18 55	18 59	19 03
	14	18 04	18 10	18 18	18 27	18 32	18 37	18 44	18 52	18 56	19 00	19 05	19 10	19 16
	19	18 02	18 11	18 20	18 30	18 36	18 42	18 50	19 00	19 05	19 09	19 15	19 21	19 28
	24	18 01	18 11	18 21	18 33	18 40	18 48	18 57	19 08	19 13	19 19	19 25	19 32	19 41
	29	18 01	18 11	18 23	18 36	18 44	18 53	19 03	19 16	19 22	19 28	19 35	19 44	19 53
May	4	18 00	18 12	18 25	18 39	18 48	18 58	19 09	19 23	19 30	19 37	19 45	19 55	20 05
	9	18 00	18 13	18 27	18 42	18 52	19 03	19 15	19 31	19 38	19 46	19 55	20 06	20 18
	14	18 00	18 14	18 29	18 46	18 56	19 07	19 21	19 38	19 46	19 55	20 05	20 16	20 30
	19	18 00	18 15	18 31	18 49	19 00	19 12	19 27	19 45	19 53	20 03	20 14	20 27	20 41
	24	18 00	18 16	18 33	18 52	19 03	19 16	19 32	19 51	20 00	20 11	20 23	20 36	20 52
	29	18 01	18 17	18 35	18 55	19 07	19 20	19 37	19 57	20 07	20 18	20 30	20 45	21 02
June	3	18 02	18 18	18 37	18 58	19 10	19 24	19 41	20 02	20 12	20 24	20 37	20 52	21 11
	8	18 03	18 20	18 38	19 00	19 13	19 27	19 45	20 07	20 17	20 29	20 43	20 59	21 18
	13	18 04	18 21	18 40	19 02	19 15	19 30	19 48	20 10	20 21	20 33	20 47	21 03	21 24
	18	18 05	18 22	18 41	19 03	19 16	19 31	19 49	20 12	20 23	20 35	20 50	21 06	21 27
	23	18 06	18 23	18 42	19 04	19 17	19 33	19 51	20 13	20 24	20 36	20 51	21 07	21 28
	28	18 07	18 24	18 43	19 05	19 18	19 33	19 51	20 13	20 24	20 36	20 50	21 07	21 27
July	3	18 08	18 25	18 44	19 05	19 18	19 32	19 50	20 12	20 22	20 34	20 48	21 04	21 23
	8	18 09	18 25	18 43	19 04	19 17	19 31	19 48	20 09	20 19	20 31	20 44	20 59	21 18
END OF ASTRONOMICAL TWILIGHT														
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Apr.	4	19 15	19 21	19 29	19 42	19 51	20 01	20 15	20 33	20 42	20 52	21 04	21 19	21 36
	9	19 14	19 22	19 32	19 46	19 56	20 07	20 23	20 43	20 53	21 06	21 21	21 38	22 00
	14	19 14	19 21	19 33	19 50	20 01	20 14	20 31	20 55	21 07	21 21	21 38	22 00	22 30
	19	19 12	19 23	19 36	19 54	20 06	20 21	20 40	21 07	21 21	21 37	21 58	22 26	23 15
	24	19 12	19 23	19 38	19 58	20 12	20 29	20 50	21 20	21 36	21 56	22 22	23 04	
	29	19 12	19 24	19 41	20 03	20 17	20 36	20 59	21 34	21 53	22 16	22 53		
May	4	19 12	19 26	19 43	20 07	20 23	20 43	21 09	21 48	22 10	22 42			
	9	19 12	19 27	19 46	20 11	20 29	20 51	21 19	22 04	22 31	23 20			
	14	19 13	19 29	19 49	20 17	20 35	20 57	21 29	22 21	22 57				
	19	19 13	19 30	19 52	20 21	20 40	21 05	21 40	22 39	23 43				
	24	19 14	19 32	19 55	20 25	20 45	21 11	21 50	23 00					
	29	19 15	19 34	19 58	20 29	20 51	21 18	21 59	23 30					
June	3	19 17	19 35	20 00	20 33	20 55	21 24	22 07						
	8	19 18	19 37	20 02	20 36	20 59	21 29	22 15						
	13	19 19	19 39	20 04	20 38	21 02	21 33	22 20						
	18	19 20	19 40	20 05	20 40	21 03	21 34	22 22						
	23	19 21	19 41	20 06	20 41	21 04	21 36	22 24						
	28	19 22	19 42	20 07	20 41	21 05	21 36	22 23						
July	3	19 23	19 42	20 08	20 41	21 04	21 34	22 19						
	8	19 24	19 42	20 06	20 39	21 02	21 31	22 14						

When no times are given, twilight lasts all night.

SOUTHERN LATITUDES (October to January)

For dates on first line *below*, enter tables above with dates on second line, and apply the correction (in minutes) given on the third line.

Date	Oct. 8	12	17	22	27	Nov. 1	Nov. 6	11	16	20	25	30	Dec. 5	9	14	19	23	28	Jan. 2	Jan. 7
Use	Apr. 4	9	14	19	24	Apr. 29	May 4	9	14	19	24	29	June 3	8	13	18	23	28	July 3	July 8
Apply	−15	−15	−15	−15	−14	−14	−13	−12	−12	−11	−10	−9	−7	−7	−5	−4	−3	−2	0	+1

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LOCAL MEAN TIME OF SUNRISE AND BEGINNING OF ASTRONOMICAL TWILIGHT—MERIDIAN OF GREENWICH

SUNRISE (UPPER LIMB)

Date		0°	+10°	+20°	+30°	+35°	+40°	+45°	+50°	+52°	+54°	+56°	+58°	+60°
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
July	3	6 00	5 43	5 25	5 03	4 50	4 36	4 18	3 56	3 46	3 34	3 20	3 04	2 44
	8	6 01	5 45	5 26	5 05	4 53	4 39	4 21	4 00	3 50	3 38	3 25	3 10	2 51
	13	6 02	5 46	5 28	5 08	4 56	4 42	4 26	4 05	3 55	3 44	3 32	3 17	3 00
	18	6 03	5 47	5 30	5 11	4 59	4 46	4 30	4 11	4 01	3 51	3 39	3 25	3 09
	23	6 03	5 48	5 32	5 13	5 03	4 50	4 35	4 17	4 08	3 59	3 48	3 35	3 20
	28	6 03	5 49	5 34	5 16	5 06	4 54	4 41	4 24	4 15	4 06	3 56	3 45	3 31
Aug.	2	6 03	5 50	5 36	5 19	5 10	4 59	4 46	4 30	4 23	4 15	4 05	3 55	3 43
	7	6 02	5 50	5 37	5 22	5 14	5 04	4 52	4 38	4 31	4 23	4 15	4 06	3 55
	12	6 02	5 51	5 39	5 25	5 18	5 08	4 58	4 45	4 39	4 32	4 25	4 16	4 07
	17	6 01	5 51	5 40	5 28	5 21	5 13	5 04	4 52	4 47	4 41	4 35	4 27	4 19
	22	5 59	5 51	5 42	5 31	5 25	5 18	5 10	5 00	4 55	4 50	4 44	4 38	4 31
	27	5 58	5 51	5 43	5 34	5 29	5 23	5 16	5 07	5 03	4 59	4 54	4 49	4 43
Sept.	1	5 57	5 51	5 44	5 37	5 33	5 28	5 22	5 15	5 12	5 08	5 04	5 00	4 55
	6	5 55	5 50	5 45	5 40	5 36	5 32	5 28	5 22	5 20	5 17	5 14	5 10	5 07
	11	5 53	5 50	5 46	5 42	5 40	5 37	5 34	5 30	5 28	5 26	5 24	5 21	5 18
	16	5 52	5 50	5 48	5 45	5 43	5 42	5 40	5 37	5 36	5 35	5 33	5 32	5 30
	21	5 50	5 49	5 49	5 48	5 47	5 46	5 46	5 45	5 44	5 44	5 43	5 42	5 42
	26	5 48	5 49	5 50	5 50	5 51	5 51	5 52	5 52	5 53	5 53	5 53	5 53	5 54
Oct.	1	5 46	5 49	5 51	5 53	5 55	5 56	5 58	6 00	6 01	6 02	6 03	6 04	6 05
	6	5 45	5 48	5 52	5 56	5 59	6 01	6 04	6 08	6 09	6 11	6 13	6 15	6 17

BEGINNING OF ASTRONOMICAL TWILIGHT

Date		0°	+10°	+20°	+30°	+35°	+40°	+45°	+50°	+52°	+54°	+56°	+58°	+60°
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
July	3	4 45	4 26	4 00	3 27	3 04	2 33	1 47						
	8	4 46	4 27	4 03	3 30	3 07	2 38	1 54						
	13	4 48	4 29	4 05	3 33	3 11	2 43	2 02	0 25					
	18	4 48	4 31	4 08	3 37	3 16	2 49	2 11	0 58					
	23	4 50	4 32	4 11	3 41	3 21	2 56	2 20	1 20					
	28	4 50	4 34	4 13	3 45	3 26	3 03	2 30	1 38	0 59				
Aug.	2	4 51	4 36	4 15	3 50	3 32	3 10	2 40	1 55	1 26	0 29			
	7	4 50	4 36	4 18	3 54	3 38	3 17	2 50	2 10	1 46	1 13			
	12	4 51	4 38	4 21	3 58	3 43	3 25	3 00	2 24	2 05	1 39	1 00		
	17	4 50	4 39	4 23	4 02	3 49	3 31	3 09	2 38	2 21	2 00	1 33	0 44	
	22	4 50	4 39	4 26	4 07	3 53	3 38	3 18	2 50	2 37	2 19	1 56	1 27	0 23
	27	4 48	4 40	4 27	4 11	3 59	3 45	3 27	3 02	2 50	2 35	2 17	1 54	1 21
Sept.	1	4 48	4 40	4 29	4 14	4 04	3 51	3 35	3 13	3 03	2 50	2 35	2 16	1 52
	6	4 46	4 41	4 31	4 17	4 08	3 57	3 43	3 24	3 15	3 04	2 51	2 35	2 16
	11	4 45	4 40	4 32	4 21	4 13	4 03	3 50	3 34	3 26	3 17	3 06	2 53	2 37
	16	4 43	4 40	4 33	4 24	4 18	4 09	3 58	3 44	3 36	3 29	3 19	3 09	2 56
	21	4 41	4 39	4 35	4 27	4 21	4 14	4 05	3 53	3 47	3 40	3 32	3 23	3 12
	26	4 39	4 39	4 36	4 30	4 26	4 20	4 13	4 02	3 57	3 51	3 44	3 36	3 27
Oct.	1	4 38	4 39	4 38	4 34	4 30	4 25	4 19	4 10	4 06	4 01	3 56	3 49	3 42
	6	4 36	4 38	4 39	4 37	4 34	4 30	4 26	4 19	4 15	4 11	4 07	4 02	3 55

When no times are given, twilight lasts all night.

SOUTHERN LATITUDES (January to April)

For dates on first line *below*, enter tables above with dates on second line, and apply the correction (in minutes) given on the third line.

Date	Jan. 2	7	12	16	21	26	Jan. 31	Feb. 4	9	14	19	23	Feb. 28	Mar. 4	9	14	19	24	Mar. 28	Apr. 2
Use	July 3	8	13	18	23	28	Aug. 2	Aug. 7	12	17	22	27	Sept. 1	Sept. 6	11	16	21	26	Oct. 1	Oct. 6
Apply	0	+1	+2	+3	+5	+6	+7	+8	+9	+10	+11	+12	+13	+13	+14	+14	+15	+15	+15	+16

LOCAL MEAN TIME OF SUNSET AND END OF ASTRONOMICAL TWILIGHT—MERIDIAN OF GREENWICH

SUNSET (UPPER LIMB)

Date \ Lat.		0°	+10°	+20°	+30°	+35°	+40°	+45°	+50°	+52°	+54°	+56°	+58°	+60°
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
July	3	18 08	18 25	18 44	19 05	19 18	19 32	19 50	20 12	20 22	20 34	20 48	21 04	21 23
	8	18 09	18 25	18 43	19 04	19 17	19 31	19 48	20 09	20 19	20 31	20 44	20 59	21 18
	13	18 09	18 26	18 43	19 03	19 15	19 29	19 45	20 06	20 15	20 26	20 39	20 53	21 10
	18	18 10	18 25	18 42	19 01	19 13	19 26	19 42	20 01	20 10	20 20	20 32	20 46	21 02
	23	18 10	18 25	18 41	18 59	19 10	19 22	19 37	19 55	20 04	20 13	20 24	20 37	20 51
	28	18 10	18 24	18 39	18 56	19 06	19 18	19 32	19 48	19 56	20 05	20 15	20 27	20 40
Aug.	2	18 10	18 23	18 36	18 53	19 02	19 13	19 25	19 41	19 48	19 56	20 06	20 16	20 28
	7	18 09	18 21	18 34	18 48	18 57	19 07	19 19	19 33	19 39	19 47	19 55	20 04	20 15
	12	18 08	18 19	18 31	18 44	18 52	19 01	19 11	19 24	19 30	19 36	19 44	19 52	20 01
	17	18 07	18 17	18 27	18 39	18 46	18 54	19 03	19 15	19 20	19 26	19 32	19 39	19 47
	22	18 06	18 14	18 24	18 34	18 40	18 47	18 55	19 05	19 09	19 14	19 20	19 26	19 33
	27	18 05	18 12	18 19	18 28	18 33	18 39	18 46	18 54	18 58	19 03	19 07	19 13	19 18
Sept.	1	18 03	18 09	18 15	18 23	18 27	18 32	18 37	18 44	18 47	18 51	18 54	18 59	19 04
	6	18 02	18 06	18 11	18 17	18 20	18 24	18 28	18 33	18 36	18 38	18 41	18 45	18 49
	11	18 00	18 03	18 06	18 10	18 13	18 15	18 19	18 22	18 24	18 26	18 28	18 31	18 33
	16	17 58	18 00	18 02	18 04	18 06	18 07	18 09	18 11	18 13	18 14	18 15	18 17	18 18
	21	17 56	17 57	17 57	17 58	17 58	17 59	18 00	18 00	18 01	18 01	18 02	18 02	18 03
	26	17 55	17 54	17 53	17 52	17 51	17 51	17 50	17 49	17 49	17 49	17 49	17 48	17 48
Oct.	1	17 53	17 51	17 48	17 46	17 44	17 42	17 41	17 38	17 38	17 36	17 35	17 34	17 33
	6	17 51	17 48	17 44	17 40	17 37	17 34	17 31	17 28	17 26	17 24	17 22	17 20	17 18

END OF ASTRONOMICAL TWILIGHT

Date \ Lat.		0°	+10°	+20°	+30°	+35°	+40°	+45°	+50°	+52°	+54°	+56°	+58°	+60°
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
July	3	19 23	19 42	20 08	20 41	21 04	21 34	22 19						
	8	19 24	19 42	20 06	20 39	21 02	21 31	22 14						
	13	19 23	19 43	20 06	20 37	20 59	21 27	22 07	23 37					
	18	19 24	19 41	20 04	20 34	20 55	21 21	21 59	23 10					
	23	19 23	19 41	20 02	20 31	20 50	21 15	21 50	22 49	23 50				
	28	19 23	19 39	19 59	20 26	20 45	21 08	21 40	22 30	23 06				
Aug.	2	19 22	19 37	19 55	20 22	20 39	21 01	21 29	22 14	22 41	23 29			
	7	19 21	19 35	19 53	20 16	20 32	20 52	21 19	21 58	22 19	22 51			
	12	19 19	19 32	19 49	20 11	20 25	20 44	21 07	21 42	22 01	22 24	23 02		
	17	19 18	19 29	19 44	20 04	20 18	20 35	20 56	21 27	21 43	22 03	22 29	23 11	
	22	19 16	19 26	19 40	19 58	20 10	20 26	20 45	21 12	21 25	21 42	22 03	22 31	23 22
	27	19 15	19 23	19 34	19 51	20 02	20 16	20 33	20 57	21 09	21 24	21 40	22 03	22 32
Sept.	1	19 12	19 20	19 30	19 45	19 55	20 07	20 22	20 43	20 53	21 06	21 20	21 38	22 01
	6	19 11	19 16	19 25	19 38	19 47	19 58	20 11	20 29	20 39	20 48	21 01	21 16	21 35
	11	19 09	19 13	19 20	19 31	19 39	19 48	20 00	20 16	20 24	20 33	20 43	20 56	21 10
	16	19 07	19 10	19 15	19 24	19 31	19 39	19 49	20 03	20 10	20 18	20 26	20 37	20 49
	21	19 05	19 07	19 10	19 18	19 23	19 30	19 39	19 50	19 56	20 02	20 11	20 19	20 30
	26	19 04	19 04	19 06	19 12	19 15	19 21	19 28	19 38	19 43	19 49	19 55	20 02	20 11
Oct.	1	19 02	19 01	19 01	19 05	19 08	19 12	19 19	19 26	19 31	19 35	19 40	19 46	19 54
	6	19 00	18 58	18 57	18 59	19 01	19 04	19 08	19 15	19 18	19 22	19 26	19 31	19 37

When no times are given, twilight lasts all night.

SOUTHERN LATITUDES (January to April)

For dates on first line *below*, enter tables above with dates on second line, and apply the correction (in minutes) given on the third line.

Date	Jan. 2	7	12	16	21	26	Jan. 31	Feb. 4	9	14	19	23	Feb. 28	Mar. 4	9	14	19	24	Mar. 28	Apr. 2
Use	July 3	8	13	18	23	28	Aug. 2	Aug. 7	12	17	22	27	Sept. 1	Sept. 6	11	16	21	26	Oct. 1	Oct. 6
Apply	0	+1	+2	+3	+[illegible]	+6	+7	+8	+9	+10	+11	+12	+13	+13	+14	+14	+15	+15	+15	+16

LOCAL MEAN TIME OF SUNRISE AND BEGINNING OF ASTRONOMICAL TWILIGHT—MERIDIAN OF GREENWICH

SUNRISE (UPPER LIMB)

Date	Lat.	0°	+10°	+20°	+30°	+35°	+40°	+45°	+50°	+52°	+54°	+56°	+58°	+60°
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Oct.	1	5 46	5 49	5 51	5 53	5 55	5 56	5 58	6 00	6 01	6 02	6 03	6 04	6 05
	6	5 45	5 48	5 52	5 56	5 59	6 01	6 04	6 08	6 09	6 11	6 13	6 15	6 17
	11	5 43	5 48	5 53	5 59	6 03	6 06	6 10	6 15	6 18	6 20	6 23	6 26	6 29
	16	5 42	5 49	5 55	6 02	6 07	6 11	6 17	6 23	6 26	6 30	6 33	6 37	6 42
	21	5 41	5 49	5 57	6 06	6 11	6 17	6 23	6 31	6 35	6 39	6 44	6 49	6 54
	26	5 41	5 49	5 59	6 09	6 15	6 22	6 30	6 40	6 44	6 49	6 54	7 00	7 07
	31	5 40	5 50	6 01	6 13	6 20	6 28	6 37	6 48	6 53	6 59	7 05	7 12	7 20
Nov.	5	5 40	5 51	6 03	6 17	6 25	6 34	6 44	6 56	7 02	7 08	7 16	7 24	7 32
	10	5 40	5 53	6 06	6 21	6 30	6 39	6 51	7 05	7 11	7 18	7 26	7 35	7 45
	15	5 41	5 55	6 09	6 25	6 34	6 45	6 58	7 13	7 20	7 28	7 37	7 47	7 58
	20	5 42	5 57	6 12	6 29	6 39	6 51	7 04	7 21	7 29	7 37	7 47	7 58	8 10
	25	5 43	5 59	6 15	6 33	6 44	6 56	7 11	7 28	7 37	7 46	7 56	8 08	8 22
	30	5 45	6 01	6 18	6 38	6 49	7 02	7 17	7 36	7 44	7 54	8 05	8 18	8 33
Dec.	5	5 47	6 04	6 21	6 41	6 53	7 07	7 22	7 42	7 51	8 01	8 13	8 27	8 43
	10	5 49	6 06	6 24	6 45	6 57	7 11	7 27	7 47	7 57	8 08	8 20	8 34	8 51
	15	5 52	6 09	6 27	6 48	7 01	7 15	7 31	7 52	8 02	8 13	8 25	8 40	8 57
	20	5 54	6 11	6 30	6 51	7 04	7 18	7 35	7 55	8 05	8 16	8 29	8 44	9 01
	25	5 56	6 14	6 32	6 54	7 06	7 20	7 37	7 58	8 07	8 19	8 31	8 46	9 04
	30	5 59	6 16	6 34	6 55	7 08	7 22	7 38	7 59	8 08	8 19	8 32	8 46	9 03
	35	6 01	6 18	6 36	6 57	7 09	7 22	7 38	7 58	8 08	8 18	8 30	8 44	9 01

BEGINNING OF ASTRONOMICAL TWILIGHT

Date	Lat.	0°	+10°	+20°	+30°	+35°	+40°	+45°	+50°	+52°	+54°	+56°	+58°	+60°
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Oct.	1	4 38	4 39	4 38	4 34	4 30	4 25	4 19	4 10	4 06	4 01	3 56	3 49	3 42
	6	4 36	4 38	4 39	4 37	4 34	4 30	4 26	4 19	4 15	4 11	4 07	4 02	3 55
	11	4 35	4 38	4 40	4 40	4 38	4 35	4 32	4 27	4 24	4 20	4 17	4 13	4 08
	16	4 32	4 39	4 41	4 42	4 42	4 40	4 38	4 35	4 33	4 30	4 27	4 24	4 20
	21	4 31	4 38	4 42	4 45	4 46	4 46	4 44	4 42	4 40	4 39	4 38	4 35	4 33
	26	4 31	4 38	4 44	4 49	4 49	4 50	4 51	4 50	4 49	4 48	4 47	4 46	4 44
	31	4 29	4 39	4 46	4 51	4 54	4 56	4 57	4 57	4 57	4 57	4 57	4 56	4 55
Nov.	5	4 29	4 39	4 48	4 55	4 58	5 00	5 03	5 05	5 05	5 05	5 05	5 06	5 06
	10	4 28	4 40	4 49	4 58	5 02	5 05	5 08	5 12	5 12	5 13	5 15	5 16	5 17
	15	4 28	4 41	4 52	5 02	5 06	5 10	5 14	5 18	5 20	5 22	5 24	5 24	5 27
	20	4 29	4 42	4 54	5 05	5 10	5 16	5 20	5 25	5 27	5 29	5 32	5 34	5 36
	25	4 29	4 44	4 57	5 09	5 14	5 20	5 25	5 32	5 34	5 36	5 40	5 41	5 45
	30	4 31	4 47	4 59	5 13	5 19	5 25	5 31	5 37	5 40	5 44	5 47	5 49	5 53
Dec.	5	4 33	4 48	5 03	5 16	5 22	5 29	5 36	5 43	5 46	5 49	5 53	5 56	6 00
	10	4 34	4 51	5 06	5 19	5 26	5 33	5 40	5 47	5 51	5 55	5 58	6 02	6 05
	15	4 36	4 53	5 08	5 23	5 29	5 37	5 44	5 52	5 55	5 59	6 02	6 07	6 11
	20	4 38	4 56	5 10	5 25	5 32	5 39	5 47	5 55	5 59	6 02	6 06	6 10	6 15
	25	4 41	4 58	5 13	5 27	5 35	5 42	5 50	5 57	6 01	6 04	6 09	6 13	6 17
	30	4 43	5 01	5 15	5 30	5 36	5 43	5 51	6 00	6 02	6 06	6 10	6 14	6 18
	35	4 46	5 03	5 18	5 31	5 38	5 45	5 53	6 00	6 03	6 07	6 10	6 14	6 18

SOUTHERN LATITUDES (April to July)

For dates on first line *below*, enter tables above with dates on second line, and apply the correction (in minutes) given on the third line.

Date	Apr. 2	7	13	18	23	28	May 3	8	13	19	24	29	June 3	9	14	19	25	30	July 5
Use	Oct. 6	11	16	21	26	31	Nov. 5	10	15	20	25	30	Dec. 5	10	15	20	25	30	Dec. 35
Apply	+16	+15	+15	+15	+14	+14	+13	+13	+12	+11	+10	+9	+8	+6	+5	+4	+2	+1	0

LOCAL MEAN TIME OF SUNSET AND END OF ASTRONOMICAL TWILIGHT—MERIDIAN OF GREENWICH

SUNSET (UPPER LIMB)

Date	Lat.	0°	+10°	+20°	+30°	+35°	+40°	+45°	+50°	+52°	+54°	+56°	+58°	+60°
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Oct.	1	17 53	17 51	17 48	17 46	17 44	17 42	17 41	17 38	17 38	17 36	17 35	17 34	17 33
	6	17 51	17 48	17 44	17 40	17 37	17 34	17 31	17 28	17 26	17 24	17 22	17 20	17 18
	11	17 50	17 45	17 40	17 34	17 30	17 27	17 22	17 17	17 15	17 12	17 09	17 06	17 03
	16	17 49	17 43	17 36	17 28	17 24	17 19	17 14	17 07	17 04	17 01	16 57	16 53	16 48
	21	17 48	17 40	17 32	17 23	17 18	17 12	17 05	16 57	16 53	16 49	16 45	16 40	16 34
	26	17 47	17 38	17 29	17 18	17 12	17 05	16 57	16 48	16 43	16 38	16 33	16 27	16 20
	31	17 47	17 37	17 26	17 14	17 07	16 59	16 50	16 39	16 33	16 28	16 22	16 15	16 07
Nov.	5	17 47	17 36	17 24	17 10	17 02	16 53	16 43	16 30	16 25	16 18	16 11	16 03	15 54
	10	17 48	17 35	17 22	17 07	16 58	16 48	16 37	16 23	16 16	16 09	16 01	15 52	15 42
	15	17 48	17 35	17 20	17 04	16 55	16 44	16 31	16 16	16 09	16 01	15 52	15 42	15 30
	20	17 49	17 35	17 19	17 02	16 52	16 40	16 27	16 10	16 02	15 54	15 44	15 33	15 20
	25	17 51	17 35	17 19	17 01	16 50	16 38	16 23	16 05	15 57	15 48	15 37	15 25	15 11
	30	17 52	17 36	17 19	17 00	16 49	16 36	16 20	16 02	15 53	15 43	15 32	15 19	15 04
Dec.	5	17 54	17 38	17 20	17 00	16 48	16 35	16 19	15 59	15 50	15 40	15 28	15 14	14 58
	10	17 57	17 40	17 21	17 01	16 49	16 35	16 18	15 58	15 49	15 38	15 26	15 11	14 55
	15	17 59	17 42	17 23	17 02	16 50	16 36	16 19	15 58	15 49	15 38	15 25	15 10	14 53
	20	18 01	17 44	17 25	17 04	16 52	16 38	16 21	16 00	15 50	15 39	15 26	15 11	14 54
	25	18 04	17 47	17 28	17 07	16 54	16 40	16 23	16 03	15 53	15 42	15 29	15 14	14 57
	30	18 06	17 49	17 31	17 10	16 58	16 44	16 27	16 07	15 57	15 46	15 34	15 19	15 02
	35	18 09	17 52	17 34	17 14	17 02	16 48	16 32	16 12	16 03	15 52	15 40	15 26	15 10

END OF ASTRONOMICAL TWILIGHT

Date	Lat.	0°	+10°	+20°	+30°	+35°	+40°	+45°	+50°	+52°	+54°	+56°	+58°	+60°
		h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
Oct.	1	19 02	19 01	19 01	19 05	19 08	19 12	19 19	19 26	19 31	19 35	19 40	19 46	19 54
	6	19 00	18 58	18 57	18 59	19 01	19 04	19 08	19 15	19 18	19 22	19 26	19 31	19 37
	11	18 59	18 55	18 53	18 53	18 54	18 57	18 59	19 04	19 07	19 10	19 13	19 17	19 22
	16	18 59	18 53	18 50	18 48	18 48	18 49	18 52	18 54	18 56	18 59	19 01	19 04	19 07
	21	18 58	18 51	18 46	18 43	18 42	18 42	18 43	18 45	18 46	18 47	18 49	18 51	18 53
	26	18 57	18 49	18 43	18 38	18 37	18 36	18 35	18 36	18 36	18 37	18 38	18 39	18 41
	31	18 58	18 49	18 41	18 35	18 33	18 31	18 29	18 28	18 27	18 28	18 28	18 29	18 29
Nov.	5	18 58	18 48	18 39	18 31	18 28	18 25	18 23	18 20	18 21	18 19	18 19	18 19	18 18
	10	19 00	18 48	18 38	18 29	18 25	18 21	18 18	18 15	18 13	18 12	18 11	18 10	18 09
	15	19 01	18 48	18 36	18 27	18 22	18 18	18 13	18 09	18 07	18 06	18 04	18 02	18 00
	20	19 02	18 49	18 36	18 25	18 20	18 15	18 10	18 04	18 02	18 00	17 58	17 56	17 53
	25	19 05	18 49	18 36	18 25	18 19	18 13	18 07	18 01	17 58	17 56	17 53	17 50	17 47
	30	19 06	18 51	18 37	18 24	18 18	18 12	18 05	17 59	17 56	17 53	17 50	17 46	17 43
Dec.	5	19 09	18 53	18 38	18 25	18 18	18 12	18 05	17 57	17 54	17 51	17 48	17 44	17 40
	10	19 12	18 55	18 39	18 26	18 19	18 12	18 04	17 57	17 54	17 50	17 47	17 42	17 39
	15	19 14	18 57	18 42	18 27	18 21	18 14	18 06	17 57	17 55	17 51	17 47	17 43	17 38
	20	19 16	18 59	18 44	18 30	18 23	18 16	18 08	18 00	17 56	17 53	17 48	17 44	17 40
	25	19 19	19 02	18 47	18 32	18 25	18 18	18 10	18 02	17 59	17 55	17 51	17 47	17 43
	30	19 21	19 04	18 50	18 35	18 29	18 21	18 13	18 06	18 02	17 59	17 56	17 51	17 47
	35	19 24	19 07	18 52	18 39	18 32	18 25	18 18	18 10	18 08	18 04	18 00	17 57	17 53

SOUTHERN LATITUDES (April to July)

For dates on first line *below*, enter tables above with dates on second line, and apply the correction (in minutes) given on the third line.

Date	Apr.	2	7	13	18	23	28	May	3	8	13	19	24	29	June	3	9	14	19	25	30	July	5
Use	Oct.	6	11	16	21	26	31	Nov.	5	10	15	20	25	30	Dec.	5	10	15	20	25	30	Dec.	35
Apply		+16	+15	+15	+15	+14	+14		+13	+13	+12	+11	+10	+9		+8	+6	+5	+4	+2	+1		0

AVERAGE MONTHLY LOCAL SUNRISE AND SUNSET TIMES

"73.79 - License to specify sunrise and sunset hours. If the licensee of a broadcast station is required to commence or cease operation, or to change the mode of operation of the station at the times of sunrise and sunset at any particular location, the controlling times for each month of the year are set forth in the station's instrument of authorization. Uniform sunrise and sunset times are specified for all of the days of each month, based upon the actual times of sunrise and sunset for the fifteenth day of that month adjusted to the nearest quarter hour. In accordance with a standardized procedure described therein, actual sunrise and sunset times are derived by interpolation in the tables of the 1946 American Nautical Almanac, issued by the Nautical Almanac Office of the United States Naval Observatory."

The geographical coordinates pertinent to the computation of sunrise and sunset times specified in Section 73.79 are those descriptive of the center of the city in which the station is located.

Standard meridians are as follows:

Atlantic Standard Time zone 60° west longitude.
Eastern Standard Time zone 75° west longitude.
Central Standard Time zone 90° west longitude.
Mountain Standard Time zone 105° west longitude.
Pacific Standard Time zone 120° west longitude.
Hawaiian Standard Time zone 150° west longitude.

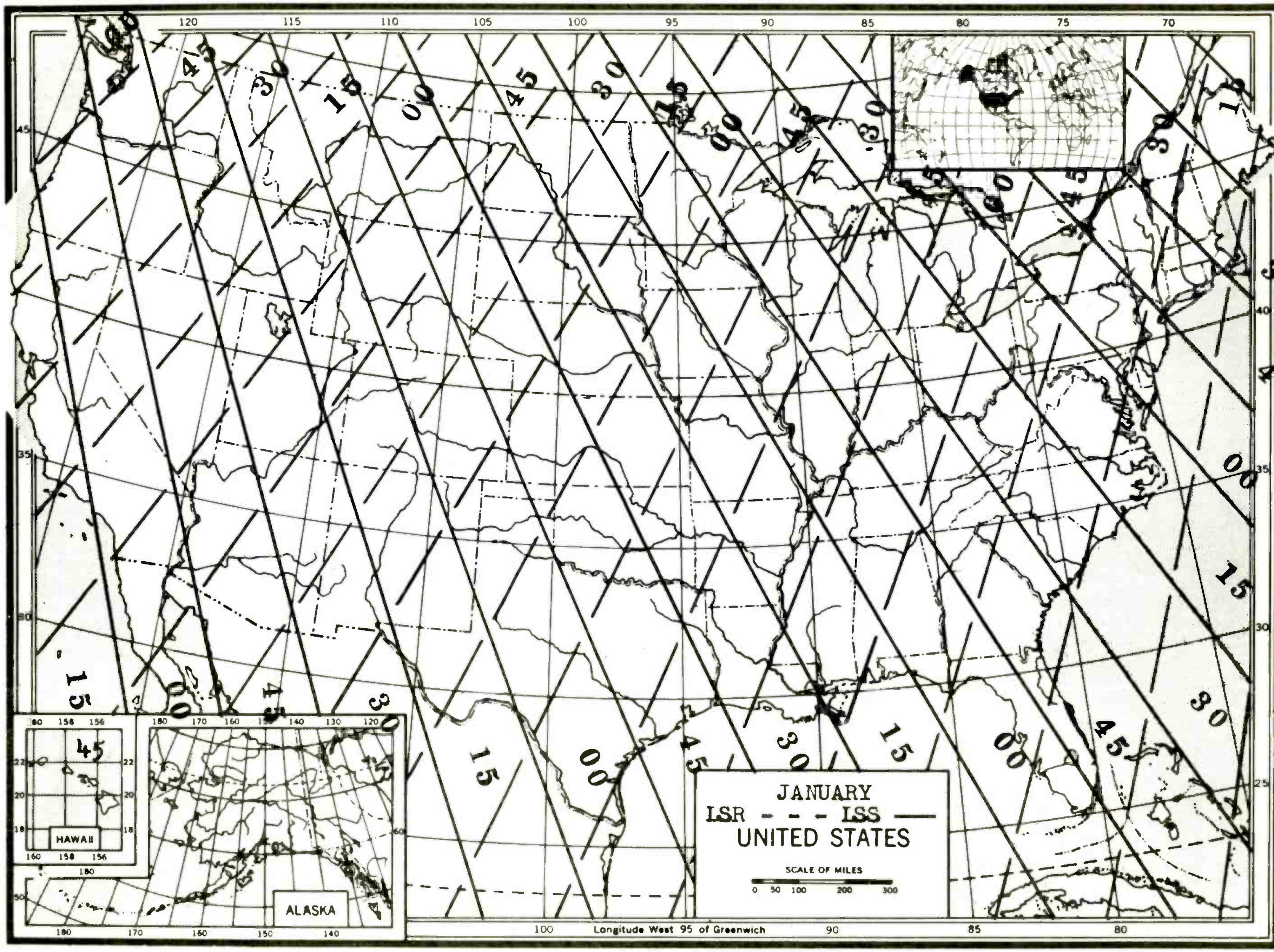
This LSR/LSS MAP BOOK is set-up with a provision for each DXer to fill in his local time. Below is the computation chart based on Eastern Standard Time. All that is necessary is for you to fill in the hour portion of the times. You may use either the 12 or 24 hour systems; I believe the 24 hour system is less confusing in this case. Start with the area of central Maine and proceed westward, adding one hour to each double zero. Be sure to double check your hours before you begin. Be careful with Dayling Saving Time too.

Month	EST LSR	EST LSS	HONOLULU
January	0715	1615	2245
February	0645	1700	2300
March	0545	1745	2315
April	0445	1830	2315
May	0415	1900	2330
June	0345	1930	2345
July	0400	1915	2345
August	0430	1845	2330
September	0515	1745	2300
October	0600	1645	2230
November	0630	1600	2215
December	0715	1600	2215

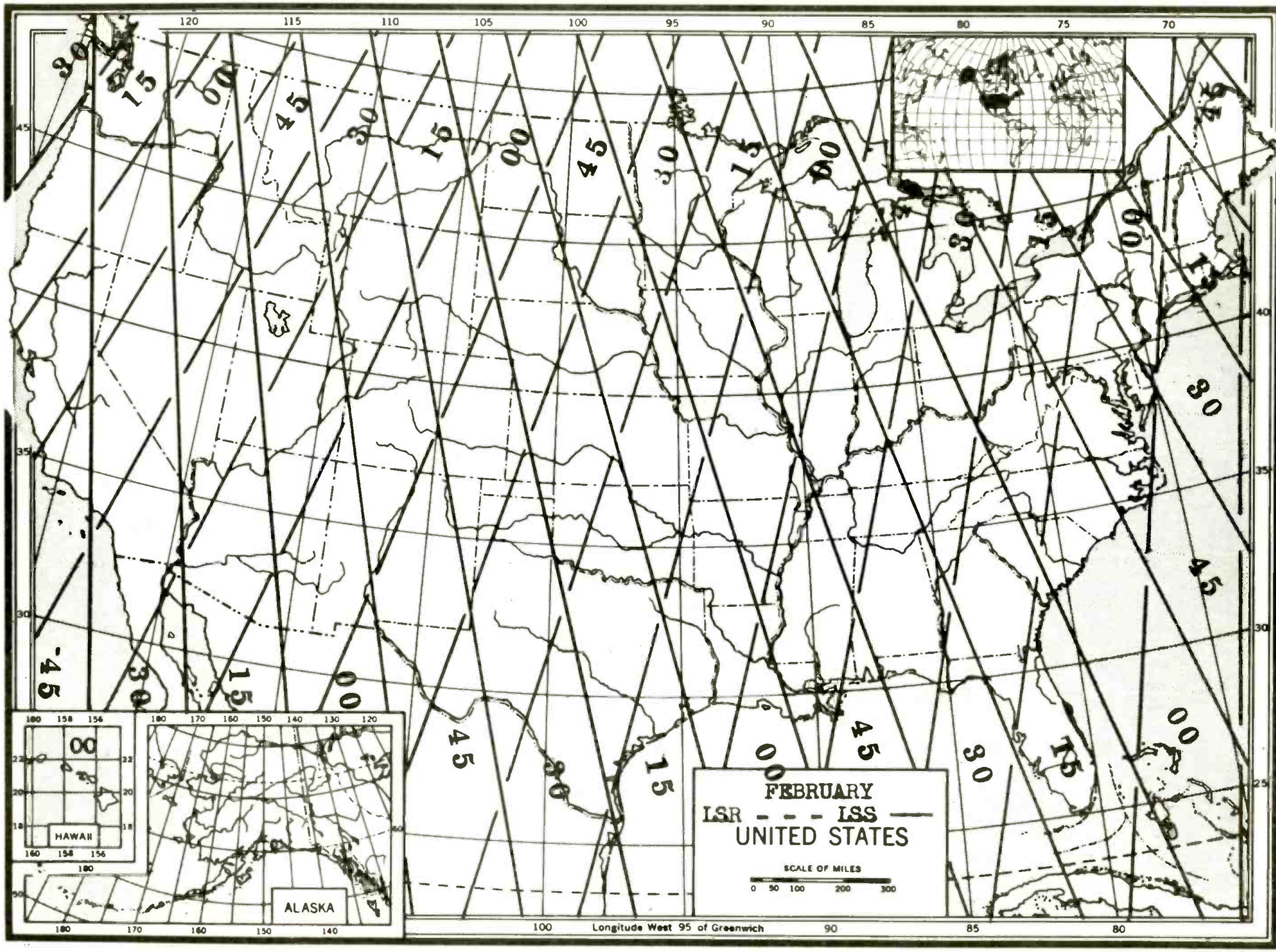
GMT + 5 Hours
AST + 1 Hour
EST True Values
CST - 1 Hour
MST - 2 Hours
PST - 3 Hours
HST - 5 Hours

Daylight Time + 1 Hour

Map corrections are within 10 miles of true average time. Actual LSR/LSS is half way between each line. Additional copies are available for $2.00 postpaid from National Radio Club Publications Center, P.O. Box 401, Gales Ferry, CT 06335. Text and computations by Ernest J. Wesolowski.



JANUARY
LSR - - - LSS ——
UNITED STATES
SCALE OF MILES
0 50 100 200 300
Longitude West 95 of Greenwich
HAWAII
ALASKA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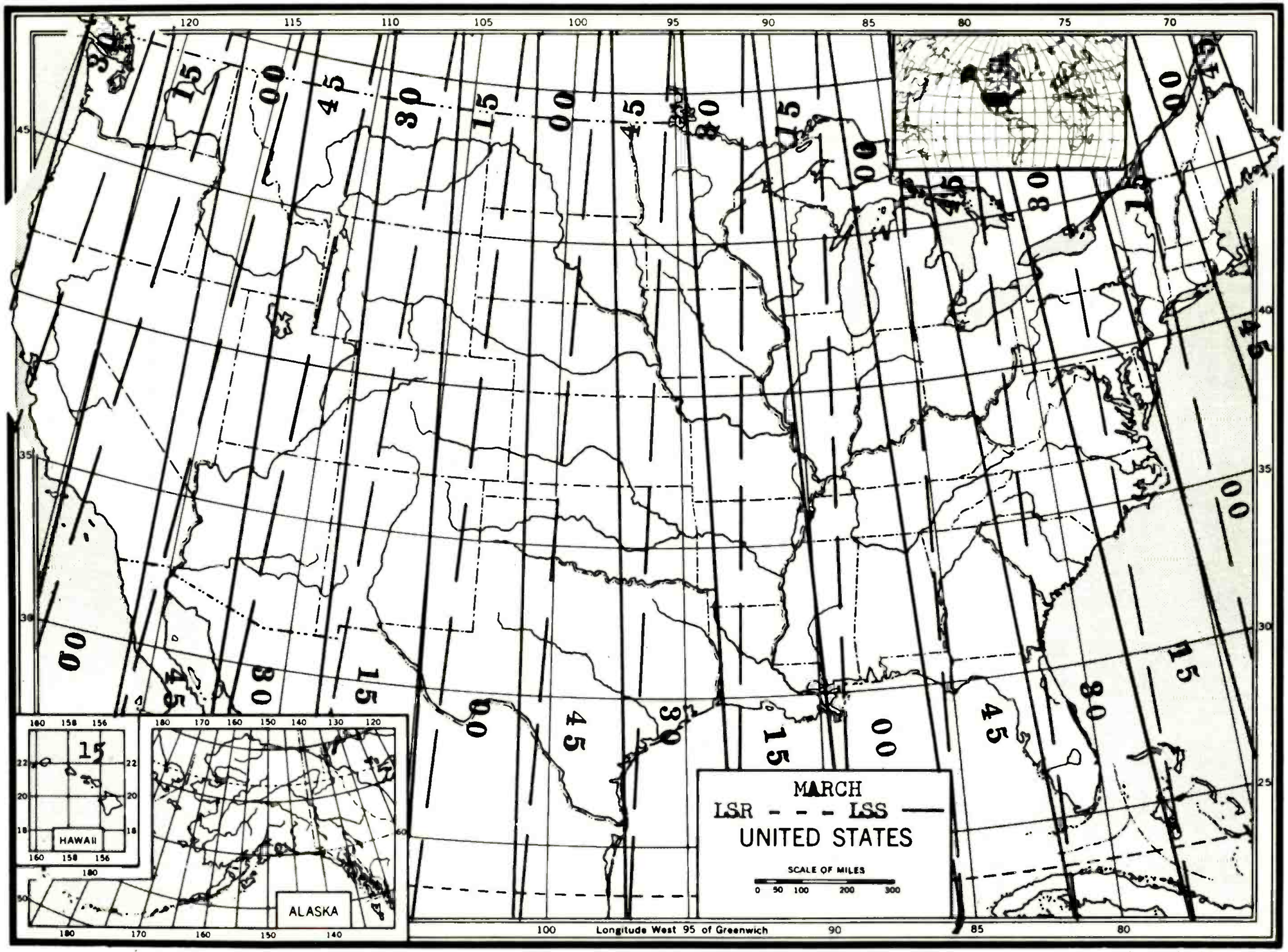
LSR - - - LSS ——
UNITED STATES
SCALE OF MILES
0 50 100 200 300
Longitude West 95 of Greenwich
HAWAII
ALASKA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LSR - - - LSS ——
UNITED STATES
SCALE OF MILES
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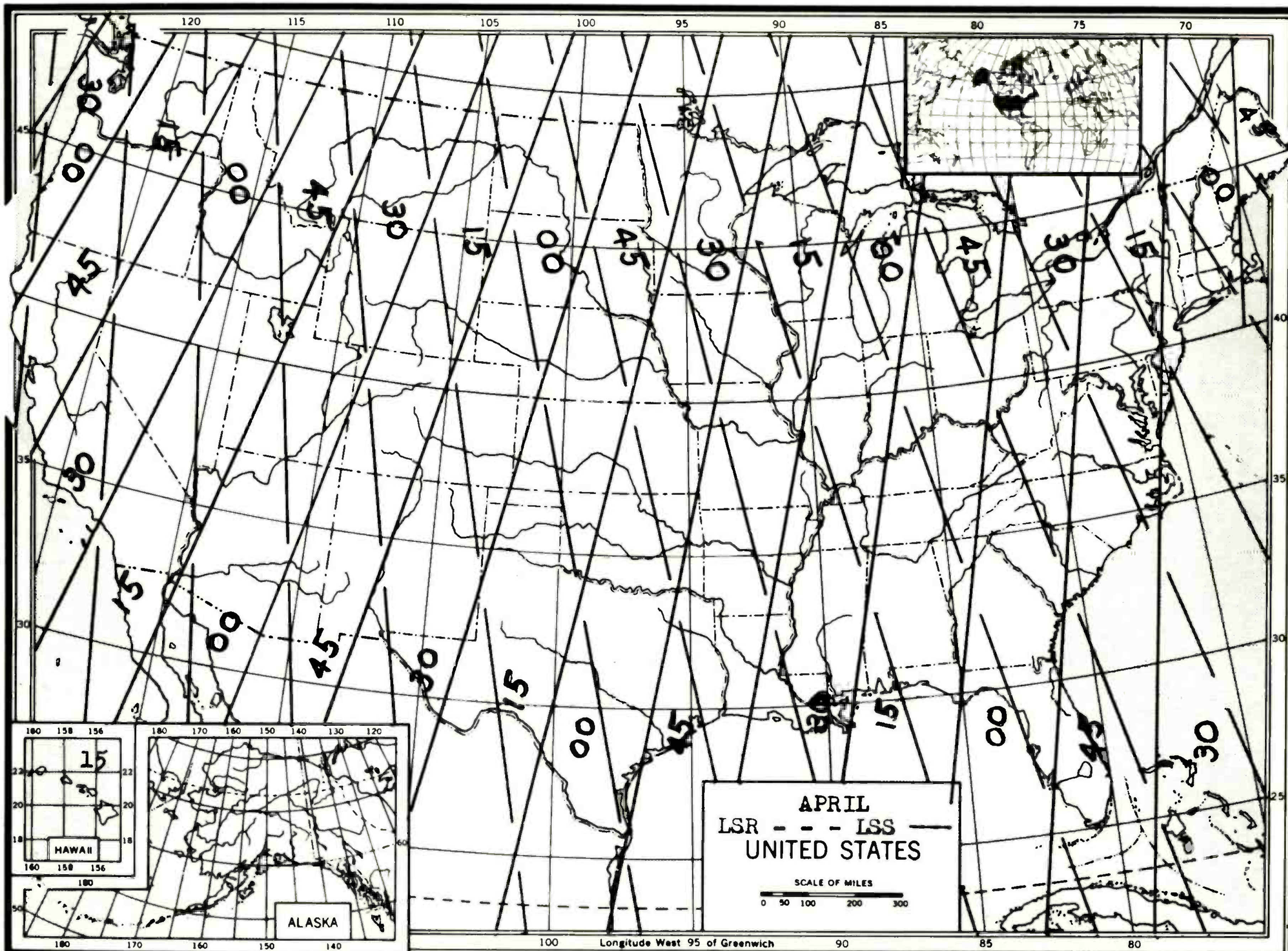
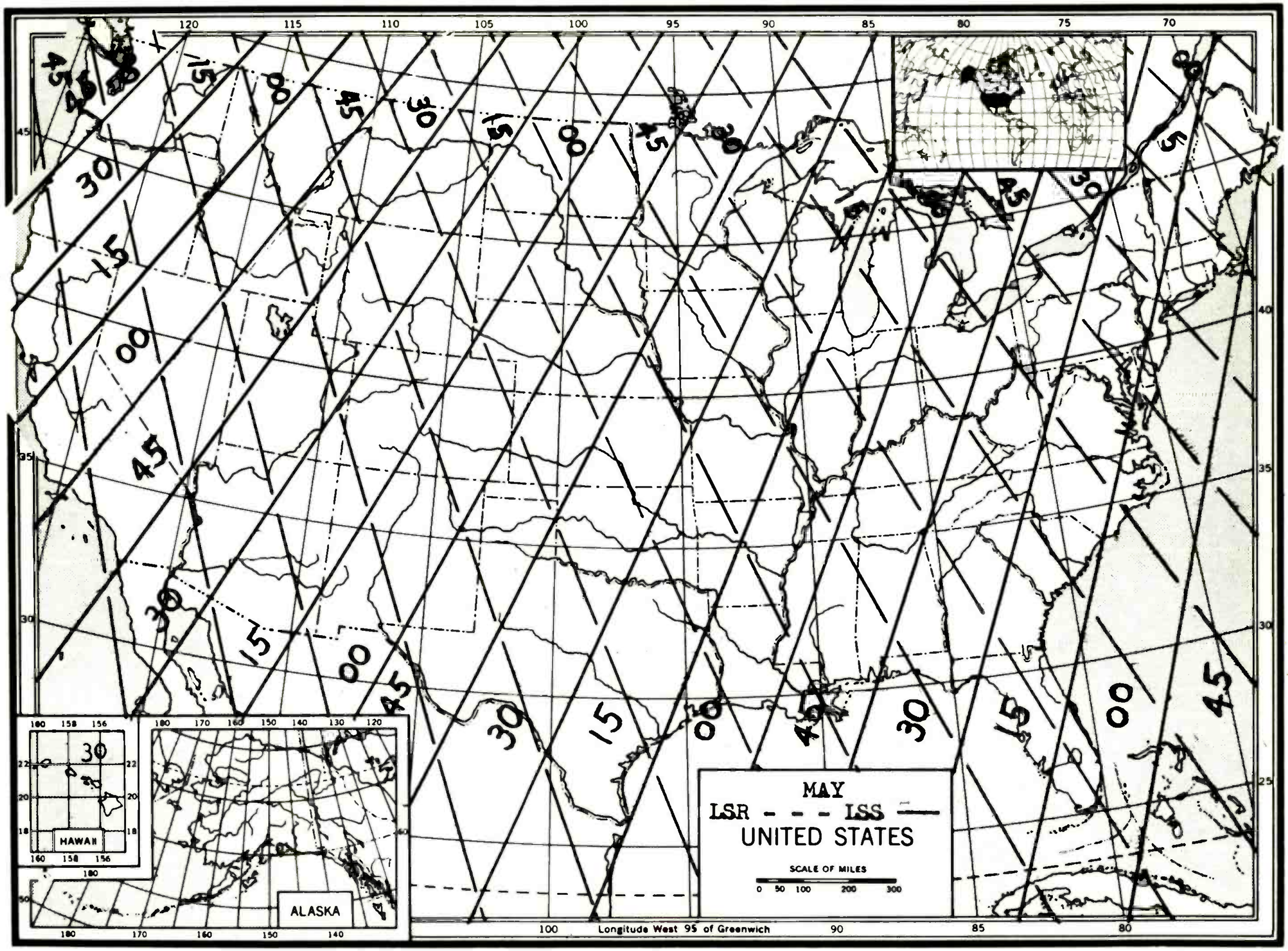
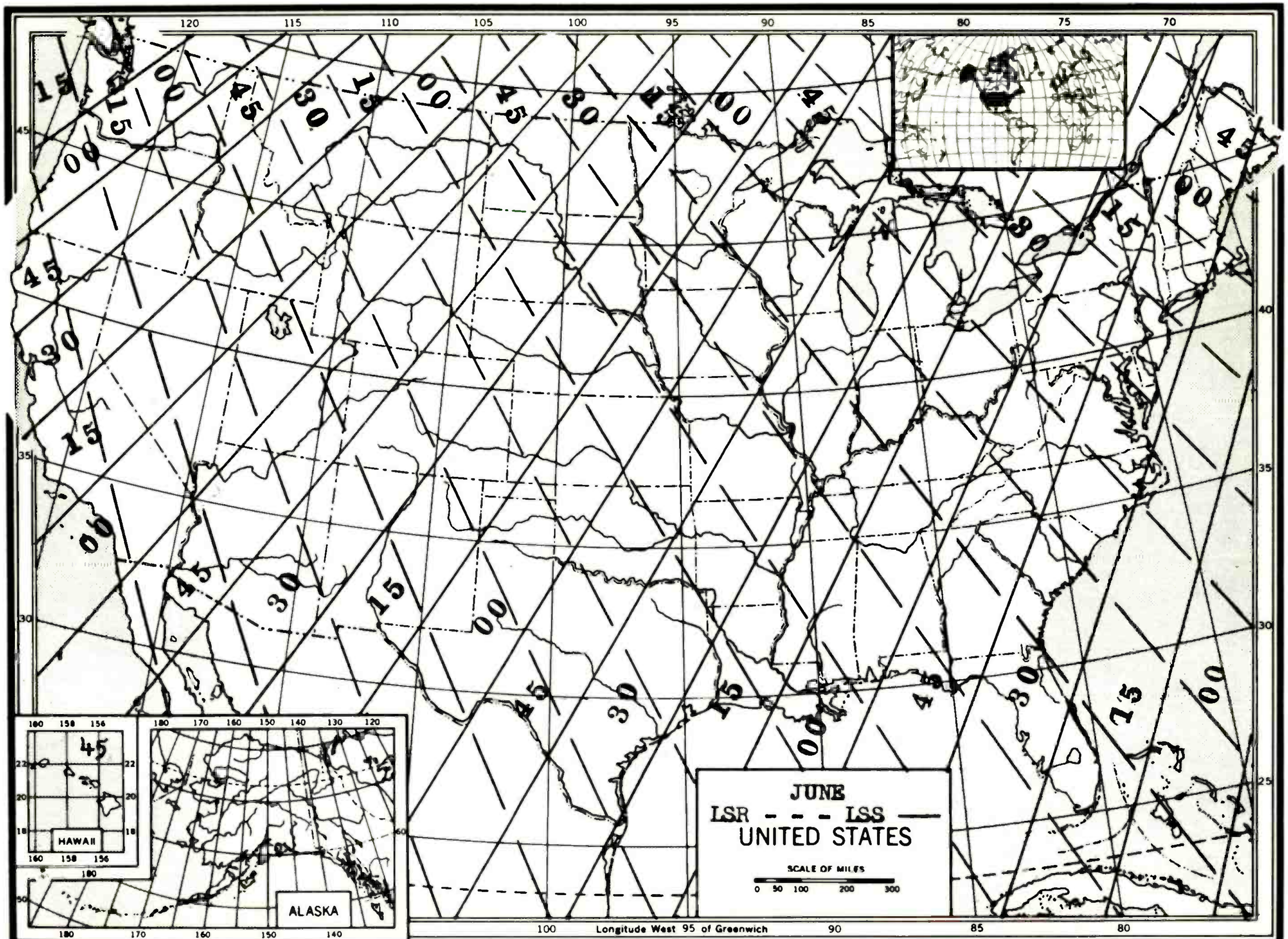
Longitude West 95 of Greenwich
HAWAII
ALASKA


APRIL
LSR — — — LSS ——
UNITED STATES
SCALE OF MILES
0 50 100 200 300
Longitude West 95 of Greenwich
HAWAII
ALASKA


MAY
LSR - - - LSS ——
UNITED STATES
SCALE OF MILES
0 50 100 200 300
Longitude West 95 of Greenwich
ALASKA
HAWAII


JUNE
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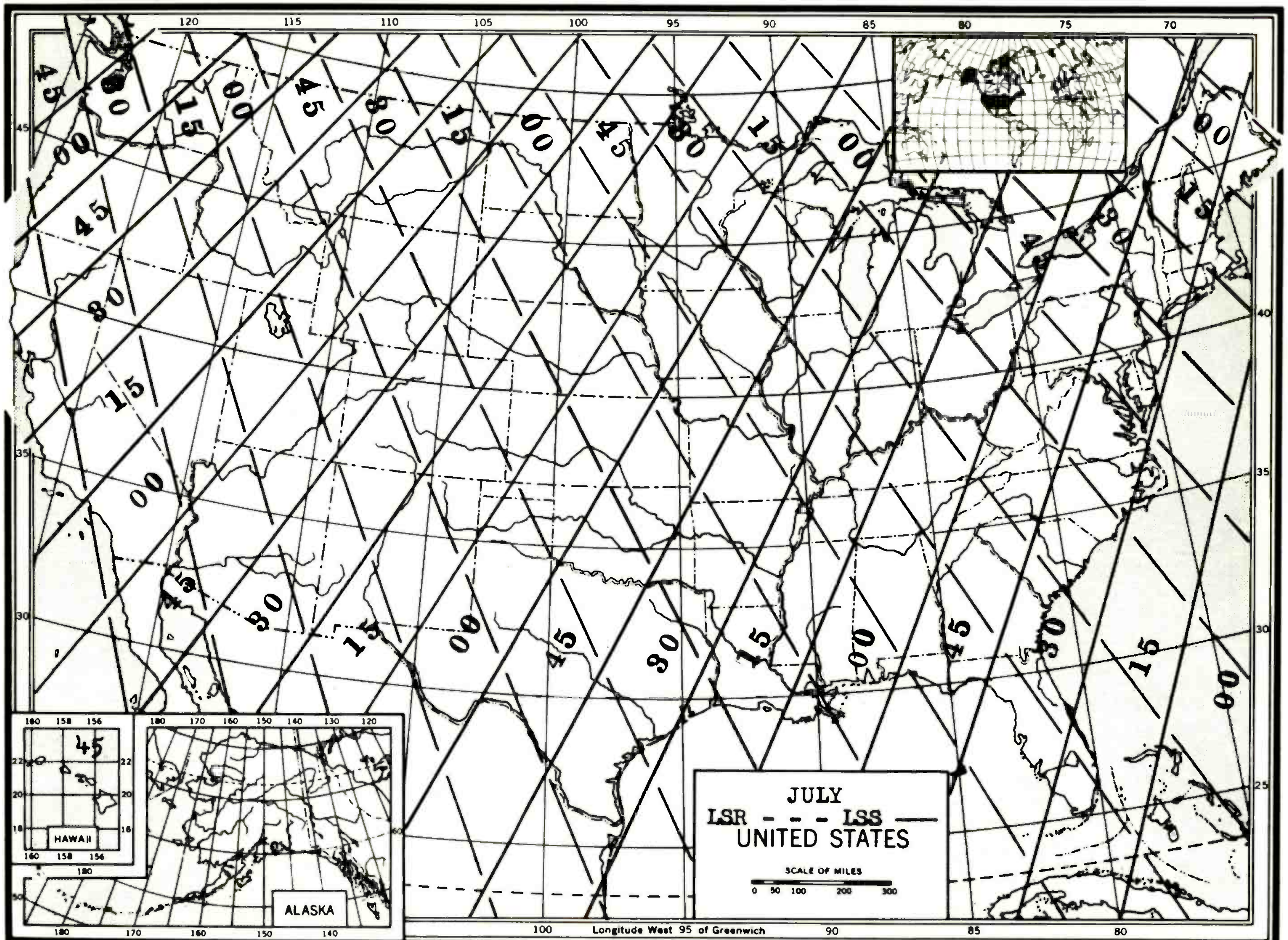
UNITED STATES
SCALE OF MILES
0 50 100 200 300
Longitude West 95 of Greenwich
HAWAII
ALASKA


JULY
LSR - - - LSS ——
UNITED STATES
SCALE OF MILES
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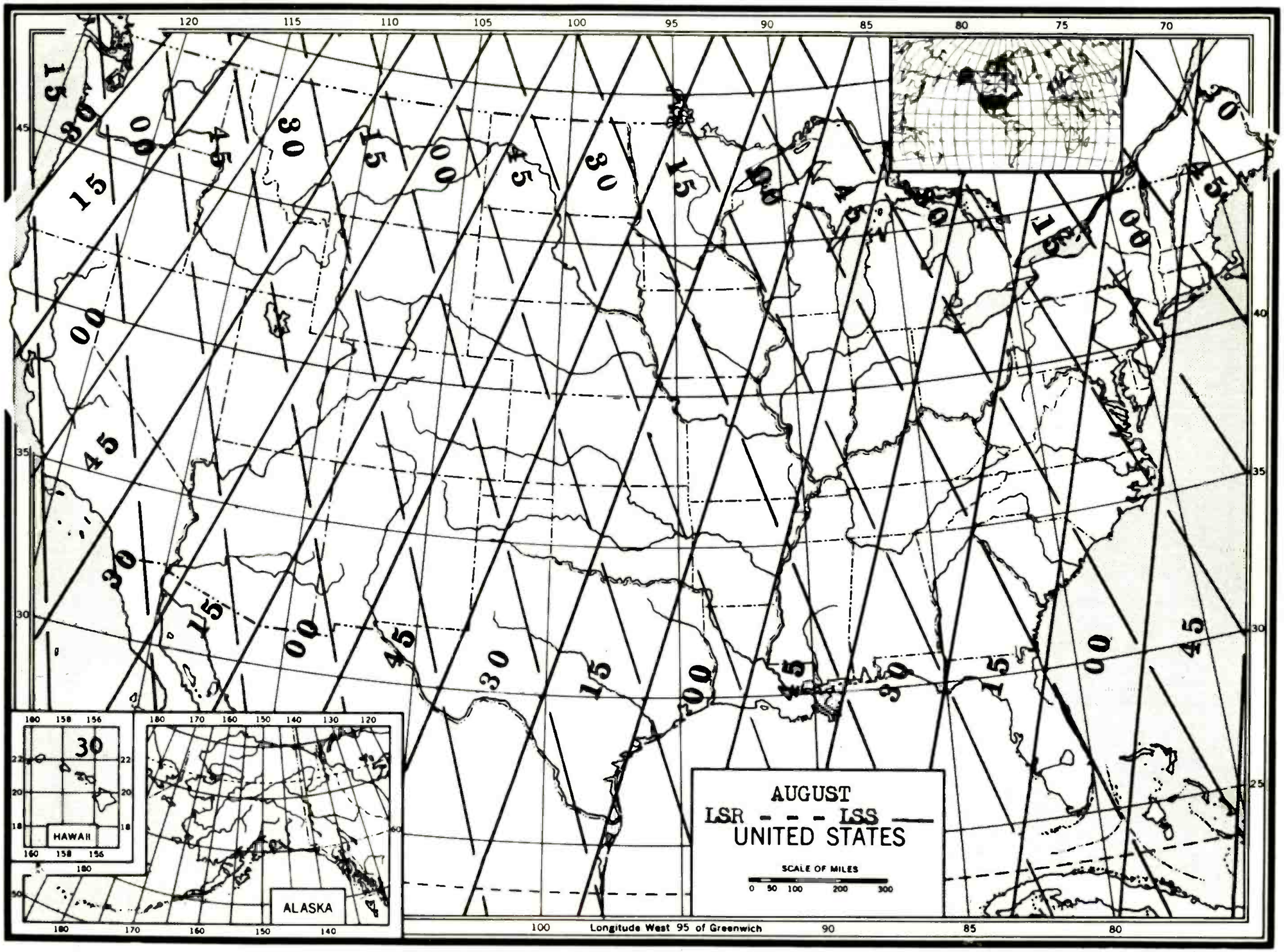
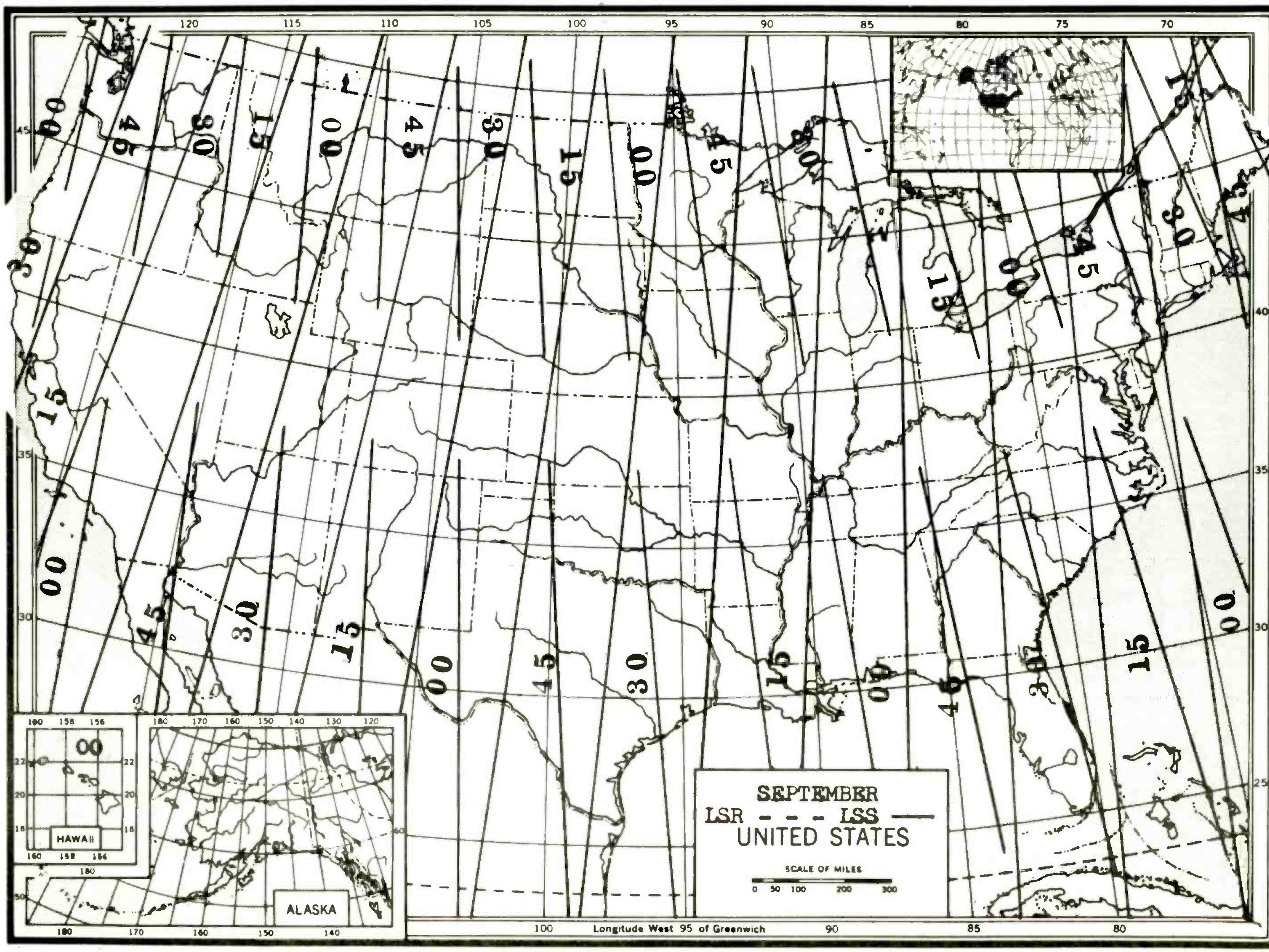
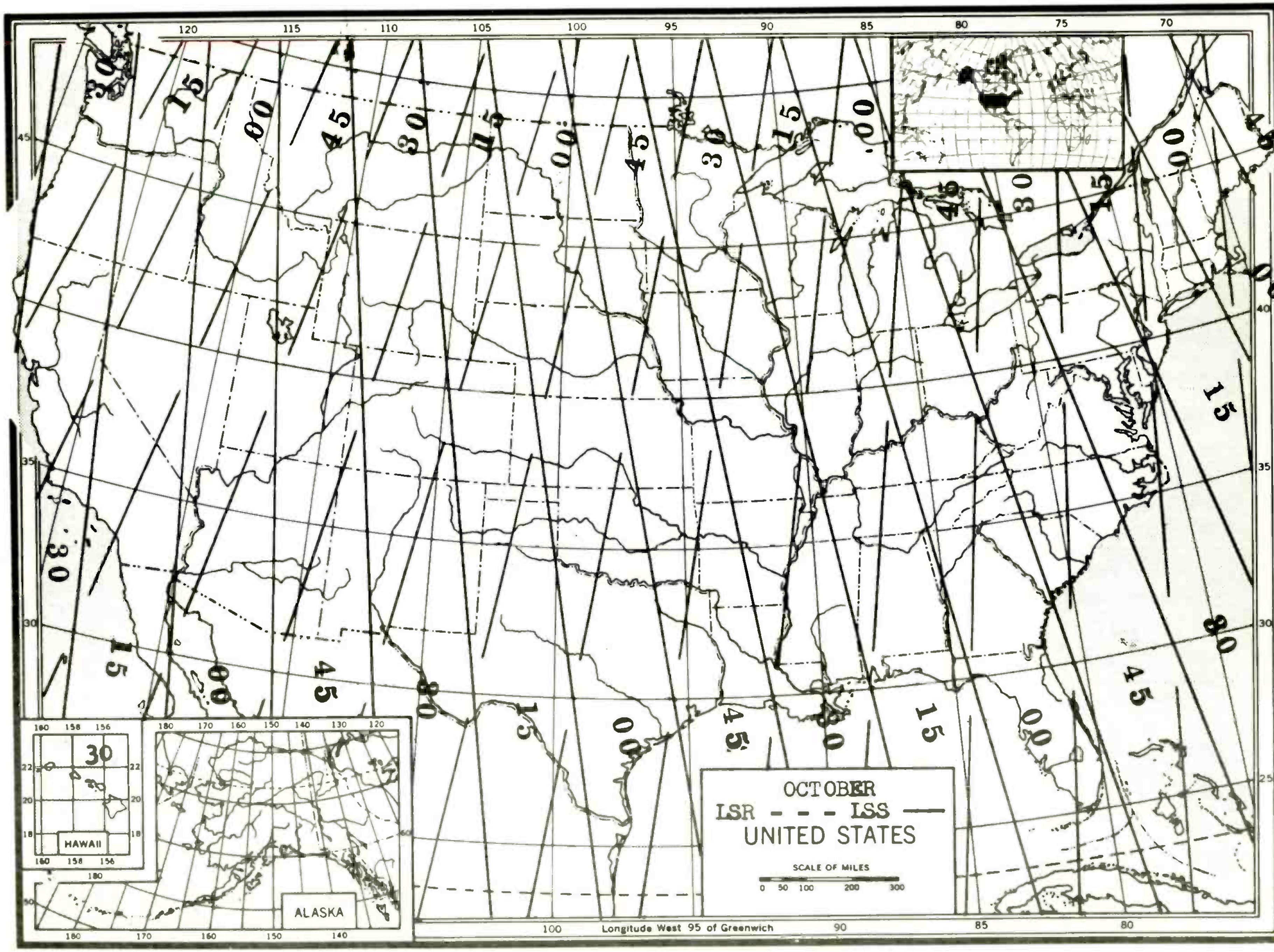
Longitude West 95 of Greenwich
HAWAII
ALASKA


AUGUST
LSR - - - LSS ——
UNITED STATES
SCALE OF MILES
0 50 100 200 300
Longitude West 95 of Greenwich
HAWAII
ALASKA


SEPTEMBER
LSR - - - LSS ——
UNITED STATES
SCALE OF MILES
0 50 100 200 300
Longitude West 95 of Greenwich
HAWAII
ALASKA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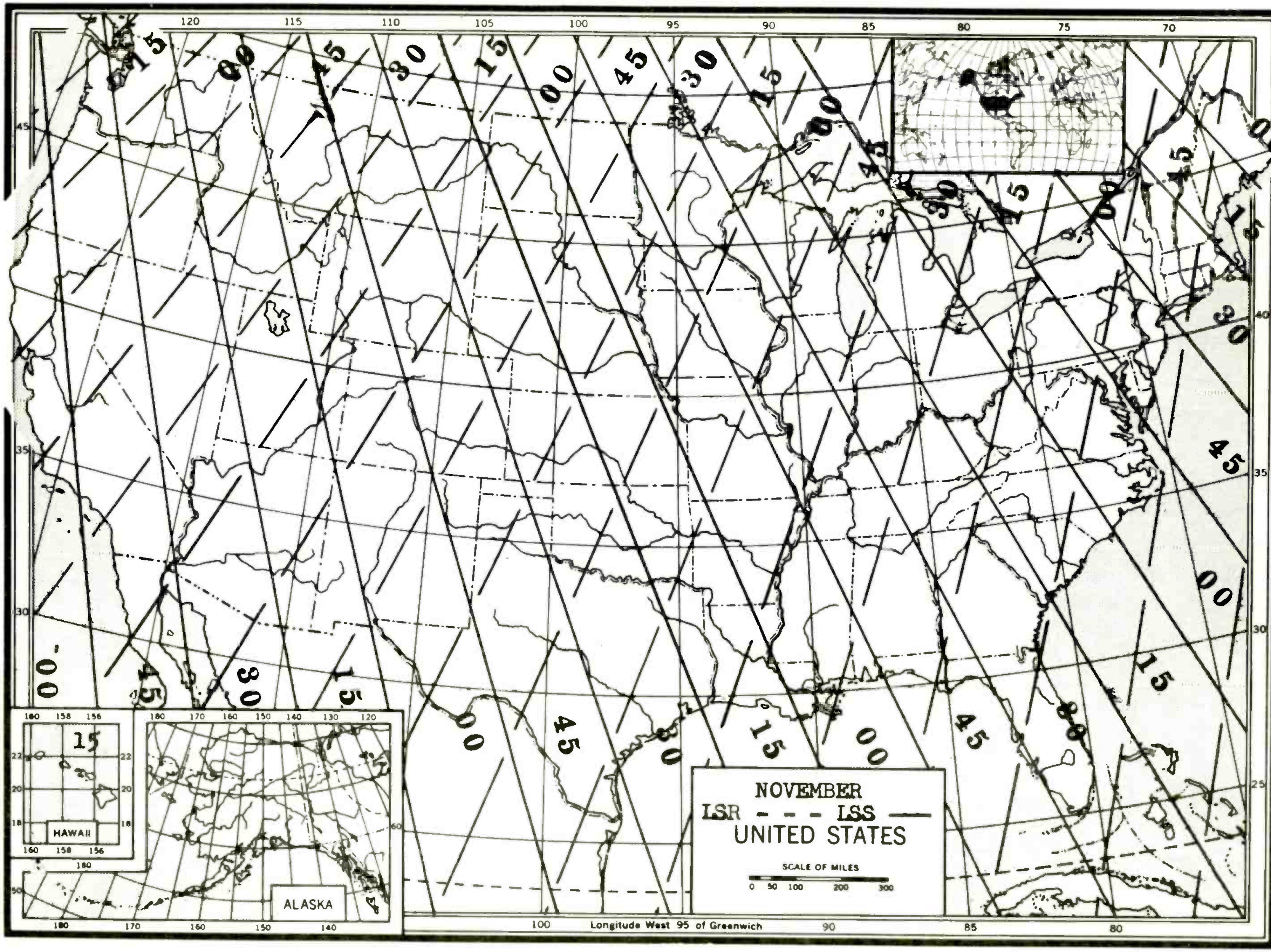

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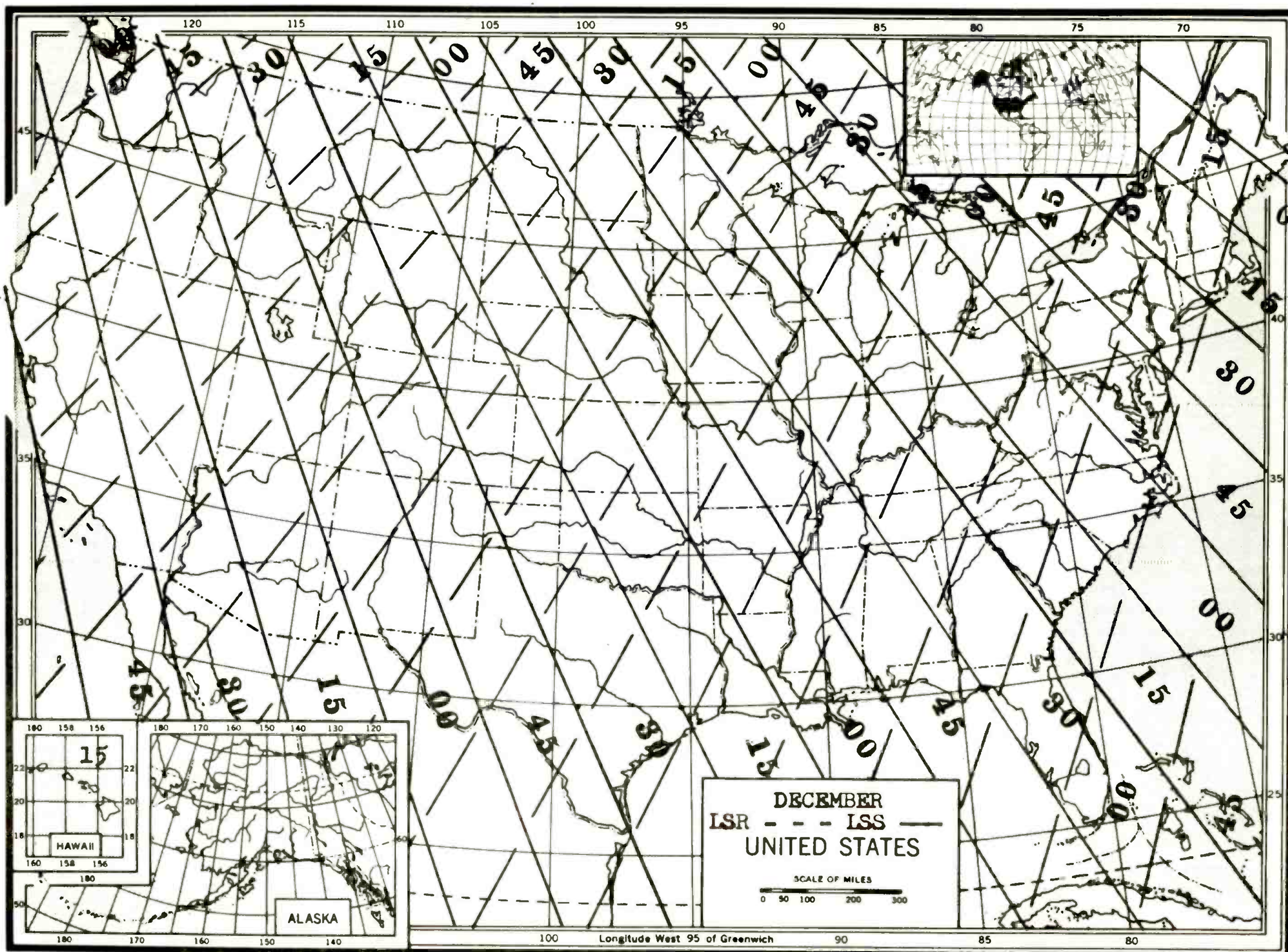
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SOME ANSWERS TO FREQUENTLY--ASKED QUESTIONS ABOUT DOMESTIC PROPAGATION

R. J. Edmunds

Perhaps the most frequently-asked question about propagation of domestic stations is some form of ' why does W--- get out so much better than W--- when they have the same (or less) power and a similar location ? '

There are actually several answers to this question, and some of the more common ones are answered below:

GROUND CONDUCTIVITY. This is the factor which most frequently effects propagation. A station located on marshy land, or other wet areas, such as seacoasts has the best location for "getting out". The station located on dry desert land, or rocky terrain is at a decided disadvantage. Wet ground conducts signals much better, and often provides a more suitable base for skywave signals. Heavy mineral deposits may actually absorb signals which would otherwise be radiated. Also a factor is the efficiency of the station's ground system. Generally, the more radials a station employs to ground its antenna, the better groundwave signal it will have.

HORIZON BLOCKAGE. After ground conductivity, horizon blockage is the major factor effecting propagation. Whether or not the blockage is man-made is of little consequence, as the signal will still be blocked. Most man-made structures are composed of metallic materials which will also absorb signals to some degree, and mountains frequently do the same thing. Natural "ducts" such as canyons, river beds, etc. will usually "carry" signals along them much farther than they would normally go over average terrain.

WEATHER. Old-timers will recognize the importance of weather patterns to the DX'er. In addition to the commonly-known fact that cold weather, plus the shorter days in winter cause lesser amounts of ionospheric absorption and make ground conductivity slightly better. Likewise, a cover of snow, or extremely wet ground due to heavy rains will also cause greater signal coverage. Occasionally, heavy frontal systems will enhance reception slightly within its area (both transmitter and receiver are under the same front). This is especially prevalent with snowstorms.

ANTENNA. The efficiency of the antenna system as a whole can make a signal get out much better. A poor system will radiate less power (regardless of the power put into the system) than a good one will. Likewise, some stations employ antennas which are especially designed to limit skywave components. WPAT-930 is one of these.

MODULATION. A station with good, clean modulation may well be heard better, (and, as a result, more easily ID'ed) than one which undermodulated or has muddy audio. A good example of this is WGSA-1310, which has very poor quality modulation and, despite a fairly good signal, is not often ID'ed.

All of the above reasons can come to bear in any given comparison of stations. One of them is usually enough to account for a significant difference between two stations of equal power equidistant from the DX'er. Likewise, these factors serve to prevent any hard and fast rules as to how far an AM station's coverage can be predicted to extend. As you can easily see, many of these factors are easily variable, either with time or personnel changes at the same station. Thus, it becomes virtually impossible to generalize about this area of propagation.

RADIO PROPAGATION AT FREQUENCIES IN THE STANDARD BROADCAST BAND

By Philip L. Sullivan

There are four basic ways by which a radio wave can propagate, or travel, from transmitter to receiver. These are illustrated in Figure 1.

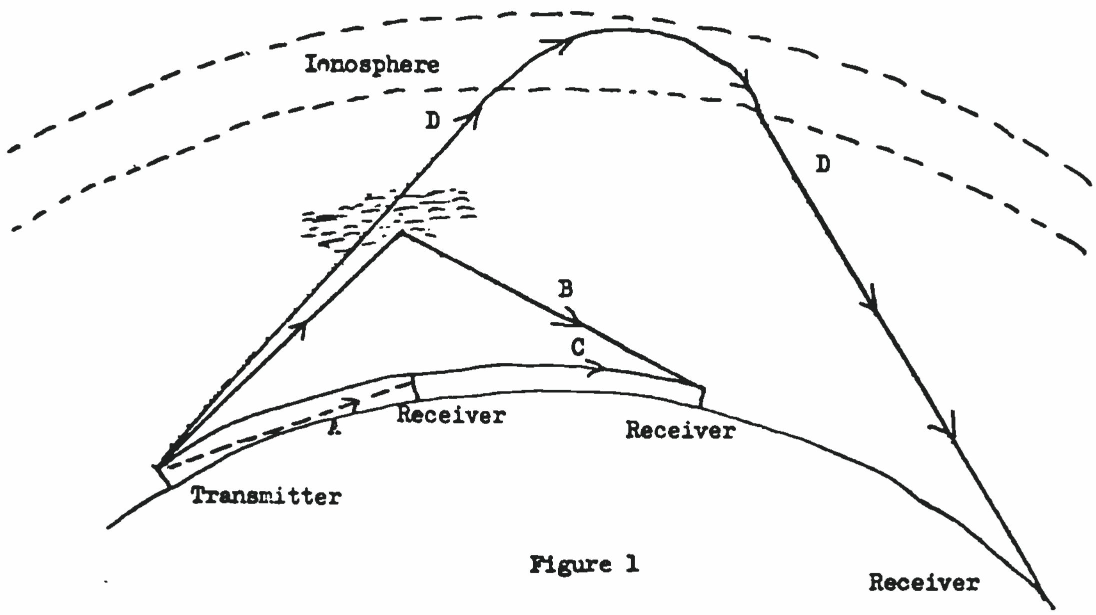


Figure 1

Path A is a direct, line-of-sight, propagation called ''space wave.'' Path B involves reflection of the signal from an irregularity in the troposphere; this is called ''tropo-scatter.'' Path C, known as ''ground wave'' propagation, is a wave guided along and by the earth's surface. Path D involves a signal travelling to and then returning from the ionosphere; this is referred to as ''sky wave'' propagation. The first two paths are not important in the reception of distant broadcast band stations (the space wave is useless beyond the horizon, and tropo-scatter is important only at high frequencies). Therefore, we will only consider the characteristics of the last two propagation modes.

Ground Wave Propagation

The wave that propagates along the surface of the earth does so as a guided wave, guided in a way analogous to a wave guided through a waveguide or along a transmission line. The waveguide encloses the wave on all sides by good, metallic conductors, whereas in the case under consideration there is a conductor (the earth) only on one side. The earth has a much lower conductivity; nevertheless, many of the same ideas apply.

Two factors contribute to the loss in signal strength during ground wave propagation. The first is the distance factor due to dispersion of the signal as it radiates out from the antenna.

C

This $1/d^2$ factor enters into the signal strength formulas no matter what the means of propagation. The second factor accounts for the amount of signal power lost by absorption by the earth because of the finite and variable conductivity of the earth. At large enough distances, combining both factors, we get the following expression for the received energy of the ground wave:

$$E_{ground\ wave} = \frac{K\sigma}{f^2 d^2}$$

where K is a constant of proportionality involving transmitter power, antenna gain, etc., f is the frequency in mhz, σ is the ground conductivity in mv/m units, and d is the distance in miles. This formula is an approximation of more general (and more complicated) formulas, but it is adequate for the values of σ, f and d that normally occur in the study of broadcast band propagation.

From the above equation for received signal strength, it is apparent that better ground wave reception will be achieved over ground with a higher conductivity, or looking at it the other way round, greatest weakening of the ground wave is over terrain having lowest conductivity. Typical values of the ground conductivity in North America range from 1 to 5 mv/m in dry, desert regions and mountainous areas; from 5 to 10 in the Great Lakes region; and from 10 or 20 in the Great Plains and Praries, with some areas in the Dakotas and just north having values up to 30. For seawater, the ground conductivity is about 5000 mv/m, meaning that ground wave reception over seawater is much better than for a corresponding distance over land. Over fresh water, σ is not as high but is still considered above that of average soil and results in very good daytime reception over the Great Lakes.

In summary, ground wave propagation is the primary means by which we receive broadcast band stations at distances of up to a few hundred (and occasionally 1000 miles) in the daytime.

Sky Wave Propagation

The important mode of propagation known as ''sky wave'' is due to the existence of a region in the upper atmosphere called the ionosphere. Although sky wave is the principal (and often only) means of propagation from a distant transmitter, it suffers from many variations and irregularities. To understand the mechanism of sky wave propagation and of the disturbances that affect it, we must first examine the ionosphere.

The ionosphere consists of several layers of ionized gases (fig. 2), the ionization being mainly profuced by ultraviolet radiation from the sun. The lowest layer, at a height of 30 to 50 miles, is the D layer. Above this is the E layer from 60 to 80 miles. The D layer exists only in the daytime; the E layer exists both day and night, being much weaker at night. Above the E layer is a region known as the F layer. At night, this consists of a single layer between 150 and 200 miles up. At broadcast band frequencies, the principal effect of the D and daytime E layers is absorption of the

signal. Since these are the lowest layers, they prevent the signal from reaching the higher layers where refraction would otherwise take place. This is why sky wave propagation of broadcast band signals is virtually non-existent in the daytime. The layers that are most important four our consideration are the nighttime E and F layers.

Many discussions of sky wave propagation consider the ionosphere to reflect the radio waves. Strictly speaking, the signals are refracted, not reflected, as shown in figure 3. A signal from the transmitter (X) enters the ionosphere at a point A at an angle Ø from the normal (N-N′). The effect of the ionization is to reduce the index of refraction (n) within the ionized layer to a value less than that of the atmosphere below it;

($n=\sqrt{1 - 81N/f^2}$, where N is the number of electrons per cm.^{2} and f is the frequency in kHz; $n_{air} = 1$.)

Using Snell's law from optics, we find that when a wave enters a region with a lower n it is bent away from the normal. Since n continues to decrease with increasing height the actual path of the signal is the curve XABCR in figure 3. For most purposes, though, the problem can be treated by pretending the signal is sharply reflected from point D. The height, h′, of D is called the ″virtual

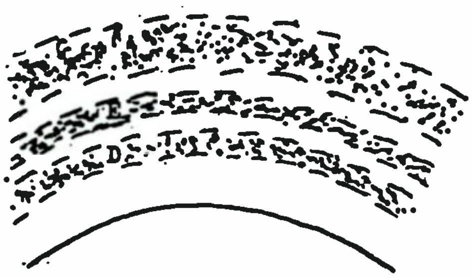


FIG 2

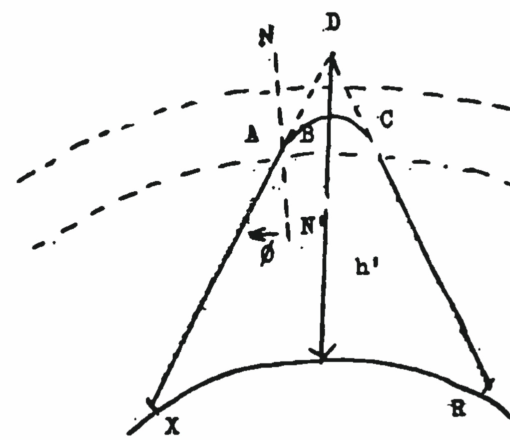


FIG 3

height″ of the ionosphere. For the nighttime E layer h′ is about 65 miles, for F it is about 190 miles.

Besides refraction, the other way in which the ionized gases of the ionosphere affect a radio signal is by absorption. As previously mentioned, this is the principal effect of the D layer and daytime E layer, but does occur to some extent in the F layer. Using a simplified model we find that the attenuation per unit is proportional to $N\nu/(v^2+4\,{}^2 f^2)$ where N is again the electron density and ν is the collision frequency of the ions. Thus a higher frequency will have a lower attentuation. Unfortunately for the broadcast band however, the earth has a magnetic field. Solving the equations of motion

of an electron in a magnetic field we find that this motion has a resonant frequency f_0 given by $f_0=B_0e/2\pi m$, where B_0 is the earth's magnetic field and e and m are the charge and mass of the electron. Evaluating this expression gives f_0, often called the ''gyrofrequency,'' a value between 1100 and 1500 kHz, right in the top of the broadcast band. (This holds over most of the world, however over parts of SA the gyrofrequency is as low as 680 kHz.) A signal at or near f_0 will have a larger portion of its energy absorbed by this resonant system and thus an attentuation higher than would otherwise result occurs in the higher part of the broadcast band. This attenuation is in addition to that normally expected when the magnetic field is not considered.

Variations and irregularities in sky wave propagation are linked to changes in the ionosphere. These can be grouped into four classes: (1) daily, (2) seasonal, (3) those following the sunspot cycle and (4) irregular.

The daily changes have already been discussed as the appearance of the D and E layers during the daytime. During the course of a year there are two major seasonal effects on broadcast band sky wave propagation. First there is the change in the electron density (N) in the F layer -- in the summer it is higher than in the winter and this results in higher attenuation (attenuation is proportional to N) and thus poorer propagation in the summer. Secondly the longer days and shorter nights in the summer result in more ionization of the D and E layers and it takes longer after sunset for this ionization to disappear. With an earlier sunrise this means there is much less time during the night when the D and E absorption is low enough for good propagation. Both of these effects, in short, make sky wave propagation of broadcast band signals much better in winter than summer.

Years of sunspot maxima also result in higher N and hence sky wave propagation is worse in such years than in years of minima. Sunspots come in 11-year cycles, the laxt maximum being 1968 and the last minimum 1963-64. We are now (in early 1977) at or near a minimum. In addition to deterioration of propagation conditions during the Summer and in years of sunspot maxima, the level of the atmospheric noise is generally higher at these times too and this further degrades reception. Sunspot maxima also increase the occurrance of ionospheric storms as discussed below.

Irregular changes in the ionosphere are by their very nature unpredictable. They do, however, have considerable effect on sky wave propagation. At broadcast band frequencies, the most important of these disturbances are the ionospheric storms. These ionospheric storms result in charged particles precipitating into the lower layers (as low as 35 miles - the D layer). The effect is the same as that produced by the normal daytime ionization of these layers - increased absorption. In areas experiencing an ionospheric storm the effect is much as if the D layer and daytime E layers lasted through the night. Propagation along any path passing through a region of ionospheric storm activity will be virtually eliminated.

While the time at which an ionospheric storm will occur is random, some idea can be obtained as to the times most likely. The cause of the ionospheric storm is the arrival in the ionosphere of highly energized particles emitted by the sun. The emission of these particles is associated with solar flares - large clouds of hot glowing gas, often millions of miles long - that erupt from the surface of the sun. These flares are the result of increased solar activity and are most prevalent near and slightly after the time of the sunspot maxima. Since the light from the flare reaches the earth some time before the particles do, sighting of a flare by an observatory is an indication of probable ionospheric storm activity in the immediate future. These particles enter the ionosphere mainly in the region above the magnetic poles, so the magnetic polar areas are the regions in which ionospheric storms are centered. For DXers in North America, an ionospheric disturbance will black out signals from the north, including those from central Asia which must come over the pole (when they do come). This clears many frequencies for reception from Central and South America. The corresponding effect in the southern hemisphere makes it almost impossible to hear South African stations from New Zealand. Besides disrupting normal propagation, these storms also cause the gas in the upper atmosphere to glow; this glow is the ''Aurora Borealis'' (or australis) and for this reason propagation conditions resulting from ionospheric storms are often called ''auroral conditions.'' Once started, such a condition may last 2 or 3 days.

In summary: sky wave propagation involves the return of a signal to the earth from the ionosphere. It is the method by which broadcast band signals travel over long distances (from a few hundred to several thousand miles), but, because of many changes in the ionosphere, the characteristics of this means of propagation are constantly changing. Of great importance is the existence in the daytime of the absorbing D and E layers, allowing sky wave propagation only when the path from transmitter to receiver is mostly or entirely dark. Summers and years of sunspot maxima are the worst times for this type of propagation, whereas winters and sunspot minima are best.

Propagation by Several Modes

So far, we have discussed ground wave and sky wave propagation as if only one of these modes was present at a given time. For daytime reception this is true: ground wave alone is present. At night, just because the sky wave becomes possible and greatly dominates over the ground wave, this does not mean that the ground wave disappears or is weaker - it is essentially constant throughout the day and night.

The presence of two possible paths for a signal to travel to a given receiver location might merely result in a greater signal strength received, but this isn't always true. The difference in the lengths of these paths results in a difference in phase between two arriving signals. The phase of the ground wave is essentially con-

stant so any change in the path differences will come from sky wave variations. A phase shift of 0°, 360°, 720°, etc. (corresponding to a path length difference of 0, 1 wavelength (λ), 2λ, etc.) results in the addition of the two signals; while a phase shift of 180°, 540°, 900°, etc. (a path length difference of 1/2λ, 1 1/2λ, 2 1/2λ, etc.) results in the subtraction of the two signals. Thus, a change of 1/2λ (from 300 to 900 feet for the BCB) in the path length difference can result in signal strength variations equal to twice the strength of the weaker of the two components. This variation in path length is so small that it occurs very readily due to normal fluctuations in the ionosphere, resulting in ''flutterings'' in the signal from many semi-local stations (out to perhaps 200 miles) at night, since for these stations the sky and ground waves are of comparable strength.

Similar effects can occur at greater distances due to the presence of ''multi-hop'' sky wave propagation (fig. 4). Path 1 is the normal one-hop sky wave that has already been discussed. Path 2 is an example of two-hop propagation: refraction from the ionosphere, reflection from the ground at point A, and another trip to the ionosphere and back, finally arriving at the receiver. Again the same signal arrives by two different paths, possibly resulting in some cancellation of the signal. While not shown, other possible paths of three or more hops exist, and scattering of waves as they pass through lower ionospheric layers causes spreading of the idealized paths, further complicating the problem. In general, the signal arriving by the fewest number of hops will be strongest. The largest distance that can be covered by a single hop is about 2000 miles. Beyond this distance, the two-hop signal predominates with the three-hop being the chief component of interference. Beyond 4000 miles the two-hop disappears and the three-hop is dominant, and so on. For multi-hop propagation, the ground conductivity at a point of reflection is important in much the same way that it is for ground wave propagation. For example, TA and TP paths are often good for receptions over long distances, but cross-country reception is more difficult. The presence of several simultaneous modes of propagation and the deviation from ideality of the received signals makes day to day reception on the BCB quite variable and difficult to predict accurately, but hopefully the above discussion will have given you an idea of the general physical phenomena that controls BCB propagation.

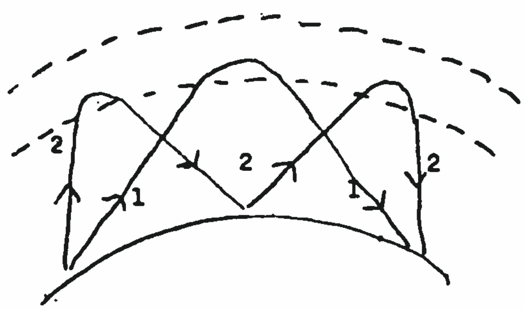


Figure 4

--This article was originally written in 1967 for the IRCA.

Article retyped by Lynn Burke

M W IONOSPHERIC PROPAGATION

Ronald F. Schatz

This article is being presented as a prerequisite to our upcoming article on Terminator Transit Mechanix (TXM). It represents several weeks of hard research at major university libraries in the South Florida area. The approach will be a fresh one, unlike the standard ARRL -type "short-wave" propagation outline that medium-wave DX'ers have had to suffer in the past as an explanation for what goes on at their end of the spectrum. New terms and concepts, representing the latest scientific discoveries and terminology, will be incorporated, and factors having naught to do with medium-wave propagation, such as the F_1 layer, will be left out. We hope you will find this novel presentation informative and useful to your DX'ing persuits.

The ionosphere is a broad region of the upper atmosphere contain- plasma; i.e., gases broken up by solar and cosmic radiation into free electrons and positive molecular ions. The plasma tends to concentrate into several horizontal layers, where electron densities (N) are thick enough to return radio-wave energy back to earth, absorb it, or both.

The lowest of these layers is the D layer, at an effective height of about 55 miles. The D layer is formed mainly by ultraviolet radiation from the sun, and its "N" values follow solar intensities very closely, reaching a maximum at noon and almost vanishing instantly as the sun's final rays disappear beyond the horizon at dusk.

The D layer absorbs MW signals during its daylight existance through a process called non-deviative absorption, thereby preventing ionospheric propagation until nightfall. There are exceptions, however:

During autumn and winter months the low angle of the sun may so attenuate the D layer that some sky-wave propagation may be possible even at local noon, though signal strengths never approach anywhere near nighttime levels.

And during geomagnetic storms, solar particle bombardment can reform the D layer at night, bringing "daytime" reception to the band during what MW DX'ers call "auroral conditions". More on this later.

Just above the D layer is the E layer, at an effective height of some 60 miles. It is generally useless for MW reception by day because of the absorbing D layer only some five miles beneath it.

At night the E layer is formed mainly by constant bombardment from meteoric dust and other cosmic radiation, therefore E-layer "N" values tend to reach a maximum at local midnight, especially in tropical latitudes.

Medium-wave signals are propagated by the E layer via both reflection and refraction, since medium wavelengths are relatively large compared to the plasmatic densities encountered in this layer. The refraction path tends to follow a parabolic curve, as illustrated in Figure 1. A lot of attenuation occurs this way, since much of the signal "gets lost" on its way from point A to point B, a process called deviative absorption.

The reflected signal tends to dominate the refracted one, since it is not reduced as much by having to travel through the plasma. Reflection occurs at the points of refraction, through a process well known in optical physics. This subject will be treated more fully in our article on TXM.

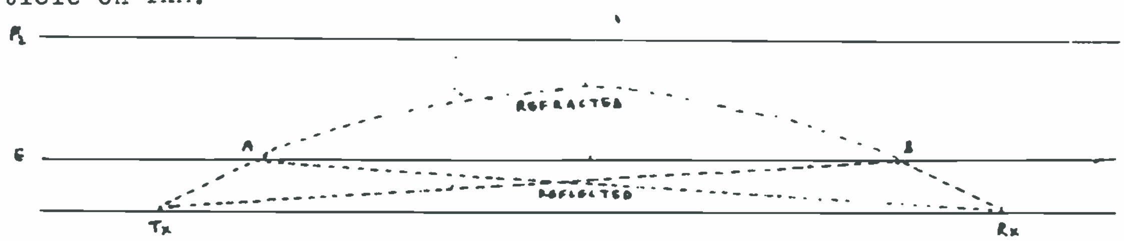


Fig. 1

The E layer is not uniform but systematically irregular in electron density (N) distribution due to tidal forces, standing waves, and gigantic eddy currents, all of which cause it to behave like a motor as it rushes across the earth's geomagnetic lines of flux. The original dynamo theory was the first to postulate the existance of the ionosphere back in the 1880's! Most long-term fading observed on the MW band is the result of this dynamo activity in the E layer.

Sporadic E (E_s) are super-thick patches of plasma occurring at E -layer heights, especially at night over tropical areas. It causes highly localised enhanced receptions on medium waves.

The only other ionospheric layer that may affect MW propagation is the F_2 layer, at three times the height of the E layer, or about 190 miles. Its existance at night is mainly due to delayed reconversion (or recombination) of the plasma back into neutral gases due to the thinness of the atmosphere at that altitude.

The F_2 layer is the principal nighttime reflector of short-wave signals, but it plays only a very minor rôle on medium frequencies, which are overwhelmingly E-layer territory.

The critical frequency (f_c) of a layer is the highest frequency that will be returned by that layer from straight overhead. The "f_c" for the night E layer averages about 400 kHz, higher at sunspot maxima, lower at minima. The oblique critical frequency (f_{co}) rises as the grazing angle drops, reaching the maximum usable frequency (MUF) at the lowest practical grazing angles (about 3°). Cf. Figure 2. For the night E layer, the MUF averages 2 MHz, similarly varying with sunspot activity.

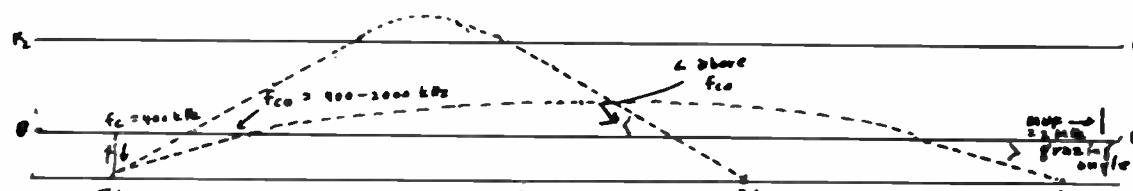


Fig. 2

Frequencies greater than the "f_{co}" for a given grazing angle will pass through the layer. Medium-wave signals that are aimed too high will therefore pass through the E layer to be reflected by the F_2 layer far above it. This sometimes happens at the top of the band on short-distance paths.

Therefore, almost all medium-wave ionospheric signals are propagated by the night E layer. F_2-layer propagation is possible at the top of the band over short distances during solar-quiet (Sq) conditions, otherwise it is normally completely buried by stronger E-layer signals - except during deep fades.

A DX'er with a trained ear can tell if a sky-wave signal is being propagated by E skip or F_2 skip. E skip is characterised by strong, steady signals; fades are slow and several minutes apart. F_2 skip is normally only half as strong and has a characteristic "short-wave" sound to it; fades are constant and rapid, only seconds apart.

During deep E-layer fades at the top end of the MW band, fady F_2 skip may take over for several seconds until the E layer recovers. A chart of that event may look something like Figure 3. Such a signal never really fades out completely, since a "backup" system is at work.

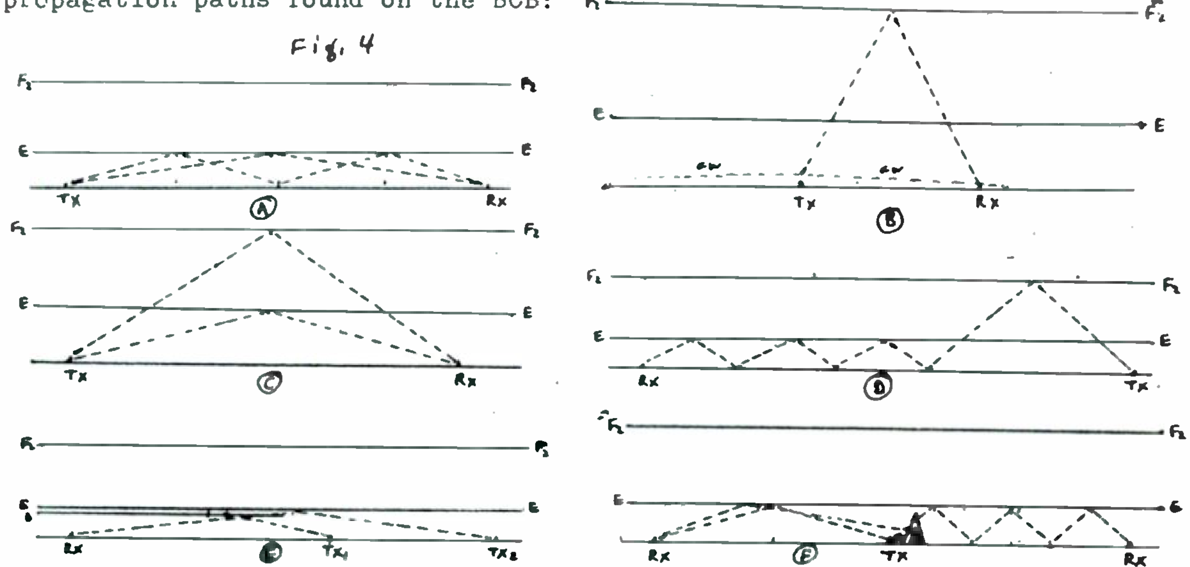
Fig. 3

Sky-wave signals may make several trips through the ionosphere by bouncing off the earth's surface a number of times. Typical MW paths across the Atlantic Ocean involve 4 to 5 E-layer hops.

The maximum skip distance via the E layer is about 1300 miles, but double E skip (2E) normally dominates past 1050 miles. Skip distances are notably greater at lower latitudes and over water paths. One skip per thousand miles or fraction is a fair rule of thumb for most DX locations.

The following vector diagrammes will help to illustrate typical propagation paths found on the BCB:

Fig. 4



a) Typical MW ionospheric modes over a thousand-mile path. Both single and double E skip are present, vying for domination and causing occasional fading in the process.

b) Hi-band semi-local at night, F_2 due to steep grazing angles. Severe fading is experienced due to interference from the ground wave and the fady nature of F_2 skip.

c) "Piggy-back" E and F_2. Normally the F_2 is completely smothered by the much stronger E, except when the latter fades out.

d) Theoretical trans-Atlantic path at the top of the dial near the "f_{co}". The first skip is F_2, the rest E. Reception quality is typical F_2, fady and "short-wave", superimposed on slow, deep E fading.

e) D-layer blanketing during "auroral conditions". Tx-1 can't get through, while Tx-2, though much further away, can.

f) Horizon blockage caused by a mountain backdrop. The signal is weaker than it should be, since the reflection area is cut down, and more hops are necessary due to the lack of low-angle paths. Signals in the opposite direction are strongly enhanced, as the mountains act as a "reflector" for them.

Fading on the MW band varies from the rapid flutter of polar-cap absorption to the all-night rise and fall of E layer cosmic bombardment (midnight peak). Almost all fading is the result of ionospheric N values changing with time or similar changes in layer heights; the ionosphere being an extremely turbulent medium. The frequent presence of more than one signal path compounds the fading situation, such as when ground and sky waves interact at short distances.

The study and prediction of solar-induced (dawn and dusk) and E-layer standing-wave fades are the specific concern of Terminator Transit Mechanix (TXM), which are covered in a separate article.

The natural frequency of movement of free electrons in the ionospheric plasma is called the gyrofrequency (f_H), which varies in average from 800 kHz in the tropics to 1500 kHz in middle latitudes, coincidentally falling within the MW band. Now ...

The presence of the earth's magnetic field causes refracted radio waves to split into ordinary (O) and extraordinary (X) rays. The overall effect is that the E layer will not return the X wave at or anywhere near "f_H". Therefore, unlike on SW, MW signals are almost entirely O waves, perhaps a primary reason why MW and SW propagation conditions are so mutually different. Certain MW signal paths, especially in the tropics, are chronically poor, since the E layer will also refuse to return vertically-polarised O waves in certain geomagnetic directions, and the X wave can't take over. Some direct north-south paths are a prime example.

The following ray-path diagrams will help to illustrate several propagation modes found on the HF bands:

a) Typical HF (long) multi-hop modes over a thousand-mile path. Both single and double F skip are present, using the Absorption and consequent occasional fading in the process.

b) Hi-band semi-local as mixed, is due to steep grazing angles. Here the fading is especially due to interference from the ground wave and the ragged nature of F-skip.

c) "Piggy-back" E and F_2. Normally the F_2 is completely smothered by the much stronger E, except when the latter fades out.

d) Theoretical trans-Atlantic path at the top of the dial near the "f_m". The first skip is F_2, the rest E, hence the quality is typically F_2, ruddy and "shore-wave", superimposed on slow, deep E fading.

e) E-layer blanketing during "auroral conditions". F_2-1 can't get through, while F_2-2, though much further away, can.

f) Horizon blockage caused by a mountain backdrop. The signal is weaker than it should be, since the reflection area is cut down, and more hops are necessary due to the lack of low-angle paths. Signals in the opposite direction are strongly enhanced, as the mountains act as a "reflector" for them.

Fading on the HF band varies from the rapid flutter of polar-cap absorption to the all-night rise and fall of E layer-caused scintillation (midnight peak). Almost all fading is the result of ionospheric multi-path varying with time or with ion changes in layer height, the ionosphere being an extremely turbulent medium. The frequent presence of more than one signal path compounds the fading situation, such as when ground and sky waves interfere at short distances.

The study and prediction of solar-induced (Dawn and Dusk) and E-layer ionospheric irregularities are the specific concern of Travelling Ionospheric Disturbances (TID), which are covered in a separate article.

The natural frequency of movement of free electrons in the ionospheric plasma is called the plasma frequency (f_N), which varies in average from 900 kHz in the daytime to [illegible] at night, usually [illegible], [illegible] within the HF band. [illegible]

The presence of the earth's magnetic field causes the plasma to split into ordinary (O) and extraordinary (X) rays. In general it means that the X layer will not return the X waves at or below about f_N. Therefore, signals on lower HF bands are almost completely [illegible], perhaps a primary reason why HF and LF propagation conditions are so completely different. Certain HF signal paths, especially in the tropics, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]. [illegible] [illegible] [illegible]

The natural frequency if interaction between the free electrons and positive ions in the ionosphere is called the plasma frequency (f_N). If the signal frequency equals or is less than "f_N", even vertical signals will be returned. As the signal frequency rises above "f_N", the reflection angle increases - until the signal is hardly affected at all. Note Figure 5:

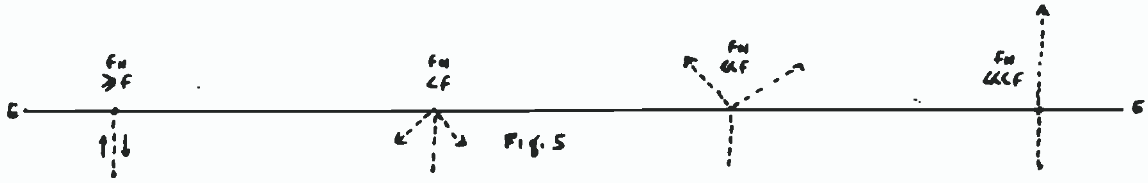


Fig. 5

Therefore, "f_c" occurs where "f_N" equals the signal frequency. Read Terminator Transit Mechanix for a complete discussion on this subject and its implications.

So far we have discussed only the normal operation of the ionosphere as it affects medium waves, but experienced DX'ers know that some nights are different from others, reception-wise.

As the DX NEWS publication schedule indicates, winter is better than summer for ionospheric propagation. The lack of thunder-static in winter is the primary reason, but some decrease in ionospheric non-deviative absorption is also a factor.

To properly understand seasonal variations in ionospheric propagation it must be known that the sun doesn't control the ionosphere with light alone but that protons and other particles are shot in our direction as well. These solar particles are retained by the atmosphere for days at a time and are distributed about the ionosphere according to season; i.e., along the equator during the equinoctes and in the respective middle latitudes then experiencing spring and summer. This is a complex subject, better treated more fully in a separate article.

This particle radiation is related to general solar activity, traditionally measured by sunspot number, but counting sunspots is becoming passé these days. Today, geophysicists prefer to use the solar flux index, which is basically a measurement of noise created by particle bombardment of the upper atmosphere. Typical flux values are around 120. On the best of days it may drop into the 60's, promising good long-distance reception. Or it may rise past 180, a hint to do something other than DX. In a way the solar flux is the ionosphere's "signal-to-noise ratio". The SF follows a regular 27-day cyclic pattern, in time with the sun's rotation.

Disturbances in the geomagnetic field mean that the E-layer"dynamo" is upset. Its specific effects on MW reception, other than to distort loop bearings, have not been empirically explored to a great extent.

Surrounding the earth's magnetic poles are doughnut-shaped "auroral zones", where the lines of geomagnetic flux are anchored. This is a region where the E layer is highly reflective but the D layer even more highly absorbent, even at night, where DX'ers visiting the Yukon often report a "dead band". When a major solar flare erupts, the oncoming front of particles knocks other particles trapped in the earth's flux field out of their stable orbits, dumping them into the auroral zones. The zones then expand like a winter cold front, often reaching as far as central Florida, thereby giving most of North America a "dead band" - except where signals from South Florida and the Caribbean can get through under the absorbing layer.

Both the A and K indices are used to measure such auroral absorption in different scales. All of these solar-terrestrial parameters are broadcast after the 18'th minute of each hour over WWV.

Finally, the infamous "mid-winter anomaly" (MwA) will also be left to our article on seasonal variations. For now we'll just say that it's the reason why TA reception is often better in October than in December and January.

MORE ON MEDIUM WAVE IONOSPHERIC PROPAGATION

RONALD F. SCHATZ

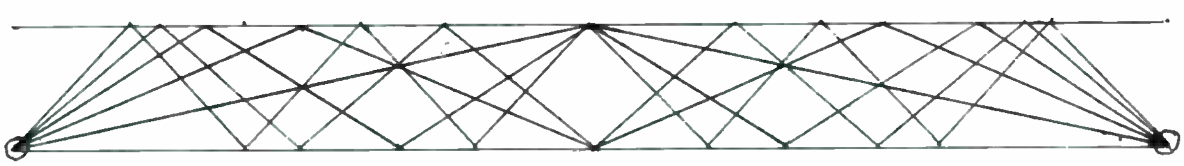
This is the promised sequel to our previous article, Medium-Wave Ionospheric Propagation - A New Perspective, which originally appeared in the 12 June 1978 issue of DX NEWS and is now available as an NRC Reprint. That article was the first to approach the subject from the perspective of the MW DX'er rather than that of the common "SWL". That philosophy will be continued herein as we expand upon those same and additional basic concepts. The references therein listed remain the same for this work.

Refraction vs. Reflection

Are radio signals refracted or reflected by the ionosphere? Perhaps the best way to answer this debate is to review the three most common theories of ionospheric propagation:

1) The best known and most accepted theory states that the ionosphere refracts radio waves according to magneto-ionic principles, meaning that the earth's geomagnetic field and the type and density of electrons and ions in the plasma determine how the waves are refracted. This "magneto-ionic theory" is a definite advantage in predicting signal paths, where critical frequencies must be calculated; but its oversimplified, unrealistic model of ionospheric structure, consisting of "Chapman layers", is of little help when changes in the signal path must be analysed on a transient level, TXM being a case in point.

2) Another theory has been very popular among engineers dealing with the longer wavelengths, especially those returned by the E layer at night (i.e., most of the MW band and below), since it allows for accurate signal-strength measurements per the "Austin-Cohen equation". This theory states that the E layer is dense enough to reflect long radio waves, and since true reflection is involved, the signal path will consist of the algebraic sum of progressively weaker 1, 2, 3, 4, 5, etc. -hop paths to the point that excessive attenuation can support no more, as suggested below:



The reality of such a signal path structure has been verified on MW with the strip-chart recorder, but it is seldom possible to discern more than the first 3 or 4 hops in this manner.

3) The newest theory, pioneered by NASA scientists and independently by the author, deals with "ionospheric transfer" or "diffusive reflection". Basically, it states that, given the example of a single-hop path, every portion of the overhead ionosphere in common sight of both transmitter and receiver will contribute to returning, or "transferring" the signal, and not just a limited centralised area between them. This theory lends itself well to transient analysis, thus to terminator-transit mechanix. It will be explained in detail in Part III of the TXM series of articles.

The three theories given above lead us to a safe conclusion to our original question: It appears that either true refraction or true reflection has its respective validity - depending on the situation and how we wish to analyse it.

E vs. F2

Which ionospheric region/layer returns MW signals - the E or the F2? In the author's qualified opinion, either one or both, depending on the circumstances. This matter has been amply settled in the better textx, for those who wish to refer to them (c.f. New Perspective reference list). The question, rather, is which layer returns the signal for any given path and when. As a start, and very roughly speaking, some 75% of MW signals are E-layer paths, 5% are F2 paths, and 20% are combinations of both, this according to the author's strip -chart research.

Because of the myriad of factors and variables involved, there is no simple, nor even moderately complex, formula for determining when either E or F2 is respectively in control of a given MW signal path. The best we can do is to list some guidelines for the reader to follow:

1) Exclusive E skip is almost certain before local sunset and after local sunrise; i.e., both transmitter and receiver must be located within the dark half of the globe for F2 skip to be possible. Obviously, "SRS" and "SSS" are exclusively E-skip phenomena.

2) The author has yet to detect any F2 below 800 khz under any circumstances; it is extremely rare below 1100 khz, and then appears only on multi-hop paths. F2 is common only in the 1500's - sometimes!

3) Exclusive F2 skip is rare, generally limited to paths within 1000 kilometers and frequencies above 1450 khz. Low solar flux is also essential. § The chance for F2 skip is directly proportional to the number of ionospheric hops, since E requires more skips than F2 to cover the same distance.

4) E-skip signals peak at midnight; F2 shortly before dawn.

5) As hinted before, E-skip signals fade up at sunset and out at sunrise. F2-skip signals fade up about an hour after sunset and out an hour before sunrise.

6) "Auroral conditions" normally preclude the possibility of F2 skip on medium waves.

Again, these are only guidelines. It takes a strip-chart recorder, and skill at reading the charts, to determine the nature of the signal path with any degree of accuracy.

Absorption

There are two kinds of ionospheric absorption, deviative and non deviative.

Deviative absorption is loss along the signal path due to scattering or "deviating" from the straight and narrow. Bits of the signal "get lost" along the journey, much like grammar-school children on a field trip.

Non-deviative absorption occurs mainly in the D and lower E layers, where the signal loses strength by bombarding with gas molecules in this region. § In both cases, "loss" would be a preferable term to "absorption".

The 3 Freqs

The "3 freqs" of ionospheric propagation are the geomagnetic frequency, the plasma frequency, and the hybrid frequency:

The gyro-frequency is the "twirl rate" of an ionospheric electron. It averages 1400 khz but varies over a wide area within the broadcast band. Its wide bandwidth absorbs the extraordinary ray, leaving only the ordinary ray to return most MW signals. (This concept is as important to the average MW DX'er as it is understandable to him).

The plasma frequency is the natural frequency of interaction between the electrons and positive ions in the ionosphere. It reflects (not refracts) signals of its same frequency. A radio signal shot straight up into the overhead ionosphere will bounce back at the level where its equivalent plasma frequency occurs. It is also the secret behind oblique ionospheric refraction.

The hybrid frequency is a heterodyne of the previous two. Beyond the study of "topside" ionogrammes (i.e., those made from satellites looking down), just knowing of its existance is enough.

Ground-wave or Sky-wave?

Daylight MW reception is propagated almost totally by groundwaves, which are characterised by rock-steady signals (not withstanding Radio Caroline in rough seas), good coverage over salt water, and poor coverage in mountainous country. Ground waves also carry better and further on the lower MW frequencies, especially below 800 khz.

Sky waves vary in signal strength over a relatively short period of time (i.e., they fade). On MW frequencies, sky-wave propagation is normally limited to night and twilight hours.

Geographical Variations in Reception

All sky waves start and end as ground waves, just as an aircraft spends its first and last moments on a runway. Since ground waves travel best over salt water, a seacoast location does wonders. Good, reliable TA and TP reception is thus limited to about a 100-km wide coastal strip on respective sides of our continent. Note that those DX'ers who have achieved fame working trans-oceanic stations reside within these coastal strips.

The normal auroral zone, which falls north of Montréal, also limits trans-oceanic reception to certain geographical areas. European signals are thus generally limited to east of the Appalachians, or a line extending from Montréal to New Orleans; and a station in Norway is more likely to be heard in Miami than in Boston on any given night. Asian signals are similarly limited to the area west of the Rockies.

Horizon blockage is caused mainly by nearby mountain ranges, which cut off low-angle signal paths in their direction. The resultant signal is thus attenuated, since only high-angle rays get through, which require more ionospheric hops than normal for the same distance. E.g., a one-hop E path over flat land may be a 3-hopper if a mountain range is in the way (going by the reflection theory of propagation - no. 2 mentioned previously), and multiple hops are not conducive to strong signals. Cases in point are Lima and Santiago, which are regularly reported in California but rarely in Florida. Honolulu stations are also far weaker in North America than they should be, thanks to horizon blockage.

The same mountain barrier enhances signals in the opposite direction, since it acts as a reflector in such cases. Honolulu stations are much stronger than they should be in the South Pacific.

Seasonal Variations in Reception

The trans-oceanic DX season in North America extends from mid-August to mid-April, while stations in Argentina and Brasil are best received in mid-summer or mid-winter - two seasons per year. What are the phenomena behind these seasonal changes?

Thunder-static is not a direct factor; the noise may discourage DX'ing in summer, but it merely masks the signal rather than reduce its strength. § Another leaky theory suggests that summer nights are too short to permit a trans-oceanic path completely in darkness. In fact, the Lisboa-Miami path never experiences less than five hours

of total darkness at any time of the year, and in spite of the RTF's 24-hour operations on 666 and 1035 khz and a rather southerly route, the path remains all but useless during the "off-season".

Actually, DX seasons are a product of two closely related variables, both related to solar flux:

The solar flux index, a practical equivalent to sunspot number, serves as a measure of signal attenuation caused by the sun's dumping of protons, corpuscles, and other particles into the upper atmosphere. As a rule, only long-distance, multi-hop paths are notably affected, such as TA's and TP's. Good DX nights normally have SFI values under 100, while bad nights sport values over 160. The SFI is an overall figure, a mean value for the planet as a whole. The "18-after" report over WWV is the best source for this valuable piece of data.

But solar particles are not distributed evenly about the earth. Just as the sun affects seasonal temperatures by changes in the angle and duration of its radiation, so it affects the ionosphere. Solar particle radiation is a factor in ionospheric absorption. During summer the combined effect of intense, high-angle radiation and a longer period of it causes a surplus of particles to build up in the lower mid-latitudes then experiencing the high sun, while the opposing hemisphere has a corresponding deficit of corpuscles. As the particles take several days to dissapate, absorption continues throughout the nights of late spring and early summer. During late autumn and early winter the relatively "clean" ionosphere promotes optimum reception over long distances on east-west paths.

In March and September the maximum radiation is over the tropics. Particles building up in that area discourage trans-equatorial reception, and that is why there are two seasons per year for DX'ing lower South America and other areas of the southern hemisphere.

If the SFI is high enough, excess particles in the "summer" hemisphere may spill across the equator into the hemisphere then enjoying winter, a likely explanation for the mid-winter anomaly!

Seasonal variations in reception, then, may be attributed to unevenly distributed solar flux. An SFI figure of 120, as per WWV, may be effectively 90 in one hemisphere and 150 in the other.

Errata

It is not uncommon in scientific journals for authors to submit corrections to errors appearing in their previous works, and we shall continue the tradition here:

In New Perspective (now NRC Reprint "P23"), kindly ignore Figure one; it was drawn with transfer theory in mind and is misleading within the scope of its presentation. Also dismiss Figure 5 and the accompanying text on the plasma frequency for the same reasons. Please forgive our trespasses.

FLASH! FLASH! FLASH!

Provincetown, Mass. (NRC)...Veteran Editor Ernest Cooper's typer is ill and is being treated. Recovery is expected. The typer nearly succumbed after the typing of a Verie Signer list and two pages of Musings and was quickly pulled from service. A trusty dusty machine of old was immediately called into service, and Ernie completed the typing for the December 11 DX News issue. His friends at HQ were thankful for the perseverance shown by Mr. Cooper. To minimize any possible printing problems from the second-string typer, a couple of pages were retyped at HQ. A clever notice (?) was then placed in DX News, lest anyone wonder if the senior editor had flipped his wig. The members were asked to endure Mr. Cooper's typer's illness and keep sending in contributions to DX News. A tired HQ typist (who only typed two pages of copy) was heard to say, "if only those guys out there had to type all this, they would really appreciate ERC". End of NEWSFLASH.

Meteorological Effects on Medium Wave Groundwave Propagation

by R. J. Edmunds

Throughout the past several years, research into Medium Wave propagation has centered around the Trans-Atlantic and Trans-Pacific paths and has dealt exclusively with skywave receptions. In this time, the area of groundwave propagation has been touched only slightly in a couple of articles.[1,2] Despite this fact, there is still a lot to be explored in this area, especially during the daytime hours when groundwave is essentially the only viable mode of propagation. By daytime hours, we generally mean the time from two hours after local sunrise until two hours before local sunset, in order to be a s free as possible of the effects of the ionisation and recombination associated with those times.

As many of the oldtimers may be aware, much of the MW DX propagation theory of the pre-1960's was associated with meteorological effects such as snowstorms, hurricanes, temperature inversions, weather fronts and the like. In the flurry of skywave propagation research, much of this older DX lore has been either pushed into the background or largely ignored. This has occurred despite the fact that there is some relevant engineering research in the area.

The most recent of these currently known to this author was conducted by Paul Godley, Jr., of Paul Godley Consulting Communications Engineers of Little Falls, NJ. which was conducted in the late 1960's, and published in 1970.[3] The author has been in touch with Mr. Godley, and has been fortunate enough to obtain copies of much of his research data, as well as some most valuable insights into the project. Also available is some older research, conducted both in the US and in Europe. The vast majority of this research deals with two areas: temperature variation and precipitation. In the former case, significant correlations have been made to indicate that there is indeed a documentable relationship between temperature, both of the ground at the receiving site and with that of the air, either at the receiving site or along the signal paths concerned. It is important to note here, however, that for the purpose of this article, there is an assumption made that the effects have a similar influence on both groundwave (where the signal is propagated essentially through the earth) and spacewave (where the signal is propagated along the earth's surface, through the atmosphere).[4] While in reality these two propagation modes are indeed separate, it is highly difficult to distinguish them in the experimental case and therefore, the foregoing assumption is made. In the latter case, the correlation is not so well defined, but is nonetheless most interesting.

Most DX'ers are aware of a number of seasonal changes in MW propagation, such as summer static, increased summer noise levels, and generallybetter DX conditions in winter. The reasons for these trends have many root causes, among them the length of the day and the resultant levels of ionisation, increased atmospheric noise, and temperature. While it is indisputable that the major factor in these long-term trends is the length of the daylight periods,the shorter-term variations are what we are concerned with here. The actual amount of short-term variation in measured signal intensity over signal paths ranging from a few miles up to several hundred miles is highly erratic, as it is dependent upon both frequency and distance, but it is somewhat larger than one might expect. The Godley study based upon paths ranging up to about 90 miles showed variations from peak to minimum of up to 300%.[3]

Earlier studies by F. R. Gracely, over paths of 76 to 558 miles yielded ratios of up to an astounding 2000%.[5] Naturally, as the distances increase, the number of variables which may have an effect likewise increase. Perhaps the most elementary of these is the expected variation of both air and ground temperature along the signal path. Obviously, the greater the distance involved, the greater the variation in these values of temperature. In addition, the values of ground conductivity, which vary with geography, become more important at these greater distances. For these reasons, the information presented herein will deal with paths of less than 100 miles, although the variations discussed may not be a factor until further away.

It should be understood that none of the engineering studies referenced in this article were DX-oriented, and thus no attempt was made in them to deal with greater distances of signal paths which may very well be open during parts of the year, but not at others. Readers who are interested in distant groundwave reception on the BCB are referred to articles available through the NRC by Gordon Nelson.[1,2]

Additional studies have indicated the possibility that the composition of the ground along the signal path and the vegetation located thereupon may play a part in the overall picture, but thus far, the results are both scanty and inconclusive. In addition, some of these studies have also addressed themselves to propagation by skywave as it is related to the earth surface at the bounce points along the paths.[6,7]

Throughout all of the available research, then, the most definitive factor is still temperature. In the earlier studies, only the air temperature was considered, although various comparisons were made using temperatures at the receiving site, the transmitting site, and points in between. In addition, three-day averages of both temperature and signal intensity were compared, again with similar results.[5]

In Figure 1,* we have a composite of data from the Godley study, showing the inverse temperature variations of both ground and air temperatures measured at the receiving site in Little Falls, NJ for several local trasnmitters. It will be noted that the levels of signal strength are very significantly related to the transmitting frequency. At these comparatively low distances, the length of the path is not sufficient to have any impact on the study, inasmuch as all of the distances lie between 8 and 23 miles. In a companion study, Godley showed that variations in signal intensity over paths of approximately 90 miles were indeed greater. We can even see that transmitter power over the shorter distances is not a major contributing factor to these variations. Whenever possible, throughout the period of this study, significant amounts of precipitation are noted on the graph, and throughout much of the first half of the period, the ground was actually snow-covered, to the extent that ground temperature measurments were impossible with the available equipment when the ground was snow-covered and frozen.[3]

Figure 2 depicts a cumulative two-and-one-half year measurement of the signal from station WMTR-1250 kHz., located in Morristown, NJ, 13.7 miles from the receiving site. In this presentation, we can see the effects of both short- and long-term variations as discussed earlier, superimposed upon one another. Figure 3 is an enlarged-scale version of the comparative variations of air temperature and signal intensity for the same station, over the period covered in Figure 1, which shows much more clearly the short-term variations.[3]

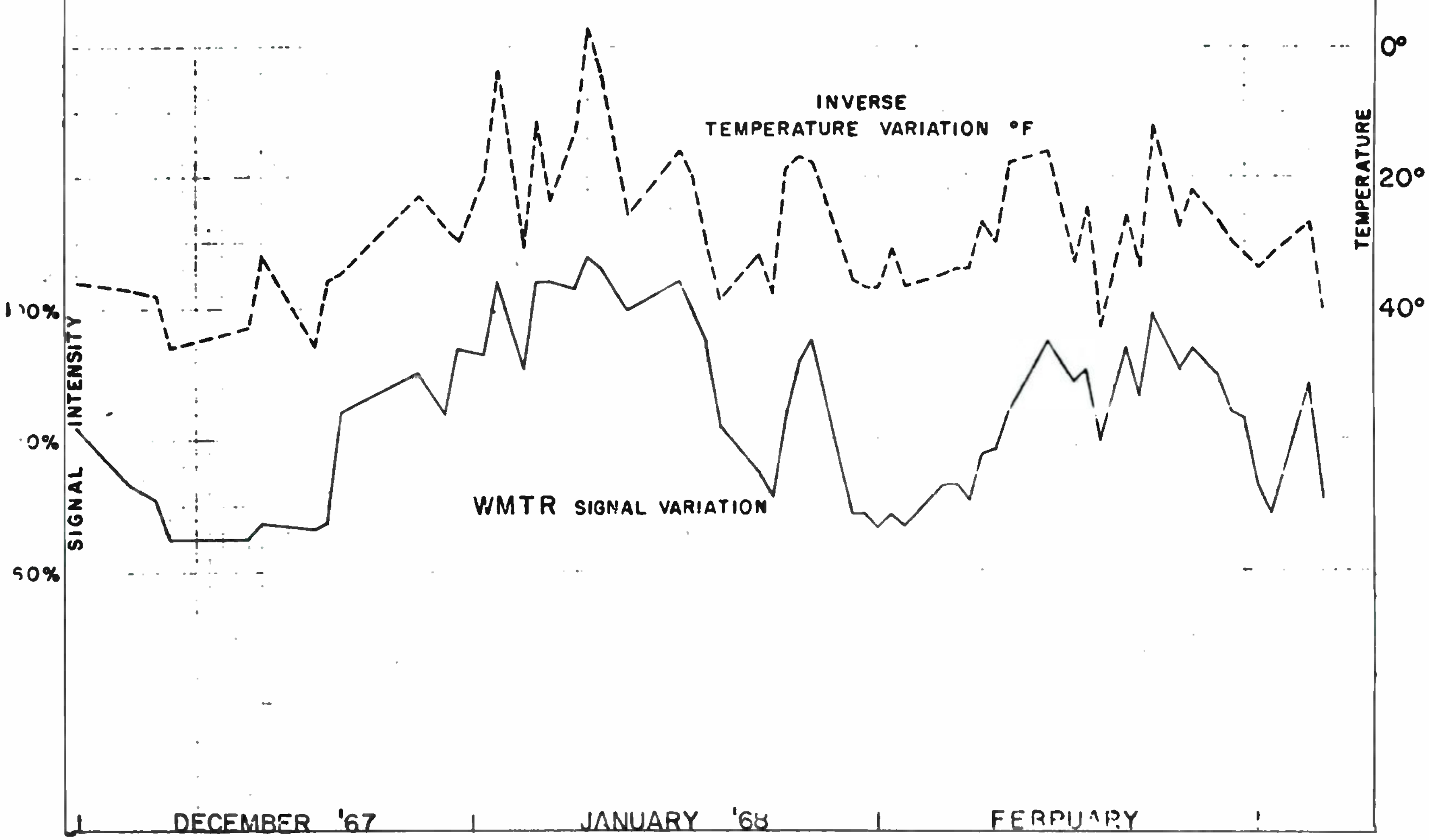
It might be useful to engage in a study to determine the total effects of power radiated in the direction of the receiver along with distance and frequency, however, to date, no such study is available. It seems reasonable to assume from the data we have that such a composite might indeed be relevant to the discussion. The author is currently engaged in pursuing the possibilities of such a project with Mr. Godley.

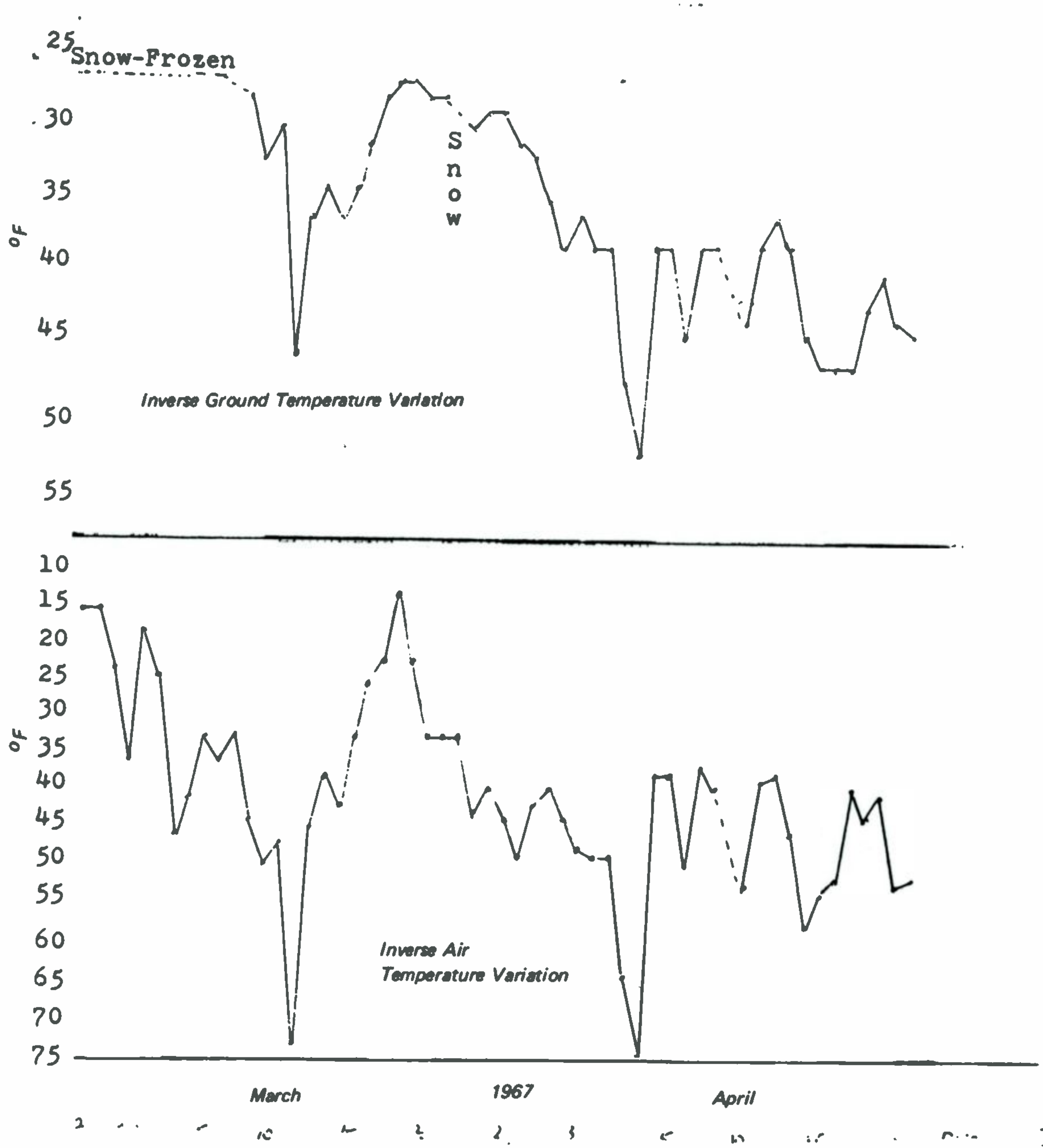
Figure 4 represents a periodic study of maxima and minima of signal variations measured in Europe over a period in excess of a year. This graph is patterned after a similar one presented by Gracely Figure 5 depicts a temperature versus signal intensity profile similar to those presented from the Godley study, also after similar diagrams in Gracely. [5]

In addition to the previously-discussed effects, Gracely suggests that there may be a maximum signal intensity at some lower-range temperature, below which temperature, the signal intensity again falls off slightly, although the data provided seem to indicate that this phenomenon may be either very frequency-selective from the middle of the band upwards, or may have even been a fortuitous occurrence, perhaps based upon some other, undefined variables. He notes also that it is difficult to prove this theory using transmitters and receivers in the temperate climates of the middle latitudes, as all of these studies have been so made, owing to the small amount of incidences of extremely low temperatures and the relative brevity of their durations in these areas.[5]((Author's note: It is indeed unfortunate that such studies were not carried out during the winter period of early 1977, when such temperatures in these areas were indeed prevalent.))

*figure 1 is on pages 12-13

Figure 3 - Enlarged scale correlation of Temperature and Field Strength for WMTR-1250





Snow-Frozen
Snow
Inverse Ground Temperature Variation
°F
25
30
35
40
45
50
55
10
15
20
25
30
35
40
45
50
55
60
65
70
75
Inverse Air
Temperature Variation
March
1967
April

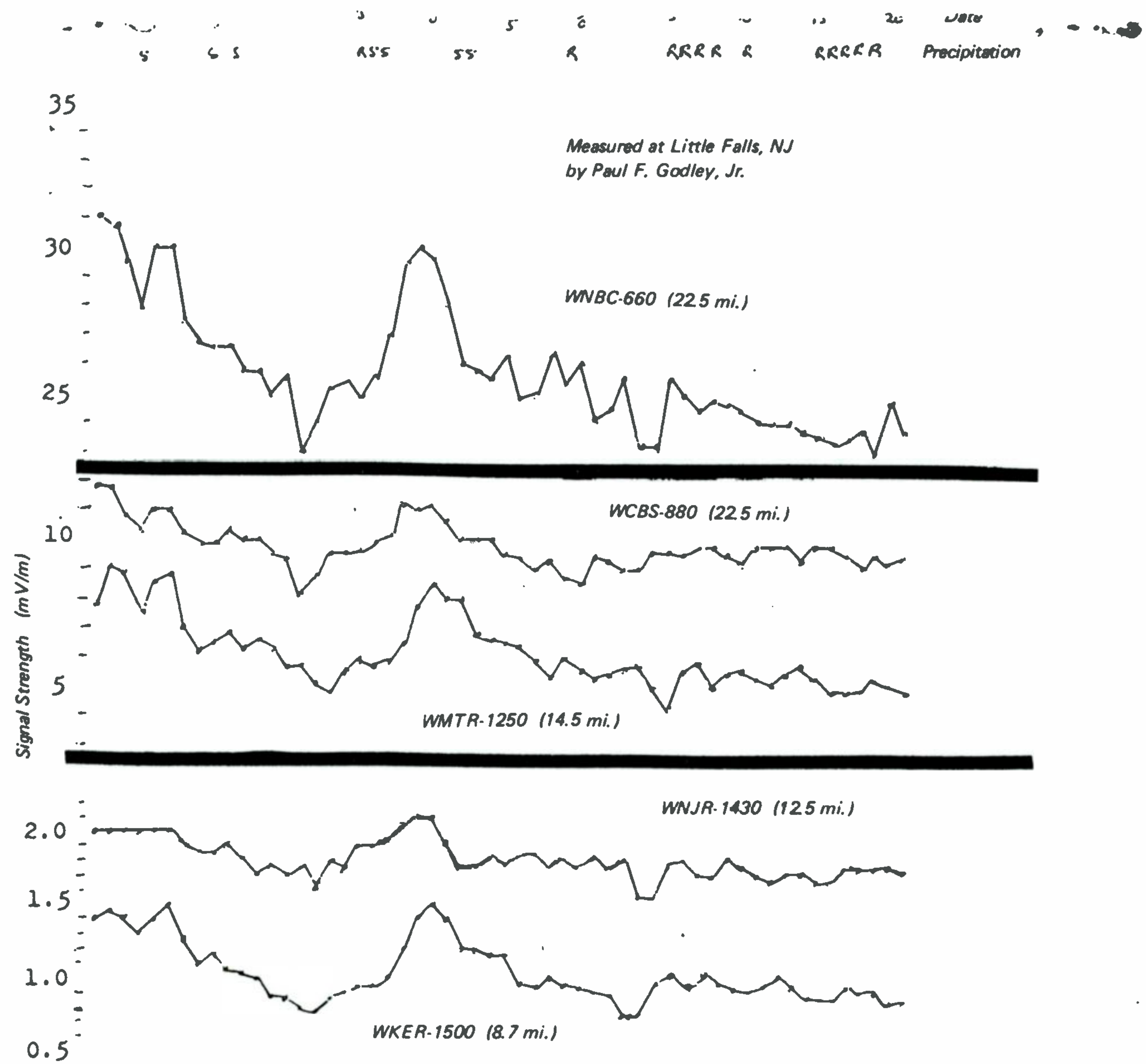
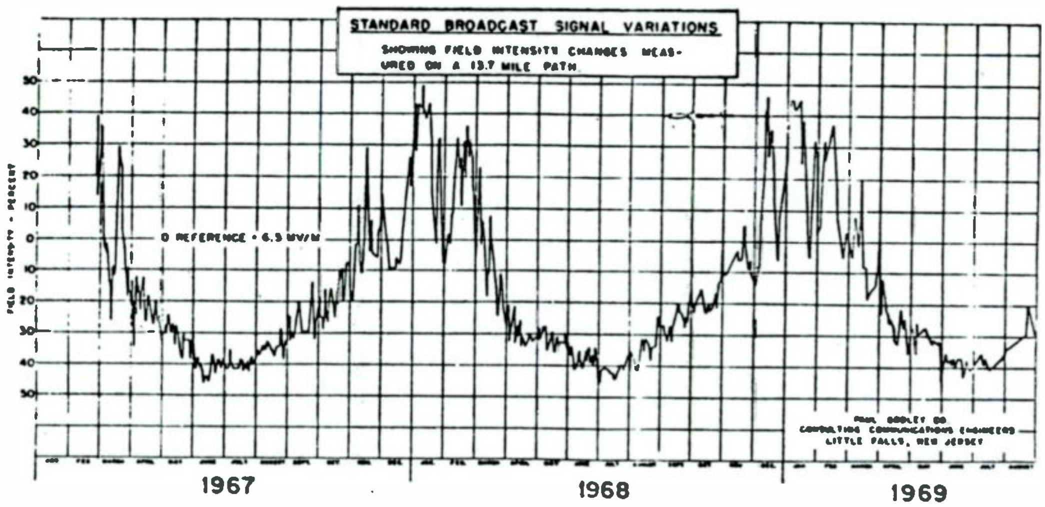
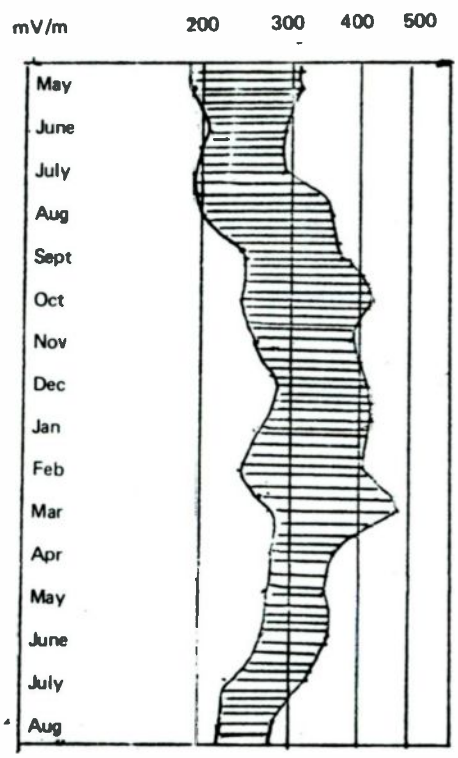

Precipitation
Measured at Little Falls, NJ
by Paul F. Godley, Jr.
WNBC-660 (22.5 mi.)
WCBS-880 (22.5 mi.)
WMTR-1250 (14.5 mi.)
WNJR-1430 (12.5 mi.)
WKER-1500 (8.7 mi.)
Signal Strength (mV/m)
35
30
25
10
5
2.0
1.5
1.0
0.5

Figure 2 - 2½-year Running Measurements of Field Strength for WMTR-1250





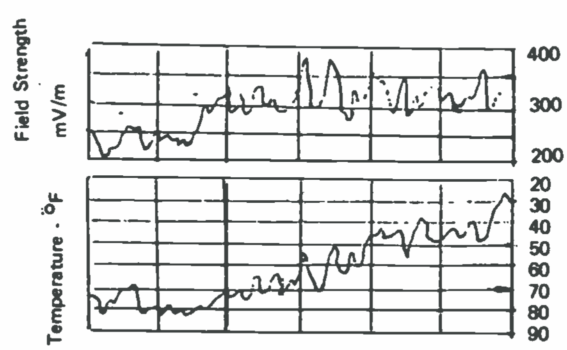
F = 1170 kHz D = 76 mi T = 1330 LT

Figure 4 - Running Graph of Field Strength Maxima and Minima over a 16-month period

←

Figure 5 - Temperature vs. Intensity Profile for 3-day averages over a 6-month period, same cx as Fig. 4

↓



Both Gracely and Al'pert discuss the possibility of precipitation with respect to signal intensity. In these studies, it was noted that during and after significant amounts of precipitation, some additional increase in signal intensity was observed, but that other factors such as the ambient ground moisture at the onset of such precipitation, the amount of runoff and evaporation must undoubtedly have an effect on the ultimate amounts of signal variation. For these reasons, no direct correlations could be made. It is believed that changes caused by the aftermath of significant precipitation at the transmitter site could have a causatory effect on the trasnmitter's grounding system which might alter not only the amount of groundwave signal actually transmitted, but perhaps the patterns (both vertical and horizontal) of skywave signals transmitted as well. This factor, coupled with the differences in precipitation patterns over the longer distances discourages any major exploratory efforts in this area.[5,8]

Many DX'ers may have noticed the effects of some minor pattern alteration caused by a heavy snow cover, or by deeply frozen ground, and may not have been aware of it. In the early 1960's, this author and other DX'ers often observed it but without any form of scientific documentation. An article by the editors of Broadcast Management and Engineering published in 1969, does make a case for better groundwave coverage, as well as local skywave coverage derived by WOR-710 when their transmitter site was relocated into a partially-reclaimed section of the Hackensack Meadowlands swamp, which tends to support the idea that significant amounts of precipitation could indeed have a material effect on how well a station may " get out " under these circumstances.[9]

It does become increasingly evident, however, that temperature variations, particularly in the extreme, do play an important role in groundwave signal intensity, and that this fact should not be lost on the MW DX'er. It is true that the practical applications of this knowledge by the DX'er are limited. Probably the best application would be a search for intermediate-range stations arriving by an "extended groundwave" sort of propagation during a spell of unseasonably cool weather, and perhaps a less noticeable corresponding skywave reception from other intermediate-range stations during periods of "reduced groundwave" accompanying a spell of unseasonably warm weather.

Acknowledgements: The author would like to extend his sincerest thanks to Paul F. Godley, Jr., for his assistance and cooperation in the preliminary stages of research for this article, and for providing the necessary data for many of the graphic presentations herein. -RjE

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ATMOSPHERIC AND GALACTIC NOISE IN THE BCB

Dallas Lankford © 1979

This article is based on Hyder's excellent discussion [1] of atmospheric and galactic noise for frequencies above 1800 khz. We also use information in the 1964 CCIR report [2]. The CCIR report has graphs like figures 1 and 2 below from which the expected values of the average atmospheric and galactic noise power can be computed for each of the four seasons and each four hour segment of the day through the frequency range of 10 hz to 100 mhz. Because the spring 0000 - 0400 graph is typical of night time noise in the BCB, we have shown a part of thatworld map of expected noise power for 1 mhz in figure 2 below. The units of the contours in figure 2 are in db above kT_0b (which will be explained in more detail below). Figure 1 allows one to compute the expected value of noise power for frequencies other than 1 mhz. For example, in the midwest near Chicago, the noise power at 1 mhz is 80 db above kT_0b. Thus, by figure 1, the noise power at 1.6 mhz is 75 db above kT_0b and at 0.54 mhz is 90 db above kT_0b.

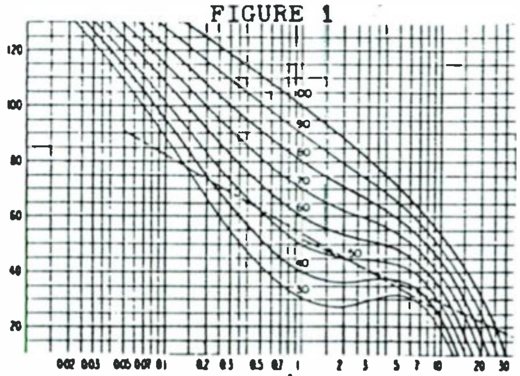
In figure 1, we have deleted the part above 30 mhz, and the parts above 130 db and below 10 db. Use of the interpolation curves has been illustrated above. There are also two broken lines. The one to the right is galactic noise. the one to the left is man made noise. In any case, the minimal noise power one can expect is galactic noise, which is about 58 db at 540 khz and 47 db at 1.6 mhz.

In figure 2, we have deleted the southern hemisphere, the part west of Hawaii and Alaska, and the part east of the Mediterranean. The contours on the graph are noise power curves at 1 mhz in db above kT_0b. Their use has been indicated above.

Several general comments can be made about the noise power based on the graphs in the CCIR report.

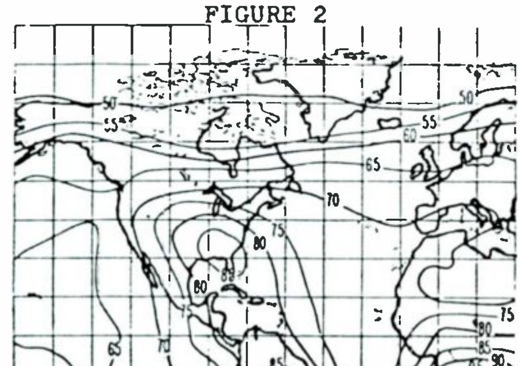
(1) Noise levels are generally higher at night than in the day.
(2) Noise levels are generally higher in the summer than in winter.
(3) Noise levels generally decrease as one gets further from the equator.
(4) Noise levels are generally higher at lower frequencies.
(5) Galactic noise is the ultimate minimum in noise power.

FIGURE 1



mhz

FIGURE 2



spring 0000 - 0400

One of the most interesting questions considered by Hyder is how much receiver sensitivity is really necessary. Although his discussion concerns the 1.8 - 30 mhz range, many of his comments and conclusions (which we reproduce below) are relevant to the BCB.

Any resistance has a thermal noise power, denoted Pt, that is independent of anything but the temperature, and is given by Pt = kTb watts, where k is Boltzman's constant, 1.38E-23 (E±n denotes 10 to the ±n power), T is the temperature in degrees Kelvin, and b is the bandwidth in hertz. In particular, the above equation holds for the radiation resistance of an antenna. For a 2.1 khz bandwidth, Pt = (4E-21)(2.1E+3) = 8.4E-18 watts at 290 Kelvin (63 F). In the CCIR report, Pt is computed for 288 Kelvin (the difference with our value is negligible), thus 8.4E-18 watts is the kT_0b mentioned above.

Let us assume we have a hypothetical receiver with a sensitivity of 0.5 μV into 50 ohms at 2.1 khz bandwidth. The thermal noise voltage is $\sqrt{Pt\ R} = \sqrt{(8.4E-18)(50)} = 0.02$ μV. In order to compare this voltage with receiver sensitivity, we must convert it from a voltage in parallel with a 50 ohm source to a voltage in series with a 50 ohm source, which we do by multiplying by two. Thus the signal to thermal noise ratio for a 0.5 μV signal is 20 log(0.5/0.04) = 22 db. The receiver is rated as having a 10 db signal to noise ratio, so the receiver has a 22 - 10 = 12 db noise figure, which we denote f. The receiver generated noise power, denoted Pr, can be computed by the formula f = 10 log((Pr + Pt)/8.4E-18). The receiver generated noise power for our hypothetical receiver is thus Pr = 1.26E-16.

We now calculate what signal levels are required to produce both 0 db and 10 db signal to noise ratios at both ends of the BCB, assuming galactic noise of 58 db at 540 khz and 47 db at 1.6 mhz. We do only the calculations for a 10 db S/N ratio at 540 khz. Galactic noise power, denoted Pg, is (8.4E-18)(E+5.8) = 5.3E-12 watts. The required signal power is 10(Pg + Pt + Pr) = 53E-12. It should be noted that thermal and receiver noise power are negligible in this calculation, but not in general. The equivalent signal voltage is $\sqrt{4PR}$ = 103 μV. The other calculations are similar, and the final results are given in the table below.

S/N	540 khz	1.6 mhz
0 db	32 μV	9 μV
10 db	103 μV	29 μV

From these figures, it is apparent that exceptional sensitivity is not necessary for weak signal reception in the BCB. In fact, it can be shown that a hypothetical 2.1 khz bandwidth receiver with a 10 μV sensitivity into 50 ohms requires a 31 μV signal for a 10 db S/N ratio, and a 10 μV signal for a 0 db S/N ratio at 1.6 mhz. Thus there is virtually no difference between a 0.5 μV sensitivity receiver and a 10 μV sensitivity receiver when used on the BCB. Evidentally these figures hold up in practice, since recent Collins receivers are rated at 10 μV for the BCB.

All of the information in the CCIR report is for a short vertical receiving antenna. The CCIR report has very little information about improvements which can be expected as a consequence of using directional antennas. We have seen it said elsewhere that balanced loops (which respond only to the magnetic field) are superior to unbalanced loops or long wires because the electromagnetic wave resulting from a lightning discharge has a larger electrostatic component. But we know of no definitive studies of this alleged phenomenon. Contrary to some recent popular misconceptions, an electrostatically shielded loop is effective only against nearby generated noise. But it still seems to us that loops we have used exhibit a noticably lower background noise in subjective listening tests relative to long wires. Perhaps this is only because a loop can be used to null local noise sources or localized thunder storms. When dealing with the ultimate limit of receiver sensitivity, galactic noise, we expect that there is no significant difference between a loop and a short vertical antenna. On the other hand, a beverage antenna may give a significant reduction in atmospheric and galactic noise, judging by user reports. So when using beverages, receiver sensitivities on the order of 1 μV may be necessary for weak signal reception in the BCB.

REFERENCES [1] H. R. Hyder Atmospheric Noise and Receiver Sensitivity, QST (Nov. 1969), 32 - 36.
[2] World Distribution and Characteristics of Atmospheric Radio Noise, International Radio Consultative Committee, C.C.I.R., Documents of the Xth Plenary Assembly, Geneva, 1963, Report 322, Published by the International Telecommunication Union, Geneva, 1964.

SPURIOUS SIGNALS

by G.P. Nelson

If you're like most of us afflicted with powerful nearby locals, you've no doubt wasted quite a few hours trying to pull an identification from a weak station on a "clear channel" only to discover that it's just a "spur" from one of your beloved locals. There is considerable confusion about some of these spurious responses and the purpose of this article is to describe some of the commoner varieties and outline their causes and cures. Most - but by no means all - of the spurious responses encountered on the BCB are the fault of the receiver and are relatively simple to eliminate once the cause is tracked down. Other types of "spurs" (external mixing products in particular) are harder to eliminate; even so it's often useful to chart them out ahead of time as we'll describe so that you will know in advance where to expect them to appear on the dial.

It's convenient to classify spurious signals into several groups on the basis of origin of the undesired signal as follows.

TRANSMITTER ORIGINATED

a. Harmonics appear only on channels that are even multiples of the original transmitter frequency. A station operating on 540 kHz also transmits a small amount of signal on 1080 (2 x 540) and so on. All transmitters radiate a small amount of harmonic signal under normal operating conditions. The FCC regulations specify only that harmonics be less than 1/10,000th as powerful as the main carrier (80 db below); in the case of a 50 kw'er, the station can legally then put as much as 5 watts into the antenna. Consequently the harmonic may be heard over quite a distance under favorable conditions without a violation of FCC regulations. The only cure is to loop out the undesired signal.

b. Parasitic radiation on the otherhand is transmitted only by a defective or improperly tuned transmitter. Parasitic radiations usually appear on both sides of the station's frequency, often on split frequencies. The audio is usually highly distorted and sounds almost like single sideband transmission; it's usually impossible to detect a carrier with the receiver BFO in addition. Some of the most widely heard parasitic radiations in past years have been from WBT-1110 (radiation on 1205 and 1015), WJR-760 (radiation on 725 and 795), and CBL-740 (radiation on 743 and 737). Note that in most cases these spurious radiations occur in pairs and on frequencies an equal distance above and below the station frequency. Station engineers usually react with considerable scepticism when informed of this type of problem and often deny its existence out-of-hand; nevertheless these radiations usually disappear immediately after the station is notified.

c. Sideband splash - the "thumping" and "banging" sounds heard on either side of a local station especially when music is being played - is almost always legal sideband radiation. Sideband splash from powerful locals is almost always seemingly reduced when mechanical filters are added to the receiver because of improved skirt selectivity (See "S.S.B. Reception on the BCB with Mechanical Filters", DX NEWS, Summer, 1967 for further information). "Overmodulation" of a BCB transmitter is quite rare due to the overly lenient nature of the archaic FCC regulations governing the amount of "splash" allowed (See "Local Sideband Splash - How Much Is Too Much?", DX NEWS, February 17, 1968). Under rare conditions a transmitter tower may suffer from modulation arcing which results in "splash" over much of the band (See "A Frequent but Rarely Discussed Cause of BCB Interference", DX NEWS, March 9, 1968).

EXTERNAL MIXING

a. Defective wiring and pipes can produce spurious signals and are responsible for many of the "spurs" experienced in large cities with several powerful stations. Figure 1 shows how this works here in Boston in the case of locals WBZ-1030 and WRYT-950. Somewhere a few miles to the East of WRYT's transmitter site there's a long piece of wire or piping with a defective soldering joint in it. This connection is corroded and behaves somewhat like the crystal in an old-time crystal receiver. The nonlinear properties of this junction cause sum and difference frequencies to be created; the wire or piping then acts like a longwire and radiates these spurious signals on a number of different frequecnies. The sum frequency, 1620 kHz (= 950 + 1030), falls outside of the band by accident in this case; likewise so does

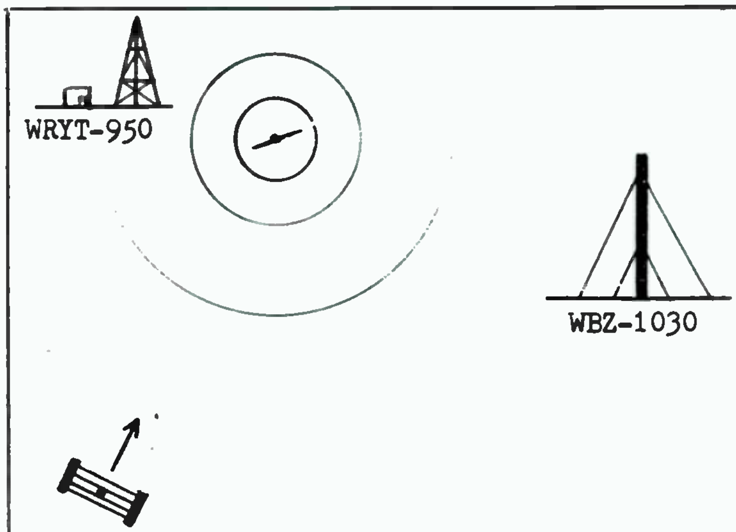


FIGURE 1. Long piece of wire or pipe acts like an antenna and picks up signals from WBZ and WRYT. Defective junction in wire or pipe acts like a mixer and produces sum and difference products on 80 kHz, 1980 kHz, 870 kHz, and 1110 kHz; mixed audio from the 2 stations is then retransmitted on those frequencies. Loop antenna null for mixing spurs on 870 and 1110 points toward the location of the mixing junction.

the difference frequency, 80 kHz (= 1030 - 950). But nonlinear junctions of this sort can also reradiate considerable energy on combinations of the difference frequency and the original channel, in this case on 870 (= 950 - 80) and 1110 (=1030 + 80). On these two frequencies, 870 and 1110, a strong signal consisting of a mixture of the programs of WRYT and WBZ is audible every day. The instant that WRYT signs off at dusk the signals on 870 and 1110 vanish of course; both signals must be present at the mixing junction if the sums and differences are radiated. The mixing junction can be many miles distant and may radiate considerable power on combination frequencies in some cases. It is important to realize that this piece of defective conductor is actually transmitting just as if small transmitters on 870 and 1110 had been set up at the location. This means that the spurious signal will be nulled out when the loop antenna faces the direction of the mixing junction and not towards either of the transmitter sites. Since the mixing junction is retransmitting only a mixture of programming on each combination frequency, a check of the channel with a subaudible heterodyne (SAH) 'scope will show only a single carrier in spite of the fact that two programs are being heard. In some cases, particularly in rural areas, the DX'er may be able to track down the defective joint or connection with a portable radio; look for wire fences with twisted joints particularly. In urban areas there may be hundreds or thousands of these defective joints scattered around the city; if this is the case the DX'er can only adopt the same philosophical attitude he does towards other urban problems such as traffic congestion or air pollution. A loop antenna may be of limited help in nulling out this type of urban spurious radiation, depending upon just how bad the problem is.

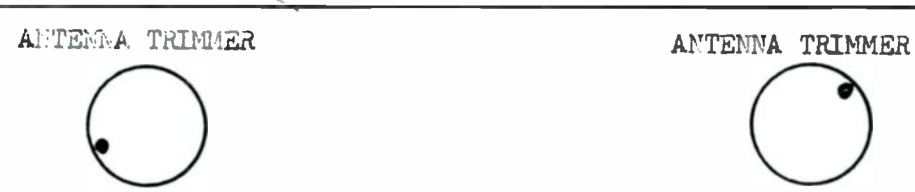
b. Receiving antennas can also have nonlinear connections of this type; for this reason all of the connections in a longwire must be soldered. A corroded connection in a longwire can produce an incredible number of spurious mixing products all over the dial; often this problem will seem to come and go if the "funny" connection is affected by the weather. Invest a few dollars in can of bottled gas and a soldering head and carefully solder all of the connections in your antenna if you suspect this to be the case.

RECEIVER DEFECTS

a. Crossmodulation is one of several types of spurious signals caused by overloading the receiver with too much signal. This type of spurious response shows as the transfer of some of the programming from a local to stations on nearby frequencies, especially on channels 10 and 20 kHz away. A local on 850 kHz would also be heard on 840 and 860 mixed in with the other stations on those channels. Cure for this and other defects due to overload is described later in the article.

b. Birdies are a type of spurious response often mistaken for heterodynes from foreign stations by novice DX'ers. Heterodynes (hets) from stations on split frequencies are tones of a single fixed pitch; as you tune across a het the loudness of the tone will vary but not the pitch or audio frequency. Birdies, on the other hand, change pitch as the receiver is tuned along the dial; programming from a local station often is heard along with the whistle. This response is usually caused by overload of the mixer stage.

c. Internal mixing produces spurs consisting of mixtures of programs from local stations on the same sum and difference frequencies described under external mixing. Internal mixing is yet another symptom of receiver overload and it is important to be able to distinguish between spurs caused by internal and external mixing since the former can be eliminated whereas the latter are usually hopeless. Figures 1 and 2 outline two different ways to tell if a particular sum or difference spur is being generated internally or externally. If you have a loop, check to see where the spurious signal nulls out; if it is caused by external mixing the null will be in the direction of the mixing site. If, on the other hand, the spur is the result of overload in the receiver, the spurious response will vanish when the loop null is pointed towards either of the two locals involved. A second check for the cause of mixing spurs makes use of the antenna trimmer control on the receiver. As the receiver is tuned to different parts of the



(a) If the mixture of WBZ and WRYT audio's heard on 870 is the result of external mixing, the spur will peak with trimmer in same position as for a real signal on 870 kHz.

(b) If, on the other hand, the spur is internal mixing because of overload in the receiver, it will be strongest with trimmer in position for reception of WRYT/WBZ.

band, the antenna trimmer must be set to different positions to peak the signal. If a spur such as our 870 WBZ/WRYT case is caused by external

mixing, the spur will be peaked up all the way when the antenna trimmer is set in the same position it would be for a real signal on 870. If instead the spur is the result of internal mixing in the receiver caused by overload, the 870 spur would not peak at the position for 870 but would peak at the positions for 950 and 1030. Both of these tests make use of the fact that an external mixing spur behaves in all ways like a signal from a real transmitter operating from the location of the mixing junction.

d. Images are a special kind of spurious response which results from a basic flaw in the design of most superheterodyne receivers (see ARRL handbook, etc., for details). Only those spurious responses which appear on channels separated by twice the receiver's intermediate frequency (usually 2 x 455 = 910 kHz away) are images! Note that most of the top quality communications receivers used on the BCB (such as the HQ-180) while advertised as "double" or "triple conversion" actually switch out the additional stages of conversion on the MW band leaving a single stage of 455 kHz conversion on the front end; such a receiver is just as prone to images 910 kHz from the true frequency as a receiver costing a third the price. While images are not strictly an overload problem, the same cures used for clearing up overload problems also help eliminate images.

ELIMINATING SPURS CAUSED BY OVERLOAD

The four types of receiver-generated spurs listed above account for the majority of the spurious signals likely to be noted by most DX'ers. Fortunately all of these problems will be reduced if not totally eliminated by the same sorts of cures. If you have serious trouble with the sorts of spurious signals listed above try the following steps:

1. Check the tubes in the receiver, especially the RF and mixer tubes. Don't use a tube that checks out as questionable; replace weakish tubes with ones testing high in the "good" scale. Weak tubes can cause both crossmodulation and internal mixing.

2. Try shortening the antenna. Most modern receivers are quite sensitive on the BCB and many DX'ers mistakenly believe that the longer the antenna the better the reception will be. Up to a certain point this is true; beyond that, however, more antenna will simply overload the receiver and create spurious responses. Experiment with the length of the antenna until a reasonable compromise is reached.

3. Get your receiver realigned with particular attention to the RF and mixer stages; this is usually effective in reducing birdies and crossmodulation.

4. Install a mixer trimmer control in the receiver as described in "The Tracking Problem - And How to Cure It", DX NEWS, Spring 1968. Some otherwise well designed communications receivers suffer from large tracking errors on the BCB and a mixer trimmer is the most effective remedy. This receiver addition often cures the most persistent of problems caused by mixer overload.

5. If you must use an outside antenna, build one of the simple antenna tuners described in past issues of DX NEWS ("A Versatile Long-Wire Antenna Coupler", Winter 1967; "A Degenerate Loop - An Excellent Antenna Coupler", Spring 1968). Antenna tuners of this type are particularly effective at eliminating true images and internal mixing spurs.

6. Replace your outdoor longwire with a good high Q loop antenna. The combination of the loop's sharp tuning properties and the lessened signal input level usually eliminates all forms of receiver-generated spurious responses. Loops are also less sensitive to locally-generated QRN.

We have often found it useful to prepare a chart showing all possible sums and differences for our local stations so that we can immediately check when we run across a weak station on a supposedly "clear" channel to make certain that it's not a mixing spur. A chart like this is particularly useful in large cities with many different combination spurs. For the sake of illustration we'll only consider 4 of our 10 Boston area locals. Lay out a checkerboard as shown below for all of the locals you want to include. Next double the frequencies of the stations; the

	WRKO-680	WBZ-1030	WCRB-1330	WMEX-1510
WRKO-680	1360 = 2 x 680 harmonic 1590 = 680 + 910 image			
WBZ-1030	(350) 1380 = 350 + 1030 mixing spur			
WCRB-1330	650 = 1330 - 680 mixing spur	(300) 730 = 1030 - 300 mixing spur		
WMEX-1510	830 = 1510 - 680 mixing spur	(480) 550 = 1030 - 480 mixing spur	(180) 1150 = 1330 - 180 mixing spur	

doubled frequencies are for the harmonics. In this list only WRKO's harmonic will be heard on the band, on 1360, and WRKO alone will be heard on 1360 since this is not a combination type of spur. Now add 910 kHz (assuming you have a 455 kHz IF) to each of the frequencies; this shows where true images will appear (again, just WRKO programming will be heard on this spur). Now we will consider the sum and difference frequencies as would arise from either internal or external mixing. Subtract each pair of frequencies; if the differences fall in the BCB you can expect a mixing spur on those channels (one carrier with a mixture of the programs from the two stations); in this case WRKO combines with WCRB and WMEX to give differences that fall within the band (650 and 830). If the differences fall below the band (350 = 1030 - 680, for example), put them down in parentheses. Now go through and add and subtract the difference frequencies in parentheses to each station; if you generate a new frequency (1380 = 1030 + 350, for example), mark it down. Also go through and add the frequencies of the stations on the bottom of the band; if the sums fall in the band mark them down also (in this case none do). In this way you will be able to build up a complete table showing where to expect harmonics, images, and sum-and-difference products from mixing. In the example above you can then expect to encounter the following spurs:

550 Mixture of WBZ and WMEX programs
650 Mixture of WRKO and WCRB programs
730 Mixture of WBZ and WCRB programs
830 Mixture of WRKO and WMEX programs
1150 Mixture of WCRB and WMEX programs
1360 WRKO harmonic
1380 Mixture of WRKO and WBZ
1590 WRKO image

In some cases it is possible for two different pairs of stations to produce spurs on the same channel; this produces a jumble of audio from all 4 stations and shows as 2 distinct carriers on an SAH display.

The Nature and DX of BCB Harmonics

Ronald F. Schatz

A harmonic is a multiple of a fundamental frequency; e.g., 1800 kHz is the "3'rd harmonic" of 600 kHz - three times the fundamental. Harmonics are created when the generating aparatus, be it sound or electromagnetic, permits a signal to heterodyne against itself to produce a sum frequency which, in turn, may recombine with the fundamental frequency to form still a higher sum, etc. Long chains of harmonics may be formed in this manner, depending upon the amount of energy in the generating system:

600 + 600 = 1200 + 600 = 1800 + 600 = 2400 + 600 = 3000 .....

Harmonics add to the esthetic quality of voice or music, and they find good use in crystal calibrators, but a harmonic radiated by a broadcasting station is a no-no. In such cases the cause may be an overdriven local oscillator in the transmitter, so that there is too much signal for the circuits to handle, or the front end (output circuits) may actually be tuned to a harmonic frequency, thanks to an incompetent station engineer, while other defects are possible in the circuitry.

In North America both the FCC and the DoT have strict regulations regarding the harmonic content of a broadcast signal, so that American and Canadian stations limit their harmonic radiations to levels that can be picked up only within a few kilometers of the transmitter site. In other lands regulations may be lax or nonexistant, such as in Latin America. There the strength of some harmonics may equal, if not surpass, that of the station's fundamental, and legal, operating frequency.

The second-harmonic "broadcast band" ranges from 1050 to 3210 kHz. Because of crowded conditions it is obvious that harmonic emissions are almost impossible to note below 1600 kHz, though the DX'er should assume that there are many present nonetheless. Only a decade ago it would have been possible to hear these low-band harmonics, but those days are gone.

So harmonic DX'ing is necessarily limited to those MW stations normally operating above 800 kHz, if we speak only of second harmonics at this point.

The place to hear harmonic emissions is on the "B" or "2" band of the average communications receiver, or the lowest SW band(s). As this is right smack in the middle of marine operations there is a lot of material present to offer both QRM and confusion to the uninitiated, so let us number some rules to follow:

1) The power output of harmonics is seldom more than a few tens of watts, so it takes a good receiver and a good ear to note most of them. Location helps too, since most of the culprits are in latin America. Harmonic DX from Florida or Texas may be fairly easy, but quite discouraging from Canada. On the other hand, a coastal location will mean more interference from marine and navigational sources.

2) Become familiar with the "B" band: Note the wide-band "noise" of LORAN centered on 1900 kHz, which kills a lot of harmonic DX in its area. Ship-to-shore AM phone communications are most common, in Spanish and French as well as English. These transmissions are of a two-way nature, play no music, and generally cut the carrier (or give a "busy" signal) between messages.

3) Look out for the 120-meter tropical band (2300-2500 kHz). Not too many stations are active here, but they will still fool the unwary. Both Guatemala and México are active on 2390 kHz during the evening. Also note 4VSO-2450, outlet of Radio 4VEH.

4) Almost all harmonics will be found on frequencies divisible by 20 kHz - this is a good rule to follow. Note the table:

800 = 1600	1100 = 2200	1400 = 2800
850 = 1700	1150 = 2300	1450 = 2900
900 = 1800	1200 = 2400	1500 = 3000
950 = 1900 (LORAN)	1250 = 2500 (WWV)	1550 = 3100
1000= 2000	1300 = 2600	1600 = 3200
1050= 2100	1350 = 2700	

5) Although a harmonic may originate from a MW transmitter, its signal is treated by the ionosphere indiscriminately according to its frequency. E.g., HIFA-1600 has a harmonic on 3200 kHz. This harmonic is propagated as a short-wave signal.

The fact above is extremely important: Any harmonic, regardless of its origin, is idemtified with the band it is found in; a harmonic of a medium-wave station is not a medium-wave signal by necessity.

With this in mind the author advocates the reporting of harmonic reception in the club bulletin of the effects are as follows:

a) Such reception confirms the existence of an otherwise unheard station.

b) The reception reveals information previously unknown on the programming, format, and schedule of the station.

But the author opposes the reporting of harmonics as an end in itself, save where the harmonic falls within the broadcast band. A description of the strength and quality of the harmonic signal itself or its propagation has no place in DX NEWS.

In other words, WILL THE INFO NOTED ON THE HARMONIC HELP ANOTHER DX'ER LOG THE STATION ON ITS FUNDAMENTAL FREQUENCY??

The author respectfully dedicates this article to Glenn Hauser, who blissfully started the whole thing.

-30-

(Note from HQ: these are essentially the same criteria long in use in DX NEWS and recently restated by the DDXD and IDXD Editors.)

R3

Subaudible Heterodynes on the MW BCB

(Second in a Series of New Techniques for the MW DXer)

The techniques to be described can enable the MW DXer to:

A. Detect the presence of weak carriers on a channel occupied by a much more powerful carrier; secondary carriers as far as 40 db below the dominant carrier can be detected.

B. Count the number of carriers on a given channel; under favorable conditions as many as 14 carriers may be characterized in this way.

C. Obtain direction finding bearings on each of several carriers on a channel.

D. Characterize even a very weak secondary carrier in a way that can make identification possible in the absence of readable audio without direction finding measurements.

These methods are completely new and original and have never before been described anywhere. Panoramic display devices such as the Heathkit Hamscan operate on an entirely different principle and are almost completely useless for DX work on the BCB. All of the examples to be cited represent actual values and receptions.

The theory of operation of this system is really very simple. Consider the case of Miramar-782 and its heterodyne with WBBM on 780. In a moderately selective receiver the Intermediate Frequency circuits pass two frequency components which correspond to the two station carriers; in particular these IF components likewise differ in frequency by 2kcs (2000 cycles per second). When these IF components reach the detector stage, the nonlinear nature of the detection process produces product mixing of the two components and thereby creates the 2 kcs difference frequency. Such a 2 kcs difference frequency is of course in the audio range and therefore is recovered along with the detected program material; this is the familiar audio het inevitably associated with the reception of stations on split frequencies. Now consider the following similar situation: say Miramar is on exactly 782.000 kcs, or equivalently, 782,000 cps, and Berg, East Germany, is transmitting at the same time on their carrier frequency of 782,020 cps. The receiver detector produces the difference frequency as before but now the heterodyne is only 20 cps and is therefore inaudible. Such SubAudible Heterodynes are familiar to all DXers; the terms "thumping","waver", and "flutter" have all been used to describe signal strength variations which were in fact due to the presence of a secondary carrier. In the special case of SAH's of less than about 8 cps, the Automatic Volume Control circuit "sees" the SAH and a truly periodic waver of the S meter needle at the SAH frequency is produced. Above about 8 cps the high frequency rolloff of the AVC filter combines forces with the inertia of the S meter movement to damp out the S meter's attempt to follow the SAH.

At this point a few points of terminology should be clarified. A pattern which is truly periodic is one which repeats itself in a perfectly regular manner every so many seconds. Certain ionospheric effects described below produce what may at first glance appear to be regular variations in signal strength; such variations are not in fact truly periodic, however, because the time interval between sucessive patterns is not constant. A secondary carrier is one that is considerably weaker than the dominant carrier on the frequency; the dominant carrier controls the demodulation process and provides most if not all of the audio information that is recovered.

For those without access to an oscilloscope, the S meter can sometimes provide information about the presence of weak secondary carriers which would ordinarily go unnoticed. Suppose you're parked on 1020 some MM with your loop pointed toward KGBS which is putting in a pretty fair signal. About 0330 the S meter needle begins to waver in a slow periodic fashion once every second or so. With a stopwatch or a clock with a sweep secondhand you determine that this S meter "flutter" occurs exactly every 1.4 seconds. You then turn your loop null in the direction of South America and observe that the periodic S meter movement is not appreciably attenuated. This observation strongly suggests that neither carrier is coming from a southern [or northern, since loops are symmetric] direction; since we already know that KGBS is located west of the receiving site, the secondary carrier must also be coming from a western (or eastern) direction. You would then probably remain on 1020 since the only

station that this can possibly be is ZCO, Tonga. Even if there is no audio coming through from the secondary carrier (it can even be an open carrier in fact), a truly periodic movement of the S meter needle means that a second carrier is definitely present and that the S meter is following the SAH.

In the oscillographic technique, a visual display is made of these SAH's in a fashion that is extremely useful to the DXer. In an oscilloscope the spot of light on the screen is swept horizontally from left to right at a regular rate by the internal sweep circuits; the rate at which the beam is swept across the screen can be changed by means of controls on the front. The vertical position depends upon the amount of voltage present at the "Y" input terminals; for SAH work this voltage comes from the receiver detector circuit. Suppose your receiver is set to 764 some October evening when conditions are good. The scope sweep is adjusted so that the beam traverses the screen once every 4 seconds. Even though Odessa-764 is putting through a readable signal, the scope display looks like Figure 1; the absence of a regular

Fig. 1. Single carrier; Odessa-764 alone on channel.

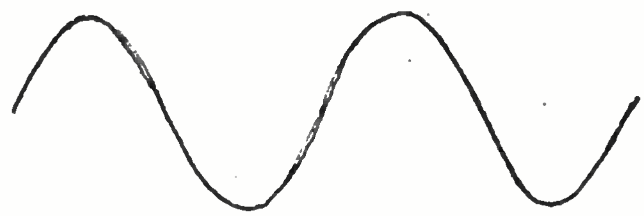


Fig. 2. Two carrier pattern; Odessa and Baghdad-764 produce 0.5 cps SAH.

pattern means that Odessa is alone on the channel. At 2122, however, the display suddenly changes to the form of Figure 2. A quite distinct sinusoidal waveform is evident with a frequency of 0.5 cps (one sweep = 4 seconds). This truly periodic waveform is the pattern of a 0.5 cps SAH; such a pattern can only arise from the presence of a second carrier. Let's assume for the sake of argument that Odessa's exact frequency is 764,000.0. [The real beauty of the SAH technique is that knowledge of true carrier frequency is not necessary, only differences count.] The 0.5 cps SAH visible is produced by Baghdad's open carrier; Baghdad of course must be on either 764,000.5 or on 763,999.5 cps; let's arbitrarily assume the higher value. Were Odessa to fade out completely or go off, the pattern would revert to that of Figure 1; if Baghdad were to off or out the pattern would similarly be extinguished.

Fade out of one of the two component carriers is not the only way that the pattern can be extinguished, however. Imagine what would happen if the loop null were pointed in the direction of Baghdad (49°): since no signal is now being picked up from Baghdad, the pattern will revert to that of Figure 1. This gives a direction finding bearing on one of the two carriers whose difference is producing the SAH. As the loop null is rotated away from 49°, the pattern of Figure 2 will again be visible until the loop null reaches the angle corresponding to that of Odessa (39°). The very same argument applies to the case where Odessa is in the loop null; the only energy then being picked up is from Baghdad so the pattern again reverts to the single carrier form of Figure 1. Thus the DXer can direction find each of two carriers on the same channel even if there is no readable audio from either station. This is the only way possible to obtain accurate loop bearings under such conditions. If one were to attempt to rely on S meter level or some other indicator of overall (i.e.,combined signal strength, one would obtain indistinct bearings at an angle intermediate between the true values for the individual stations. This and similiar topics will be discussed in a later article dealing with the techniques of high precision direction finding on the MW BCB.

But the full potential of this technique has not yet been realized. We're still parked on 764 watching the two carrier pattern of Figure 2 when suddenly the pattern of Figure 3 appears. This indicates that a third carrier has come onto the channel

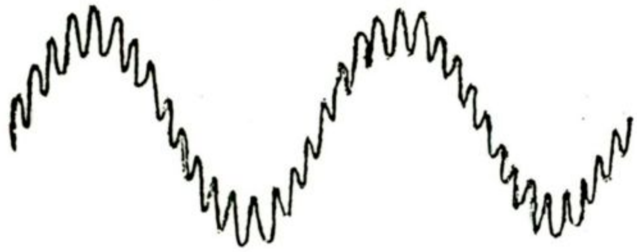


Fig. 3. Three carrier pattern; Odessa, Baghdad and SABC produce a mixture of 0.5 and 20 cps SAH's.

Fig. 4. Graveyard pattern, the sum of many individual SAH's.

on a frequency of 764,020 cps (or, of course, perhaps 763,980 cps). This new carrier is interacting with the other two carriers to produce a new SAH of about 20 cps which is now being displayed along with the 0.5 cps SAH. While rotation of the loop null to the vicinity of 40°-50° produces a slight attenuation of this new 20 cps SAH, all traces of the 20 cps component dramatically disappear when the loop null is brought to 106°; the pattern reverts to that of Figure 2. This indicates that the new signal is the carrier (probably an open carrier at first) of the SABC station at Pietermaritzburg, South Africa (located 106° from Boston). We therefore have been able to obtain good direction finding bearings on each of the three carriers on 764 without the necessity of readable audio from any of them. Were a fourth carrier to come onto the channel this process could in principle be repeated and the new SAH nulled to give a direction finding bearing on the new station. However three is usually just about the maximum number of carriers that can be accurately measured by eye without the special filter described below.

FCC regulations require that US BCB stations maintain their frequencies within 20 cps of their allocated channel; as is the case with many foreign stations, most US stations hold their carrier frequencies essentially constant but no two stations are on exactly the same frequency. This of course means that SAH's should abound on US channels and this is indeed the case. The "graveyard sound" so familiar to US DXers is indirectly the result of the jumble of SAH's produced by the interaction of the many individual carriers on one channel. While this complex SAH pattern is not directly audible, the action of this complex SAH on the AVC and detector circuits produces the "graveyard" sound. Figure 4 is the kind of SAH displayed from a graveyard channel; it is the summation of many individual truly periodic SAH's. The same type of waveform is displayed on 1484 and 1594, the European Common Wave channels. While it is impossible to untangle such a snarl of SAH's by eye, there exist a number of mathematical techniques which, when applied to the terrible jumble of SAH's on a graveyard channel, can resolve the exact number of carriers present. While Fourier Analysis is rather cumbersome, I have sucessfully appled it to the jumble on 1484 and have been able to resolve at least 14 carriers on at the same time. Unfortunately this approach requires that the waveform be permanently recorded on paper with an automatic recorder; since this is a facility not usually available to the average DXer, I won't go into specifics. Anyone interested in this problem should consult Time Series, by N. Weiner, MIT Press.

The almost unbelievable sensitivity of the SAH display to the presence of very weak secondary carriers is crucially dependent upon one tacit assumption: namely that truly periodic variations in the strength of a MW skywave signal can only be caused by a second carrier. If some natural phenomenon could produce waveforms like that of Figure 2, the power of the SAH technique would be severely limited; one could never be really certain if a given pattern were due to the presence of a secondary carrier or not. It is not at all obvious that such mechanisms do not exist; in fact there are a number of known ionospheric phenomena which could conceivably produce periodic variations in the strength of the carrier from a distant source. One of these effects, the "Luxembourg Effect", could possibly mimic the appearance of the SAH pattern from

a secondary carrier. Unfortunately little information on the "Luxembourg Effect" mechanism is currently available; much of the relevant research is classified. I have conducted an extensive literature search on the problem and have also made extensive experimental investigations during the past year. Apparently only one piece of prior research contains information relevant to the problem: in 1957 Brennan and Phillips of MIT made extensive measurements of the statistics of fading of a MW signal from a research transmitter on 543 kcs. Their paper, "Phase and Amplitude Variability in Medium Frequency Ionospheric Transmission", presents a great deal of this data in the form of autocorrellograms of amplitude envelopes; these indicate that truly periodic fades do not occur. On a few occasions, however, these workers encountered a very mysterious phenomenon which has also been observed here a few times: namely, nearly periodic variations in the absence of a secondary carrier. They concluded that this rare phenomenon could be caused by reradiation from nearby flying objects; i.e., aircraft. On the night of 11/24/64 I observed nearly periodic variations from Barbados-795 around 2000; while these variations at first seemed to be truly periodic, a more careful oscillographic examination revealed that the time interval between sucessive patterns varied by quite a bit. This strange and unexpected variation began gradually, reached a peak and gradually disappeared all within the space of about three minutes; it has not been observed since. Direction finding equipment indicated that the apparent secondary carrier was located vaguely south of Boston. It is believed that this effect was due to the presence of a slow flying aircraft approaching Boston from the south. Data on the natural resonant frequencies of certain aircraft suggests that quite a bit of airplane reradiation is possible on such wavelengths. Similiar episodes have been encountered on a few other occasions; never did the pseudo-SAH last more than a couple of minutes at most. It is believed that flying objects were also responsible for these episodes.

There are two other types of natural phenomena that can produce what appear to be periodic SAH patterns. Both effects produce what appear at first glance to be slow (1-20 cps) SAH's; however more careful examination shows that such waveforms cannot be due to secondary carriers because these patterns are not truly periodic. Auroral Flutter is the name given to the characteristic very rapid (typically 3 cps) fade of signals on far northern paths passing through Auroral regions. This flutter is the result of multipath interactions and, like airplane flutter, can be differentiated from the true SAH because the pattern is not truly periodic over the space of several minutes. This effect was very pronounced during reception of Pyongyang-655 last year; while at first encounter Auroral Flutter may seem to mimic a secondary carrier SAH, careful examination of the pattern will always reveal its true origin.

The second type of pseudo-SAH is encountered during reception of West African stations around their E20 time [roughly dawn at the transmitter site]. West African fa is very characteristic and not well understood. This type of fade produces pseudo-SAH's in the range of 0.3-2 cps and is remarkable because of the very rapid onset of the fades; typically the signal can drop 30 db in less than 500 milliseconds. This effect is especially pronounced during summer reception of such stations as Nigeria-1358, 1458; Conakry-1403; and Dakar-1304. Since the same sort of pattern has also been observed from SABC-764, 1286 and Mozambique-737, it seems likely that such disturbances in transequatorial signals are the result of the tropical Sporadic E or spread F associated with the Equatorial Electrojet. Were decent reception of trans-equatorial DX possible during the Northern Hemisphere winter, the exact mechanism of West African fade might be resolved; unfortunately the combination of unfavorable E20 and European QRM makes such transequatorial reception very difficult.

After a year of very careful research on the problem, I can state that virtually all truly periodic patterns observed were due to the presence of secondary carriers, and not to propagational effects. The best rule of thumb to eliminate patterns possibly due to Auroral or West African flutter is the following: if the scope display shows truly periodic patterns of constant frequency lasting for more than 5 minutes, there must be at least one secondary carrier present. Every night I see a 16 cps SAH on ZBM1-1235 but I've never been able to get any audio from the second station. Nevertheless, because this SAH is always there and consistently loops Colombia, I'm certai

that there is a HJ station there. Without the scope the second carrier would go unnoticed.

Before describing how to connect the oscilloscope to the receiver in order to display these SAH's best, let me briefly discuss just what is required of an oscilloscope for this application. Experience indicates that the following properties are desirable: 1) High input impedance, at least 500 k to prevent loading of the AVC or detector circuits. 2) Provision for very slow sweep speeds, 5 seconds per sweep or more. Most scopes do not go this low; be certain that there is provision for a slow sweep external capacitor. Medium or long persistence phosphor on the screen (P1, P2 or P17). A short persistence phosphor does not leave the glowing trail essential if one wishes to display several seconds of record at one time. 4) A five inch screen is vastly more desirable than a 3 inch screen for the same reason that a long persistence phosphor is desirable: more data can be displayed at once.

Eico produces a suitable 5-inch scope kit, the model 460K for $119.95; the assembled version goes for $169.95 An eminently suitable obsolescent scope, the Dumont 304H, is available for less than $50 from many of the surplus dealers who advertise in the Ham magazines. Rather than being an esoteric piece of gear suitable only for watching SAH's, the oscilloscope is without a doubt the most versatile piece of test gear in existence. It can measure frequencies, voltages and impedances; test amplifiers and trouble-shoot receivers. In fact it can do almost anything but write reception reports.

The simplest way to connect the scope to the receiver is to run a shielded cable (same type as used in audio work will do) from the receiver AVC line to the AC "Y" scope input as shown in Figure 5. While one must dive into the circuitry of the receiver, it is a very simple and noncritical modification. Locate the first RF tube of the receiver; in a receiver which lacks an RF stage, find the first IF tube and proceed the same way. On the pin corresponding to Grid number 1 there will be found a resistor with a very high value, typically 500 k- 2 megohms; this is the AVC isolating resistor. To the side of this resistor AWAY from the tube socket attach the center conductor of the cable. Connect the braided shield of the cable to any convenient chassis ground. Run this cable to the scope AC "Y" input; connect the center conductor to the input terminal and the braided shield to the ground terminal. And that's all there is to it. If you are hesitant about diving into your receiver, take it to any radio repairman and tell him to attach a shielded cable to the AVC line. It should only take a few minutes and will cost next to nothing. The voltage on this line is only a couple of volts at most and provides no shock hazard whatsoever; it should not be shorted, however, or the gain of the receiver will be seriously affected. Once properly connected to the scope, this line can be left in place whether or not the scope is in operation; the high impedance of the scope input guarantees that the receiver doesn't even "see" the connection.

It must be kept in mind that the waveforms displayed on the scope in this fashion are not audio waveforms; essentially no audio frequency signals get past the AVC filter. There are a number of applications for which the DXer may desire an audio display. An audio display will permit exact measurements of the audio frequency of tone tests, an item which can be handy when writing reception reports to stations conducting equipment test. A rather amusing application of the audio display occurs in connection with certain low powered Latin American stations. Since many of these stations use homebrew transmitters with inadequate power supply filtering, display of the carrier hum can frequently tell the DXer whether the station is operating from a 50 or 60 cycle power line! An audio line suitable for such displays can be connected to the receiver at the same time that the SAH line is installed. The audio connection can consist of a piece of shielded cable whose center conductor is attached to the MIDDLE terminal of the receiver volume control potentiometer; the braided shield is connected to the chassis ground. Of course the SAH line must be disconnected from the scope terminals when audio waveforms are to be viewed.

This simple connection to the AVC line can provide the DXer with an entirely new "view" of DXing. For the technically oriented DXer, Figure 6 shows the method used to

obtain the ultimate in interference-free <u>single SAH displays</u>. An infinite impedance detector is used to feed a variable low frequency bandpass filter prior to scope display to remove most of the visual "noise" that is ocassionally a nuisance encountered during AVC line displays. Such a device will provide a display of a single SAH (for example, only the 20 cps component of Figure 3) and is the next step beyond SAH displays from the AVC line. Discussion of such devices is beyond the scope of this article; details will be supplied upon request.

While the SAH technique that I have described may appear to be rather technical, one scope display is worth a thousand words. Only by <u>watching</u> a DX channel can you really be certain exactly who is there!

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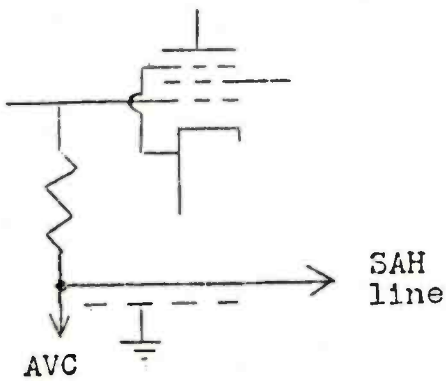

Fig. 5. Method of connecting the SAH line to the receiver.

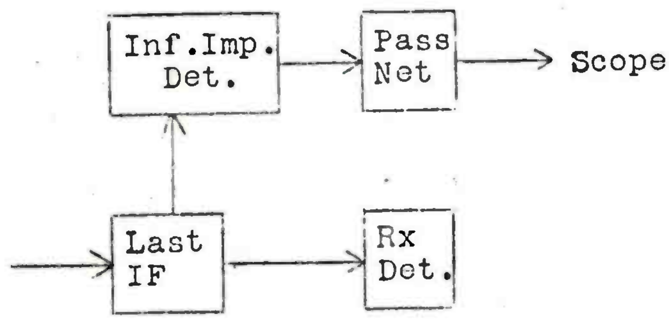

Fig. 6. Bandpass network connection for the ultimate in SAH displays.

Fig. 7. Pseudo-SAH of the effect described as "airplane flutter"; note the lack of true periodicity.

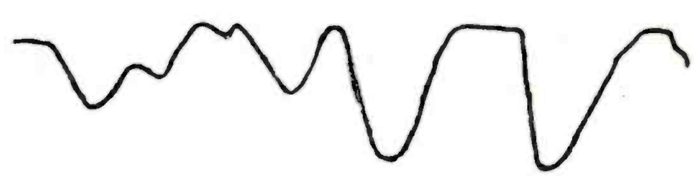

Fig. 8. Typical "West African" pseudo-SAH; again note lack of true period.

obtain the wideband in interference-free signals SSB channels. To [illegible] tape-[illegible] detector is used to feed a variable low frequency [illegible] filter prior to audio display to ensure one of the visual [illegible] by a [illegible] produc-ered during AVC line displays. Such a device will provide a display of a single [illegible] (for example, only the 10 cps component of Figures [illegible] in the [illegible]) SSB display from the AVC line. Discussion of such [illegible] is beyond the scope of this article; details will be supplied upon request.

SUPPRESSION OF INDUCTIVE INTERFERENCE

THE CONTROL OF RADIO INTERFERENCE FROM TELEVISION RECEIVERS

On September 24, 1964, the Minister of Tranport amended the Order Respecting the limits of Radio Frequency Noise made by Order of November 25, 1963, to control radio interference from television receivers.

The following extracts from the Radio Noise Limits Order apply:

ORDER RESPECTING THE LIMITS OF RADIO FREQUENCY NOISE

1. Short Title - This Order may be cited as the Radio Noise Limits Order.

2. Interpretation - In this Order:

   (a) "Department" means the Department of Communications; (s 100, c28, 1968-69)

   (c) "Minister" means the Minister of Communications; (s 100, c28, 1968-69)

   (d) "Radio frequency noise" or "radio noise" means any electrical disturbance:

      (i) produced by any mechanical, elctrical or other device, line, system, apparatus or equipment, and

      (ii) capable of being received by a radio receiving apparatus;

   (e) "Television receiver" means a radio receiving apparatus intended for use by the general public for the reception of television broadcasting, including colour television.

"PART II"

Limits for Radio Noise from Television Receivers: (SOR 64/405)

8. This part applies to television receivers manufactured in Canada or imported into Canada on or after April 1, 1966.(SOR 64/405)

..../2

9. Radio frequency noise produced by a television receiver at any frequency between 535 and 1610 kilocycles and conducted over the power supply lines of the television receiver shall not exceed:

(a) 100 micro-volts (R.M.S.) if the television receiver is manufactured in Canada or imported into Canada before April 1, 1972, and

(b) 40 micro-volts (R.M.S.) if the television receiver is manufactured in Canada or imported into Canada on or after April 1, 1972. (SOR/67-407)

10. (1) A television receiver of each type or model to which this Part applies shall, at the time it is first manufactured in Canada or imported into Canada, be tested to determine that the radio frequency noise produced by it does not exceed the applicable radio frequency noise limit prescribed by section 9. (SOR/64-405)

(2) Where any change is made in any type or model of television receiver that is liable to affect its electrical characteristics, including any major change in a metal cabinet or a change from a metal to a non-metal cabinet or vice versa, a sample of that changed type or model of television receiver shall be tested in order to determine that the radio frequency noise produced by it does not exceed the applicable radio frequency noise limit prescribed by section 9. (SOR/64-405)

(3) A television receiver of each type or model tested pursuant to subsection (1) or (2) shall be taken from the production line at reasonable intervals and tested to determine whether that type or model of television receiver continues to comply with the applicable limit for radio frequency noise prescribed by section 9. (SOR/64-405)

11. (1) Subject to section 12, all tests to determine radio frequency noise shall be made as follows:

(a) a signal shall be fed to the television receiver through a resistive pad that has an attenuation of 20 decibels and provides a path of less than 420 ohms impedance to ground from each terminal to which the receiver is connected;

(b) the power supply to the television receiver shall pass through a power line impedance stabilizing network consisting of an inductor of 5 microhenries in series with each power supply conductor, with a by-pass capacitor of 1 microfarad connected in series with a resistance of 1 ohm from each power supply conductor to ground on the supply side of the inductors;

. . . /3

(c) the radio noise level (voltage) shall be measured on the receiver side of the stabilizing network between each power supply conductor and ground;

(d) the user operating controls of the television receiver shall be adjusted for maximum conducted radio noise; and

(e) the tests shall be made in a screened enclosure with the power line impedance stabilizing network mounted on and solidly grounded to the floor of the enclosure.

(2) The voltage measuring instrument shall present a 50 ohm resistive load to the circuit and shall be connected via a coupling capacitor between the power supply conductor and solid ground, the other supply conductor being also connected via another coupling capacitor and a 50 ohm resistance to ground.

(3) The coupling capacitor shall each have a value of not less than 1/10 microfarad.

(4) The measurements shall be in micro-volts (R.M.S.) and the measuring set-up shall be arranged and measurements made in accordance with good engineering practice.

12. Where a television receiver is to be tested pursuant to subsection (3) of section 10,

(a) if the measured radio noise of the original receiver was within the limits specified in section 9 by a margin of at least 4 decibels; and

(b) if any changes in styling or other changes in non-metallic cabinets are changes that have no effect on the electrical characteristics of the receiver or its antenna,

continued compliance with section 9 may be ascertained by using a broadcasting or communications receiver to compare aurally or by other means the actual interference picked up from the receiver used in making the original measurements with that produced under similar conditions by the receiver being tested.

13. Records of measurements and tests made to ascertain compliance with this Part shall be retained for at least three years and shall upon the request of the Director, Telecommunications and Electronics Branch of the Department, be made available to him.

* Since 1970 Director General Telecommunications Regulation

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Explanatory Note

For the purpose of applying the testing requirements of section 11, the procedure as outlined in the IRE standards on radio interference, method of measurement of conducted interference output to the power line from FM and Television Receivers, published in the September 1961 issue of IRE, is appropriate.

Television Interference

by Bruce Portzer

BCB DXers usually are in the hobby only a short time before they learn that TV sets and DX listening don't mix very well. Nearly all television sets emit a raucous buzz throughout the broadcast band. In some cases, the noise in the form of a "noisy" carrier every 15 kHz, extends well into the shortwave bands. These carriers are caused by the horizontal oscillators in the sets. The oscillators themselves are "locked" to sync pulses transmitted by television stations and are rich in harmonic content, the result being that all sets generate the harmonics at the exact same frequencies (to within a few fractions of a hertz). The main difference from set to set is the strength of the harmonics. On some, the problem is barely noticeable on a radio next to the set. Others can interfere with local AM stations on car radios over 40 feet away.

What can be done to solve the problem? Very little actually. The most effective cure is to turn off the TV. Unfortunately this solution is not always enthusiastically welcomed by the person(s) watching the TV. A second possibility is to move either the TV or the receiver and/or antenna. This solution is not always practical, especially if your wife is watching her favorite program on the 200 pound console TV while, ten feet away, you're trying to hear Falkland Islands on your R-390A.

Two solutions which might work are mentioned in ARRL's Radio Frequency Interference manual. One is to install a high pass filter at the set's antenna terminals. The filter should be the same type that is used to prevent CB and ham interference. A second possible solution is to use an AC line filter at the TV set. While most TVs have such filters built-in, external filters have been known to reduce or eliminate the TV birdies. The use of antenna or line filters is based on the assumption that the interference is radiated along the TV antenna lead-in or through the AC lines. If it's radiating straight out through the cabinet, you're out of luck. I'd be interested in knowing if anyone has had any success in using these or other methods to reduce or eliminate interference from TV sets.

TVI Frequencies:

534.965	723.776	912.587	1101.40	1290.21	1479.02
550.699	739.510	928.321	1117.13	1305.95	1494.76
566.433	755.244	944.055	1132.87	1321.68	1510.49
582.167	770.979	959.790	1148.60	1337.41	1526.23
597.902	786.713	975.524	1164.34	1353.15	1541.96
613.636	802.447	991.258	1180.07	1368.88	1557.70
629.370	818.181	1006.99	1195.80	1384.62	1573.43
645.104	833.916	1022.73	1211.54	1400.35	1589.16
660.839	849.650	1038.46	1227.27	1416.09	1604.90
676.573	865.384	1054.20	1243.01	1431.82	1620.63
692.307	881.118	1069.93	1258.74	1447.55	1636.37
708.042	896.853	1085.66	1274.48	1463.29	

These are the harmonics of the TV horizontal oscillator which operates at 15.734264 kHz. This is the frequency used by color TV stations (which comprise virtually all U.S. and Canadian broadcasts). A TV set tuned to a black-and-white only station would generate birdies at slightly different frequencies.

SUPPRESSION OF INDUCTIVE INTERFERENCE, CROSS-MODULATION, INTERMODULATION AND SWAMPING.

0. INDEX

"SUPPRESSION OF INDUCTIVE INTERFERENCE, CROSS-MODULATION, INTERMODULATION AND SWAMPING"

1. MODULATION THEORY

1.1 Foreword.

In order that the problem may be understood it is necessary to make a very brief statement on the theory of modulation of electromagnetic waves.

1.2 Description of an Electromagnetic Wave.

An electromagnetic wave can be described in the most simple sense by three parameters, i.e. "Measureable Characteristics", amplitude, frequency and phase. In a sense, the amplitude is the "Size" of a wave, usually defined in terms of current or voltage. The frequency is the number of times that the wave changes sign per second. A wide range of frequency can be encountered. In North America the power frequency is usually 60 Hertz (cycles per second); in Europe and much of Asia 50 Hz. For communications purposes, waves with frequencies between 10,000 and 40 billion Hz are used. The phase of a wave defines the times at which it momentarily has a value of zero. In principle, if a wave could be examined, one could observe these three parameters and that would be all that could be obtained from it. However if any one of these parameters be systematically varied in a manner relating to the content of a message, this message, with minor impairment, can be extracted from the received wave. In the standard broadcast band, 540 KHz to 1680 KHz, the amplitude of the wave is varied. For the FM broadcast band, 88-108 MHz, the frequency is varied. For monochrome television, amplitude is varied for the picture transmission and the frequency is varied for the sound transmission. With colour television, the monochrome picture content is transmitted by varying amplitude, the colour picture content by varying phase and frequency and by varying frequency only for sound. The above presentation of television is severely over-simplified. Modulation is an essential part of the process of conveying and receiving desired material and many cases of interference result from occurrence of inadvertent modulation processes.

1.3 Modulation and Multiplicative Processes.

Much engineering skill has been applied to the task of modulating a wave with the content of a message wave but the techniques have an essential common feature; multiplication. The two waves are fed to a device wherein they are combined in such a manner that the instantaneous mathematical values of the output wave are determined, in part by the products of instantaneous values of the individual waves. The separate waves can also be present and more complex terms as well. This multiplication process takes place whenever one or more waves pass through a non-linear circuit component.

To clarify this somewhat, it will be necessary to discuss linearity and non-linearity of electronic components. A component is described as linear if, when a varying voltage is applied and the current measured and plotted against the voltage with uniformly divided scales of current and voltage, the resulting graph is a straight line. If the line is not straight the element is called non-linear. If two voltage waves with different amplitude,frequency and phase parameters, especially frequency, be applied to a linear circuit element, the current wave flowing in that element can be described exclusively in terms of the sum of the two original waves. If the element is non-linear such will not be the case; the instantaneous values can be described only by including terms obtained by multiplying the instantaneous values of the waves. When such a wave is described in terms of individual component waves, there will be found not only waves of the original frequencies but additional waves with twice the frequency of each of the original waves and in some cases, additional components, whose frequencies are the sum or difference of the original frequencies, will be found as well. Passive elements such as resistors, capacitors and inductors are almost absolutely linear but amplifying or rectifying elements are inherently non-linear. In the case of rectifiers, the non-linearity is either acceptable or required; in amplifiers the non-linearity can be very largely compensated over a satisfactory operating range by highly developed engineering techniques. However when an amplifier is subjected to excessive input i.e. a wave of amplitude exceeding its operating range, during a part of every cycle it will be driven into non-linearity and the modulation effects can result in unwanted signals affecting its behaviour. In some cases the effect is that an amplifier ceases to amplify; such an effect is known as "Blocking". Modulation interference effects are classed into two modes, intermodulation and cross-modulation.

1.4 Intermodulation.

The general case of application of two voltage waves of different parameters, (especially frequency) to a non-linear element producing current waves which can be described in terms not only of the two original frequencies but also of the sum and differences of those frequencies has been described above. If the frequency of one wave is very much higher than that of the other and if the amplifiers concerned are constructed to respond only to a band of frequencies centred on the higher frequency, the result will be the original higher frequency and two other frequencies which are the sum and difference of the two original frequencies. These waves are usually referred to as "Side Bands". The process by which waves of new frequencies are produced when two waves enter a non-linear circuit component is known as intermodulation.

1.5 Cross-Modulation.

As mentioned above the modulated wave can be described in terms of a number of separate waves. When two modulated voltages are applied to a non-linear element it can happen that among the other waves that will be produced, there will be one in which a desired carrier and its side bands are accompanied by another wave consisting of the same desired carrier but with side bands corresponding to an unwanted modulation. Such a case is called "Cross-Modulation". It is essentially a special case of intermodulation.

1.6 Swamping.

This is not exactly a modulation process in the sense that intermodulation and cross-modulation are. It depends however on non-linearity of amplifying devices and the term applies to a case where an excessive signal drives an amplifying element into non-linearity. Swamping usually takes one of two forms:

(a) If it occurs in the R.F. or I.F. stages, the stage can be disabled for the duration of the signal. If the disabling of the amplifier is continuous the observed effect will be a cessation of sound. If such disabling is intermittent, the wanted signal may appear intermittently during the times that the interference is absent.

(b) If it occurs in the audio frequency stages, the modulation of the interference signal may dominate the device's output.

2. CONTROL OF MODULATION INTERFERENCE

Such interference can be controlled only by keeping unwanted signals out of amplifiers. Once the intermodulation process has caused signals of unwanted modulation to accompany those with wanted modulation in the same frequency band, it is inherently impossible to remove them. In case of two speech signals sometimes the ear can listen to one instead of the other but in an apparatus, except in cases of extremely sophisticated signalling systems and circuit design, nothing can be done at this point. This bulletin is therefore concerned with methods of preventing unwanted modulated signals entering amplifiers. Most interference cases arise because the steps necessary to do this have not been taken during manufacture. It must be remembered that domestic equipment has been made at various times, especially before use of high power transmitting equipment in residential areas started to become common. To a degree this problem may not have existed at the time of manufacture. Thus shielding or filtering necessary to control it was left out of the sets because it was in most cases unnecessary and in all cases would be somewhat expensive. Its unnecessary introduction would cost the manufacturer competitive advantage and loss of business. It must be noted that the fault usually lies in the equipment suffering interference, not in the equipment causing it. In most cases such equipment is operating within its licence. If it is suspected that a source of interference is operating other than as licenced, the case should be referred to the Department of Communications.

In the following paragraphs, modifications to domestic electronic equipment to render it less susceptible to interference will be described. Because most such equipments use voltages which are dangerous to human life it is recommended that "Mods" be incorporated by qualified technicians. A further reason for this is the increasing use of printed wiring and "Miniaturised" circuitry which accompanies the growth in use of solid state electronic devices. Such equipment is far more susceptible to damage than tube-using equipment with "wired" wiring.

3. LOCATION OF MODULATION ELEMENTS.

The non-linear element causing modulation interference can be either without or within the equipment affected. They are described as external and internal modulation respectively.

3.1 External Modulators.

The most common sort of external modulating element consists of a corroded joint between two pieces of metal, especially two pieces of dissimilar metal. This is most likely to occur if one of the pieces of metal is copper or copper alloy such as bronze or brass. Copper forms two oxides of which one, cuprous oxide, along with copper or another metal, can be used to constuct a rectifier. At one time copper-oxide rectifiers were quite important commercially. If such a joint occurs in an element of sufficient length to intercept a moderate signal strength it can intermodulate two signals and reradiate them and any set picking up these reradiated signals is liable to suffer interference. Any corroded metal joint can cause such interference because, although the non-linear element so-formed would be of quality far lower than acceptable for construction of apparatus, its effect in producing interference can still be too great to be tolerable. Thus metal joints in clothes lines constructed with wire can be trouble-sources or the metal flashing on a roof, a connection to a ground terminal, a T.V. receiving antenna mast, accidental contact between metal parts in a house, especially if this is intermittent, accidental contact between a metal-foil vapour barrier and other metal parts of a house, wire mesh beneath stucco, fire escapes, telephone lightning arrestors. When an equipment suffers interference from such a mechanism it is because the interfering signal has been rendered, to the apparatus, essentially indistinguishable from the desired signal and the only remedy is to locate and eliminate the defect. Location is described in paragraph 3.2, its elimination in paragraph 3.3.

3.2 Location of Elements Causing External Modulation.

The effect of an external modulator is not significantly different from that of an internal modulator in the results that it produces so observation of the characteristics of the interference is not helpful in determining whether it is internal or external or if it is external, locating it. However it may be observed that in a certain room, an equipment cannot be used but that it can be used elsewhere. In such a case, it would be worthwhile to try to determine whether or not the interference source is internal or external to that set. The easiest way to investigate this is by use of a portable receiver capable of operating in the same frequency band as the set observed to be affected. Normally, the interference, if the source is a cross-modulator, will be louder, the closer one can move to it. Shaking a floor or guy wires or ground wires of a T.V. antenna may be observed to make the cross-modulation come and go. In some cases the cross-modulator may actually be a rectifier of another A.C. powered device requiring direct current for its operation. In such a case the interference would be eliminated if this set were not operating. Fluorescent lamps have been known to cause cross-modulation on account of a non-linearity of the discharge.

3.3 Elimination of External Modulation.

If some junction or article has been identified as the source of external modulation a number of remedies may be applicable.

(1) If it is a joint which should normally be conductive it should be either tightened securely or soldered.

(2) If the metal parts are not normally required to be in contact, they can be either permanently separated such as by introducing insulating material or they could be securely connected, if it is optional whether they be connected or not. The principle here is that either complete insulation or complete conduction will equally well eliminate an external modulator.

(3) If the external modulator is a rectifier in some other apparatus it can be bypassed with a small capacitor, of the order of .05 microfarad. If this is not sufficient an additonal .001 microfarad R.F. capacitor should be added. The point to be observed here is that the capacitive reactance of a capacitor does not continuously decrease as the frequency increases; at some frequency a capacitor becomes resonant and develops inductive reactance at all higher frequencies. This effect in a given capacitor can be countered by shunting it with another much smaller unit in which this change from capacitive to inductive reactance takes place only at a much higher frequency.

3.4 Internal Modulation.

Internal modulation unlike external modulation, cannot usually be remedied by elimination of a non-linear element, because, almost always, it is a component necessary to the set, the interference resulting from unwanted signals reaching it. A possible rare exception is an imperfect solder joint, easily repaired by momentarily melting it with a soldering iron and letting it freeze. The remedy, then is to:

a) prevent the unwanted signals from entering the equipment and/or

b) prevent such signals within the set from reaching non-linear elements.

In practice, simple prevention is impossible but by reasonable effort, access by unwanted signals to the non-linear elements of a domestic electronic apparatus can be reduced to a level far below the as-manufactured condition and usually to the point where it is negligible.

3.5 Elimination of Internal Modulation Interference.

3.5.1 Measures to reduce stray fields inside set.

3.5.1.1 Loose Enclosure.

If a set has a box chassis with a bottom plate, clean and tighten all connections between them.

3.5.1.2 Missing tube shields.

If a set uses tubes, check that shields are used on all sockets capable of accepting them.

3.5.1.3 Chassis lacking bottom plate.

If a set has a box chassis but no bottom plate; add a bottom plate, taking care (a) to avoid creating a shock hazard and (b) to allow ventilation; most tube sets produce heat which if not removed by air currents can cause damage. Wire screen is almost as effective as solid sheet but impairs ventilation much less.

3.5.1.4 Apparatus using tubes but lacking shield sleeves.

If the early stages of a tube-using apparatus lack sleeves for mounting tube shields, a temporary installation of tube shields should be tried (improvising a connection to the chassis) to see if they will help. As a last resort, since replacing a socket can be troublesome, sockets for the initial stages could be replaced with sockets with tube-shield sleeves, or the sleeves and shields could be added.

3.5.1.5 Apparatus with remote speakers.

The most common entry point of strong radio or radar signals into an amplifier system is via the loudspeaker leads. This is because most good quality amplifiers have a feedback loop which couples a portion of the audio output signal back to the earlier stages to provide some degeneration for imporved frequency response. Thus any signals picked up on the loudspeaker leads will find an easy path of entry to the early stages of the amplifier which are the most sensitive. Interference is then amplified along with the desired signals.

Recommended cures for the above are:

3.5.1.5 (i) Replace the speaker leads with shielded wire, grounding the outside metallic braid to the amplifier chassis. (See sub-section 4.6.)

3.5.1.5 (ii) By-pass the loudspeaker leads to the amplifier chassis using 0.01 mfd to 0.03 uF disc ceramic capacitors. See sub-section 4.1. Keep all leads as short as possible. See Fig. 3.5.1.5 (ii).

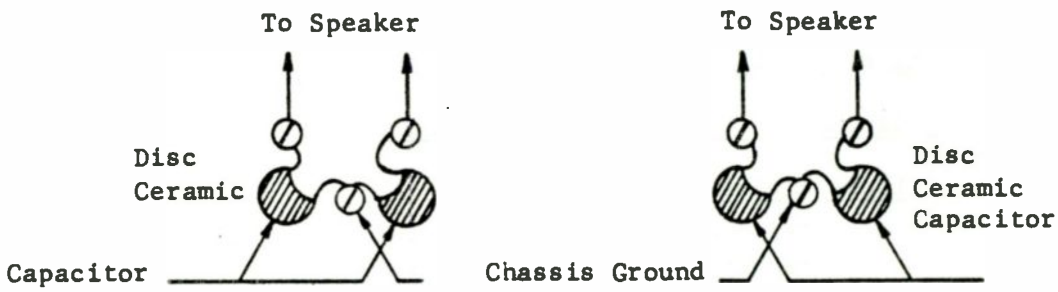
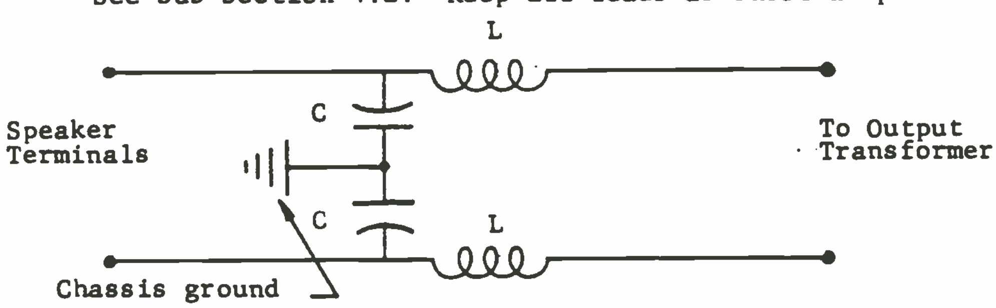


Fig. 3.5.1.5 (ii)

R.F. By-Passing speaker leads

3.5.1.5 (iii) Insertion of Low-Pass Filters into speaker leads.

Another method used by some manufacturers and applicable to more difficult cases consists of a filter network installed under the amplifier chassis between the speaker terminals and the output transformer. This filter consists of two capacitors as in Fig. 3.5.1.5 (ii) above plus two small radio frequency chokes. See sub-section 4.2. Keep all leads as short as possible.



L Radio Frequency choke, 1.3 microhenry choke 2.0 Ampere current capacity
C .01-03 uF. ceramic 500 volt

Fig. 3.5.1.5 (iii) Insertion of Low-pass filters into speaker leads.

With the low impedance of the loudspeakers the above components will not affect frequency response of the amplifier.

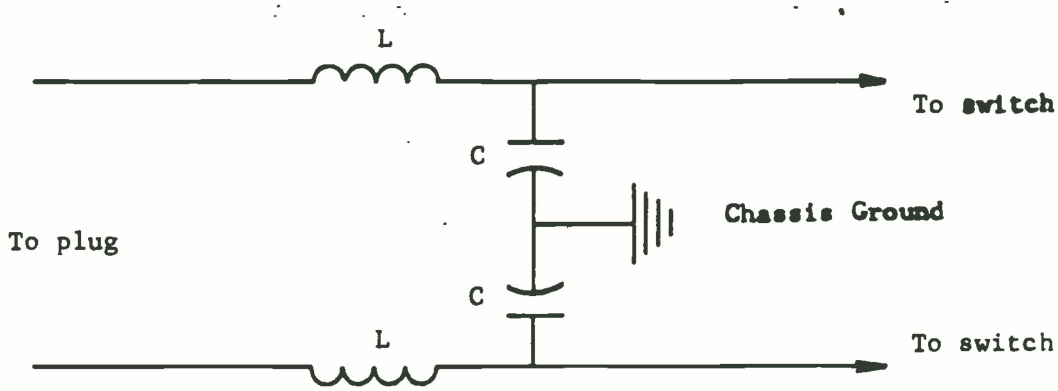
3.5.1.6 Interference entering via power cord.

In many instances strong signals gain entry via the power cord. This can be prevented by:

(a) installing 0.01 to 0.03 uF disc ceramic capacitors, 500 volt rating, from each side of the AC line to chassis ground where the line enters the chassis. Capacitance greater than 0.03 uF should not be used because such would increase shock hazard with transformerless apparatus.

(b) installing a 0.01 uF disc ceramic capacitor across the high voltage power supply output filter capacitor.

(c) in extreme cases a filter network similar to that in paragraph 3.5.1.5(iii) may be necessary as shown below. See section 4 for details on selection of components.



L. R.F. Choke, insulated, 1.7 micro henry, current capacity 2.5 amperes

C Capacitor, .01 to .03 uF 500 volt

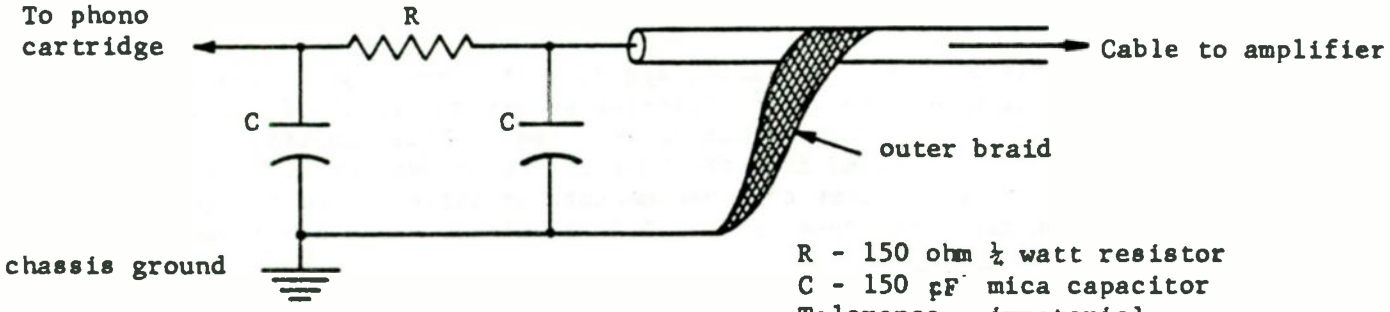
Fig. 3.5.1.6

Insertion of Low-pass filter into power cord.

3.5.1.7 Interference entering via low impedance input terminals, e.g. dynamic microphone input. The measures described under 3.5.1.4 (iii) apply.

3.5.1.8 Interference entering via low impedance input terminals e.g. piezo-electric microphone input or record pick-up.

Some turntable phone arms use a short length of unshielded wire from the cartridge to terminals in the base of the turntable chassis where it connects to a shielded cable running to the amplifier input. This is an ideal entry point for strong radio or radar signals. Where possible this unshielded wire should be replaced by special light weight shielded wire made specially for this purpose. If the added weight of this shielded wire upsets the phono arm tracking force, the only alternative is to insert a filter at the tie point referred to above. This consists of two mica capacitors and one resistor. In the case of stereophonic pick-ups a filter will be required in each lead.



R - 150 ohm ½ watt resistor
C - 150 pF mica capacitor
Tolerance - immaterial

Fig. 3.5.1.8

Insertion of Low-pass filter into phonograph cartridge or microphone terminals.

3.5.1.9 Interference entering via antenna terminals.

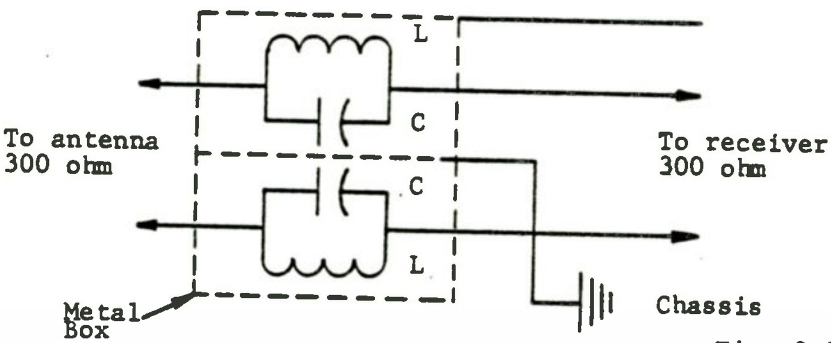
The essence of this method is to place additonal selectivity ahead of the antenna terminals.

On some AM/FM stereophonic receivers, FM receivers, TV sets and combination units, strong radio or radar signals may gain entry into the chassis via the antenna circuit and eventually find their way into the audio circuitry to produce interference.

Disconnecting the antenna lead will prove whether or not it is the pick-up source. If this is found to be the case, the cure is to filter these signals out before they enter the chassis as follows:

(a) If the interfering signal is below 50 MHz., connect a high pass filter in the antenna lead. Several models are commercially available.

(b) Connect parallel traps in the antenna feed line, these being tuned to the frequency of the interfering signal.



L & C to be chosen in accordance with sub-section 4.3

Fig. 3.5.1.9
Insertion of parallel trap in antenna leads

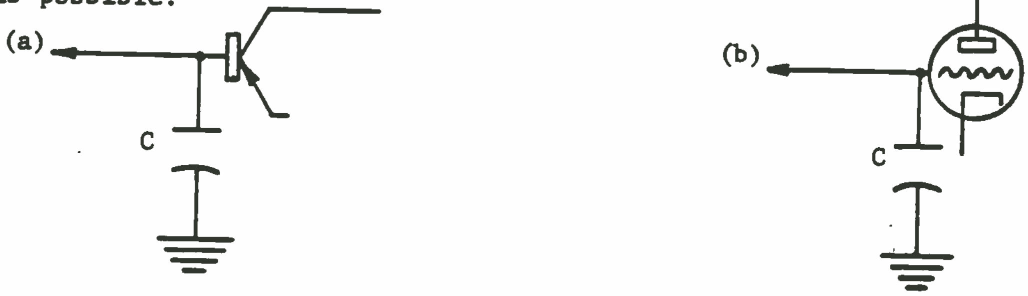
(c) Connect a quarter wave stub tuned to the frequency of the interfering signal across the antenna terminals. Construction and installation of quarter-wave stubs is described in sub-section 4.7.

3.5.2 Modification to Circuitry to Reduce Interference.

The measures discussed in 3.5.1 are essentially peripheral in that they do not involve the internal circuitry of the equipment, only its enclosure, input leads and output leads. They therefore can be applied with minimum danger to the equipment. However, they may not always be adequate. The following measures should give additional interference abatement in such cases.

3.5.2.1 By-passing amplifiers input.

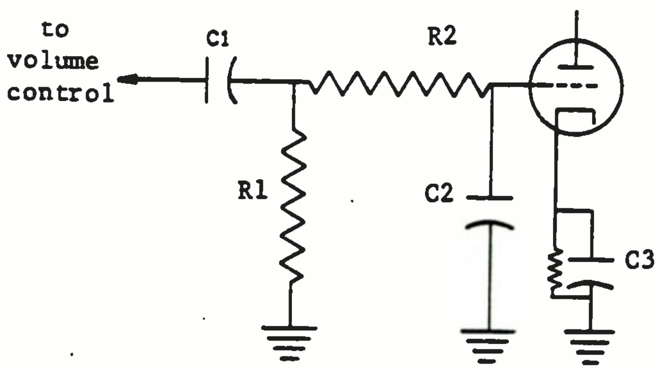
If the interference persists after applying the above cures, (sub-section 3.5.2) it may be necessary to apply filtering across the input of the first transistor stage (or grid of the first vacuum tube). This consists of a 100 to 250 pF. capacitor connected from the base of the transistor to chassis ground (Fig. 3.5.2.1a), or in the case of a vacuum tube amplifier, from the grid to chassis ground on the first tube (Fig. 3.5.2.1b below). Keep all leads as short as possible.



C - mica capacitor
C - 100-200 pF

Fig. 3.5.2.1 (a) (b) By-passing Amplifier

Tube type radio and television sets, particularly the AC/DC variety, often use grid leak biasing on the first audio amplifier stage. The grid resistor in such cases is generally in the order of 5 to 10 megohms which places the grid so high above ground it is very prone to overloading by strong radio or radar signals. A suggested modification is shown below.

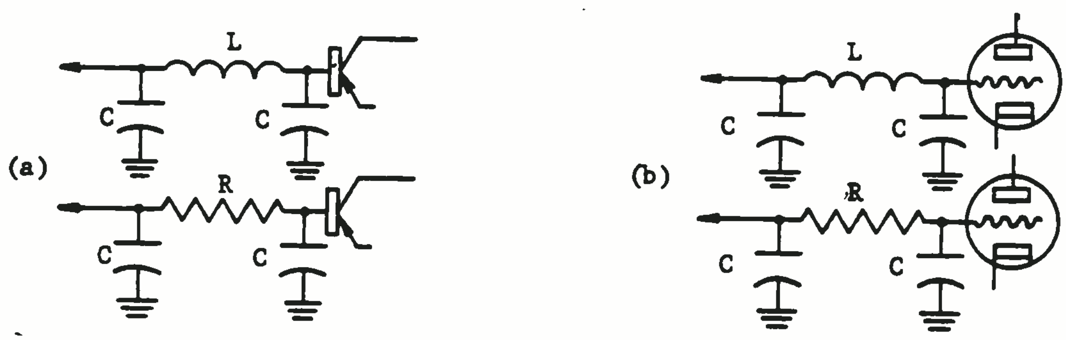


C1 - 0.01 uF paper or ceramic capacitor
C2 - 100 to 250 pF mica capacitor
C3 - 0.001 mfd ceramic capacitor on AC/DC sets
R1 - 2 megohm ½ watt resistor
R2 - 50,000 to 75,000 ohm resistor

Fig. 3.5.2.1 (c) R.F. By-Passing grid-leak.

3.5.2.2 Insertion of Low-Pass Filter into Amplifier.

In extreme cases a small radio frequency choke or a 50,000 - 75,000 ohm resistor and a second condenser may be required as follows. The effect is to insert a Low-pass filter.



C - 100 - 250 pF mica capacitor
R - 50,000 to 75,000 ohm ½ watt resistor
L - Radio Frequency Choke, 1 microhenry.

Fig. 3.5.2.2 Insertion of Low-Pass Filter into amplifier.

3.6 "Swamping" (Excessive Signal) Interference.

The remedies for swamping interference are essentially the same as those for other types namely:

(i) as far as possible exclude the unwanted wave from the equipment affected by building shielding into the cabinet.

(ii) if measure (i) is inadequate, add by-pass capacitors to external leads.

(iii) if measures (i) and (ii) are inadequate, insert low-pass or band-pass filtering into external leads.

(iv) if measures (i), (ii), (iii), are inadequate, selectively by-pass amplifier inputs.

(v) measures (i-iv) are listed in order of increasing difficulty, danger to the operator, and of required expertise to avoid damage to equipment.

Basically the approach to curing this type of interference is to find out how the signal is being picked up or where it is gaining entry into the amplifier and then eliminate its pick-up or entry by the addition of shielding or filters as outlined above. An open-minded and objective approach is necessary; stray fields can enter an equipment in peculiar ways. Sets have been encountered where the interfering signal was fairly weak but on placing one's hand near or on the volume control, the interference increased greatly in level. Investigation revealed that the volume control shaft was insulated from the ground and was actually serving as the pick-up point. The cure here is to replace the volume control with one whose shaft is grounded.

3.7 Measures to Prevent Interference from Paging Systems.

These measures could be included under sub-section 3.5 and 3.6 but with rapid growth of such systems and the detailed nature of the solution, applicable to the band being used, it is considered advantageous to place them in a single sub-section. The following examples illustrate the problem and the nature of remedial measures.

3.7.1 Interference to Television Receivers with Antennas.

Television receivers; various effects being noted ranging from modulation of the video signal by paging tones to complete blanking of both sound and video signals.

As this interference was entering the receiver via the antenna, a 300 ohm balanced high pass filter was used. In its original form the filter cut off at approximately 54 MHz with 4 dB insertion loss in the video band channel 2. By adjusting the inductance of the centre series circuit (as shown by Fig. 3.7.1) the insertion loss was improved and with a cut-off frequency of 50 MHz this filter proved satisfactory.

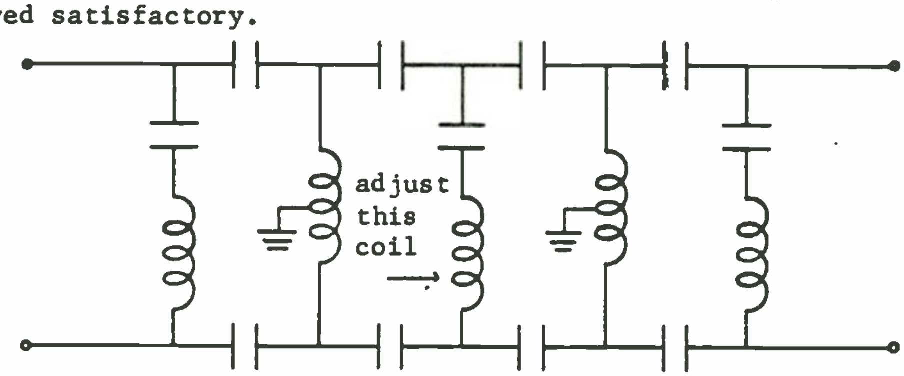


Fig. 3.7.1

3.7.2 Interference to Television Receivers connected to CATV systems.

Over 200 television receivers in an apartment block, fed by low impedance co-axial systems were suffering interference.

Solution

a 75 ohm unbalanced high-pass filter is required. Since there does not seem to be a suitable commercial product, a design is given. See Fig. 3.7.2.

This filter has a pass-band from 44 MHz to 1000 MHz and more than 60 dB attenuation below 40 MHz.

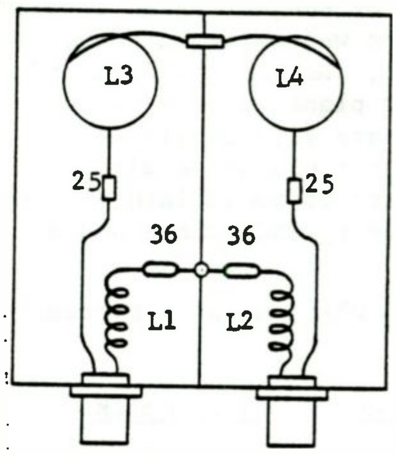
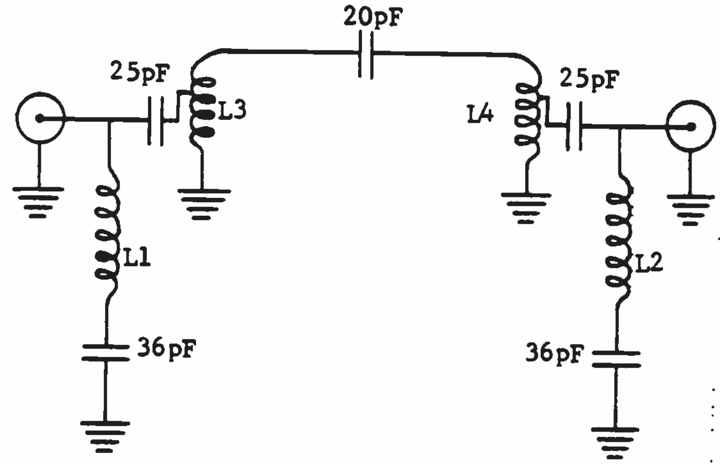


Fig. 3.7.2 (a) Mechanical Assembly



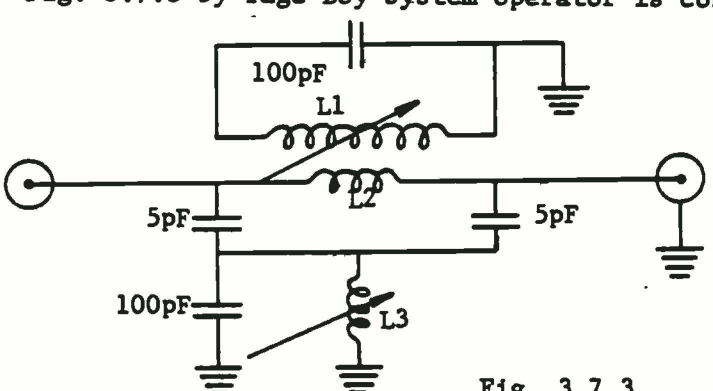
Schematic Diagram

Fig. 3.7.2 (b)

L1 and L2,10 turns No. 22 enamelled wire, 1/4 inch diameter form. L3 and L4, 4 turns of 14 wire 1/4 inch diameter, tapped 1/2 turn from end of coil at high R.F. potential, coil spaced 8 turns per inch. Capacitor tolerance 5%.

3.7.3 Interference to Citizen Band Receivers.

Interference was found to be entering a Citizen-Band receiver via the antenna, therefore a trap was required that was capable of withstanding the high output voltage of the transmitter. Commercial trap seems to be available, but the design Fig. 3.7.3 by Page Boy system operator is considered by them to be superior.



L1 and L3-8 turns No. 22 AWG magnet wire wound on 3/8" Ceramic Form Diameter of Coil 1/2"

L2 - Single Turn Loop of Polythene Covered Wire Inductively Coupled to L1. All Capacitors 100 Volts Working, 5% tolerance, Mica.

Fig. 3.7.3

4. Components Required for Filter Construction.

The components required for construction of filters tend to be somewhat specialized and they cannot always be bought "over the counter". It is hoped that these notes may be helpful.

4.1 Capacitors.

A capacitor is a device in which energy is stored by subjecting an insulating material to an electric field. Formerly, such a device was called a "Condenser" and they are still widely known by this name. However, the name "Capacitor" has been adopted to avoid confusion; every steam power plant has one or more condensers wherein steam is condensed to water. With steadily growing use of electronic control devices in such places, confusion could arise with the older name and the new name permits a desirable symmetry of nomenclature, i.e. a Resistor is characterized by Resistance, and Inductor by Inductance and a Capacitor by Capacitance.

The insulator is usually in the form of a sheet to which metal electrodes are applied. The following combinations are common.

Electrode Material	Insulator	Capacitance Range	See Remark
Aluminum Silver-plated brass	Air	1 - 1000 pF	1
Silver or Nickel-plated Spring brass	Air, mica	1 - 1000 pF	2
Sprayed Zinc	Paper, Synthetics	1000 pF to 10uF	3
Aluminum Foil Deposited Silver	Mica	5 pF tq .016 uF	4
Deposited Silver	Ceramic	100 pF to 2.2 uF	5
Aluminum, Electro-lyte	Aluminum-Oxide	1 - 70,000 uF	6
Tantalum, Electro-lyte	Tantalum Oxide	1 - 50 uF	6

Capacitors are also characterized by maximum rated voltage for which they are suitable. A rating of 100 volts is acceptable unless otherwise stated.

REMARKS.

1. The metal-plated air-insulated capacitor is quite stable and if one set of plates be mounted on a shaft, a capacitance variable over a range 30:1 is readily obtained. Such capacitors are therefore commonly used as the variable elements of tuners, especially in the AM broadcast band.

The same construction is used also for high quality variable capacitors intended for occasional adjustment, to compensate drift in other circuit elements.

This type of capacitor could be used for constructing a tuned circuit (para. 4.3) but it is much larger and more expensive than the compression trimmer described below and would usually require more care in mounting.

2. In this capacitor, one electrode or set of electrodes is made of spring bronze nickel-plated. The electrodes, separated by mica insulators, are interleaved and a screw, insulated from the electrodes, can be tightened so as to bring the spring electrodes solidly in contact with the mica separating them from the other electrodes The capacitance can thus be varied. The range of adjustment varies with the number of plates and the voltage rating but for a common unit rated at 175 D.C. working, the following apply:

Plates	Capacitance pF
1 - 1 1/4	1.5 - 15
1 - 1 3/4	2.7 - 30
2	5 - 80
3	9 -180
4	25 -280
5	50 -380
6	80 -480

These capacitors are compact (typically 3/4" x 5/8" x 3/8"), light enough in weight that, if it is inconvenient to attach them to a panel, they can be supported by the terminals. The principal problem of using them may be the extent to which their capacitance can be disturbed by the presence of a screw-driver and in tuning out an unwanted signal it may be necessary to make repeated small adjustments, removing the screw-driver after each and observing whether the last adjustment improved the performance.

3. Capacitors made in this way are commonly used for blocking passage of direct current while passing alternating current. They are reasonably stable and can be made suitable for voltage from 100 VDC to 2000 VDC. They are primarily useful at frequencies up to a few hundred kHz. Their restricted frequency range and fairly large physical size render them unsuitable for the purposes of this circular.

4. Capacitors made in this way are called silver-mica or foil-mica capacitors. They are compact, light, stable and inexpensive. Usually, units made for 500 volts DC are light enough to be supported by their leads. Their frequency range extends from DC to several hundred MHz. The above advantages have given rise to extensive use for military quality-oriented equipment so that high quality is almost universal. Manufacturing tolerances are 1%, 2%, 5%, 10% and 20%. On the presumption that the smaller tolerances are available only to bulk purchasers, recommendations for choice of capacitance made in this circular are based on the premise that units of 10% tolerance are available. Mica capacitors are suitable for any fixed-capacitor application cited in this bulletin but for by-pass applications, ceramic insulated units will be less bulky and possibly easier to install, especially if a transistor amplifier is to be by-passed.

5. Such units are made by coating a thin plate of ceramic material (typically Barium Titanate, or another composition with a solution containing silver). The plate is heated and the solution decomposes leaving a thin tightly-adhering layer of silver. This is done for both sides. Leads are attached and a plastic encapsulation applied. Such capacitors are suitable to use over a wide range of frequencies but their manufacturing tolerance is high and their capacitance also varies widely depending on temperature. Typical tolerances are +80% -20% so they are unsuitable for use as tuning elements. However, their small size makes them eminently suitable for addition into crowded space such as, for example, by-passing the input to a transistor amplifier.

6. Capacitors made in this way are called Electrolytic since they contain electrolyte. The metal is also specified because in most ways, Tantalum electrolytic capacitors are greatly superior to Aluminum capacitors. Most electrolytic capacitors are usable only if polarized with a DC voltage exceeding any AC voltage present.

Their frequency range is much lower than that of other types, their capacitance is usually quite high (the reason why they are used,) much too high for any purpose relevant to this circular and imprecise. For this reason, they are limited to low frequency by-pass, especially rectifier filters. They are wholly unuseable for interference control as described in this circular.

4.2 Inductors.

An inductor is a component in which energy is stored in a magnetic field, It can also be called a "Coil", after the form of the wire winding or "Choke" because many inductors are used in a rectifier to pass the direct current but to "choke" off alternating current.

An inductor typically consists of a wire winding, usually enamelled copper (Magnet wire) placed on a "core". The core is characterized by a number known as permeability, the ratio by which the inductance of the inductor is greater than that obtainable with magnetically neutral material. Generally cores or core materials with permeability different from 1.00 suitable for purposes relevant to this bulletin are available only to manufacturers and they will not be considered further.

An inductor is primarily characterized by its "inductance", stated in Henries, after Henry, an early researcher, or more usually in millihenries or microhenries. Since an inductor contains a winding of conductive material it is also characterized by an unwanted resistance and for the same reason, it will have a current capacity limited by heating. In some cases, it will be found that an inductor of the inductance value required for a given application is commercially available. In such a case one should check the current capacity, especially if an inductor is to be inserted in series with a power cord.

4.2.1 Making Inductors.

Often, the most convenient way to obtain an inductor is to make it. This is especially so if there are two convenient terminals already present to which it can be attached electrically and mechanically.

4.2.1.1 1.3 Microhenry unsupported inductor, low precision, current capacity 1.5 amperes.

Wrap 24 turns of No. 18 solid enamelled wire on a 1/4 inch diameter form, with adjacent turns touching. Any round or approximately-round object such as a pencil of approximate diameter 1/4 inch will do. A narrow strip of cellulose tape laid along the winding to make it more rigid will make it easier to handle but this is only a convenience. The winding will expand enough to slip easily off the form.

4.2.1.2 1.6 Microhenry unsupported inductor, low precision, current capacity 2.5 amperes.

Make as per 4.2.1.1 above but use a 3/8" diameter form and No. 16 solid enamelled wire. A layer of electric tape (preferably PVC tape) should be placed over the coil to prevent accidental contact between the coil and more delicate circuit elements.

4.2.1.3 1.0 Microhenry inductor, moderate precision current capacity 1 ampere.

See Fig. 4.3.1 and 4.3.2, determine the required inductive reactance. Obtain a 2 watt.resistor, of resistance at least 500 times the reactance.

The resistor is to be used as a precise stable coil form with lead wires. The wattage rating defines the exterior dimensions as length 11/16", diameter 5/16." The resistance, if chosen as above, is irrelevant because it will be shunted by a much smaller reactance. Then, with No. 20 enamelled wire, close-wound, on the resistor and the ends soldered to the leads, inductors of the following values can be made with fair precision;

TABLE 4.3.2.3(i)

Number of Turns.	Inductance Microhenries.
20	1.52
18	1.34
16	1.17
14	1.00

A strip of tape will hold the winding temporarily in place - a small drop of cement at each end (nail polish will do) will hold them permanently. Care must be taken not to use too much lest the insulation on the wire be dissolved permitting an inter-turn short which will alter the inductance unacceptably.

4.2.1.4 General case, inductance of moderate precision.

If a precise inductor capable of carrying a current greater than 1.6 amperes must be made, or if No. 20 wire or a form of 5/16" diameter is not available, the following formula may be used:

$$L = \frac{n^2 a^2}{9a + 10b} \text{ in microhenries}$$

n = number of turns

a = the radius of a turn, centre of form to centre of wire in inches

b = n x the turn-spacing, inches.

To use the formula - first choose a form diameter and a wire size. "a" is then half their sum. Assume a number of turns - n. and work out the formula. If the inductance is too large, reduce "n" and work out the formula again. It must be remembered that in the formula, both numerator and denominator are changed with "n". Wire sizes are given below:

TABLE 4.3.2.3(ii)

Wire size AWG	Current Amp.	Diameter, Inches.
20	1.6	.0334
18	2.0	.0418
16	2.5	.0524
14	3.1	.0659

4.3 Resonant Circuit Construction.

An inductor free of resistance draws a current wave which lags the voltage by 90 degrees, i.e. it is a quarter cycle later than the voltage. A capacitor draws a current which leads the voltage by a quarter cycle.

A current leading by a quarter cycle is equivalent to a negative current, of the same value lagging by a quarter cycle. Thus, in principle, for any frequency, for any inductor, a capacitor can be found such that, when connected in parallel, the lagging current of the inductor is equal in magnitude to the leading current of the capacitor and the two currents add to zero. The combination will then conduct very little current. This effect is called "parallel resonance". By similar reasoning it can be shown that the same elements, connected in series, will carry a current of the same frequency but the voltage across the inductor and capacitor cancel. This is called "Series resonance". In practice, capacitors almost absolutely free of resistance are readily obtainable but all inductors have significant resistance. However, for many purposes the above description is adequate.

It is therefore possible by connecting a suitable inductor-capacitor parallel combination in the antenna leads, to prevent the resonant frequency being passed to the receiver. The following describes the selection of a suitable inductor and capacitor to reject a known frequency. The procedure follows:

(1) Determine the frequency to be rejected.

(2) Draw on Fig. 4.3.1 a vertical line at that frequency, between the lines AA and BB, slanting downward to the right. These lines mark the upper and lower limits of easily available variable capacitors.

(3) Observe the range of inductance values represented by lines standing diagonally upward to the right.

(4) Choose an inductance value in the range observed in Step 3 for which construction data are given in sub-section 4.2.

(5) Identify the capacitance line intersecting the frequency line and the inductance line corresponding to the inductance chosen in Step 4.

(6) Note the reactance corresponding to this intersection.

(7) Dividing by 10, 100, 1000 as necessary, draw on Fig. 4.3.2:

(a) a line corresponding to the frequency to be rejected.

(b) a line corresponding to the reactance chosen in Step 6.

(c) a line corresponding to the inductance chosen in Step 4.

The three lines should intersect at a common point; minor care must be taken in Step (c).

(8) Note the capacitance line which passes through the intersection of lines 7(a) and 7(b). This should be approximately equal to the value given in Step (5) but will be much more accurate. Let this value be C.

The capacitance C should then be made up of 2 units, a fixed mica capacitor, 10% tolerance of capacitance .8C and variable capacitor (Trimmer) of maximum capacitance .3C, connected in parallel.

e.g., suppose a capacitance of 30 pF is required. It will be made up of a fixed mica capacitor of 24 pF, 10% tolerance and a trimmer with a maximum capacitance 9 pF. Then, if the exact capacitance required to tune the combination is 30 pF, depending on the departure of the fixed capacitor from its exact value, the capacitance could be distributed as follows:

Fixed Capacitor, low limit 21.6 pF, Variable Capacitor 8.4 pF.
Fixed Capacitor, nominal 24 pF, Variable Capacitor 6 pF.
Fixed Capacitor, high limit 26.4 pF, Variable Capacitor 3.6 pF.

The choice of components should therefore provide for departure of either the inductor or the fixed capacitor from nominal. Some "trading" on the fixed and variable capacitors may be necessary if very small values are needed.

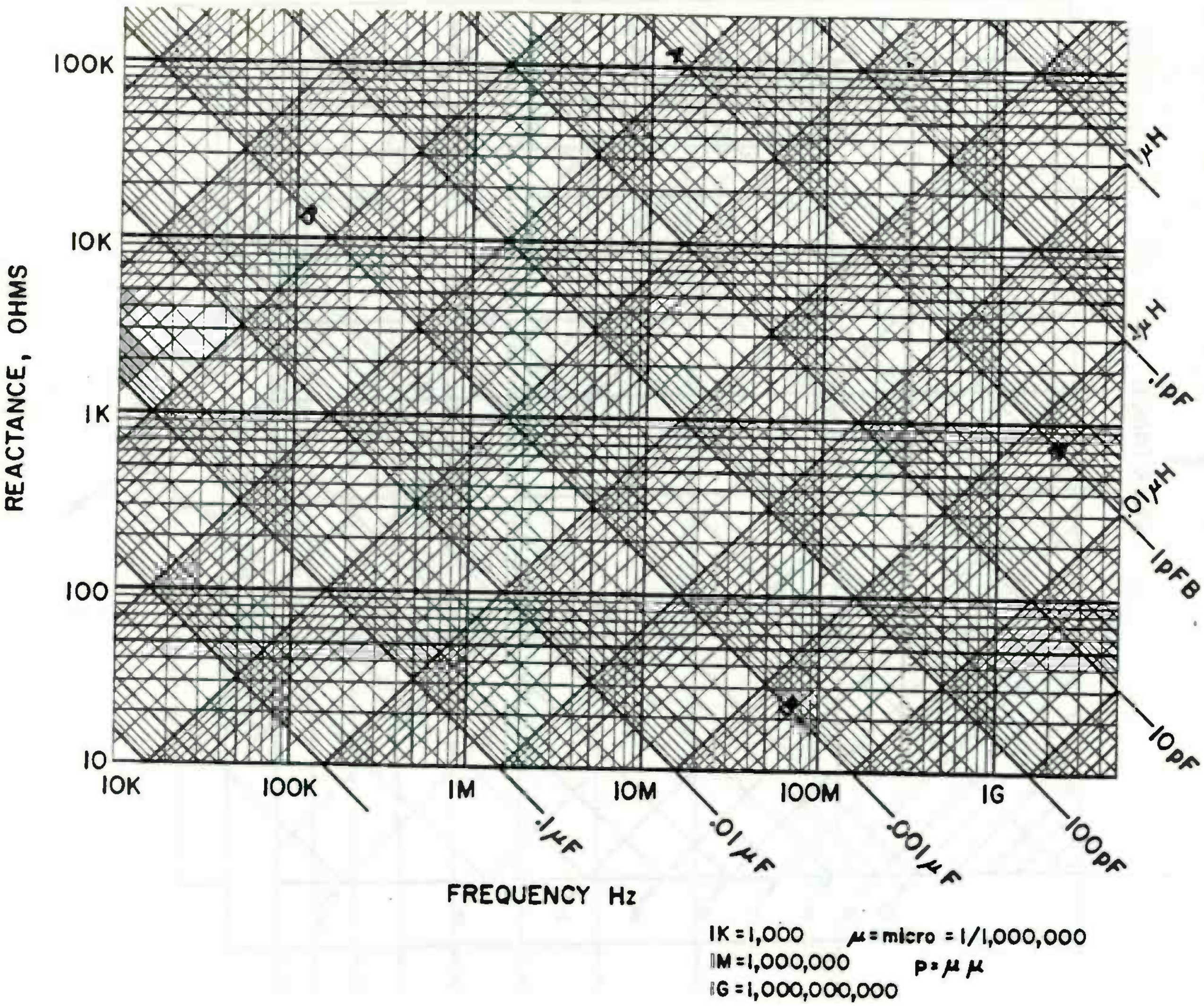


Fig. 4.3.1
Reactance Frequency Chart. Coarse

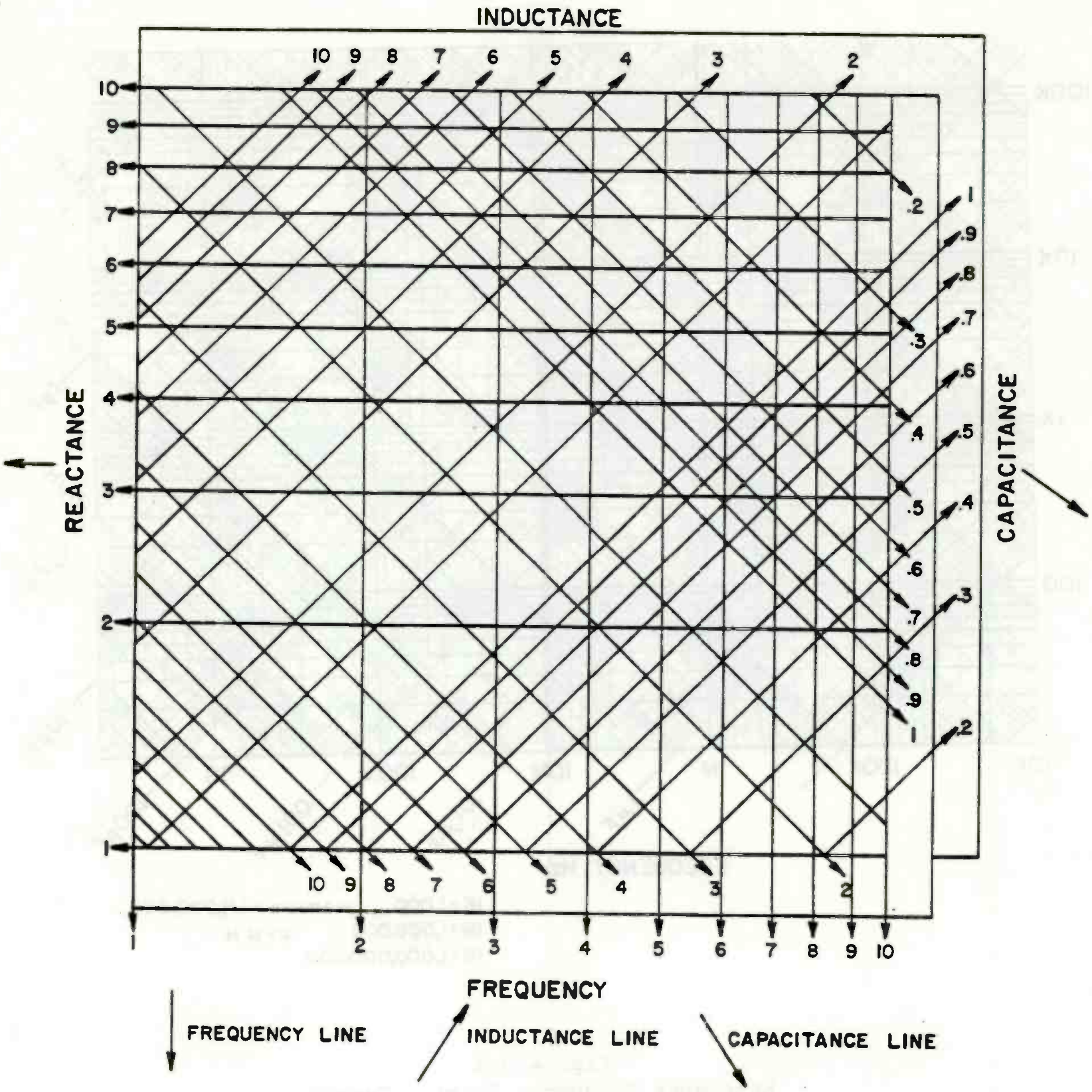


Fig. 4.3.2
Reactance Frequency Chart. Fine

4.4 Construction Principles.

It is recommended that all alterations to domestic electronic equipment be made by qualified technicians, for safety to both personnel and apparatus. If this is not convenient, the following should be observed.

(1) Only rosin flux ("Radio") solder may be used. Acid-core solder or soldering paste, unless guaranteed free of zinc chloride, must not be used. Such materials leave a residue of zinc chloride which promotes corrosion and conducts current with possible severe damage. If there is doubt about a soldering flux being free of zinc chloride, a bit, or slight smear on the finger tip, can be touched to the tongue. If there is any sharp taste, the material must not be used. It is advisable not to use a soldering iron which has been used with zinc chloride, but if necessary, this is permissible after careful cleaning with a rag after the tip is hot, with care also to avoid fire.

(2) Magnet wire comes with several different insulation materials roughly identifiable by colour. The most common is a dark brown colour; it is readily scraped off with a knife or sand paper. It can be dissolved with paint remover. The most common alternative is much more reddish and transparent - sometimes wire with this insulation appears bare. This material is much more difficult to remove and care must be taken that the coil not be damaged by the force required to grip it.

4.5 Nomenclature.

Electronics is characterized by use of a very wide range of numbers. The custom has therefore been developed of having names for units and a set of multiplicative adjectives which combine to give units from 1 million times larger to 1 million - million times smaller. The units are:

Characteristics	Symbol	Units	Symbol
Resistance or Reactance	R	Ohm	
Capacitance	C	Farad	F
Inductance	L	Henry	H
Frequency	f	Hertz (cycle per second)	Hz
Voltage	E or V	Volt	V
Current	I	Ampere	A
Power	W	Watt	W

Multiplicative Adjective	Multiplies by	Symbol
Kilo	1,000	K
Mega	1,000,000	M
Giga	1 thousand million	G
milli	1/1,000	m
micro	1/1,000,000	u or m*
pica or micro-micro	1/1,000,000,000,000	p or mm

* used exclusively with microfarad. Capacitances greater than .1 Farad are practically never used.

4.6 Connecting Shielded Wire

Shielded wire consists of an inner conductor, made up of a number of strands for flexibility, insulated and covered with a sheath of fine braided tinned copper wire. A braided cotton or extruded plastic sheath is often added. The sheath covers approximately 98% of the inner wire so that it cannot "see" electric fields outside the sheath because they terminate (for the most part) there. Use of such wire is an effective remedy for interference, but in making connections care must be taken that the sheath not touch the inner conductor. Many co-axial connectors are constructed so that this is done very simply and with no loss of shielding, but in some cases, the shielded wire must be converted to simple 2-conductor cable. To do this, it is necessary only to remove, or push back the protective covering and about 2 inches from the end, with a plastic knitting needle, tooth pick or any pointed tool unlikely to pierce the inner insulation, tease the shielding wires apart to leave a small hole. Bend the cable double at this point with the hole showing. The inner conductor can then be pulled out and straightened. Pulling the sheath through the fingers will greatly reduce its size so that it can be inserted into a terminal for soldering. This operation will be found quite simple when tried with a piece of shielded wire.

4.7 Quarter-Wave Stubs

A piece of transmission line of length equal to one-quarter of the wavelength of a wave of a given frequency propagated along a line of the same construction displays what might at first sight seem surprising characteristics; if one end is shorted, the other end presents an open circuit to voltages at that frequency, and if the end is opened, it presents a short to voltage of that frequency. This property is quite frequency-selective and it can be used to eliminate an interfering signal from a television receiver by shorting it out. Such short lengths of transmission line, used as filter elements, are called "stubs". To eliminate an interfering signal by a stub, proceed as follows:

(a) identify the channel to be eliminated;
(b) from Table 4.7. a) determine the length of line to cut;
(c) cut a piece of cable, length equal to that given in step (b);
(d) remove the insulation from a length of the cut piece given in Table 4.7. a) (length to strip);
(e) bend the stripped conductors so that they lie parallel at 3/4 of their original spacing. (This preserves a parameter known as characteristic impedance, which depends on cable insulation and spacing.)
(f) connect the stub to the receiver antenna terminals, placing it as closely as possible to the position it will occupy, preferably not in contact with a metal surface. The stub should not be held in the hand because the conductivity of the hand will alter the stub's characteristic;
(g) determine the position at which the best cancellation of the unwanted channel is obtained;
(h) cut the bare wire extending beyond the antenna terminals to one-half of its length;
(i) repeat steps (g) and (h) until the unused bare wire is about 1/2" long;
(j) bend the unused bare wire around the terminal screws and tighten.

This trial and error process is unavoidable because the velocity of propagation along the lead-in is significantly different from its free-space value and this difference is strongly affected by manufacturing details such as thickness and formulation of insulation. The finished stub should not be rolled up on itself but may be draped against insulating materials and fastened with cellulose tape.

Table 4.7. a) Nominal Length for Open Quarter-Wave Stub to Trap Out the Unwanted Television Channel

Channel	Nominal Length, inches	Length to cut	Length to strip
2	46.5	47	2
3	42	43	1 7/8
4	38.2	39	1 3/4
5	33.2	34	1 3/4
6	30.8	31 1/2	1 3/8
7	14.5	14 7/8	9/16
8	14.0	14 3/8	9/16
9	13.6	13 7/8	9/16
10	13.1	13 3/8	9/16
11	12.7	13	9/16
12	12.35	12 9/16	9/16
13	12.0	12 3/8	9/16

G.H. Stewart

for W.J. Wilson,
Director-General,
Telecommunications
Regulation Branch.

IDENTIFYING AND SUPPRESSING

RADIO AND TELEVISION INTERFERENCE

Department of Communications Radio Inspectors endeavour to be of assistance in resolving interference problems to radio and television reception when such assistance is requested, subject to personnel limitations and prior commitments. Normally, Radio Inspectors are not available to perform preliminary tests which should be carried out by the person reporting the problem or by the technical staff of the radio station or organization experiencing the interference.

This circular is intended as a guide for locating and suppressing common interference problems and includes a list of symptoms, possible causes and suggested cures.

NOTE: All modifications to electrical and/or electronic equipment should be performed by a qualified serviceman or technician due to the danger of electrical shock.

A. ANALYZING THE INTERFERENCE

AM RADIO

Symptoms	Possible Interference Sources	What To Do
a) Intermittent harsh buzz	Thermostats: Heating pads, electric blankets, ovens, hot water heaters, aquarium warmers, refrigerator butter conditioners, linotype lead pot, thermostats (for doorbell or chimes, electric fly catcher); etc.	Qualified personnel only: while listening to the interference on a portable receiver at the electrical fuse or breaker panel, try to isolate the "noise" to a particular circuit by momentarily interrupting the power to the individual circuits in turn. If the "noise" has not been interrupted after carefully repeating this test, it indicates the source is external to the home.
b) Intermittent hum	Lights: fluorescent, neon signs, mercury vapour or arc lights.	As above.
c) Steady hum	As above; also Therapeutic and Germicidal lamps: Ultra violet lamps, sun lamps, germicidal lamps in refrigerators and closets. Defective filter capacitor in receiver.	As above.

d) Intermittent heavy crackling	Electric Motors: Electrical appliances using some type of motor, such as electric razor, refrigerator, vacuum cleaner, water pump, fan, sewing machine, drill, food/drink mixers, and toys (electric trains and cars). Note: The motor is not necessarily the only potential interference source in motor operated equipment. Power Lines and Wiring: Insulators, circuit breakers, transformers, lightning arrestors, pole ground wire cut or poor contact, clamps, grounding by tree branches or foliage. Defective (broken) wiring, loose connections, high resistance, loose fuse, BX touching other metal.	As above or advise hydro company if suspected to be on hydro-electric power line.
e) Intermittent crackling	As above: also Switches and Contacts: relays, sign flashers, starters for fluorescent lamps, light blinkers. Ignition Systems: Internal combustion engines, ignitors for oil furnaces or heaters. Electrostatic Devices: Smoke precipitators, dust collectors (e.g. used in flour mills); static from machinery, belt static, anti-friction bearings, printing press static eliminators; electrically operated devices such as adding machines, calculators or cash registers, etc.	As above.
f) Steady crackling	Same as c) and d); also, static from machinery, belt static, anti-friction bearings, printing press static eliminators, smoke precipitators, dust collectors.	As above.
g) Whistling	Radiation: from other receivers; converters, or booster amplifiers. Spurious Response: The receiver itself may be at fault. Direct intermediate frequency pickup, image, front end overloading resulting in cross modulation; frequency multiplying; inadequate receiver selectivity, oscillator harmonic response; spurious oscillation originiating in receiver including regeneration in I.F. stages; noisy or faulty receiver requiring servicing.	Similar to above. Compare the operation of your set with one you know is in proper condition.

	External Cross Modulation: Through non-linear rectification two or more strong radio frequency signals can mix together and re-radiate a new frequency which is determined by the sum and difference of the original frequencies with modulation from one or both of the initial signals. Non-linear rectification is commonly caused by poor connections (corroded joints) in antenna systems, guy wires, clothes-lines, eavestroughs, stucco wire mesh, BX sheathing, fencing, air ducts, etc.	

TELEVISION

Symptoms	Possible Interference Sources	What To Do
h) AUDIO: Weak or fading. VIDEO: "Ghosting" (double or many images) "rolling" or "snowy".	Propagation Conditions: Interference from distant stations due to unusual propagation conditions; reflections appearing as ghosts on TV receivers, "airplane flutter" due to reflections from passing aircraft. Antenna Installation: Distant stations, poor antenna, faulty connections, antenna improperly oriented, reflected signals.	Identify station, check if within reasonable receiving range. Check antenna orientation and installation for defects.
i) AUDIO: Intermittent harsh buzz. VIDEO: Horizontal "bars" or "tearing".	Same as a); also: Switches and Contacts: relays, sign flashers, fluorescent lamp starters, light blinkers; set trouble, horizontal out of sync.	If interference is audible on portable AM receiver, follow instructions in AM Radio. If not, try to isolate circuit by using TV on other circuit outlets.
j) AUDIO: Intermittent or steady "hash". VIDEO: Horizontal "dotted" lines, varying in intensity.	Same as e).	Locate and suppress if practicable. If suspected of being on hydro-electric power line, advise local hydro company.
k) AUDIO: Intermittent "crackling". VIDEO: "Flashing" horizontal lines, noticeable on windy days.	Same as above; also includes: ultra-violet lamps, sun lamps, germicidal lamps in refrigerators and closets.	Same as above.

l) AUDIO: "Heavy" intermittent "roar" varying in intensity, lasting from several seconds to minutes. VIDEO: 1 or 2 black "bars", severe herring-bone pattern.	Medical Equipment: Diathermy, X-ray, etc. or Industrial: Radio frequency heaters, dielectric heating for plastics and glue drying; induction heating for metals.	Note the times of operation and request assistance from one of our District Offices.
m) AUDIO: Could be garbled. VIDEO: Vertical lines or bars; picture distorted or displaced; wavy or herring-bone pattern; tearing.	Radiation: from other receivers, converters or booster amplifiers; adjacent channel overlap. CATV Cable System: A "leak" can develop in a cable system from such things as loose connectors, malfunctioning line amplifiers or use of unshielded wire by a subscriber; this "leak" of radio frequency energy can cause interference to nearby TV receivers.	Try to isolate defective receiver; advise CATV company.
n) AUDIO: Voices (sometimes garbled) or "dots" and "dashes" as used in morse code transmissions. VIDEO: Cross-hatch (screen effect).	Nearby operation of Radio Amateur, General Radio Service, or other radio transmitter.	Attempt to identify and request DOC assistance.
o) AUDIO: Erratic yet often rythmnic clicking or static type noise. VIDEO: Horizontal "dotted" lines.	Same as j); also: fluorescent lights, neon signs, mercury vapour or arc lights.	As above; if suspected to be from Ignition Systems, have antenna leads shielded and/or install a hi-pass filter.

p) Any "noise" or poor picture, either steady or intermittent, which "appears" as an external interference.	Your receiver may be at fault, i.e. an internal defect.	Compare the operation of your set with one you know is in proper condition.

B. GENERAL INFORMATION

1. The control of interference to radio and television reception in Canada is legislated for in the General Radio Regulations, Part I, Sections 17, 18, 19, 20 and 21 and the Radio Noise Limits Order. Copies of these publications are available through Information Canada.

2. All interference cannot be eliminated under all circumstances.

3. The strength of the signal being received in relationship to the strength of the interfering signal determines the degree of interference which may be tolerated.

4. Any interference that affects black and white television reception can affect colour reception, or vice versa.

5. An outside antenna is desirable to help reduce coupling between the antenna and electrical circuits and to provide maximum signal pickup.

6. Observing the "on-off" cycle of intermittent interference can often help in determining the cause.

7. The safest and most practical solution to interference caused by a defective thermostat in an electric pad or blanket is to replace the pad or blanket with a model which employs a non-interfering type of thermostat.

8. There are many potential sources of interference on hydro-electric transmission and distribution lines which may cause intermittent or continuous interference to television or radio reception. Weather conditions can affect both the type and severity of hydro line interference:

    a) if a sporadic, spitting interference is present only during windy weather, then loose line hardware (clamps, etc.) may be suspect; or a guy wire may be making intermittent contact with a metal pin, bolt or bracket.

    b) Contrary to common belief, more interfering "noise" is produced from hydro lines during dry weather than during damp weather when a good electrical path is provided by the moisture, whereas when dry, these "leaks" must arc across varying size gaps.

9. Interference can travel for many miles on power lines. The following factors determine how far a disturbance may be heard:

   a) the voltage on line;

   b) resonance of wires carrying the interference;

   c) coupling between circuits;

   d) the type of source.

10. Audio Circuit Rectification (in receivers and audio amplifiers): Through rectification a strong AM radio frequency signal can be converted to an audible signal in the audio stage of a radio receiver irrespective of the dial setting, or in audio reproduction devices such as tape recorders, turntables, hearing aids, amplifiers, electronic organs, intercoms, telephones, etc.

C. INTERFERENCE SUPPRESSION FILTERS

1. A suppressor filter should be installed as close to the source of the interference as practicable.

2. Two filters are sometimes required on sign flashers; one on the line side to suppress line radiation with another on the load side to suppress direct radiation from the sign.

3. When installing filter capacitors on motors or generators ensure that the ground return is connected to the frame.

4. The possibility of shock hazard from a large filter capacitor may be reduced by installing a small capacitor in the ground lead.

5. A hi-pass filter is designed to attenuate frequencies below a certain frequency (e.g. 50 MHz) while a low-pass filter is designed to attenuate frequencies above a certain frequency.

6. Interference from fluorescent lamps may be reduced to a satisfactory level or eliminated entirely by installing a suitable suppressor network across the line inside the fixture:

   Three capacitors are normally required with the following optimum values:

   #1 - .02 uF.; #2 - .002 uF.; #3 - .002 uF.

   Install #1 across 110V line inside fixture.

   Install #2 and #3 to fixture ground from each side of #1.

R.R.B. Hoodspith,
Director-General,
Telecommunication.

SUPPRESSION OF INDUCTIVE INTERFERENCE

Suppression of Appliances and Small Motors

1. Interference from electrical appliances is nearly always due to the appliance containing either a commutator-type (A.C.-D.C., Universal) motor, or to electrical contacts which open and close frequently, such as a thermostat.

2. Interference from thermostats and other contacts can usually be readily cured by connecting a capacitor directly across the contacts, using as short leads as possible. A 0.1 microfarad or 0.05 microfarad size capacitor is usually best, though a 0.01 microfarad is often satisfactory, especially if the interference is principally to television frequencies. Plug-in suppressors, as described below, are also fairly effective. Inductances and feed-through capacitors are effective in the more difficult cases.

3. The simplest corrective action, to reduce the noise from small A.C.-D.C. motors, is to stiffen the brush springs. The pressure on the brushes has a pronounced effect on the intensity of radio noise generated. As the brushes wear, the spring pressure decreases; stiffening (stretching) the brush springs will often reduce the radio noise by as much as 20 decibels (ten times). When removing the brushes to stretch the springs, care should be taken not to rotate the brush a half turn, as it then will not fit the commutator properly until it is worn in, and consequently will be noisy in the interim.

4. There is a distinct limit to the amount of noise reduction which can be obtained by stiffening the brush springs, and the next simple step to obtain further suppression is to connect a 0.05 microfarad or a 0.1 microfarad capacitor across the power line, near the motor. The simplest way of doing this is to obtain a small plug-in EMI filter.

5. The next simplest type of suppression is the 0.05 or 0.1 μF capacitor across the power line, plus a 0.006 μF capacitor connected from each line to the frame of the motor. Capacitors which connect to the frame of an appliance should not be much larger than 0.006 μF as the current passing through larger capacitors will produce a perceptible shock. These can be installed inside the appliance case if there is room. This suppression

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5. (cont'd) arrangement has proved adequate in actual cases on quite a number of sewing machines and similar motors, though if the interference is heavy enough to tear the TV picture badly on a properly adjusted set, it is doubtful whether this amount of suppression will be sufficient to eliminate the interference completely.

6. The next step to obtain further suppression is to also connect a capacitor of 0.006 μF or less from each brush-holder to the frame of the motor, using as short leads as possible. The compactness of ceramic capacitors (Discaps, etc.) make them very convenient. Also small inductances should be placed in each lead coming from the motor to the capacitor assembly. The leads from the capacitor assembly to the power wires should be as short as possible, and where possible the line lead should be at right angles to the other two wires, to avoid coupling. Some further suppression can be obtained by also putting an inductance in each power line lead where it leaves the capacitor assembly on its way to the power supply.

7. The length of the leads of the capacitors which are connected from power line or brushes to frame is rather important. The leads should, in general, be kept as short as possible, but if the interference problem exists only in connection with a single television channel, additional suppression can be obtained at that particular frequency by co-ordinating the length of the capacitor leads and the capacitance value. The curves in the attached copy of Appendix "A" give the optimum capacitance, for various lead lengths, to obtain resonance, and maximum suppression, at a given frequency.

8. For suppressing television interference, the inductances mentioned above need merely be a solenoid of ordinary wire, close wound, in a single layer, on a fountain pen or broomstick, which is then removed. Maximum effectiveness occurs when the length of wire in the inductance is roughly one-third of a wavelength at the frequency at which suppression is most desired. The attached curve sheet (Figure 1) gives the length of wire to be used for each inductance, to obtain maximum suppression in the neighbourhood of the frequency indicated. (Curve is applicable to inductances whose diameter is between half and double their length.)

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9. EMI filters are manufactured which contain an assemblage of capacitors and inductances.

10. If further suppression is necessary, the best means of obtaining it is by means of feed-through capacitors. Ceramic type feed-through capacitors are very compact and consist of a threaded sleeve or bushing with the conductor passing through the centre. The outer sleeve is one plate of the capacitor and, in this way, the lead length is virtually zero. To take advantage of this zero lead length, however, it is necessary that each feed-through capacitor be mounted so that it passes through the wall of a metal enclosure which completely encloses the noise source. When a feed-through is so installed, the noise currents flow away from it radially in all directions and, under these conditions, the current path has zero inductance. The metal casing of an appliance often will serve this purpose, but it is important that the enclosure be as complete as possible, without long slits or large openings. If the enclosure is in several pieces, clean metal-to-metal contact throughout the length of the joints is very important.

11. In arranging such an enclosure it is well to keep in mind what is a similar arrangement on a larger scale:- the screened room, or cage, with a filter where the power supply enters the cage, and no other openings. A good cage commonly gives nearly 120 dB, (one million times) isolation, as between the noise on the inside and on the outside, including the power line. If a motor can be contained in a metal (or metal screen) enclosure with the power supply entering via feed-through capacitors which pass through the wall of the enclosure, suppression of a comparable order can be obtained, at television frequencies. A bag of bronze window screening wrapped around the motor is highly effective. Inductances can be added, but they are not usually necessary.

12. The feed-throughs should, of course, be limited in capacitance to about 0.006 μF to avoid shocks. This amount of capacitance is rather too small to give good suppression in the Standard Broadcast band so it is usually necessary to add a 0.05 μF or 0.1 μF capacitor across the line, preferably inside the enclosure.

13. In the case of electrical apparatus which is permanently grounded, or completely insulated, so that there is no danger of shock, instead of 0.006 μF capacitors, 0.05 μF or larger capacitors can be used to advantage in any of the above arrangements, if difficulty is being experienced with Broadcast, rather than TV, interference.

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14. Each Departmental radio interference car carries a set of plug-in and other type suppressors, and the nearest Department of Communications Radio Inspector is glad to advise as to the most economical and effective method of suppressing interfering appliances or apparatus. Circulars are also available at Radio Inspection Offices concerning the suppression of interference from oil burners, fluorescent lights, various industrial apparatus and equipment, etc.

G.H. Stewart

for W.J. Wilson,
Director,
Telecommunication
Engineering Branch.
Telecommunication Regulatory
Service.

Attachments.

FIGURE - 1

SELF-RESONANT FREQUENCY
Vs
LENGTH OF WIRE

IN A SINGLE LAYER SOLENOID, WHOSE DIAMETER IS BETWEEN HALF AND DOUBLE ITS LENGTH

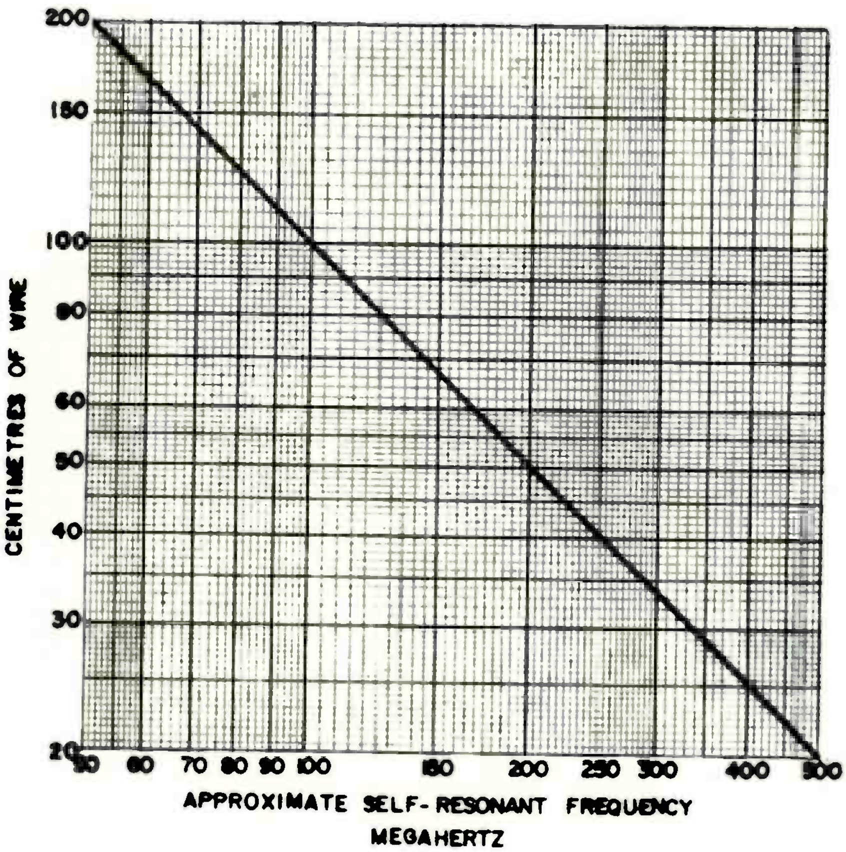
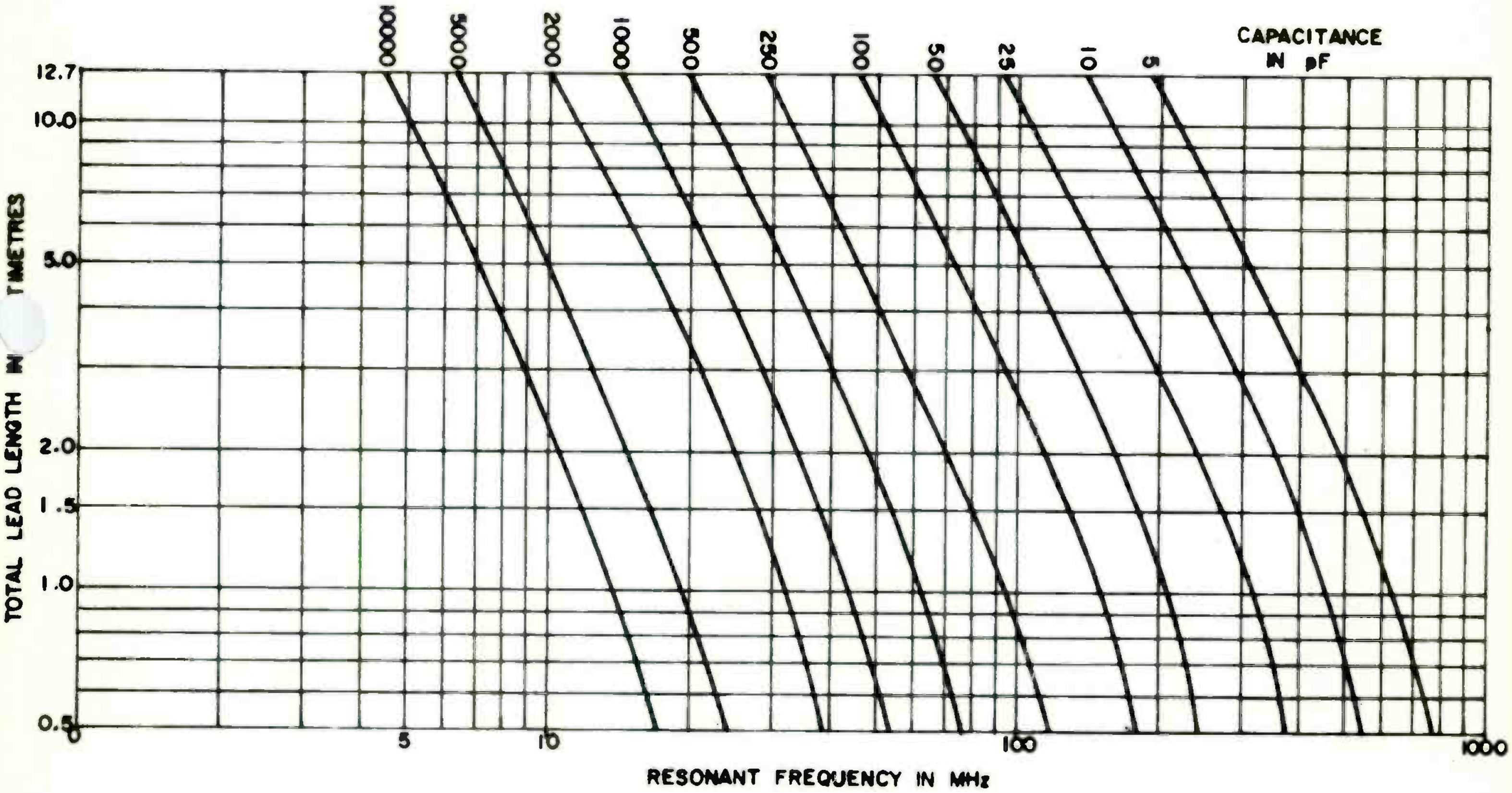


FIGURE-2


10000
5000
2000
1000
500
250
100
50
25
10
5
CAPACITANCE IN pF
12.7
10.0
5.0
2.0
1.5
1.0
0.5
TOTAL LEAD LENGTH IN CENTIMETRES
0
5
10
100
1000
RESONANT FREQUENCY IN MHz

APPENDIX "A"

Suppression Capacitors for Television Frequencies

1. Large capacitors often are not very effective in suppressing radio noise at very high frequencies, from household appliances and other apparatus. Particularly if interference is arising on only a single television channel, or a small band of frequencies, much better results can be obtained by using a small capacitor whose capacitive reactance will just equal, and cancel, the inductive reactance of its leads.

2. Figure 2 gives the capacitor size which will series resonate with the inductance of various lengths of lead, at any given frequency.

3. Best suppression occurs when a given capacitor, with leads, is at its series resonant frequency, but at frequencies above resonance it is more effective than larger capacitors would be, with the same length leads. It is also more effective (impedance is less) at frequencies somewhat below resonance than much larger capacitors would be, down to about three-quarters of its resonant frequency, but not lower.

4. On commutator motors, suppression capacitors may be most effective if connected from each brush holder to the frame, or across the brush holders, or from each line to the frame, or a combination of these. They should always be installed with the shortest possible leads and the appropriate capacitance to resonate this length should be used. While the lead length may not greatly affect the suppression obtained at the resonant frequency, it should be noted that the impedance of the capacitor-plus-leads at frequencies above or below resonance is directly proportional to the reactance, and hence length, of the leads at resonance.

5. The C.S.A. has shock hazard standards that specify the maximum amount of current that can be carried in a wire connected from an appliance to ground. This varies with the appliance involved though in most cases it is 0.5 mA. These specifications will place a limit on the value of suppression capacitors connected between the power leads and the chassis of an un-grounded appliance. C.S.A. should be referred to for the applicable specification and rigidly adhered to.

Government
of Canada

Department of Communications

TRC - 29

TELECOMMUNICATIONS REGULATION CIRCULAR

PREVENTION EASIER THAN CURE OF POWER LINE RADIO INTERFERENCE

JUNE 1, 1976
(REPLACES SII-13-53 OF AUGUST 1, 1962)

TELECOMMUNICATION REGULATORY SERVICE

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PREVENTION EASIER THAN CURE OF POWER LINE RADIO INTERFERENCE

Practical construction rules followed in designing and erecting distribution lines will eliminate the common sources of radio interference which cause most trouble. L.V. Blake, Arkansas Power & Light Co., Pine Bluff, Ark.

(Extract from "Electrical World", September 21, 1940)

1. We believe that any distribution engineer who swaps one ounce of radio interference prevention for a pound of cure has made a bad bargain. But, fortunately, he does not have to abide by his bargain, for there are some simple rules which, if followed consistently, will result in construction of distribution lines essentially free from avoidable sources of interference. Our bargain-minded engineer can start his prevention program with his next line extension.

2. All the construction rules which can be laid down are corollaries of one simple, general rule which will keep sources of radio interference at a minimum.

3. Connect all pole hardware solidly together, or keep it spaced well apart. The corollaries are these:

   (a) See that all hardware remains tight by periodic tightening.

   (b) Keep ground wires on poles clear of all ungrounded hardware.

   (c) Keep guy wires clear of all other wires and hardware.

   (d) Keep tie wires tight; on lines of above 5 000 volts, avoid weatherproof insulation at ties and dead-ends.

   (e) In disk insulator assemblies use only standard type brass cotter pins.

   (f) Remove all pieces of "haywire" found hanging on line wires.

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4. The explanation of radio interference caused by violation of these rules has not been given the attention it deserves. Briefly, it may be said that most important causes of radio interference are associated with the electric field such as exists between any two conductors across which a voltage exists. Just as a magnetic field induces a voltage in conductors within its range, isolated conductors, such as line hardware, in an electric field are subject to electric induction. On an a.c. line a charge and discharge take place in such hardware exactly as in the plates of a capacitor. Finally, if two units of hardware thus acted upon are almost touching, the intense electric field in the small gap may ionize the air at this point and allow the formation of a continuous arc. This explains the reason for the basic rule already given that: In constructing lines of 2 300 volts and above, all pole hardware should be either solidly connected together or spaced well apart.

5. Five centimetres or more spacing between units of hardware is sufficient, although it is well to instruct linemen to provide as much spacing as is consistent with good construction.

6. Interference is caused most frequently by lines which operate in the voltage region between 5 000 and 15 000 volts, although under "ideal" conditions the same trouble will occur in 2 300 volt lines. Lines of above 15 000 volts are generally used for transmission rather than distribution; there is less hardware on the poles, and accordingly, fewer chances for this kind of trouble.

7. It is occasionally difficult for some linemen to understand exactly what occurs. As a result, some may tend to laxity in observing the rules. Seriousness of radio interference will be appreciated, however from the fact that in many cases radio interference caused by an arc between two units of hardware on a 13 kV line has been found to affect radio reception of customers along the line fifteen or more kilometres from the actual source of trouble. Frequently, customers within 1.5 kilometres of such a source of interference cannot receive any programs whatsoever.

Watch out for:

8. Discussion of the corollary rules laid down in the early part of the article may disclose some vulnerable points of construction which might otherwise be overlooked.

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(a) Keep all hardware tight. Periodic retightenings are recommended. Loose hardware is as frequent a source of radio interference as is hardware improperly spaced. If lagscrews, carriage bolts or through-bolts become loose a solid electrical connection may no longer exist between units of a hardware assembly. Arcing may therefore occur across the tiny gaps thus formed. Shrinkage of wood poles and cross arms almost inevitably results in loose hardware four or five years after a line is built. Loose cross arm braces are very often found to be causing radio interference. A periodical "tightening up" is about the only thorough remedy that can be suggested at present.

(b) Keep ground wires on poles clear of all ungrounded hardware. This rule is often violated in connection with lightning arrester ground wires on transformer poles. Particular care should be taken to keep arrester grounds clear of such electrically charged objects as insulator pins and switch assemblies, as well as cross arm braces, transformer hangers and metal "kickers". If weatherproof insulated ground wire is used, staples should not be driven hard enough to crush the insulation. If bare ground wire is used staples should be driven tight. Staples within a few feet of a high-voltage lead wire become charged, and will discharge to the ground wire if these rules are not observed.

(c) Keep guy wires clear of all other wires and hardware. An ungrounded section of guy wire (the section above the strain insulator) becomes electrically charged and care should be taken to insure against guy and neutral wires touching or slapping together in windy weather.

(d) Provide solid electrical connection between line and tie wires. This means keep tie wires tight. On circuits of above 5 000 volts, if the line wire is weatherproof insulated, the insulation should be removed at insulator ties and disk insulator dead-ends. If this is not done arcing or "spitting" will occur between the line and tie wires, especially after the insulation has aged a few years.

.....

(e) Avoid the use of any metals which will rust or corrode. Where rust or corrosion occurs good electrical connection no longer exists. Even such small articles as the cotter pins used in disk insulator assemblies are important in this respect - only the standard brass type should be used. Steel cotter pins or makeshifts should never be substituted. Electric discharge to a rusted or corroded cotter pin will cause considerable radio interference. Metals which ordinarily will not corrode may do so when in contact with a different metal; this principle has, of course, been recognized and taken into account in the design of special devices for making connection between copper and aluminum conductors.

Recently considerable trouble was experienced at the ties on the neutral wire (grounded) of a 7 620 volt rural line. The conductor was stranded aluminum, the ties, copper, and the neutral support brackets, galvanized iron. The cause was found to be "spitting" at some of the neutral wire ties; the lineman could hear the arc by placing his ear close to the tie. Removing the tie wire caused the radio interference to stop. This condition was occurring all along the line and was very difficult to remedy as it appeared to be due not so much to looseness of the tie as to corrosion formed by electrolytic action between the dissimilar metals.

(f) "Haywire" should always be removed when found hanging on high-voltage line wires. This should be done even if it is on the neutral wire and cannot possibly swing into contact with other wires, as radio interference will result if such pieces of scrap are rusted.

Bothersome Interference

9. In general, the most serious interference to radio reception will be caused by a discharge between two pieces of hardware when one is grounded and the other quite close to a "hot" line wire. These conditions are fulfilled, for example, when the ungrounded mounting assembly of a transformer primary switch almost touches the grounded mounting assembly of a lightning arrester, or when an arrester ground wire almost touches a steel insulator pin.

.....

10. On the other hand, a discharge between two ungrounded pieces of hardware may cause comparatively slight interference. An example of this sort is the arcing that takes place between the two arms of a set of loose cross arm braces or between a loose insulator pin washer and the pin itself. Note, however, that comparatively slight should not be interpreted as negligible.

11. It may be of interest to mention here that radio interference caused by the type of condition being discussed may disappear in wet weather, or may come and go with changes in temperature. During a rain, water may form a temporary "bond" between closely spaced units of hardware, literally quenching the arc. Temperature changes may cause sufficient contraction or expansion of hardware to close a small gap or widen it, causing an arc to start or stop. Ordinarily, the size of the gaps across which these troublesome arcs occur is less than 3 mm.

C H Stewart

for W.J. Wilson,
Director,
Telecommunication Engineering Branch,
Telecommunication Regulatory Service.

Government
of Canada

Department of Communications

TRC-30

TELECOMMUNICATIONS REGULATION CIRCULAR

CAUSES OF RADIO INTERFERENCE
FROM SERIES STREET LIGHTING SYSTEMS

JUNE 1, 1976
(REPLACES SII-14-12 OF SEPTEMBER 10, 1962)

TELECOMMUNICATION REGULATORY SERVICE

M

SUPPRESSION OF RADIO INDUCTIVE INTERFERENCE

CAUSES OF RADIO INTERFERENCE FROM SERIES STREET LIGHTING SYSTEMS

1. Interference Carries Far:

(a) Surges which cause radio interference are usually carried farther on series street lighting circuits than on distribution systems and thus a single source of interference, whether it originates on the circuit in question or is induced on to this circuit from outside sources, will affect a wide area. This is due to the fact that a series street lighting line has less capacitance to ground than the average distribution lines and therefore, a single source of interference will frequently affect the broadcast receivers whose antennae are near the line at a distance of many kilometres from the source.

(b) The distance interfering surges carry along a series line may be reduced by adding capacitance from line to ground. This may most conveniently be done by grounding any fixtures on this line such as frames of transformers, switches, or other apparatus connected to the circuit. It is not generally convenient to ground all lamp fixtures connected to a circuit, but considerable improvement may be obtained if fixtures are grounded on poles which are already equipped with a ground wire for other circuits.

2. Discharge to Ungrounded Hardware:

(a) In the design and construction of a series street lighting system it is necessary to consider electric potential from a different point of view than the standard practice used in dealing with power problems, in order to ensure against excessive electric potential gradients which might cause radio interference. The matter of electric potential may best be understood by reference to a typical diagram.

Fig. 1

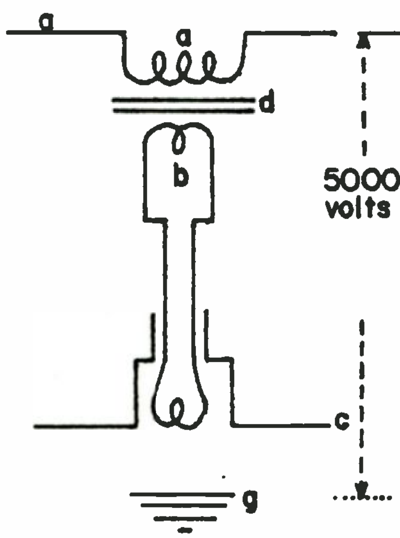
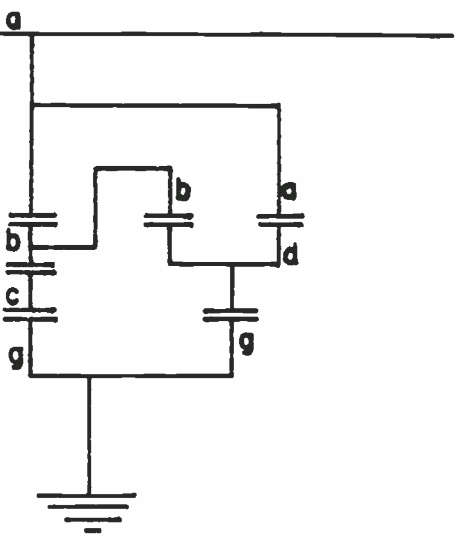


Fig. 2



a - represents the series circuit which may be at any voltage to ground up to the maximum voltage of the system, dependent on the point of the circuit under consideration with regard to ground. If the system is ungrounded, there is bound to be a certain leakage which might cause the electric potential at any one point to vary from day to day. For this purpose, assume that this part of the circuit is 5 000 volts above ground.

d - represents the individual lamp transformer core and frame.

b - represents the low voltage circuit to the lamp which is ungrounded and insulated from the line.

c - represents the lamp fixture including the gooseneck or other metal in close proximity to the secondary wiring.

g - represents ground.

Figure 2 - schematically represents the capacitances between these various circuits.

(b) If the metal of the street light fixture is grounded the capacitor cg is short-circuited.

(c) From Figure 2 it is seen that the low voltage circuit to the lamp should be considered at high voltage above ground. If, therefore, the insulation on the wire of this circuit is designed to withstand only low voltage required for the lamp it is possible that it may be broken down due to charging current from the low voltage wiring (b) to the hardware of the lamp fixture (c). If this breakdown occurred it would not interfere with the operation of the lamp as the current would be very small and there would not be sufficient heat at the point of breakdown to cause any material damage.

(d) This electric discharge, however, would cause a surge to be set up on the system which would produce severe radio interference affecting all receivers within a distance of many kilometres from the source.

3. Means of Preventing Electric Discharge:

It is recommended that the entire low voltage circuit be insulated from all hardware or other circuit, whether grounded or ungrounded, so that it will withstand a voltage test of 25% above the maximum operating voltage of the system. Insulation which will withstand this test will probably stand up under normal operation as it is seen from the diagrams above that the voltage from the secondary circuit to hardware will never be as great as the maximum voltage from line to ground although under some conditions it may approach this value.

C H Stewart

for W.J. Wilson,
Director,
Telecommunication
Engineering Branch,
Telecommunication Regulatory Service.

Government
of Canada
Department of Communications

TRC - 47

TELECOMMUNICATIONS REGULATION CIRCULAR

SUPPRESSION OF INDUCTIVE INTERFERENCE
SUPPRESSION CAPACITORS FOR TELEVISION FREQUENCIES

MARCH 31, 1978
(REPLACES S11-13-46 OF AUGUST 1, 1962)

TELECOMMUNICATION REGULATORY SERVICE

M

SUPPRESSION OF INDUCTIVE INTERFERENCE

SUPPRESSION CAPACITORS FOR TELEVISION FREQUENCIES

1. Large capacitors often are not very effective in the suppression of radio noise at very high frequencies, from household appliances and other apparatus. Particularly if interference is arising on only a single television channel, or a small band of frequencies, much better results can be obtained by using a small capacitor whose capacitive reactance will just equal, and cancel out, the inductive reactance of its leads, which amounts to something like 10 ohms per centimeter of lead at 100 megahertz.

2. The curves of Figure I give the capacitor size which will series resonate the inductance of various lengths of lead, at any given frequency.

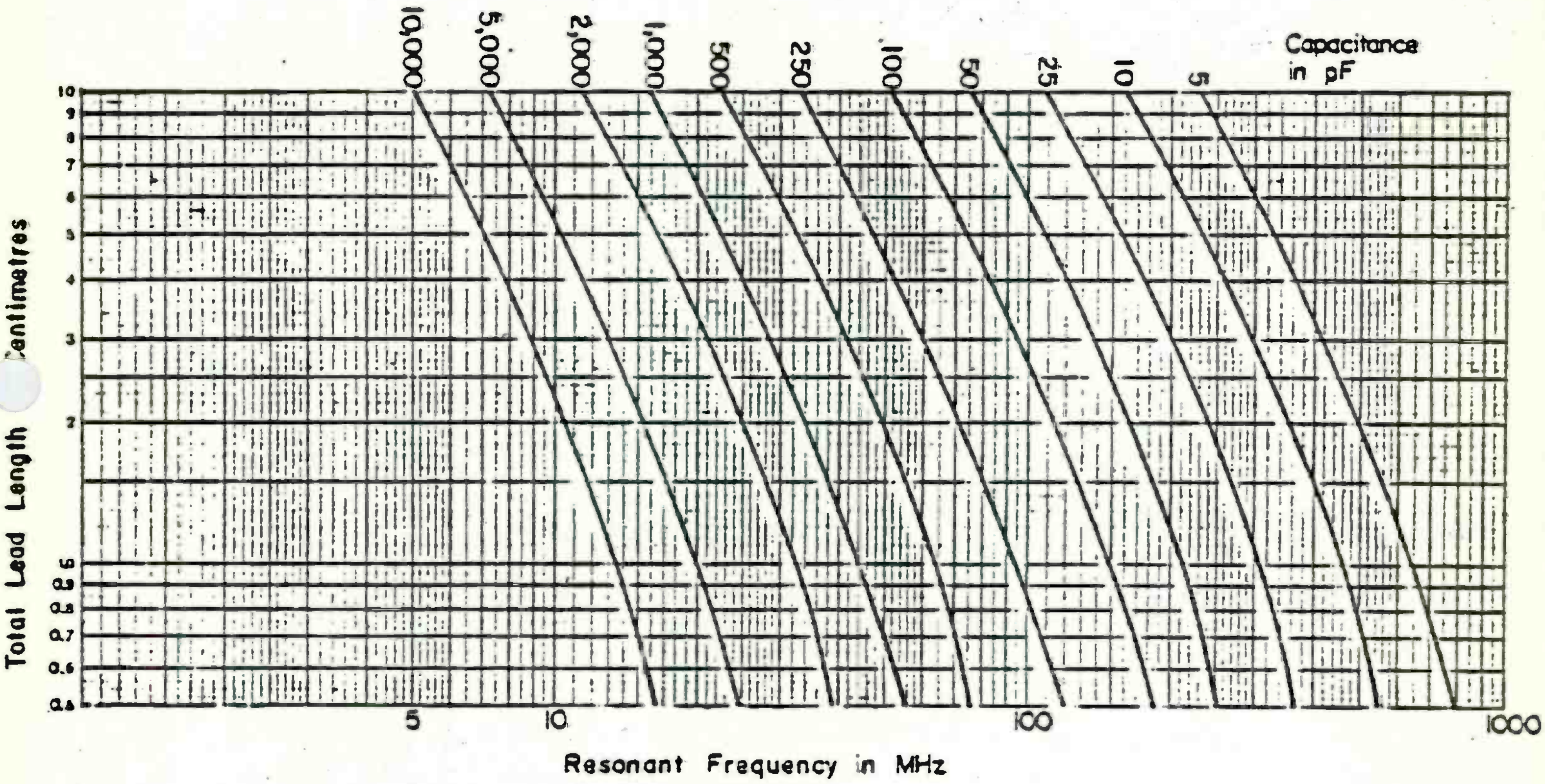
3. Best suppression occurs when a given capacitor, with leads, is at its series resonant frequency. At frequencies above resonance it is more effective than larger capacitors would be, with the same length leads. It is also more effective (impedance is less) at frequencies somewhat below resonance, than much larger capacitors would be, down to about three-quarters of its resonant frequency, but not lower.

4. On commutator motors, suppression capacitors may be most effective if connected from each brush holder to the frame, or across the brush holders, or from each line to the frame, or a combination of these. They should always be installed with the shortest possible leads and the appropriate capacitance to resonate this length should be used. While the lead length may not greatly affect the suppression obtained at the resonant frequency, it should be noted that the impedance of the capacitor-plus-leads at frequencies above or below resonance is directly proportional to the reactance, and hence length, of the leads at resonance. For this reason the shortest possible leads should always be used, and the capacitor size chosen accordingly.

5. The Canadian Electrical Code specifies the allowed leakage currents in order to limit shock hazard. This Code must always be met when attempting to suppress radio noise.

Nisar Ahmed.

Nisar Ahmed,
Director,
Engineering Programs Branch,
Telecommunication Regulatory
Service.



10,000
5,000
2,000
1,000
500
250
100
50
25
10
5
Capacitance in pF
Total Lead Length Centimetres
Resonant Frequency in MHz
5
10
100
1000

FIGURE †

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TRC - 48

TELECOMMUNICATIONS REGULATION CIRCULAR

TELEVISION RECEPTION AND INTERFERENCE
SERVICE AREA OF A TELEVISION STATION

MARCH 31, 1978
(REPLACES SII-13-44 OF JUNE 21, 1962)

TELECOMMUNICATION REGULATORY SERVICE

M

TELEVISION RECEPTION AND INTERFERENCE

SERVICE AREA OF A TELEVISION STATION

1. The degree of annoyance from interference to television reception is dependent, among other things, on the relative intensities of the desired signal and the interfering signals, and on the type of interfering signal. This is somewhat similar to the effect of radio noise on the reception of speech and music. Unlike reception in the standard broadcast band, the intensity of a television signal usually falls off very rapidly beyond the primary service area, which is about 50 to 60 kilometres from the television broadcast station, and radio noise becomes correspondingly more objectionable. A limited area beyond this distance is referred to as the "fringe area", and although satisfactory reception may be obtained when conditions are favourable, continuous noise-free reception cannot be expected. Certain types of interference are generally found to be troublesome only beyond the primary service area while other types of interference are likely to be troublesome even within this area.

2. Most television receivers are made very sensitive in order that they may be usable with as low a signal as possible. There is, however, a practical limit to the minimum usable signal which will give satisfactory television reception, because there exists in all locations an unavoidable background noise. The noise level varies from place to place and, in general, determines for any particular locality the minimum satisfactory radio signal. Background radio noise offers no problem in the vicinity of transmitters; its effects are seen only where signals are weak. Weak signals mean that more gain has to be used, with the net result that noise is also amplified to such an extent that it becomes apparent on the television screen, and there is no practicable escape.

3. Some types of interference are attributable to limitations in the receiving system, as some receivers will respond not only to the signals to which they are tuned but also to signals at other frequencies. Some of these shortcomings are inherent in the design of certain receivers, and the difficulty can be overcome only by obtaining a receiver having greater selectivity. In other cases, however, the serviceman can do much to alleviate the trouble by improving the antenna system or installing a filter or "trap circuit" especially designed to reject the unwanted signal.

4. Other types of interference are due to radiation on the allotted frequency channel and these may be most effectively cured by suppression at the actual source.

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VARIABLE RECEPTION CONDITIONS (FADING)

5. Reception conditions for television vary considerably with location and time. Outside the primary service area the intensity of the received signal is likely to vary considerably with time. This variation may be rapid, for instance at distances of 130 kilometres or more the received signal may fade and return to strength within a few minutes. There is likely to be random variation in the field strength from day to day and from season to season.

6. Furthermore, fading conditions for television signals are not the same as those for signals in the standard broadcast band, in so far as fading may be present in the former and not in the latter, and vice versa.

ANTENNAE

7. In order to obtain a satisfactory TV picture, adequate signal voltage at the receiver input terminals is necessary. Where the receiver is installed within a few kilometres of the TV broadcast station and the receiver is not shielded by a metal building, an indoor antenna may be satisfactory, but if the receiver is more than a few kilometres from the TV station, an outdoor antenna with a radio frequency transmission line is necessary.

8. Great care should be exercised in selecting a suitable type, location, direction, and height for this antenna to pick up the signal without undue noise.

9. As a general rule, increased height of the receiving antenna considerably improves the reception at distances greater than thirty kilometres from the TV broadcast station. However, there are sometimes exceptions to the rule, and whenever possible, tests should be made to determine the best height, location, and orientation of the antenna. Particularly in cities, the movement of the antenna a few metres will sometimes considerably affect the TV signal voltage delivered to the receiver.

10. Buildings and hills cause reflection of TV signals and sometimes the reflected signal causes "ghosts" on the TV screen, as the reflected signal in taking the longer path reaches the receiver at a later time, and a double image is produced. Occasionally a reflected signal is so much stronger than a direct one that the direct may be ignored and the antenna oriented to receive the reflected signal.

11. An aircraft flying overhead may cause reflections which temporarily ruin reception for short periods.

12. When more than thirty to sixty kilometres from the TV broadcasting station, a special antenna array is usually necessary in order to deliver adequate signal to the input terminals of the TV receiver.

...3

SOURCES OF INTERFERENCE TO TV RECEPTION

13. Undesired TV Signal on Adjacent Channels - This type of interference may be caused when a TV signal from an adjacent channel is strong compared to the desired signal, and the TV receiver is not sufficiently selective. Such interference may be eliminated by using a filter, in the antenna lead-in, tuned to prevent reception on the undesired frequency, or a quarter-wave stub. Where the direction of the undesired TV station is different from that of the desired station, improved reception may often be obtained by changing the orientation of the antenna.

14. Co-Channel TV Interference - Where the receiver is located within the range of two television transmitting stations on the same channel, there is likely to be considerable interference. If the desired signal is sufficiently strong, the interference may be overcome by the use of a directional array oriented so as to avoid reception from the undesired station.

15. Radio Signals on Frequencies Other Than the Desired TV Channels

(a) This type of interference includes the reception of radio signals from commercial and amateur radio stations, and medical diathermy and industrial-heating equipment. The interference is more pronounced on receivers which have not adequate selectivity, and on receivers capable of picking up radiation on the intermediate frequencies.

(b) This type of interference may, in some cases, be reduced by the use of a filter, in the antenna lead-in, designed to reject the undesired signals. In other cases, it may be necessary to shield the receiver to prevent pick-up on the intermediate frequency. Severe cases may require the application of both methods.

16. Other Radio Signals on the Desired TV Channel

(a) In licensing other radio communication stations, the Department of Communications endeavours to avoid making frequency assignments which might result in interference to TV reception. Occasionally, however, through faulty equipment or design, radio transmitters may radiate excessive harmonics, and if these harmonics fall on the TV channel they will cause interference. Such harmonics must be reduced to a reasonable level, at the transmitter, so that the effect on TV reception is not objectionable when receiving stations within normal range.

(b) Operators of medical diathermy and industrial heating apparatus are allotted certain frequency bands in which to operate, and are required to limit the radiation from their equipment on all communication frequencies. Some TV receivers located near such apparatus may be subject to interference because of this limited radiation.

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17. Radiation from other TV Receivers - TV receivers radiate a certain amount of energy at several frequencies, particularly on the frequencies of the receiver oscillators, and may cause interference to other TV receivers near by. This receiver radiation is greater in the case of the earlier models as manufacturers are now improving the design to reduce this radiation.

18. Motor Vehicles

(a) The ignition systems of some automobiles cause interference to TV reception.

(b) For some time, the Department of Communications has been working with the Canadian Standards Association, the Society of Automotive Engineers, and the manufacturers' representatives in the study of this problem. Great progress has been made, and most modern cars now cause very little TV interference. A considerable number of vehicles which cause excessive interference to television reception are still in operation however.

(c) There is no known means of adequately suppressing ignition interference at the TV receivers, and the only cure is the application of suppression to all motor vehicles which cause interference. The use of efficient antennas and receivers will, however, reduce the effect of such interference by improving the signal-to-interference ratio.

19. Electrical Appliances - Various types of electrical appliances may cause interference to television reception, but commonly the interference at the high frequencies used for television is not as objectionable as the interference from appliances in the standard broadcast band. The following household equipment may cause interference to TV reception:

(a) Faults, such as loose connections in wiring, outlet receptacles, appliance cords, etc.;

(b) A type of incandescent lamp in which the filament is zigzagged between two spiders supported at top and bottom of a glass rod. This type of lamp causes radiation at high frequency, and when its frequency falls within the TV channel, it may cause interference up to a distance of 300 metres and appears as a horizontal bar across the screen;

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(c) Other appliances such as:

defective thermostats of warming pads,
electric razors,
flashing fluorescent lights,
commutator motors in vacuum cleaners,
light dimmers, etc.

20. The cure for all these types of interference is either to replace the equipment or apply interference suppressors at the terminals of the equipment causing the interference. Interference which cannot be cleared up by the listener himself should be reported to the nearest Department of Communications' Radio Inspector.

Nisar Ahmed

Nisar Ahmed,
Director,
Engineering Programs Branch,
Telecommunication Regulatory
Service.

Government
of Canada
Department of Communications

TRC-56

TELECOMMUNICATIONS REGULATION CIRCULAR

SHIELDING FOR THE SUPPRESSION OF RADIO INTERFERENCE

MARCH 31, 1979
(REPLACES S11-10-43 of JANUARY 15, 1972)

TELECOMMUNICATION REGULATORY SERVICE

SHIELDING FOR THE SUPPRESSION OF RADIO INTERFERENCE

SECTION 1 - GENERAL

1.1 Necessity for Shielding.

Interference to radio communications may be caused by the operation of electrical equipment whenever radio noise on communication frequencies is radiated or conducted from the apparatus. When such radio noise exceeds specified tolerable limits, or harmful interference to communication occurs, the radio noise must be suppressed.

Shielding is the only known method of suppressing radio noise which is radiated directly from the apparatus. As the noise invariably leaves the apparatus by both conduction and radiation, it is also necessary to insert interference suppressors in the power line supplying the apparatus, and in all conductors which pass through the shield.

1.2 General Requirements of a Good Shield.

1.2.1 Include all noise radiators.

The shielded enclosure must include all components and accessories of the noise producing apparatus and any object which may radiate. For example, a shielded cubicle for the suppression of radio noise from diathermy apparatus must enclose, in addition to the apparatus, the patient and operator.

1.2.2 Conductivity of Shielding Material.

The effectiveness of a shield largely depends on the use of material which has a low surface impedance and is continuous.

1.2.3 Continuity.

It is very important that no breaks occur in the shield, such as openings around the perimeter of a door, etc. The material may be either sheet metal, metal foil, or woven screen, provided that the contacts between the wires of the screen are of very low impedance. Galvanized wire mesh provides an excellent material for screening, provided that the mesh is galvanized after weaving. Very small openings in the shield, such as the mesh of wire screening, are not detrimental. A crack 3 - 4 centimetres long, even though less than 0.2 millimetres wide, is usually detrimental. It is, therefore, important that all sections of the shield, such as panels and door openings, etc., be thoroughly bonded. A defect in the shielding produced by paint preventing thorough bonding between sheet metal plates, may form an opening for the radio noise similar to a slot antenna, and allow excessive radiation at high frequency.

1.3 Types of Shielding Material.

A number of materials are available for shielding purposes including:-

Sheet metal, such as aluminum or copper, galvanized iron, etc.

Metal foil, such as aluminum or copper, which may be less than 0.01 millimetres thick.
Metal foil mounted on paper or plywood is frequently used.

Wire gauze or screening and perforated metal, provided that the perimeters of the openings do not exceed two centimetres. The finer the mesh the more effective is the shielding, particularly at high frequencies.

NOTE: Most so-called conducting paints are of limited value for screening, on account of the high impedance. The binder insulates the conducting particles of metal or carbon from each other.

1.4 Single and Double Shield.

A single shield, well constructed and maintained, should provide an attenuation of 40 dB (99% effective) or greater. When a more effective shield is required double or triple shielding should be considered (see para. 2.1).

The usual method of providing a double shield for a room or cubicle is to provide a framework of well-dried lumber preferably sealed to prevent the absorption of moisture. Cover the inside and outside with the shielding material from four to eight centimetres apart. For best results it is important that there should be no contact or electrical connection between the inside and outside shields, except at one point usually where the power supply enters, where the inner and outer shields are bonded together.

Another method of constructing a double shield is the use of a type of construction known as cell type in which panels shielded on both sides and bonded around the perimeter are assembled to form a complete enclosure. Further details of construction are given in subsequent sections.

1.5 Automatic Switch.

In cases where serious interference may arise with the door open, a switch or relay should be installed on the door frame which will make it impossible to operate the machine with the door open. As an alternative, a warning signal may be used to indicate when the door is open.

SECTION 2 - ATTENUATION REQUIRED AND METHODS OF TESTS

2.1 Type of Shield.

Before construction is commenced consideration should be given to the effectiveness or attenuation required. The required attenuation may be calculated by dividing the intensity of the noise from the unsuppressed source, by the permissible intensity of the reduced noise. If the levels are expressed in decibels they should of course be subtracted.

In deciding the attenuation required a liberal allowance should be made for possible deterioration of the shielding with age and the possibility of new radio receiving stations being installed in the vicinity.

As a general rule, single shielding may be relied on for an attenuation of 40 dB (a reduction of 100 times of the field strength in microvolts per metre). However, careful design, construction, and maintenance of the enclosure, together with good line suppression, may result in attenuation up to 66 dB (a 2,000 times reduction of the field in microvolts).

When attenuation greater than 40 dB is required the merits, complexity, and costs of single and multiple shielding, should be compared before a decision is made. With care, double shielding may give attenuation of the order of 100 dB (a 100,000 times reduction of the field in microvolts).

2.2 Measurements of Radiated Noise Intensity.

Unless an estimate can be made of the intensity of the unsuppressed noise, tests should be conducted.

2.2.1 Standard Noise Measuring Instrument.

Canadian Standards Association Standard C 108.1.1 - 1977 "Electromagnetic Interference Measuring Instrument - C.I.S.P.R. Type", specifies the circuit characteristics of the standard noise measuring instrument.

2.2.2 Location of Noise Meter.

The various standards of CSA series C 108 specify the location of the noise meter relative to the noise source for measurements in connection with recommended limits from various types of interfering apparatus.

2.3 Attenuation of the Power Line Filter or Suppressor.

A filter should be installed in the power supply leads to the interfering apparatus at the point where they enter the shielded enclosure, and this suppressor should provide sufficient attenuation of the conducted radio noise to ensure that the remaining noise on the conductor outside the cage is sufficiently low.

The effectiveness of the filter is usually expressed in terms of insertion loss (attenuation) in dB for a specific frequency or frequency band. The insertion loss should be measured in the laboratory but as the effectiveness of the filter may differ in actual practice it is recommended that 10 to 20 dB additional insertion loss be required.

Some of the factors which should be taken into consideration in the design of the filter are:

(a) Frequency range over which the filter is required to be effective.

(b) Power requirements of the power supply.

(c) Ability of the filter to operate under the environmental conditions such as temperature, humidity and corrosion.

To help cope with conditions such as are outlined in section (c), a proper cabinet for housing the filter should be considered.

Power line filters and cabinets are available from engineering firms as stock items or can be custom built.

2.4. Test of Shields for Leaks of RF Energy.

2.4.1 Scanning The Spectrum.

After the shielding has been completed and the suppressors installed in all conductors entering the shield, tests may be made to determine the location of any faulty construction of inadequate suppression.

A portable sensitive radio receiver may be used at various points, approximately 3 metres from the shield. In each location the section of the radio frequency spectrum of interest should be scanned, and the location of the instrument and the frequency of the noise should be noted. If it is found that the noise field within 30 centimetres of the conductors is considerably greater than elsewhere, the effectiveness of the interference suppressor should be improved.

2.4.2 Location of Faults.

When the suppressors are considered satisfactory, according to this test, more detailed investigation may be made by probing.

A small portable radio receiver with loop antenna, or a noise meter with a loop probe, may be used to investigate the noise field in close proximity to the outside of the shield. The sensitivity of the receiver or noise meter should be reduced so that the minimum noise near the shield is just perceptible. The noise field near all openings such as doors, windows, and near the joints of the shielding material, should be investigated. The suppression should be improved at all places where the noise is found to be excessive.

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A useful indicating device for locating leaks can be easily constructed using a tuned circuit consisting of a coil and tuning capacitor together with a 0-100 microampere meter diode detector (1N34).

SECTION 3 - SHIELDING ROOM OR CUBICLE

3.1 Location.

3.1.1 For noise suppression a preferred location for radio frequency equipment for industrial or medical purposes, is on the ground floor or in the basement of a building. If located elsewhere, greater care in the design and construction of the shielding is required, to attain the same degree of suppression.

3.1.2 The shielding should not be very close to wiring of power or communication circuits which may pick up the radio frequency energy from the eddy currents in the shielding. Any wiring in the walls adjacent to the shielding should be in grounded conduit.

3.1.3 No metal pipes, such as used for heating or ventilating should be within a few centimetres, or touch or enter the shielding, if the same can be avoided. If it is necessary that pipes should enter the shield they should enter very close to the point where the power circuit enters, and should be bonded to the shielding at the one location only. Connection to the shield at more than one point may provide a loop which may transmit noise energy.

3.2 Doors, Windows, Light, Ventilation, Appearance, etc.

In order to decide on the type of construction, consideration should be given to various requirements, such as doors, windows, light, ventilation, appearance, etc. The appearance of a shielded room or cubicle for use in diathermy treatment is of greater importance than the appearance of a screened enclosure in a factory. Light and ventilation may be provided by the use of wire screen for the walls and the ceiling or parts thereof, and sheet metal or metal foil may be used where light and ventilation are not required.

To avoid the possibility, in electro-medical work, of electric shocks a dado of wallboard may be installed about one metre high around the inside of the booth. This also protects the screen from mechanical injury and may improve the appearance of the booth.

3.3 Choice of Cubicle or Shielding Walls of Building.

The walls of an existing building or new permanent walls may be shielded, or a cubicle installed which may be either fixed or portable. Tenants frequently prefer a portable cubicle which may be removed in sections.

Prefabricated cubicles of various standard sizes, consisting of sections which may be conveniently assembled, may be purchased.

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3.4 Use of Metal Foil.

3.4.1 Material

Copper or aluminum foil, when properly applied, forms an excellent shield for the suppression of radio noise. Large sheets of unmounted foil are difficult to handle and, therefore, copper and aluminum foil for this purpose is usually supplied mounted on a paper base or some form of wall board. "Copper Armored Fibreen" is a trade name for one of these products.

3.4.2 Preparation of Room.

The room to be shielded should be prepared by removing as many of the projections and fixtures as possible, so as to provide plain smooth surfaces for the shielding material. The electric fixtures, doors, base boards, window and door moldings, picture moldings, and other irregularities should be temporarily removed. The surface of the walls, ceiling, floor and door should be made as regular as possible, and wall board may be fitted over irregularities, such as panels.

3.4.3 Shielding Ceiling and Walls.

Paper backed foil may be mounted on the walls and ceiling with the use of a good waterproof glue. The foil may be applied to the walls in vertical strips, metal surface showing, in a manner similar to that of mounting wallpaper. Care should be taken to make perfect contact between the paper backed foil and the wall and to avoid the trapping of air bubbles. A paperhanger's heavy brush may be used, or a wide roller.

If tinned copper bonding strips are available, copper foil may be mounted with butt joints, as described in paragraph 3.4.5. These butt joints should be made on the flat surface, avoiding the corners wherever possible. If tinned bonding strips are not available, one edge of the paper backed copper foil must be folded before mounting, as described later.

In cutting the foil a few extra centimetres should be allowed for any irregularities in the shape of the room, and the foil trimmed to size when mounting. Ten extra centimetres should be allowed, to permit the wall strips to extend along the floor.

3.4.4 Shielding Floor.

The floor may be covered with paper backed foil, or other shielding material. If foil is used it is recommended that the metal surface be turned down, so as to avoid being damaged during the construction period, or by wear due to slight movement of the linoleum or other floor finish. In order to bond the floor to the walls, it is necessary to fold the edge two centimetres or more, bringing the

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metal surface available for bonding to the walls and to the adjacent strips. Great care must be exercised to ensure that there are no loose boards or any irregularities which might cut through the foil. After the bonding, linoleum may be laid on the floor and may or may not be cemented, as desired.

The floor shielding may be bonded to the bottom of the doorway in the following manner:-

The linoleum should be cut in a straight line immediately below the door. Sheet copper may be bonded to the floor shielding and brought up to the surface of the linoleum where it is bonded to a brass sill. This brass sill should be two centimetres or more in width, 1.5 millimetres in thickness, and of a length equal to the width of the doorway.

A simpler method of treating the bottom of the doorway may be tried in cases where no electric wiring below the floor is within one metre of the door. This method consists of extending the floor shielding 30 centimetres beyond the door and omitting the metal door sill, described above. The gap between the floor shield and the door shield should be as small as possible. If tests indicate insufficient suppression, it will probably be necessary to bond the bottom of the doorway, as described in the previous paragraph.

3.4.5 Bonding Copper Foil.

All butt joints of copper foil should be bonded with a tinned copper strip five centimetres wide. The foil should be thoroughly cleaned and flux applied at all butt joints for a width of about five to six centimetres, to ensure that the area covered by the strip is completely cleaned and covered with flux. The bonding strip should then be applied and soldered by merely applying a hot iron and immediately pressing the copper strip to the foil with a handful of cotton waste. A soldering iron (250 watt), having a special five centimetres broad tip, may be used.

When tinned copper strips are not available, paper backed foil may be soldered, provided that precautions are taken to avoid the heat from the soldering iron causing the tar used to mount the copper foil on the paper, from running out. One edge of the paper backed foil should be folded over two centimetres (copper face outside rolled flat) before mounting. This folded edge is then mounted, overlapping the plain edge of the strip previously mounted. The edge of the folded joint and the two centimetres of the lower strip should be cleaned and flux applied. "Plumber's Black" may be applied to the adjacent surface, to prevent the solder from flowing where it is not required. The joint should then be soldered and wiped. Those experienced in making lead pipe joints can make a neat bond.

3.4.6 Bonding Aluminum.

Paper backed aluminum foil may be mounted by folding the edges of the adjacent strips in the form of a pleat with the metal sides together. This type of bond usually requires tacking at frequent intervals, or covering with a molding strip of wood or metal, to provide pressure.

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All bonds between ceiling, walls, and floor shielding, and around the windows and doors may be made in a similar manner.

3.4.7 Wiring and Piping near Shield.

There is a considerable field of radiation within a few centimetres of all shielding and it is therefore, necessary to keep all unshielded wire more than thirty centimetres from the outside of the shield. Where such wiring exists, it should be either relocated or placed in conduit.

Long lengths of metal conduit, water or other pipes should not be run in close proximity to the shield, and in no case should conduit or other piping come within five centimetres of the shield.

All pipes or metal which pass through the shielding, such as used for heating, ventilating, water, or electric conduit, should be thoroughly bonded to the shielding; also, the shielding should be fitted tightly around such pipes. Before bonding, care should be taken to ensure that such piping is properly grounded.

All conduit boxes should be covered with a metal plate and bonded to the shield with a short lead. Hot and cold air registers and ventilators should be covered with bronze wire mesh behind the grating.

3.4.8 Door.

The molding which protrudes from the surface of the door may be removed and the panels filled in to a flush surface by wallboard. The surface may then be made smooth by filling crevices with linoleum cement. Paper backed metal foil is then mounted over the door and continued over all edges.

A screen door may be used provided it is completely shielded and bonded on all sides. A screen door frame may be made of wood and covered with insect wire cloth either copper, bronze or iron wire galvanized after weaving. The wire cloth should extend over the entire surface and over the four edges. The screen on the edges should then be covered with spring bronze weather strip. The weather strip should be nailed to the door and soldered to the screen.

3.4.9 Window.

The window should be covered with a wire mesh, either inside or out, as desired. The screen should be thoroughly bonded on all sides with the wall shield. This may be accomplished by using spring bronze weather strip.

3.4.10 Replace Moldings, etc.

The base boards, window and door frames, and door, may then be replaced

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3.4.11 Finish.

The foil should first be cleaned with a weak solution of acetic acid or vinegar and should then be given a coat of sizing, as ordinary paint and paste for wall paper will not adhere to metal finish. This sizing may consist of shellac or lacquer. Paint, enamel or wallpaper may be applied in the ordinary manner. Some prefer the natural appearance of the copper. If this is required, however, the copper should be thoroughly cleaned and be given a coat of clear lacquer, as otherwise the metal will tarnish.

The woodwork may require to be repaired and refinished.

3.5 Power Supply.

The power is provided through an interference suppressor, mounted in an iron box at the point where the service enters. All circuits in the room for lighting or power must be provided through this suppressor.

SECTION 4 - SHIELDING APPARATUS

4.1 General.

A shield for apparatus generally requires to be even more carefully constructed than the shield for a room, due to the fact that conductors carrying large noise currents are frequently in close proximity to the shield. The general instructions given in Sections 1 (General) and 2 (Attenuation Required and Methods of Tests) should be carefully followed, and many of the suggestions given in Section 3 regarding shielding a room or cubicle, are also applicable to the shielding for apparatus.

4.2 Generator and Load Circuit within a Single Shield.

Wherever possible, a single enclosure should contain the entire installation including the RF generator and load circuit. When one generator supplies RF energy for a number of applicators, great care must be taken to ensure that the various sections of the shield are at the same RF potential.

4.2.1 RF Transmission Line.

In order to prevent radiation from the transmission line connecting the generator with the applicator or load circuit, this line should be double shielded.

4.3 Material.

Sheet metal which has sufficient strength and is noncorroding and has low surface conductivity, is best for all parts of the shield except where ventilation is required. Sheet copper or galvanized iron are suitable.

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Where ventilation is required panels may be made of woven wire, but is essential that the resistance of each wire contact of the mesh, and from the screen to the frame remains extremely low. Woven wire galvanized after weaving, or perforated galvanized iron, is suitable, provided that the circumference of the largest opening does not exceed two centimetres.

4.4 Construction

The bonding between panels should preferably be continuous, by either welding or soldering. If the panels are to be spot welded, rivetted, or bolted, the panels should have a liberal overlap and the connecting points close together. It is essential that the bonding between panels has very low resistance at all points and maintains this low resistance throughout its life.

4.5 Openings for Inspection and Movement of Products.

The doors of all openings should have a liberal overlap and means provided to ensure low contact resistance at all points about their perimeters. In order to ensure low contact resistance at all times the contact must be kept free from dirt or corrosion. A wiping contact at the door tends, as the door is closed, to remove dust and loose dirt which might otherwise increase contact resistance. Some type of spring material or cushion is required between the door and the door frame, and this may be spring bronze weather stripping or copper braid covering a rubber tube.

4.6 Grounding.

The grounding of the shield is not essential for the suppression of radio noise. In fact, the radiation of noise is sometimes increased by grounding the shield. The shield is usually required to be grounded according to safety regulations. If it is found that the grounding increases the radiation of noise, the RF currents may be kept out of the ground wire by the insertion of a radio frequency choke. All connections from shield to ground, including the power supply conduit, must be treated in this way. The choke coil should have a current carrying capacity equal to that of the ground wire and should be enclosed in a metal shield throughly bonded to the shield of the interfering apparatus.

SECTION 5 - MEANS OF IMPROVING EFFECTIVENESS OF A SHIELDED ROOM OR CAGE

5.1 Conducted Noise.

When the radio noise on any conductor is found to be excessive, an effort should be made to improve the installation of the suppressor, paying particular attention to the bonding of the suppressor.

The suppressor case should be thoroughly bonded to the shielding material of the room or cage. The case of the suppressor should be in rigid contact with the shielding at the point where the electric circuit enters the shield. The use of leads for bonding the suppressor case to the shield of the room or compartment is not satisfactory, as the impedance of leads will retard the flow of the noise currents from the suppressor to the shield.

Ensure that all instructions for the installation of the suppressor have been accurately carried out.

If, after the best suppressor for the purpose has been correctly installed and the noise on the conductor is excessive, the bonding of the conduit from the suppressor to ground should be checked. The ground lead from the conduit to earth should be as short as possible, preferably only a few centimetres. If necessary, a special driven ground should be used for the purpose and the conduit carried to this driven ground.

Where radio noise is excessive on other conductors which do not enter the shield, it may be caused by such conductors being closely coupled to the shielding material. Wherever possible no electrical conductors should be run within twenty centimetres of the shielding materiel. Where it is impossible to provide sufficient space for such conductors, the section of such conductors in clcse priximity to the shield should be enclosed in grounded metal conduit.

5.2 Radiated Noise.

After all leaks found by the method of test described in para. 2.4 have been corrected, and the radiated interference is found to be excessive, improved suppression may be attained by adding an additional shield in parts of the interior of the enclosure.

Where conductors carrying large noise currents are in close proximity to the shielding material, excessive eddy currents are induced in this shield. These excessive eddy currents may cause excessive radiation beyond the shielded enclosure. In order to prevent this condition the coupling between the conductors carrying excessive noise currents within the shield and the shielding material should be reduced, either by increased separation or additional shield. If such conductors are lying on the floor improved suppression may be attained by installing a sub-floor, to increase the separation of such conductors from the shield, or a barrier to keep the wires from the shielding on the wall. If this separation should not be sufficient, an extra partial shield may be installed here and bonded to the common bond at the electric power inlet.

Dr. John deMercado
Director General
Telecommunication
Regulatory Service

Government of Canada

Department of Communications

R.I.I. SPECIFICATION 204
ISSUE: 3
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SUPPRESSION OF INDUCTIVE INTERFERENCE

EXEMPTION OF WIRELESS MICROPHONES FOR OPERATION WITHOUT A RADIO LICENCE

TELECOMMUNICATION REGULATORY SERVICE

Suppression of Inductive Interference

EXEMPTION OF WIRELESS MICROPHONES

For Operation without a Radio Licence

1. Under Section 6 of the General Radio Regulations, Part II, certain radio equipment, which has been Exempted for that purpose, may be used without a Radio Licence. Subsection (1) paragraph (a) (ii) of Section 6 authorized the exemption from Licensing of Equipment which is to be used only as a wireless microphone in conjunction with a licensed radio station, or a public address system. A list of equipment which has been so exempted, and the Exemption Numbers, are contained in Circular SII-18-1.

2. Those seeking exemption of such equipment shall satisfy the Department that the equipment actually meets the performance requirements set out below. If the individual or organization applying for an Exemption is not the prime manufacturer of the equipment, then exemption shall be applied for under a designation and type number which is the property of the applicant. After exemption, all units offered for sale shall bear this exemption number, and the holder of the Exemption shall be responsible for ensuring that the equipment he offers for sale is identical to the original unit on which the Exemption was granted.

3. Unless prior approval in writing is granted Exemption tests shall be made in Canada. The Engineer responsible for making the test shall be an electrical engineer who is a member of or is licensed by the Association or Corporation of Professional Engineers of a Province of Canada and shall certify on the test report, over his seal, that the tests were made in accordance with the requirements set out below. The Department of Transport reserves its right to make tests of any equipment, for which exemption is requested, in its own laboratories or to witness tests in the laboratory of the applicant.

4. The following information shall be submitted to the Director of Telecommunications, Department of Transport, Ottawa, to obtain Exemption:

   (a) One copy of the Test Report. The Test Report shall confirm that all tests were made in strict accordance with the methods prescribed herein; it shall give the numerical results of the measurements made and shall confirm that the equipment meets the requirements in all respects. It shall clearly designate the make and model number of the equipment which was tested. The report shall be signed by the test officer.

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(b) Two copies of the schematic diagram and a parts list showing the manufacturers name and type number of each component part.

(c) Photographs of the unit showing details of external and internal construction, including a direct top, and a direct bottom, view of the chassis.

(d) One copy of all advertising literature and of the Instruction book, as supplied with the equipment, shall also be submitted if available, if not available they may be submitted at a later date, as soon as available. Also, upon the subsequent publication of any new technical information, instructions, etc., relating to the equipment, the manufacturer concerned shall forward this information to the Department.

5. Every piece of Exempted equipment offered for sale shall bear the manufacturer's name, or brand name under which it was exempted, the model number and the operating frequency, and shall bear the following statement:

"Department of Transport Radio Licence Exemption No............"

The Exemption Number, which will be issued to the applicant, shall be inserted in the above statement.

6. The Exemption covers the model specified in the test report. In subsequent manufacture or repair, components of different makes but identical characteristics may be substituted, but the Exemption will be rendered void if any subsequent modifications are made which will degrade the performance of the equipment.

7. Attention is called to the fact that the receiver unit, being a power line operated device, also requires Canadian Standards Association approval in connection with shock and fire hazards. Department of Transport exemption for operation without a radio licence does not, in any way, obviate the need for C.S.A. approval.

PERFORMANCE REQUIREMENTS

8. The equipment shall operate on one of the following Industrial Scientific and Medical bands and the emissions must be confined within the limits shown:

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Centre Frequency	Emission Limits
27.12 Mc/s	± .6%
40.68 "	± .05%
915 "	± 25 Mc/s
2450 "	± 50 "
5800 "	± 75 "

9. Test Voltages: Unless otherwise specified, all dry-battery operated equipment shall be tested with batteries whose voltage is at least 90% of that of new batteries.

10. Power Output: The modulated radio frequency power output capability of the transmitter shall not exceed 1 watt. The output power shall be taken as one half the direct current power to the final output stage.

11. Frequency Stability: The transmitter carrier shall remain within ± 0.01% of its mean frequency under the following conditions:

> The transmitter shall be turned on and allowed to warm up for a period of one minute. Thereupon, and every 10 minutes thereafter for one hour, the carrier frequency shall be measured. A frequency meter having an accuracy of at least .001% shall be used for all frequency measurements.

12. Harmonic and Spurious Emission: Any emission on a frequency outside the I.S.M. band limits specified in paragraph 8 shall be at least 30 decibels below the carrier level.

The spurious radiation shall be measured as follows:

> A sensitive field strength meter shall be used, and the field strength of the fundamental and spurious emissions shall be measured, at a distance of ten feet. The loop antenna and the measuring antenna shall be at a height of 4 feet above the ground. Spurious radiation shall be checked at all frequencies between 500 kilocycles and at least 220 megacycles for equipment operating in the 27 Mc/s band, and up to at least the third harmonic in the higher bands. All spurious outputs shall be noted and the most intense ones also be measured, and their values recorded. The fundamental shall also be measured, and the ratio in decibels between it and the spurious outputs computed.

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13. <u>Temperature Stability</u>: The transmitter carrier shall remain within ± 0.01% of its mean frequency under the following conditions:

The transmitter shall be placed in a box or room, the temperature of which can be accurately measured, controlled and maintained over the range minus 25 to plus 65 degrees Centrigrade. Measurements are to be made at minus 25°C, at plus 20°C and at plus 65°C after the equipment has been stabilized at each temperature under stand-by conditions, (i.e. the transmit switch opened). The transmit switch shall then be closed and the measurement made.

14. <u>Vibration Stability</u>: The transmitter carrier shall remain within ± 0.01% of its mean frequency under the following conditions:

The transmitter shall be dropped a distance of 12 inches on to a pad or rubber one half inch thick. It shall be dropped at least 10 times and the frequency measured initially, and after each drop.

15. <u>Voltage Stability</u>: The transmitter carrier shall remain within ± 0.01% of its mean frequency under the following conditions:

The transmitter shall have been shut off during a period of at least one half hour immediately preceding the start of the test. Test voltages shall be that of new batteries, and 2/3 of this value, or the lowest voltage at which the transmitter will produce output, if this is more than 2/3 of nominal battery voltage. Full voltage shall be applied, and a frequency measurement made one minute after supply voltage is applied. Next the reduced voltage shall be applied, with the transmitter in stand-by condition for at least one half hour. The frequency shall than be measured.

RECEIVER PERFORMANCE

16. Receivers having a nominal supply voltage of 110-120 volts AC shall be tested at 117 volts. The receiver shall be unsquelched to maximum.

17. <u>Radiation (R.F. Emission)</u>: The radio frequency energy appearing on the antenna terminal or the power leads shall not exceed 50 microvolts when measured under the following conditions:

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(a) Using a sensitive field strength meter as a two terminal voltmeter any R.F. voltages appearing between the antenna terminal and receiver chassis shall be measured, with no antenna connected to the receiver.

(b) Next, any R.F. voltages present on the power line shall be measured by connecting the two terminal voltmeter through a blocking condenser to each power line conductor, with the other terminal of the voltmeter connected to the chassis.

(c) During measurement, power supply leads at least 6 feet long shall be used and shall be coiled into a choke (inductance), to reduce R.F. coupling to the power source. A correction shall be made for any reduction in the readings due to the presence of the blocking condenser. This test shall be omitted if the receiver is operated from batteries contained within the receiver case.

(d) The input impedance of the meter, if other than 50 ohms, shall be padded to a value of 50 ohms. R.F. emission from the receiver shall be checked at all frequencies from 400 kilocycles to three times the operating frequency of the receiver, and to at least 220 megacycles, and shall be measured on the frequencies at which it is a maximum.

(e) If the receiver uses only a built-in loop antenna, then the radiation shall not exceed 10 microvolts per meter on any frequency. Conducted voltage will not be measured. The field strength shall be measured in the open, at a distance of 10 feet from the receiver, with receiver and measuring antenna at a height of 7 1/2 feet above the ground. The receiver shall be oriented for maximum field strength at each frequency radiated. It shall be checked over the same frequency range as specified above for antenna voltage measurements.

Issued under the authority of the Minister of Transport.

F.G. Nixon

(F.G. Nixon),
Director,
Telecommunications and
Electronics Branch.

R F Pollution

By Glenn Hauser

Pollution has surged into national prominence as one of the most vital issues of the decade -- that is, pollution of the air, water, soil -- the environment. But little outcry has yet been heard against another form of pollution, intangible but insidious.

Radio frequency (RF) pollution is a mushrooming problem which has already severely restricted the variety of stations a person can listen to. As it worsens, the public will have to rely more and more on local stations only, which have the power to cut through the slush caused by manmade noise and interference.

I'm not talking about the growing preponderance of blah programming, or of the congestion caused by too many stations in too little spectrum -- that's another problem.

RF pollution refers to the growing menace of noise and interference invading the short and medium wave bands. It's getting worse -- as 'civilization' progresses -- because of the neglect of electronic and automotive manufacturers and service personnel.

Here is where the Association of North American Radio Clubs (ANARC) can and should serve as a national lobby representing the interests of radio listeners. Just what are the offenders? Television sets, fluorescent lighting equipment, high voltage electrical distribution equipment, and a myriad of devices from electric shavers to fish bowl heaters. Plus a good portion of the vehicles on the road.

Let's look at the offenders one by one.

Televisions sets. High voltages are required to produce a good picture -- in the tens of kilovolts, in fact. This power goes into the horizontal oscillator circuit, which in most sets is poorly shielded. As a result, AM radios anywhere near the TV set, sometimes for blocks around, are beset with "swish" all over the dial (at harmonics of the 15.75 kHz horizontal oscillator frequency). The peaks are often so broad that hardly any clear spectrum remains between them. A listener lucky enough to be away from a house full of boob tubes may still find one of these TV sweep harmonics fouling up and confusing the reception of weak signals.

Colour TV's -- now selling like wildfire -- are even worse because they require much higher voltage. And they operate on a slightly different sweep frequency, which happens to put every fifth harmonic within ½ kHz of a "trans-Atlantic" medium wave channel, i.e., one used in European/African allocations and hence of prime interest to the medium wave DXer. Just try DXing on 566, 629, 692, 755, 818, etc. in a colour-TV infested area.

And TV set pollution is often so severe that it extends high into the shortwave bands, too.

Like most aspects of pollution, there's a cure for this, requiring the spending of money and effort. TV sets can be shielded so that a comparatively small amount of radiation escapes the cabinet. A foil lining inside the cabinet can work wonders, as can improved design from the beginning. TV set manufacturers should be required to meet much stricter radiation standards. But there will still be the problem of so-called "repairmen" who fail to replace tube shields properly, and jack up the voltage to compensate for a weak picture, thus not only increasing pollution but heightening the danger of shock and X-irradiation. Sure, the poor listener can take some steps to alleviate the effects of polution, at his end, but the place to stop it, obviously, is at the source.

Flucrescent lights have experienced an explosion of popularity - they're cooler, whiter, and more efficient than incandescents. But they get old and gassy and make a horrendous buzz in various parts of the medium wave and short wave spectrum. Starting transformers also cause the buzz.

Here again the solution is simple -- better design, perhaps a built-in filter to keep the buzz from feeding into power lines. Right now, it's a good bet that fluorescent tube makers (if they're aware of the problem at all) laugh off

any idea of putting some of their precious profit back into cleaning up their product.

Ignition systems in internal combustion engines are another source of noise -- which often hits short wave and VHF listeners with an ear-splitting razz without any warning as the engine starts up. Clean spark plugs and a grounded hood eliminate the problem. The former could be part of state safety inspections; the latter should be a factory feature of every vehicle rolling off the assembly line.

Power companies -- already in hot water for air and water pollution -- must be recognized as prime RF polluters, too. Every transformer in their electrical distribution network -- indeed, every loose connection -- is a potential noise emitter. And since power lines reach everywhere -- especially into radio listening equipment -- any malfunction in the systems affects a wide area.

The answer to this is two-fold : improved equipment design, and a greatly increased maintenance programme. Most power companies already have a small staff to handle interference complaints, but they are seldom effective or concerned with eliminating the root of the problem. Usually the noise level they find tolerable is intolerable to the person who wants to be able to monitor weak signals.

Any motor with brushes can produce radio noise, once wear and dirt set in. Again, better design, shielding, and maintenance is needed.

Any device with a thermostat in it is likely to produce anything from periodic loud clicks to a constant stream of obliterating radio noise. This includes electric stoves, fish tank warmers, electric balnkets, central gas heating systems, and so on.

Yet again, improved design and shielding should solve the problem, if anybody cared.

The list of electrical appliances that wreak havoc upon the RF spectrum is endless, but let's take just one as a represantative example. The electric shaver. There are 2 kinds : one that produces noise that totally obliterates everything from long wave to VHF; and one that doesn't. I know; I've had experience with both. The solution to this is too obvious to state; but it would probably infringe on some manufacturer's vested interest to phase out the offending type -- so concerted action is needed to have any hope of getting anything done.

Which brings us to the practical aspects of fighting RF polution.

Every radio listener can only stand to gain from the reduction of artificially produced RF noise. Hence, every SWL, DXer, and casual AM listener should get busy writing literate letters explaining the severity and seriousness of the problem to congressmen known to be concerned with pollution. And to the major electronic manufacturers, and so on.

Other pollution-fighters have demonstrated that if enough people are aroused enough at least some start can be made to alleviate the problem. It's just a question of how dedicated we radio listeners really are.

RF pollution is perhaps the most insidious pollution of all : it affects the mind of the victim, by narrowing his horizons, his sources of information -- usually without his even being aware of it!

Here is our chance to make a contribution to cleansing our rapidly deteriorating environment, and with pollution an issue capturing the attention of the general public, the time to act is now.

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Thanks, Glenn. Such a job is almost impossible in so many ways. I recall that there have been cases where large electrical installations (factory motors, etc.) have interfered with airport communications and the government agency responsible for control of RF noise has successfully removed the noise source. But the physical threat to life was pretty strong, and this gave the necessary motivation for action. That's what's keeping the air and water pollution campaigns going just now - real threats to our existence. A look at charts showing white noise now, and noise levels measured earlier in this century show a drastic increase! Any comments, or formal proposals? KGS.

A.M. BROADCAST RECEIVERS FOR RADIO RECEPTION IN THE 535-1605 KC/S BAND SUITABLE FOR USE DURING A NATIONAL EMERGENCY

INTENT

1. This Specification shall cover all transistorized battery operated receivers operating in the standard broadcast band 535 to 1605 kc/s as approved for use in an emergency. To distinguish from non-approved receivers on the market, equipment tested and approved under this Specification shall have a lable affixed to the case stating - "Approved by the Department of Transport for Emergency Use".

GENERAL

2. The Government feels that one of the most important items in any shelter is a radio receiver which those in the shelter may use to receive instructions from the area emergency broadcasting station(s) regarding their safety and welfare.

3. This Specification has been prepared to define the important technical characteristics of a receiver to be used for this purpose. It is not to be used as a standard for licensing purposes.

4. While a type of radio receiver may be approved as meeting this Specification, users are advised that the performance of a radio receiver may deteriorate as a result of rough usage, high humidity or failure to maintain the batteries in a proper condition.

5. The manufacturer seeking approval shall satisfy the Department at his own expense that receivers actually meet this Specification.

RELATED SPECIFICATIONS

6. Radio Standards Procedure 100 - Procedure for obtaining Type-Approval of Equipment for Licensing.

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STANDARD TEST CONDITIONS

7. Definition - Standard test conditions are those conditions which shall apply to a receiver while it is being tested for minimum requirements. These conditions apply unless otherwise specified.

8. Standard Test Equipment - Standard test equipment shall be as specified for each individual test. Measuring equipment shall be sufficiently accurate to ensure no appreciable error in the quantity being measured due to test equipment.

9. Standard Temperature and Humidity - Shall be prevailing room conditions provided that the temperature is held at 25°C ± 5°C.

10. Standard Test Batteries - Shall consist of new batteries of the same kind for which the receiver is designed to operate.

11. Standard Dummy Load - Shall consist of a pure resistance whose value is equal to the 400 cycle per second impedance of the loudspeaker used in the set and shall be of sufficient power capacity to carry the maximum power output of the receiver without change in resistance.

12. Standard Signal Generator - The standard signal generator shall provide an undistorted sine wave output over the broadcast band and calibrated in open circuit microvolts. The source impedance shall be small compared to 400 ohms. The electrical leakage should be sufficiently low so as not to affect measurements made at the lowest voltage levels.

13. Standard Power Output - Shall be 5.0 milliwatts of audio power into the standard dummy load.

14. Standard Test Frequencies - Shall be the carrier frequencies 600, 1000, and 1400 kc/s in the broadcast band.

15. Standard Test Modulation - Shall be 400 c/s at 30% modulation.

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16. Tuning Procedure - Where tuning is not a function of signal level, receivers with AVC may be tuned for peak response to a relatively weak signal (below AVC threshold) with the volume control at maximum, after which the input signal may be increased and the volume control reduced to desired values. Other equivalent methods may be used.

17. Standard Receiver Inputs

(a) Ferrite Core Loop Antennas - The standard signal generator is connected to a shielded test loop as described in Appendix A. The position of the test loop with respect to the ferrite core loop antenna is shown in Appendix B, together with other test conditions. To a close approximation, the equivalent electric field intensity E, in microvolts per meter at the receiving loop antenna, as a function of the observed current I_1, in amps in the radiating test loop is given by

$$E = 94.25 \frac{n_1 a_1^2 \quad I_1}{x^3}$$

Where n_1 = number of turns in radiating test loop
a_1 = mean radius of radiating test loop in meters
x = distance in meters between the axis of radiating test loop and ferrite rod receiving loop.

If the test loop of Appendix A or equivalent is used and x = 24 inches, the above relation reduces to E = .05 V where V is the open circuit output voltage of the signal generator.

(b) Standard External Antenna - A standard dummy antenna shall be used and connected as shown in Appendix C to simulate receiver performance with an external antenna.

18. Standard Test Set-Up - This shall consist of the standard signal generator connected to the receiver through the standard dummy antenna or by way of the standard test loop with the standard dummy load connected to the receiver output.

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MINIMUM STANDARDS

Construction

19. Circuitry - The receiver shall be of a conventional transistorized type. The circuitry shall be kept as simple as possible and constructed to permit easy servicing. No special controls such as tone or selectivity controls are required.

20. Power Supply - The power supply shall be from standard flashlight type batteries, types "D", "AA", or other batteries readily obtainable on the market. Battery replacement shall be simple and not dependent on tools.

21. Mechanical Assembly - The components shall be assembled and mounted in such a way as to ensure rigidity. Where printed circuits are used, the printed circuit board shall have sufficient rigidity to discourage bending under mild shock conditions.

22. Tuning Ranges - The tuning range of the receiver shall cover at least the normal broadcast band 535 - 1605 kc/s.

23. External Antenna - Means shall be provided whereby an external antenna may be coupled to the receiver.

24. Enclosure - The case shall be constructed of material capable of withstanding normal handling without damage and shall be provided with a carrying handle.

ELECTRICAL PERFORMANCE

Note: In each of the following tests, measurements shall be made at standard temperature and humidity for both ferrite antenna and dummy antenna inputs.

Sensitivity

25. Definition - The sensitivity of a receiver is the least signal input voltage or signal field strength at standard modulation, which results in the standard output power at a given SINAD ratio when all controls are adjusted for maximum sensitivity. It is expressed in microvolts or microvolts per meter.

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Note: SINAD is an abbreviation for the ratio of signal plus noise plus distortion to noise plus distortion.

26. Method of Measurement - The receiver shall be set-up as specified under the standard test set-up and shall be measured under standard test conditions at each test frequency. With standard modulation applied and the receiver volume control at maximum, the input signal is adjusted to produce standard output. Under these conditions, the SINAD ratio shall be measured at the output with a distortion analyzer or other suitable means. The sensitivity of the receiver shall be the highest of the 3 figures obtained on the 3 test frequencies.

27. Minimum Standard - The minimum sensitivity shall be:

(a) 300 microvolts per meter for ferrite antenna input.

(b) 1200 microvolts for dummy antenna input.

In each case the SINAD ratio shall not be less than 6 db.

Selectivity

28. Definition - The selectivity of a receiver is a measure of its ability to differentiate between a desired R.F. signal and signals which differ in frequency from the desired signal.

29. Method of Measurement - The receiver shall be set-up as specified under standard test set-up and shall be measured under standard test conditions, except that the AVC shall be disabled. The receiver is tuned in succession to each test frequency. With the input signal level set to that obtained in the sensitivity test, the receiver volume control shall be adjusted to produce standard output. The generator output shall be increased 6 db and detuned above and below mid-frequency until standard output is again obtained in the receiver. The difference between the detuned frequencies is the 6 db bandwidth. This procedure shall be repeated at the 60 db points.

30. Minimum Standard - The detuned frequencies determining the bandwidth shall not lie anywhere within the cross-hatched areas of Appendix D.

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Audio Frequency Response

31. Definition - The audio frequency response of an AM receiver is the relative output for an input of constant percentage modulation as the modulating frequency is varied over the audio range.

32. Method of Measurement - The receiver is tuned to a signal at 1000 kc/s with standard modulation having an input of 5000 microvolts for dummy antenna or 5000 microvolts per meter for ferrite antenna. The receiver volume control is adjusted to give standard output. The output is measured at the dummy load by a vacuum tube voltmeter or thermocouple type ammeter or other suitable means. The modulation frequency is then varied from 30 to 10,000 c/s and the output relative to the 400 c/s value is observed.

33. Minimum Standard - Relative to the 400 c/s output, the 10 db down points shall not be greater than 50 c/s for the low end or less than 4000 c/s for the high end.

Maximum Undistorted Output

34. Definition - Maximum undistorted output denotes the audio frequency power that the receiver will deliver into the Standard Dummy Load without exceeding 10% distortion.

35. Method of Measurement - The receiver shall be set-up as specified under Standard Test Set-Up with an input of 5000 microvolts for dummy antenna input or 5000 microvolts per meter for ferrite antenna input. A distortion meter shall be connected across the dummy load. The impedance of the distortion meter must be high compared to the dummy load. The receiver volume control shall be increased from minimum to a point where the distortion measures 10% and the audio power output noted. This will be the maximum undistorted output. If the volume control can be advanced to its maximum position without exceeding 10% distortion, then the audio power output so obtained shall be the maximum undistorted output.

36. Minimum Standard - The maximum undistorted output shall not be less than 50 milliwatts.

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Battery Capacity

37. Definition - Battery capacity is the ability of the battery to supply sufficient energy to the receiver for a specified length of time without causing a loss in receiver performance beyond the minimum standard given below.

38. Method of Measurement - A signal input at 1000 kc/s with standard modulation and an R.F. input of 5000 microvolts in the case of a dummy antenna input or 5000 microvolts per meter for ferrite antenna input shall be applied and the receiver's volume control adjusted for 50 milliwatts output into the standard dummy load. The receiver shall be subjected to a duty cycle of 12 hours "ON" and 12 hours "OFF" over a period of 14 days. At the end of the "ON" period on the fourteenth day the audio power output shall again be measured.

39. Minimum Standard - The audio power output shall not have decreased by more than 3 db.

ENVIRONMENTAL PERFORMANCE

Operation at Temperature Extremes

40. Definition - Operation at temperature extremes refers to the electrical performance of the receiver at extremes of temperature.

41. Method of Measurement - Using the dummy antenna input only, the sensitivity, selectivity and maximum undistorted output shall again be measured as outlined in paragraphs 26, 29 and 35 respectively while in a temperature chamber maintained at 0°C and + 45°C.

42. Minimum Standard - Any degradation of receiver performance from the minimum standards at standard temperature and humidity shall be fully outlined in the test report.

Drop Test

43. Definition - The drop test is a test to demonstrate compliance in terms of rigidity of mechanical construction and to demonstrate electrical performance under mild shock conditions.

44. Method of Measurement - The receiver shall be tuned to a local station and adjusted for normal listening. It shall be dropped once on each of its six sides from a height of 8 inches onto a sponge rubber mat not more than one inch in thickness resting upon solid concrete.

45. Minimum Standard - The receiver shall be examined physically throughout. It shall show no evidence of damage and shall meet the electrical requirements of this specification.

EQUIPMENT IDENTIFICATION

46. The serial number of the equipment, the name, the type of unit, the manufacturer's name, the country of manufacture, the type-approval number, the words "Approved by the Department of Transport for Emergency Use" as well as any other information required to identify the equipment shall be stamped on each chassis or on a nameplate permanently fastened to the chassis.

EQUIPMENT CHANGES AND MODIFICATIONS

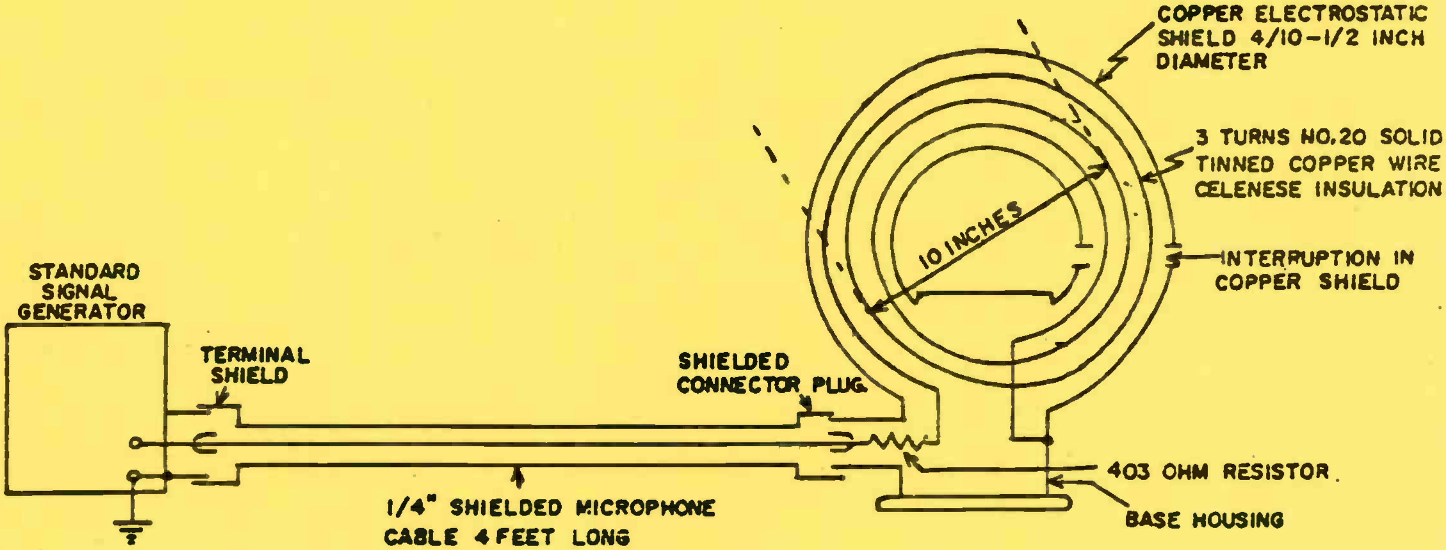
47. No design or equipment changes outside of the replacement of defective component parts by factory equivalent or by electrically or mechanically equivalent parts shall be made to an approved equipment without voiding the approval.

Issued under the authority of the Minister of Transport.

F.G. Nixon

(F. G. Nixon)
Director,
Telecommunications and
Electronics Branch.

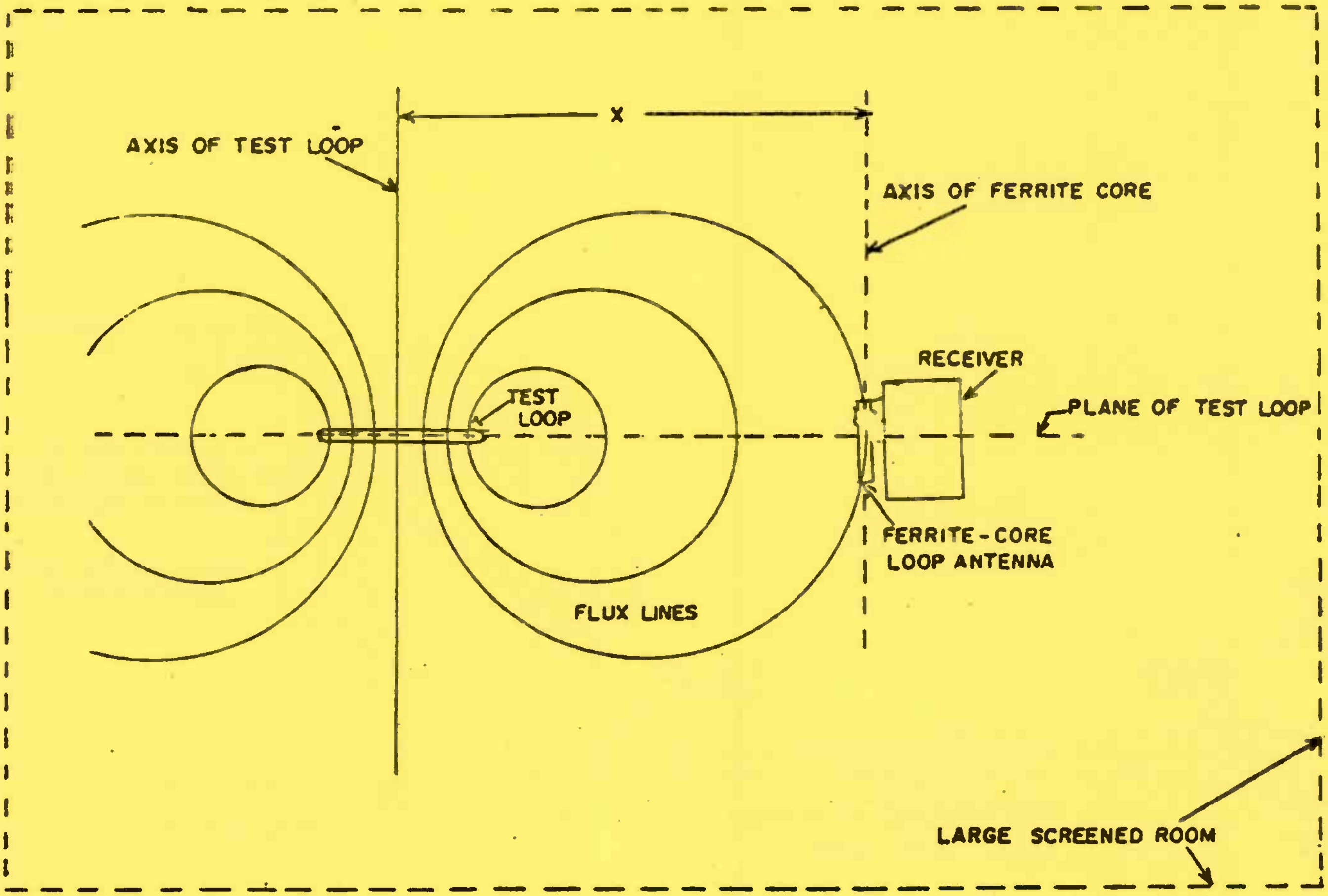
APPENDIX-A



CONDITIONS OF USE -

1. FREQUENCY RANGE APPROXIMATELY 20 MC/S.
2. STANDARD SIGNAL GENERATOR MUST HAVE LOW LEAKAGE FIELDS.
3. INTERNAL IMPEDANCE OF GENERATOR MUST BE SMALL COMPARED TO 400 OHMS

SHIELDED TRANSMITTING TEST LOOP



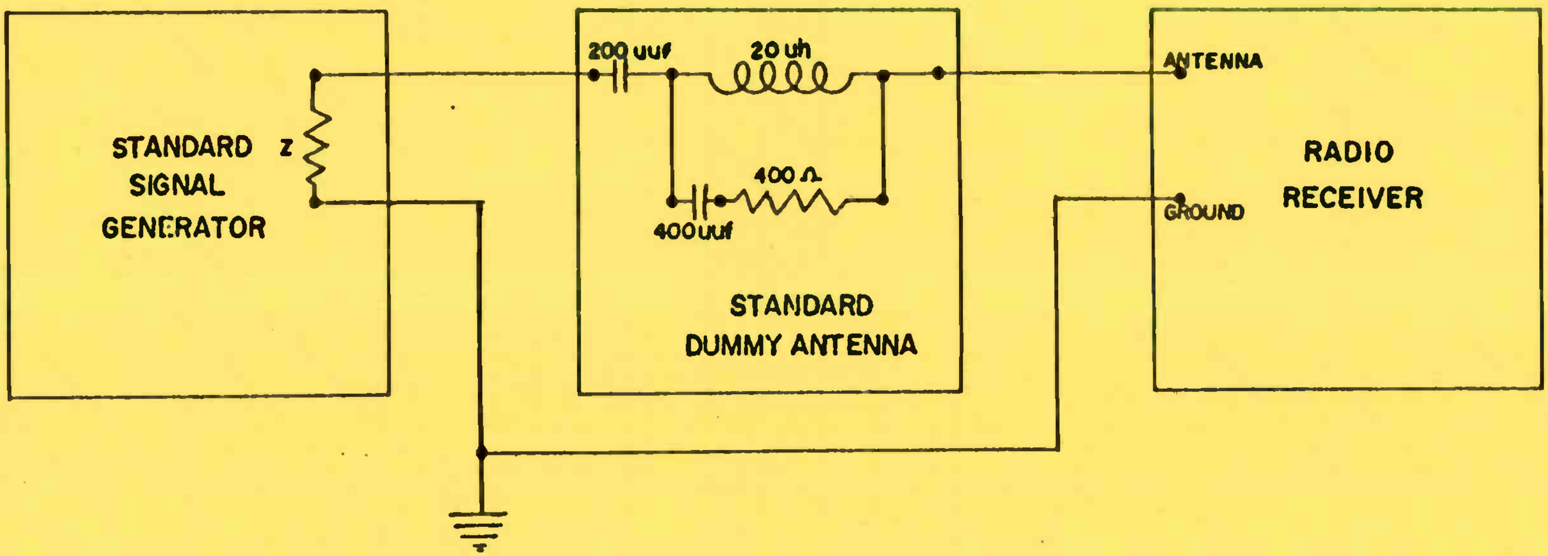
CONDITIONS

1. AXIS OF FERRITE ROD IS PLACED NORMAL TO THE PLANE OF THE TEST LOOP WITH THE CENTER OF THE ROD IN THE PLANE OF THE TEST LOOP.

2. TRANSMITTING AND RECEIVING LOOPS MUST BE KEPT WELL AWAY FROM LARGE METAL OBJECTS WHICH WOULD DISTORT THE MAGNETIC FIELD. THIS APPLIES TO THE CONDUCTING WALLS OF A SHIELDED ROOM. A CLEARANCE AROUND EACH LOOP EQUAL TO TWICE THE DISTANCE BETWEEN LOOPS IS CONSIDERED A SATISFACTORY MINIMUM VALUE. THE RECEIVING LOOP IS GENERALLY LEFT IN PLACE IN THE RECEIVING CABINET BECAUSE THE EFFECT OF THE CHASSIS IS DESIRED, SINCE IT IS PRESENT IN NORMAL OPERATION.

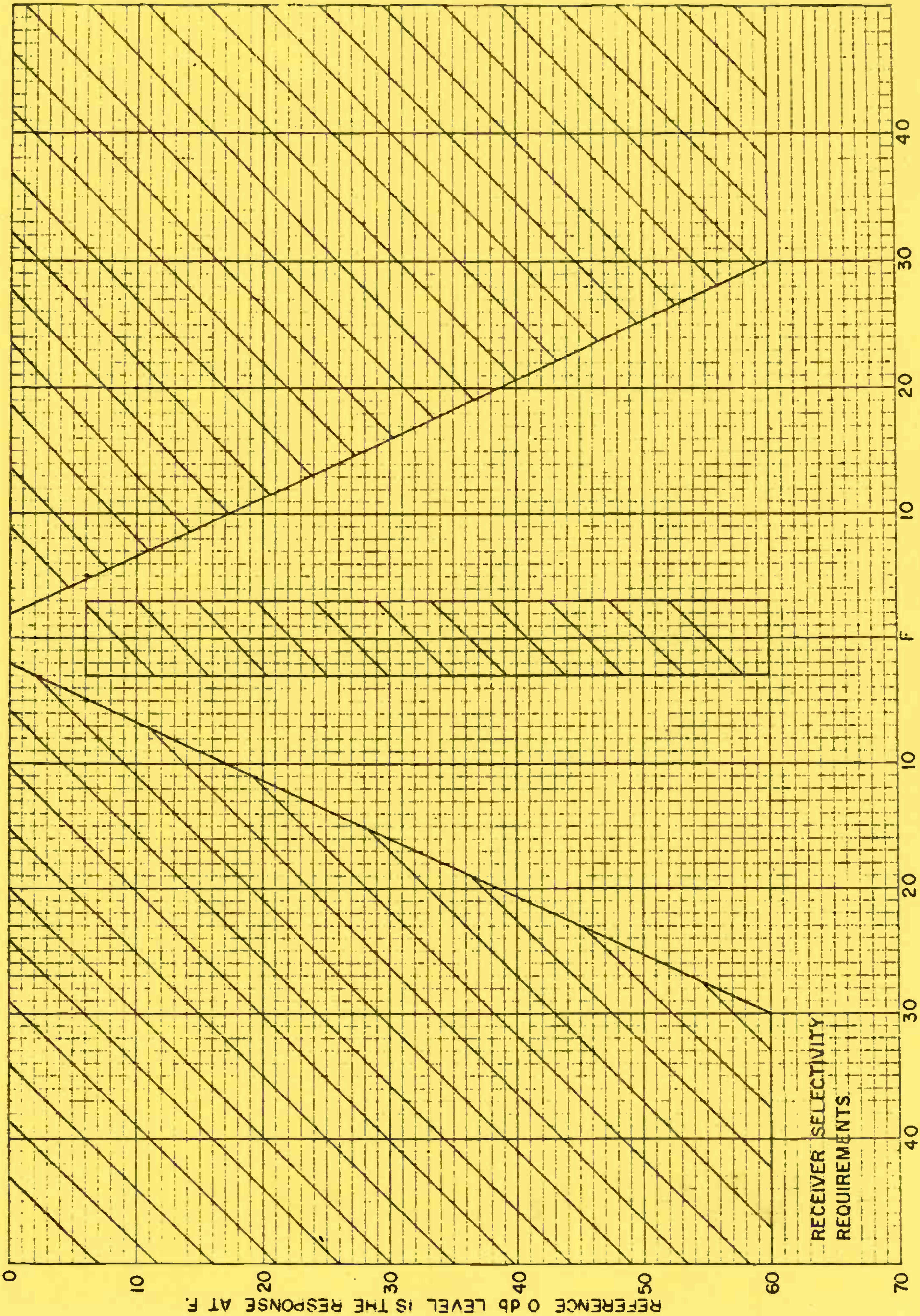
ORIENTATION OF RADIATING LOOP AND RECEIVER UNDER TEST

APPENDIX-C



NOTE - GENERATOR IMPEDANCE MUST BE SMALL COMPARED TO 400 OHMS

STANDARD DUMMY ANTENNA AND METHOD OF CONNECTIONS


RECEIVER SELECTIVITY REQUIREMENTS.
FREQUENCY IN KC/ OM FREQUENCY F
REFERENCE 0 db LEVEL IS THE RESPONSE AT F.
0
10
20
30
40
50
60
70
F

Communications
Canada

SUPPLEMENT
RSS-150
ISSUE 2
PROVISIONAL

RADIO STANDARDS SPECIFICATION

PROVISIONAL SUPPLEMENT FOR STEREOPHONIC AM BROADCASTING TRANSMITTERS OPERATING IN THE 535-1705 kHz FREQUENCY BAND AT 10 kHz SPACING

EFFECTIVE DATE: FEBRUARY 6, 1988

BROADCASTING REGULATION BRANCH

SUPPLÉMENT
CNR-150
2e ÉDITION
PROVISOIRE

CAHIER DES CHARGES SUR LES NORMES RADIOÉLECTRIQUES

SUPPLÉMENT PROVISOIRE POUR LES ÉMETTEURS DE RADIODIFFUSION AM STÉRÉOPHONIQUE FONCTIONNANT DANS LA BANDE DE FRÉQUENCES DE 535 À 1705 kHz AVEC ESPACEMENT ENTRE VOIES DE 10 kHz

MISE EN VIGUEUR: le 6 FÉVRIER 1988

DIRECTION GÉNÉRALE DE LA RÉGLEMENTATION DE LA RADIODIFFUSION

SUPPLÉMENT
CNR 150
2e ÉDITION
PROVISOIRE

SUPPLÉMENT PROVISOIRE DU CNR 150, 2e ÉDITION, POUR LES ÉMETTEURS DE RADIODIFFUSION AM STÉRÉOPHONIQUE FONCTIONNANT DANS LA BANDE DE FRÉQUENCES DE 535 À 1705 kHz AVEC ESPACEMENT ENTRE VOIES DE 10 kHz

1. OBJET

1.1 Le présent supplément du CNR 150, 2e édition, expose des exigences minimales relatives à l'homologation des émetteurs de radiodiffusion AM conçus pour fonctionner en stéréophonie dans la bande de fréquences de 535 à 1705 kHz.

1.2 Les exigences minimales du CNR 150, 2e édition, relatives aux émetteurs conçus pour fonctionner en monophonie ne sont pas changées.

2. NORMES MINIMALES DE PERFORMANCE EN STÉRÉOPHONIE

2.1 À moins d'indication contraire dans le présent supplément, tous les paragraphes du CNR 150, 2e édition, sont applicables et l'on devra s'y conformer pour obtenir l'homologation. A cet égard, les conditions générales, les conditions d'essai, les définitions et les méthodes de mesure exposées dans le CNR 150, 2e édition, sont applicables.

2.2 Les normes minimales de performance des émetteurs de radiodiffusion AM stéréophonique sont données dans le tableau 1. Les méthodes et normes de mesure supplémentaires sont données dans la section 3 du présent supplément.

3. MESURES ET NORMES SUPPLÉMENTAIRES

3.1 Capacité de modulation

3.1.1 Norme minimale - L'émetteur doit pouvoir être modulé en amplitude à 85% sur les crêtes positives et négatives et être modulé en phase à 1,25 radian (71,5%) à toute fréquence porteuse de la bande de radiodiffusion.

3.2 Largeur de bande occupée

3.2.1 Définition - Largeur de bande occupée par la porteuse et les produits de modulation connexes qui sont en deçà des limites spécifiées.

SUPPLEMENT
RSS 150
ISSUE 2
PROVISIONAL

PROVISIONAL SUPPLEMENT TO RSS 150 ISSUE 2 FOR STEREOPHONIC AM BROADCASTING TRANSMITTERS OPERATING IN THE 535-1705 KHZ FREQUENCY BAND AT 10 KHZ SPACING

1. INTENT

1.1 This supplement to RSS 150 Issue 2 provides the minimum requirements for the type approval of AM broadcasting transmitters intended for stereophonic operation in the frequency band 535-1705 kHz.

1.2 Minimum requirements currently in RSS 150 Issue 2 for transmitters intended for monophonic operation are unchanged.

2. MINIMUM STEREOPHONIC PERFORMANCE STANDARDS

2.1 Unless indicated otherwise in this supplement, paragraphs of RSS 150 Issue 2 are applicable and should be complied with to obtain type approval. In this regard, general conditions, test conditions, definitions, and methods of measurement now in RSS 150 are to be employed.

2.2 The minimum performance standards for stereophonic AM broadcasting transmitters are outlined in TABLE 1. The additional measurement methods and standards are detailed in section 3 of this supplement.

3. SUPPLEMENTAL MEASUREMENTS AND STANDARDS

3.1 Modulation Capability

3.1.1 Minimum Standard - The transmitter shall be capable of amplitude modulation to 85% on positive and negative peaks and capable of phase modulation to 1.25 radians (71.5%) at any carrier frequency within the broadcast band.

3.2 Occupied Bandwidth

3.2.1 Definition - The bandwidth occupied by the carrier and associated modulation products such that they fall within the specified limits.

3.2.2 **Méthode de mesure** - La mesure de la largeur de bande occupée doit être effectuée au moyen d'un signal de bruit d'essai normal. Le signal d'essai doit provenir d'une source de bruit blanc avec pondération USASI (United states of America Standards Institute). La pondération est produite par filtrage du bruit blanc au moyen d'un réseau passe-haut de 100 Hz, 6 dB par octave, et d'un réseau passe-bas de 320 Hz, 6 dB par octave. Le signal de bruit USASI est ensuite acheminé dans un circuit générateur d'impulsions où le rapport entre l'amplitude de crête et l'amplitude moyenne du signal de bruit est réglé à 20 dB à la sortie du générateur d'impulsions.

Le générateur d'impulsions doit fonctionner à la fréquence de 2,5 Hz avec un facteur d'utilisation de 12,5%. Le signal de bruit d'essai provenant du générateur d'impulsions doit être appliqué à l'entrée de l'émetteur par l'intermédiaire d'un réseau donnant une préaccentuation de 75 us modifiée, puis d'un filtre passe-bas de 10 kHz. La préaccentuation est une courbe de 75 us modifiée avec coude à haute fréquence à 8700 Hz. Le filtre passe-bas est un filtre à point de coupure raide assurant une atténuation de 15 dB à 10 kHz, de 30 dB à 10,5 kHz, de 40 dB à 11 kHz et de 50 dB èa 15 kHz et plus haut. La source de bruit est divisée en deux voies, droite et gauche, qui ont des distributions spectrales identiques. Le niveau de chaque voie est réglé de façon à obtenir un rapport entre L + R (information de somme) et L - R (information de différences) de 3 dB (c'est-à-dire un rapport de 1,4 sur 1).

On utilisera un analyseur de spectre RF à balayage de fréquence convenable pour mesurer les rayonnements spectraux. L'analyseur de spectre doit être réglé ainsi:

a. largeur de bande: résolution de 300 Hz
b. 5, 10 ou 20 kHz/division horizontale (au besoin)
c. 10 dB/division verticale
d. référence: crête de la porteuse
e. temps de maintien de crête: 10 minutes.

En utilisant la largeur de balayage appropriée, mesurer le rayonnement à ± 30 kHz de la porteuse.

3.2.3 **Norme minimale** - Les rayonnements provenant d'un émetteur AM stéréophonique et consistant en la porteuse et les produits de modulation connexes doivent se trouver sur des fréquences en deçà de ± 15 kHz de la porteuse. Tout rayonnement apparaissant sur une fréquence comprise entre plus de 15 kHz et 30 kHz doit être atténué d'au moins 25 dB au-dessous du niveau de la porteuse non modulée.

3.3 Rayonnement non désirés

3.3.1 **Définition** - Les rayonnements non désirés sont des rayonnements sur une ou des fréquences situées en dehors de la largeur de bande occupée qui sont dus au processus de modulation, à l'exclusion des rayonnements non essentiels.

3.2.2 **Methods of Measurement** - Measurement of the occupied bandwidth shall be conducted using a standard noise test signal. The test signal shall consist of a white noise source with USASI (United States of America Standards Institute) weighting. The weighting is produced by filtering white noise with a 100 Hz, 6dB per octave high pass network and a 320 Hz, 6 dB per octave low pass network. The USASI noise signal is then passed through a pulser circuit wherein the ratio of the peak to average amplitude of the noise signal is set to 20 dB at the output of the pulser.

The pulser shall operate at a frequency of 2.5 Hz with a duty cycle of 12.5%. The noise test signal from the pulser shall be input to the transmitter through a network providing a modified 75 µS preemphasis and a 10 kHz low pass filter. The preemphasis is a modified 75 µS curve with a high frequency break point at 8700 Hz. The low pass filter is a sharp cutoff filter providing attenuation of 15 dB at 10 kHz, 30 dB at 10.5 kHz, 40 dB at 11 kHz and 50 dB at 15 kHz and greater. The noise source is split into two channels left and right that have identical spectral distributions. The individual level of each channel is adjusted to obtain the ratio of L+R (sum information) to L-R (difference information) of 3 dB (i.e. a ratio of 1.4 to 1).

A suitable swept frequency RF spectrum analyzer shall be used to measure the spectrum emissions. The spectrum analyzer setup shall consist of

a. 300 Hz resolution bandwidth
b. 5, 10 or 20 kHz/horizontal division (as appropriate)
c. 10 dB/vertical division
d. Reference: Carrier peak
e. Peak hold: 10 minute duration.

Using the appropriate scan width, measure the emission within ±30 kHz of the carrier.

3.2.3 **Minimum Standard** - Emissions from a stereophonic AM transmitter consisting of the carrier and associated modulation products shall be confined to frequencies within ±15 kHz of the carrier. Emissions appearing on any frequency more than 15 kHz and up to 30 kHz shall be attenuated at least 25 dB below the level of the unmodulated carrier.

3.3 **Unwanted Emissions**

3.3.1 **Definition** - Unwanted emissions are emissions on a frequency or frequencies outside the occupied bandwidth which result from the modulation process but exclude spurious emissions.

3.3.2 **Méthode de mesure** - En utilisant le même montage qu'au paragraphe 3.2.2 et la largeur de balayage appropriée, mesurer les rayonnements en deçà de ± 100 kHz de la porteuse.

3.3.3 **Norme minimale** - Tout rayonnement apparaissant sur une fréquence située à plus de 30 kHz de la porteuse doit être atténué d'au moins:

(a) 35 dB au-dessous du niveau de la porteuse non modulée pour toute fréquence située à plus de 30 kHz jusqu'à 75 kHz de la porteuse;

(b) 43 + 10 log P (puissance en watts) dB, ou 80 dB, (choisir la valeur correspondant au signal du niveau le plus élevé) au-dessous du niveau de la porteuse non modulée pour toute fréquence située à plus de 75 kHz de la porteuse.

3.4 **Niveau d'entrée audio**

3.4.1 **Norme minimale** - Le niveau normal d'entrée audio pour une modulation de 85% sera de +10 dBm ±2 dBm.

3.5 **Réponse audiofréquence**

3.5.1 **Définition** - La réponse audiofréquence est le rapport entre les tensions d'entrée et la tension à 1000 Hz, exprimé en dB, nécessaire pour maintenir un taux de modulation constant sur toute la gamme des audiofréquences.

3.5.2 **Méthode de mesure** - Échantilloner le signal de sortie de l'émetteur au moyen d'un démodulateur stéréo d'essai avec sorties audio pour les voies de gauche et de droite. Établir des niveaux de modulation constants en maintenant constants les niveaux de sortie du démodulateur d'essai. Déterminer le niveau d'entrée audio nécessaire pour maintenir des taux de modulation constants de 25, 50 et 85% sur la gamme des fréquences de 50 Hz à 10 kHz pour chacune des voies de gauche et de droite.

3.5.3 **Norme minimale** - La réponse en fréquence de la voie de gauche ou de la voie de droite doit demeurer à 2dB près de la réponse à 1000 Hz sur la gamme des fréquences comprises entre 50 Hz et 10 kHz dans toutes les conditions de modulation de la voie stéréophonique de gauche ou de droite jusqu'à 85%.

3.6 **Distorsion harmonique**

3.6.1 **Méthode de mesure** - En utilisant la méthode exposée au paragraphe 7.4.2 du CNR 150, mesurer la distorsion harmonique dans chacune des voies de gauche et de droite.

3.3.2 **Method of Measurement** - Using the same setup as in paragraph 3.2.2 and the appropriate scan width, measure the emissions within ±100 kHz of the carrier.

3.3.3 **Minimum Standard** - Any emissions appearing on a frequency removed by more than 30 kHz from the carrier shall be attenuated at least;

(a) 35 dB below the level of the unmodulated carrier for any frequency more than 30 kHz and up to 75 kHz from the carrier

(b) 43 + 10 log P (Power in Watts) dB or 80 dB, whichever is the lesser attenuation, below the level of the unmodulated carrier for any frequency more than 75 kHz from the carrier.

3.4 **Audio Input Level**

3.4.1 **Minimum Standard** - The standard audio input level for 85% modulation shall be +10dBm ±2 dBm.

3.5 **Audio Frequency Response**

3.5.1 **Definition** - The audio frequency response is the ratio of the input voltages relative to the voltage at 1000 Hz, expressed in dB, required to maintain a constant percentage of modulation across the audio frequency range.

3.5.2 **Method of Measurement** - The output of the transmitter shall be sampled with a stereo test demodulator with audio outputs for the Left and Right channels. Constant modulation levels shall be established by maintaining constant output levels from the test demodulator. The audio input level to maintain constant modulation levels of 25, 50, and 85% shall be determined over the frequency range 50 Hz to 10 kHz for each of the left and right channels.

3.5.3 **Minimum Standard** - The frequency response of either the left or right channel shall remain within 2 dB of the response at 1000 Hz over the frequency range between 50 Hz and 10 kHz under all conditions of modulation of the left or right stereophonic channel up to 85%.

3.6 **Harmonic Distortion**

3.6.1 **Method of Measurement** - Using the method of paragraph 7.4.2 of RSS 150, measure the harmonic distortion in each of the left and right channels.

3.6.2 **Norme minimale** - La distorsion harmonique totale, y compris les harmoniques allant jusqu'à 20 000 Hz, mesurée séparément dans la voie de gauche ou la voie de droite, ne doit pas excéder 5 % sur la gamme des fréquences de 50 Hz à 10 000 Hz dans toutes les conditions de modulation jusqu'à 85%.

3.7 **Équilibre des voies**

3.7.1 **Définition** - L'équilibre des voies est la différence entre le niveau de sortie de la voie de gauche et celui de la voie de droite pour des niveaux d'entrée égaux.

3.7.2 **Méthode de mesure** -Déterminer l'équilibre des voies en comparant les réponses obtenues dans la section 3.5.

3.7.3 **Norme minimale** - L'équilibre entre la réponse dans la voie de gauche et la réponse dans la voie de droite doit être en deçà de 1 dB de 50 Hz à 10 000 Hz à tous les taux de modulation jusqu'à 85%.

3.8 **Distorsion d'intermodulation**

3.8.1 **Méthode de mesure** - En utilisant la méthode indiquée au paragraphe 7.5.2 du CNR 150 et le démodulateur stéréo d'essai, mesurer la distorsion d'intermodulation dans les voies de gauche et de droite.

3.9 **Ronflement et bruit de la porteuse**

3.9.1 **Définition** - Le ronflement et le bruit de la porteuse est le rapport, exprimé en dB, entre le niveau de modulation d'un signal de référence et le niveau de la modulation résiduelle causée par les composantes de ronflement et de bruit.

3.9.2 **Méthode de mesure** - La mesure du niveau de ronflement et de bruit peut se faire au moyen du démodulateur stéréo d'essai couplé à la sortie de l'émetteur. La sortie du démodulateur doit être couplée à un mesureur de distorsion et de bruit par l'intermédiaire d'un filtre passe-bas de 10 kHz. Prendre des lectures du signal de sortie avec modulation normale d'essai de 85% et sans modulation mais en terminant l'entrée audio au moyen d'une résistance égale à l'impédance d'entrée audio. Effectuer cette mesure pour la voie de gauche et la voie de droite.

3.9.3 **Norme minimale** - Le niveau du ronflement et du bruit dans la voie de gauche ou la voie de droite pour les fréquences audio au-dessous de 10 000 Hz doit être d'au moins 48 dB au-dessous du niveau de référence pour une modulation de 100% à 1000 Hz.

3.6.2 **Minimum Standard** - The total harmonic distortion including harmonics up to 20,000 Hz measured separately in either the left or right channel shall not exceed 5% in the frequency range 50 Hz to 10,000 Hz under all conditions of modulation up to 85%.

3.7 Channel Balance

3.7.1 **Definition** - The channel balance is the difference in output level of the left and right channels for equal inputs.

3.7.2 **Method of Measurement** - The channel balance shall be determined by comparing the response obtained in section 3.5.

3.7.3 **Minimum Standard** - The balance between the response in the left and right channels shall be within 1 dB from 50 Hz to 10,000 HZ at all levels of modulation up to 85%.

3.8 Intermodulation Distortion

3.8.1 **Method of Measurement** - Using the method of paragraph 7.5.2 of RSS 150 with the stereo test demodulator measure the intermodulation distortion in the left and right channels.

3.9 Carrier Hum and Noise

3.9.1 **Definition** - Carrier hum and noise is the ratio in dB of a reference signal modulation level to the residual modulation level caused by hum and noise components.

3.9.2 **Method of Measurement** - Measurement of the carrier hum and noise level may be made by the use of the stereo test demodulator coupled to the output of the transmitter. The output of the demodulator shall be fed through a 10 kHz low pass filter to a distortion and noise meter. Readings shall be made of the output with standard test modulation of 85% and without modulation but with the audio input terminated with a resistance equal to the audio input impedance. The measurement shall be made in each of the left and right channels.

3.9.3 **Minimum Standard** - The level of hum and noise in either the left or right channel for audio frequencies below 10,000 Hz shall be at least 48 dB below the reference level for 100% modulation at 1000 Hz.

3.10 **Séparation stéréophonique**

3.10.1 **Définition** - Rapport, exprimé en dB, entre le niveau de sortie de la voie gauche (ou de droite) dû à un signal destiné à cette voie et le niveau de sortie de la voie de droite (ou de gauche) dû au même signal.

3.10.2 **Méthode de mesure** - Appliquer un signal d'essai à l'entrée de la voie de gauche seulement à un niveau équivalent à une modulation de 85%. Mesurer le signal démodulé de la voie de gauche et de la voie de droite et déterminer la séparation sur la gamme de fréquences de 400 Hz à 10 000 Hz. Répéter le même essai en appliquant le signal d'essai seulement à la voie de droite.

3.10.3 **Norme minimale** - La séparation entre la voie de gauche et la voie de droite doit être d'au moins 20 dB sur la gamme des fréquences de 400 Hz à 10 000 Hz à tous les taux de modulation jusqu'à 85%.

3.11 **Diaphonie**

3.11.1 **Définition** - Signal indésirable qui apparaît dans la voie somme par suite de la modulation de la voie différence, ou dans la voie différence par suite de la modulation de la voie somme.

3.11.2 **Méthode de mesure** - En utilisant les signaux normaux d'essai (L = R) pour produire une modulation de 85% seulement dans la voie L + R, mesurer les composantes du signal apparaissant dans la voie L - R. Répéter l'essai avec les signaux d'essai (L = -R) pour produire une modulation de 85% dans la voie L - R et mesurer les composantes du signal apparaissant dans la voie L + R.

3.11.3 **Norme minimale** - La diaphonie entre la voie somme (L + R) et la voie différence (L -R) ainsi que la diaphonie inverse entre la voie différence (L - R) et la voie somme (L + R) doivent être d'au moins 30 dB au-dessous du niveau de référence pour une modulation de 100% à 1000 Hz.

3.12 **Compatibilité monophonique**

3.12.1 **Définition** - La compatibilité monophonique est la réception compatible des émissions stéréophoniques par un récepteur monophonique utilisant la détection d'enveloppe.

3.12.2 **Méthode de mesure** - En utilisant un démodulateur d'essai réglé pour le fonctionnement monophique, mesurer la réponse audiofréquence, la distorsion harmonique audiofréquence ainsi que le ronflement et le bruit de la porteuse à la sortie audio monophonique du démodulateur. On pourra utiliser les méthodes d'essai respectives des paragraphes 3.5.2, 3.6.2 et 3.9.2. Le signal de sortie du démodulateur doit provenir d'un détecteur d'enveloppe ayant réponse à large bande.

3.10 **Stereophonic Separation**

3.10.1 **Definition**- The ratio in dB of the output of the left (or right) channel due to a signal intended for that channel to the output of the right (or left) channel due to the same signal.

3.10.2 **Method of Measurement** - Input a test signal to the left channel only at a level equivalent to 85% modulation. Measure the demodulated output of the left and right channels and determine the separation for the range of frequencies from 400 Hz to 10,000 Hz. Repeat the above with the test signal applied only to the right channel.

3.10.3 **Minimum Standard** - The separation between the left and right channels shall be at least 20 dB in the frequency range from 400 Hz to 10,000 Hz at all levels of modulation up to 85%.

3.11 **Crosstalk**

3.11.1 **Definition** - An undesired signal occurring in the sum channel from modulation of the difference channel or that occurring in the difference channel from modulation of the sum channel.

3.11.2 **Method of Measurement** - Using the standard test signals (L = R) to produce 85% modulation only in the L + R channel, measure the components of the signal appearing in the L - R channel. Repeat the procedure with test signals (L= -R) to produce 85% modulation in the L - R channel and measure the components of the signal appearing in the L + R channel.

3.11.3 **Minimum Standard** - The sum channel (L + R) to the difference channel (L - R) crosstalk and the inverse difference channel (L - R) to the sum channel (L + R) crosstalk shall be at least 30 dB below the reference level for 100% modulation at 1000 Hz.

3.12 **Monophonic Compatibility**

3.12.1 **Definition** - Monophonic compatibility is defined as the compatible reception of stereophonic transmissions on a monophonic receiver with envelope detection.,

3.12.2 **Method of Measurement** - Using a test demodulator set for monophonic operation, measure the audio frequency response, audio frequency harmonic distortion, and carrier hum and noise at the monophonic audio output of the demodulator. The respective test methods of paragraphs 3.5.2, 3.6.2 and 3.9.2 may be used. The output of the demodulator shall be derived from an envelope detector with wideband response.

3.12.3 **Norme minimale - Réponse audiofréquence** - La réponse audiofréquence doit demeurer à 2 dB près de la réponse à 1000 Hz sur la gamme des fréquences de 50 Hz à 10 000 Hz dans toutes les conditions de modulation du système stéréophonique jusqu'à 85%.

3.12.4 **Norme minimale - Distorsion harmonique audiofréquence** - La distorsion harmonique totale, y compris les harmoniques jusqu'à 20 000 Hz ne doit pas excéder 5% sur la gamme des fréquences de 50 Hz à 10 000 Hz dans toutes les conditions de modulation du système stéréophonique jusqu'à 85%.

3.12.5 **Norme minimale - Ronflement et bruit de la porteuse** - Le niveau du ronflement et du bruit sur toutes les fréquences audio au-dessous de 10 000 Hz doit être d'au moins 55 dB au-dessous du niveau de référence pour une modulation de 100% à 1000 Hz.

Publication autorisée par le
ministre des Communications

Le directeur général
Direction de la réglementation
de la radiodiffusion

G.R. Begley

3.12.3 **Minimum Standard-Audio Frequency Response** - The frequency response shall remain within 2 dB of the response at 1000 Hz over the frequency range from 50 Hz to 10,000 Hz under all conditions of modulation of the stereophonic system up to 85%.

3.12.4 **Minimum Standard-Audio Frequency Harmonic Distortion** - The total harmonic distortion including harmonics up to 20,000 Hz shall not exceed 5% over the frequency range from 50 Hz to 10,000 Hz under all conditions of modulation of the stereophonic system up to 85%.

3.12.5 **Minimum Standard-Carrier Hum and Noise** - The level of all hum and noise for audio frequencies below 10,000 Hz shall be at least 55 dB below the reference level for 100% modulation at 1000 Hz.

Issued under the authority of
the Minister of Communications

G.R. Begley
Director General
Broadcasting Regulation Branch

TABLEAU 1

NORMES MINIMALES DE PERFORMANCE

ÉMETTEURS DE RADIODIFFUSION AM STÉRÉOPHONIQUE

ESSAI	RÉFÉRENCE	MÉTHODE DE MESURE	NORME
Puissance nominale de sortie	6.1 CNR 150	6.1.2 CNR 150	6.1.3 CNR 150
Capacité de modulation	6.2 CNR 150	6.2.2 CNR 150	6.2.3 CNR 150 3.1.1 Supplément
Stabilité de fréquence de la porteuse	6.3 CNR 150	6.3.2 CNR 150	6.3.3 CNR 150
Changement de niveau de la porteuse	6.4 CNR 150	6.4.2 CNR 150	6.4.3 CNR 150
Rayonnements non essentiels	6.5 CNR 150	6.5.2 CNR 150	6.5.3 CNR 150
Largeur de bande occupée	3.2 Supplément	3.2.2 Supplément	3.2.3 Supplément
Rayonnements non désirés	3.3 Supplément	3.3.2 Supplément	3.3.3 Supplément
Rayonnement du meuble	6.6 CNR 150	6.6.2 CNR 150	6.6.3 CNR 150
Impédance d'entrée audio	7.1 CNR 150	S.O.	7.1.1 CNR 150
Niveau d'entrée audio	7.2 CNR 150	7.2.2 CNR 150	3.4.1 Supplément
Réponse audiofréquence			
Voie de gauche	3.5 Supplément	3.5.2 Supplément	3.5.3 Supplément
Voie de droite	3.5 Supplément	3.5.2 Supplément	3.5.3 Supplément
Distorsion harmonique			
Voie de gauche	3.6 Supplément	3.6.1 Supplément	3.6.2 Supplément
Voie de droite	3.6 Supplément	3.6.1 Supplément	3.6.2 Supplément
Distorsion d'intermodulation			
Voie de gauche	7.5 CNR 150	3.8.1 Supplément	7.5.3 CNR 150
Voie de droite	7.5 CNR 150	3.8.1 Supplément	7.5.3 CNR 150
Ronflement et bruit de la porteuse			
Voie de gauche	3.9 Supplément	3.9.2 Supplément	3.9.3 Supplément
Voie de droite	3.9 Supplément	3.9.2 Supplément	3.9.3 Supplément

TABLE 1

MINIMUM PERFORMANCE STANDARDS

STEREOPHONIC AM BROADCASTING TRANSMITTERS

TEST	REFERENCE		MEASUREMENT METHOD		STANDARD	
Power Output Rating	6.1	RSS 150	6.1.2	RSS 150	6.1.3	RSS 150
Modulation Capability	6.2	RSS 150	6.2.2	RSS 150	6.2.3 3.1.1	RSS 150 Supplement
Carrier Frequency Stability	6.3	RSS 150	6.3.2	RSS 150	6.3.3	RSS 150
Carrier Level Shift	6.4	RSS 150	6.4.2	RSS 150	6.4.3	RSS 150
Spurious Emissions	6.5	RSS 150	6.5.2	RSS 150	6.5.3	RSS 150
Occupied Bandwidth	3.2	Supplement	3.2.2	Supplement	3.2.3	Supplement
Unwanted Emissions	3.3	Supplement	3.3.2	Supplement	3.3.3	Supplement
Cabinet Radiation	6.6	RSS 150	6.6.2	RSS 150	6.6.3	RSS 150
Input Impedance	7.1	RSS 150	N.A.		7.1.1	RSS 150
Input Level	7.2	RSS 150	7.2.2	RSS 150	3.4.1	Supplement
Audio Frequency Response						
Left Channel	3.5	Supplement	3.5.2	Supplement	3.5.3	Supplement
Right Channel	3.5	Supplement	3.5.2	Supplement	3.5.3	Supplement
Harmonic Distortion						
Left Channel	3.6	Supplement	3.6.1	Supplement	3.6.2	Supplement
Right Channel	3.6	Supplement	3.6.1	Supplement	3.6.2	Supplement
Intermodulation Distortion						
Left Channel	7.5	RSS 150	3.8.1	Supplement	7.5.3	RSS 150
Right Channel	7.5	RSS 150	3.8.1	Supplement	7.5.3	RSS 150
Carrier Hum and Noise						
Left Channel	3.9	Supplement	3.9.2	Supplement	3.9.3	Supplement
Right Channel	3.9	Supplement	3.9.2	Supplement	3.9.3	Supplement

ESSAI	RÉFÉRENCE	MÉTHODE DE MESURE	NORME
Équilibre des voies	3.7 Supplément	3.7.2 Supplément	3.7.3 Supplément
Séparation stéréophonique	3.10 Supplément	3.10.2 Supplément	3.10.3 Supplément
Diaphonie	3.11 Supplément	3.11.2 Supplément	3.11.3 Supplément
Compatibilité monophonique	3.12 Supplément	3.12.2 Supplément	
Réponse audiofréquence			3.12.3 Supplément
Distorsion harmonique			3.12.4 Supplément
Ronflement et bruit de la porteuse			3.12.5 Supplément

TEST	REFERENCE	MEASUREMENT METHOD	STANDARD
Channel Balance	3.7 Supplement	3.7.2 Supplement	3.7.3 Supplement
Stereophonic Separation	3.10 Supplement	3.10.2 Supplement	3.10.3 Supplement
Crosstalk	3.11 Supplement	3.11.2 Supplement	3.11.3 Supplement
Monophonic Compatibility	3.12 Supplement	3.12.2 Supplement	
Frequency Response			3.12.3 Supplement
Harmonic Distortion			3.12.4 Supplement
Carrier Hum and Noise			3.12.5 Supplement

Communications Canada

BTS 1-1
ISSUE 1
PROVISIONAL

BROADCAST TRANSMISSION STANDARD

AM BROADCASTING

STEREOPHONIC OPERATION

EFFECTIVE DATE: FEBRUARY 6, 1988

BROADCASTING REGULATION BRANCH

NER 1-1
1ère ÉDITION
PROVISOIRE

NORME SUR LES ÉMISSIONS DE RADIODIFFUSION

RADIODIFFUSION AM

EXPLOITATION STÉRÉOPHONIQUE

MISE EN VIGUEUR: le 6 FÉVRIER 1988

DIRECTION GÉNÉRALE DE LA RÉGLEMENTATION DE LA RADIODIFFUSION

Norme sur les émissions de radiodiffusion

Radiodiffusion AM

exploitation stéréophonique

1. GÉNÉRALITÉS

1.1. La présente norme décrit le système C-QUAM* (modulation d'amplitude en quadrature compatible) d'émission stéréophonique en radiodiffusion AM et donne les exigences de performance pour l'exploitation stéréophonique du système d'émission AM.

1.2 La radiodiffusion stéréophonique AM nécessite l'émission de signaux qui s'ajoutent au signal monophonique de la porteuse AM, ce qui permet la réception de signaux stéréophoniques dans les canaux de gauche et de droite en plus du signal monophonique original.

1.3 Le signal audio stéréophonique est formé de deux signaux: le signal de gauche (L) et le signal de droite (R). La modulation d'amplitude s'effectue en conformité des normes de radiodiffusion AM actuelles, c'est-à-dire par le signal somme (L+R). La modulation de phase en quadrature au moyen du signal différence (L-R) permet de transmettre d'autres informations sur la porteuse. Un autre signal pilote ajouté au signal différence indique qu'il s'agit d'une émission en stéréophonie.

* C-QUAM est une marque de commerce déposée de Motorola Inc.

2. DÉFINITIONS

2.1 Voie de radiodiffusion AM. Bande de fréquences occupée par la porteuse et par les bandes latérales inférieure et supérieure d'un signal de radiodiffusion AM; la porteuse se trouve au centre du canal. Les voies sont identifiées par la fréquence de la porteuse qui leur est assignée.

2.2 Signal de gauche (ou de droite). Sortie électrique d'une source audio ou de plusieurs sources qui communiquent avec fidélité les relations d'intensité, de temps et d'origine des sons provenant surtout de la gauche (ou de la droite) de l'auditeur.

2.3 Voie stéréophonique de gauche (ou de droite). Trajet suivi par le signal de gauche (ou de droite) dans un système de radiodiffusion stéréophonique AM.

Broadcast Transmission Standard

AM Broadcasting

Stereophonic Operation

1. GENERAL

1.1 This standard describes the C-QUAM* (Compatible Quadrature Amplitude Modulation) system for AM stereophonic sound broadcasting transmission and gives performance requirements for stereophonic operation of the AM transmission system.

1.2 Stereophonic AM broadcasting involves the transmission of additional information with the monophonic signal on the AM carrier allowing the reception of the original monophonic signal and left and right stereophonic signals.

1.3 The stereophonic audio information is composed of two signals; left (L) and right (R). As in the present AM broadcast standards, the carrier is amplitude modulated by the sum (L+R) signal. The additional information in the form of the difference (L-R) signal is added to the carrier by quadrature phase modulation. A separate pilot signal is added to the difference signal to indicate the presence of a stereophonic broadcast.

* C-QUAM is a registered trademark of Motorola Inc.

2. DEFINITIONS

2.1 **AM Broadcast Channel.** The band of frequencies occupied by the carrier and the upper and lower sidebands of an AM broadcast signal with the carrier frequency at the center. Channels are designated by their assigned carrier frequencies.

2.2 **Left (or Right) Signal.** The electrical output of an audio source or combination of sources conveying the intensity, time, and location of sounds originating predominantly to the listener's left (or right).

2.3 **Left (or Right) Stereophonic Channel.** The left (or right) signal path through an AM stereophonic broadcasting system.

2.4 **Voie somme L+R.** Bande des fréquences audio correspondant à la somme vectorielle des signaux de gauche et de droite qui module la porteuse en amplitude.

2.5 **Voie différence L-R.** Bande des fréquences audio correspondant à la différence vectorielle entre les signaux de gauche et de droite qui module la porteuse en phase.

2.6 **Diaphonie stéréophonique.** Signal indésirable qui apparaît dans la voie somme par suite de la modulation de la voie différence, ou dans la voie différence par suite de la modulation de la voie somme.

2.7 **Tonalité pilote stéréophonique.** Tonalité audio de fréquence fixe (25 Hz) qui est présente dans la voie différence pendant la transmission des émissions stéréophoniques.

2.8 **Séparation stéréophonique.** Rapport, exprimé en dB, entre le niveau de sortie de la voie gauche (ou de droite) dû à un signal destiné à cette voie et le niveau de sortie de la voie de droite (ou de gauche) dû au même signal.

3. NORMES D'ÉMISSION

3.1 Le signal de modulation d'amplitude doit correspondre à la somme (L+R) des signaux stéréophoniques de gauche et de droite.

3.2 La modulation d'amplitude des crêtes fréquentes du signal somme (L+R) ne doit pas dépasser 125 % dans le cas des crêtes positives et 100 % dans le cas des crêtes négatives.

3.3 Le signal de modulation de phase en quadrature doit correspondre à la différence (L-R) entre les signaux stéréophoniques de gauche et de droite.

3.4 L'information de phase en quadrature doit faire varier la phase de la porteuse en conformité de la relation suivante:

$$\phi_c = \tan^{-1} \frac{m(L-R)}{1+m(L+R)}$$

où:

ϕ_c = phase instantanée de la porteuse
L = signal audio dans la voie audio de gauche
R = signal audio dans la voie audio de droite
m = facteur de modulation

2.4 **Sum Channel L+R.** The band of audio frequencies consisting of the vector sum of the left and right signals which amplitude modulates the carrier.

2.5 **Difference Channel L-R.** The band of audio frequencies consisting of the difference of the left and right signals which phase modulates the radio frequency carrier.

2.6 **Stereophonic Crosstalk.** An undesired signal occurring in the sum channel from modulation of the difference channel or that occurring in the difference channel from modulation of the sum channel.

2.7 **Stereophonic Pilot Tone.** An audio tone of fixed frequency (25 Hz) present on the difference channel during the transmission of stereophonic programs.

2.8 **Stereophonic Separation.** The ratio in dB of the output of the left (or right) channel due to a signal intended for that channel to the ouptut of the right (or left) channel due to the same signal.

3. TRANSMISSION STANDARDS

3.1 The amplitude modulating signal shall consist of the sum (L+R) of the stereophonic left and right signals.

3.2 Peaks of frequent occurrence of the sum (L+R) signal shall produce amplitude modulation not exceeding 125% for positive peaks and 100% for negative peaks.

3.3 The quadrature phase modulating signal shall consist of the difference (L-R) of the stereophonic left and right signals.

3.4 The quadrature phase information shall vary the phase of the carrier in accordance with the following relationship:

$$\phi_c = \tan^{-1} \frac{m(L-R)}{1+m(L+R)}$$

Where:

ϕ_c = instantaneous carrier phase
L = audio signal in the left audio channel
R = audio signal in the right audio channel
m = modulation factor

3.5 La phase de la porteuse doit avancer (dans la direction positive) lorsqu'un signal de gauche cause la modulation de l'enveloppe de la porteuse dans une direction positive et doit retarder (dans la direction négative) lorsqu'un signal de droite cause la modulation de l'enveloppe de la porteuse dans une direction positive.

3.6 Le contrôle de la modulation de phase maximale doit être tel que les conditions suivantes sont satisfaites:

a) ϕ_C max = 1,25 radian (71,5°)
pour la modulation d'une seule voie lorsque la modulation d'enveloppe de la voie unique est 75 %, ce qui signifie que m(L) ou m(R) = 0,75.

b) ϕ_C max = 0,79 radian (45°)
lorsque m(L) = -m(R) et m(L) -m(R) = 1 (ce qui équivaut à moduler la porteuse à 100 % par le signal L+R, puis à inverser la phase d'un des signaux; la modulation d'enveloppe devra disparaître et la porteuse être modulée en phase seulement).

3.7 Le signal composite doit comprendre une tonalité pilote de fréquence fixe (25 Hz) qui indique qu'il s'agit d'une émission en stéréophonie. Ce signal est ajouté à la voie différence. Le niveau de modulation de phase due à la tonalité pilote doit varier en fonction inverse de la modulation d'amplitude de la porteuse. La phase du signal pilote doit être

$$\phi \text{ PILOTE} = \tan^{-1} \frac{(0{,}05 \pm 0{,}01) \sin 50\pi t}{1 + L+R}$$

Si la porteuse n'est pas modulée, la déviation due au signal pilote doit équivaloir à 5 % de la déviation maximale admissible dans la voie L-R.

4. EXIGENCES RELATIVES À LA PERFORMANCE DES SYSTÈMES D'ÉMISSION EN RADIODIFFUSION STÉRÉOPHONIQUE AM

4.1 **Généralités** - La performance des systèmes stéréophoniques AM, qui consistent d'un générateur stéréo AM raccordé à un émetteur homologué, doit satisfaire aux exigences de cette section, que ces systèmes soient exploités en mode monophonique ou stéréophonique. Les nouveaux émetteurs stéréophoniques doivent satisfaire pleinement aux exigences de CNR-150 et le supplément du CNR 150 2e édition.

3.5 The carrier phase shall advance in a positive direction when a left signal causes the carrier envelope to be modulated in a positive direction and shall retard in a negative direction when a right signal causes the carrier envelope to be modulated in a positive direction.

3.6 Maximum phase modulation shall be controlled in such a manner that the following conditions are satisfied:

a) ϕ_C max = 1.25 radians (71.5°)
for single channel modulation where the single channel envelope modulation equals 75% i.e. m (L) or m (R) = 0.75.

b) ϕ_C max = 0.79 radians (45°)
when m (L) = -m (R) and m (L) -m (R) = 1 (equivalent to modulating the carrier 100% with L+R and then reversing the phase of one signal, the envelope modulation should disappear and the carrier modulation is phase modulation only).

3.7 The composite signal shall include a fixed frequency (25 Hz) pilot signal for indicating the presence of a stereo transmission. This signal is added to the difference channel. The amount of phase modulation produced by the pilot signal shall vary as the inverse of the amplitude modulation on the carrier. The pilot signal phase shall be

$$\phi \text{ PILOT} = \tan^{-1} \frac{(0.05 \pm 0.01) \sin 50\pi t}{1 + L + R}$$

When the carrier is unmodulated, the pilot signal shall produce 5% of the maximum allowable deviation in the L-R channel.

4. TRANSMISSION SYSTEM PERFORMANCE REQUIREMENTS FOR AM STEREO

4.1 **General** - The performance of AM stereophonic systems, consisting of the AM stereo exciter interfaced with a type approved transmitter shall meet the requirements of this section when operated in either the monophonic or stereophonic mode. New stereophonic transmitters shall meet the full requirements of RSS 150 and the supplement to RSS 150 Issue 2.

4.2 **COMPATIBILITÉ RF** - Le système de radiodiffusion stéréophonique AM doit être compatible avec les systèmes de radiodiffusion AM existants du point de vue des rapports de protection contre le brouillage et du plan de répartition des fréquences AM.

4.2.1 **Largeur de bande occupée** - Les rayonnements provenant d'un émetteur AM stéréophonique et consistant en la porteuse et les produits de modulation connexes doivent se trouver sur des fréquences en deçà de ± 15 kHz de la porteuse. Tout rayonnement apparaissant sur une fréquence comprise entre plus de 15 kHz et 30 kHz doit être atténué d'au moins 25 dB au-dessous du niveau de la porteuse non modulée.

4.2.2 **Rayonnements non désirés** - Tout rayonnement apparaissant sur une fréquence située à plus de 30 kHz de la porteuse doit être atténué d'au moins:

(a) 35 dB au-dessous du niveau de la porteuse non modulée pour toute fréquence située à plus de 30 kHz jusqu'à 75 kHz de la porteuse;

(b) 43 + 10 log P (puissance en watts) dB ou 80 dB (choisir la valeur correspondant au signal du niveau le plus élevé) au-dessous du niveau de la porteuse non modulée pour toute fréquence située à plus de 75 kHz de la porteuse.

4.3 **COMPATIBILITÉ MONOPHONIQUE** - Les émissions effectuées en stéréophonie doivent être compatibles avec le matériel de réception monophonique qui utilise la détection d'enveloppe. Les exigences de performance doivent être satisfaites en utilisant une détection d'enveloppe à bande large, raccordée à la sortie de l'émetteur.

4.3.1 **Réponse audiofréquence** - La réponse audiofréquence doit demeurer à 2 dB près de la réponse à 1 000 Hz sur la gamme des fréquences de 50 Hz à 10 000 Hz dans toutes les conditions de modulation du système stéréophonique jusqu'à 85 %.

4.3.2 **Distorsion harmonique audiofréquence** - La distorsion harmonique totale, y compris les harmoniques jusqu'à 20 000 HZ ne doit pas excéder 5 % sur la gamme des fréquences de 50 Hz à 10 000 Hz dans toutes les conditions de modulation du système stéréophonique jusqu'à 85 %.

4.3.3 **Ronflement et bruit de la porteuse** - Le niveau du ronflement et du bruit sur toutes les fréquences audio au-desous de 10 000 Hz doit être d'au moins 55 dB au-dessous du niveau de référence pour une modulation de 100 % à 1000 Hz.

4.2 RF COMPATIBILITY - The AM stereophonic system shall be compatible with the present AM monophonic system with respect to interference protection ratios and the AM channeling plan.

4.2.1 Occupied Bandwidth - Emission from a stereophonic AM broadcasting system consisting of the carrier and associated modulation products shall be confined to frequencies within ±15 kHz of the carrier. Emissions appearing on any frequency more than 15 kHz and up to 30 kHz from the carrier shall be attenuated at least 25 dB below the level of the unmodulated carrier.

4.2.2 Unwanted Emissions - Any emissions appearing on a frequency removed by more than 30 kHz from the carrier shall be attenuated at least;

(a) 35 dB below the level of the unmodulated carrier for any frequency more than 30 kHz and up to 75 kHz from the carrier.

(b) 43 + 10 log P (Power in watts) dB or 80.dB, whichever represent the lesser attenuation, below the level of the unmodulated carrier for any frequency more than 75 kHz from the carrier.

4.3 MONOPHONIC COMPATIBILITY - The stereophonic transmissions shall provide compatible reception on monophonic receivers with envelope detection. The performance requirements shall be satisfied using an envelope detector with wideband response coupled to the transmitter output.

4.3.1 Audio Frequency Response - The frequency response shall remain within 2 dB of the response at 1000 Hz over the frequency range from 50 Hz to 10,000 Hz under all conditions of amplitude modulation for the stereophonic system up to 85%.

4.3.2 Audio Frequency Harmonic Distortion - The total harmonic distortion including harmonics up to 20,000 Hz shall not exceed 5% over the frequency range from 50 Hz to 10,000 Hz under all conditions of amplitude modulation for the stereophonic system up to 85%.

4.3.3 Carrier Hum and Noise Level - The level of all hum and noise for audio frequencies below 10,000 Hz shall be at least 55 dB below the reference level for 100% modulation at 1000 Hz.

4.4 **PERFORMANCE STÉRÉOPHONIQUE** - Le système d'émission en radiodiffusion stéréophonique AM comprend tout le matériel situé entre les amplificateurs d'entrée audio (entrée de générateur stéréo) des voies de gauche et de droite de l'émission diffusée et l'antenne d'émission. Chaque voie doit satisfaire individuellement aux exigences de performance séparément à l'aide d'un détecteur audio approprié à bande large à la sortie de l'émetteur.

4.4.1 **Réponse fréquence audio** - La réponse en fréquence de la voie de gauche ou de la voie de droite doit demeurer à 2 dB près de la réponse à 1 000 Hz sur la gamme des fréquences comprises entre 50 Hz à 10 kHz dans toutes les conditions de modulation de la voie stéréophonique de gauche ou de droite jusqu'à 85 %.

4.4.2 **Distorsion harmonique audiofréquence** - La distorsion harmonique totale, y compris les harmoniques allant jusqu'à 20 000 Hz, mesurée séparément dans la voie de gauche ou la voie de droite, ne doit pas excéder 5 % sur la gamme des fréquences de 50 Hz à 10 000 Hz dans toutes les conditions de modulation jusqu'à 85 %.

4.4.3 **Équilibre des voies** - L'équilibre entre la réponse dans la voie de gauche et la réponse dans la voie de droite doit être en deçà de 1 dB de 50 Hz à 10 000 Hz à tous les taux de modulation jusqu'à 85%.

4.4.4 **Séparation stéréophonique** - La séparation entre la voie de gauche et la voie de droite doit être d'au moins 20 dB sur la gamme des fréquences de 400 Hz à 10 000 Hz à tous les taux de modulation jusqu'à 85 %.

4.4.5 **Ronflement et bruit de la porteuse** - Le niveau du ronflement et du bruit dans la voie de gauche ou la voie de droite pour les fréquences audio au-dessous de 10 000 Hz doit être d'au moins 48 dB au-dessous du niveau de référence pour une modulation de 100 % à 1000 Hz.

4.4.6 **Diaphonie** - La diaphonie entre la voie somme (L+R) et la voie différence (L-R) ainsi que la diaphonie inverse entre la voie différence (L-R) et la voie somme (L+R) doivent être d'au moins 30 dB au-dessous du niveau de référence pour une modulation de 100% à 1000 Hz.

Publication autorisée par le
ministre des Communications

Le directeur général
Direction de la réglementation
de la radiodiffusion

G.R. Begley

4.4 **STEREOPHONIC PERFORMANCE** - The stereophonic AM broadcast transmission system includes all equipment from the output of processing amplifiers (stereo exciter input) for both the left and right program channels up to the transmitter antenna output. The performance requirements shall be satisfied in each channel separately using a suitable audio detector with wide band response at the transmitter output.

4.4.1 **Audio Frequency Response** - The frequency response of either the left or right channel shall remain within 2 dB of the response at 1000 Hz over the frequency range between 50 Hz and 10,000 Hz under all conditions of modulation of the left or right stereophonic channel up to 85%.

4.4.2 **Audio Frequency Harmonic Distortion** - The total harmonic distortion including harmonics up to 20,000 Hz measured separately in either left or right channel shall not exceed 5% in the frequency range 50 Hz to 10 000 Hz under all conditions of modulation for the stereophonic system up to 85%.

4.4.3 **Channel Balance** - The balance between the output level in the left and right channels shall be within 1 dB from 50 Hz to 10,000 Hz at all levels of modulation up to 85%.

4.4.4 **Stereophonic Separation** - The separation between the left and right channels shall be at least 20 dB in the frequency range from 400 Hz to 10,000 Hz at all levels of modulation up to 85%.

4.4.5 **Carrier Hum and Noise Level** - The level of hum and noise in either the left or right channel for audio frequences below 10,000 Hz shall be at least 48 dB below the reference level for 100% modulation at 1000 Hz.

4.4.6 **Cross-talk** - The sum channel (L+R) to the difference channel (L-R) cross-talk and the inverse difference channel (L-R) to the sum channel (L+R) cross-talk shall be at least 30 dB below the reference level for 100% modulation at 1000 Hz.

Issued under the Authority of
the Minister of Communications

G.R. Begley
Director General
Broadcasting Regulation Branch

AM STEREO: Four Systems in an Open Market

The basis for this article is actually quite old. I did a paper on the feasibility of a conversion to AM stereo when I was putting in time at CKEY-590 in late 1978. I don't know why I didn't adopt it at that time for DXN.

At that time the FCC was still up in the air on which way to go. There were five systems in competition at that time:

Belar - AM/FM
Magnavox - AM/PM
Harris - CPM
Motorola - CQUAM
Kahn - ISB

Since Belar has dropped out of the picture, this article covers the other four. The actual realizations for the various systems may have been updated in the past five years, but as far as I know no major changes in concept have occurred. The following descriptions do not get too specific so that the material is still quite valid.

A number of features are common to all four systems. Each of the systems had its own strengths and weaknesses, as I shall try to point out.

Common to all systems is the feature of matrixing. One of the initial criteria of an AM stereo system is that it must be compatible with existing AM radios on the market. In order to make a meaningful signal then, the left and right channels are summed together (L + R) and this is transmitted so that a conventional radio will receive a useable signal. The difference signal (L - R) is imposed on the transmitter in some other form to provide enough information that a receiver at the other end can once again separate the L and R signals.

In all designs the two matrixed channels go very different routes to the transmitter. This establishes a need for time correction networks to bring the L+R and L-R signals to a common time base. The time correction, which may or may not be explicitly illustrated on the block diagrams of the respective systems, restores something of the original stereo separation.

The systems all have some form of stereo indication information for the receiver. Tones varying from 5 to 25 Hz are inserted on the stereo (L-R) information and these tones are decoded at the receiver end to turn on a stereo indicator light and/or automatically switch the radio into stereo mode.

Let us turn to the individual systems:

Kahn Communications of Freeport N.Y. has been actively involved in the field of AM stereo since the late fifties (no kidding !!!) so the ISB system is the granddaddy of AM stereo.

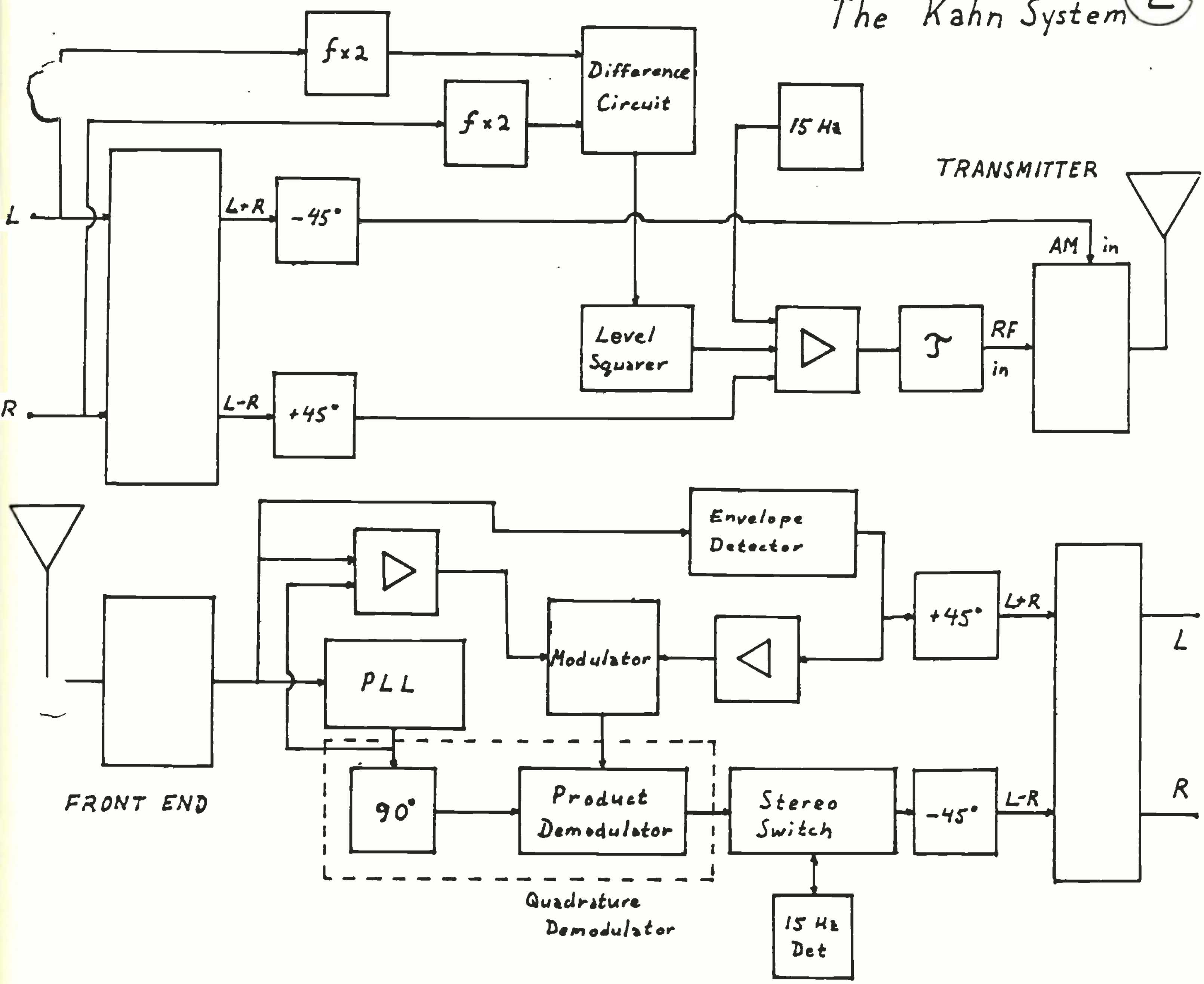
To start with,(reference to diagrams) the L and R channels are matrixed to provide L+R and L-R. After the monaural (L+R) signal is phase-shifted -45 degrees it is applied as amplitude modulation for conventional receivers. The stereo path splits - one path is phase-shifted +45 degrees and sent to a summing amplifier. The other path is put through a frequency doubler and restored to the same time base as the first one before it too reaches the summing amo;ifier. The frequency doubling results in a dramatic increase in stereo separation, according to Kahn. This modified L-R conversion is sent to a phase modulator and impressed on the carrier at that point.

The advantage of this system is that the resulting pair of independent sidebands may be monitored by anyone with two monaural radios. (It was your Muse, erroneous, of Vol. 51 #3, Paul Swearingen, that put me onto the article in the first place...) The left channel can be monitored by tuning below centre frequency and the right channel by slightly above centre frequency.

The AM stereo receiver as proposed by Kahn is conventional from the front end through the IF stages. The monaural (L+R) signal is demodulated conventionally with an envelope detector and provided to the audio matrix. The stereo (L-R) signal is put through a phase locked loop and a quadrature

Independent Sideband (ISB)

The Kahn System (2)



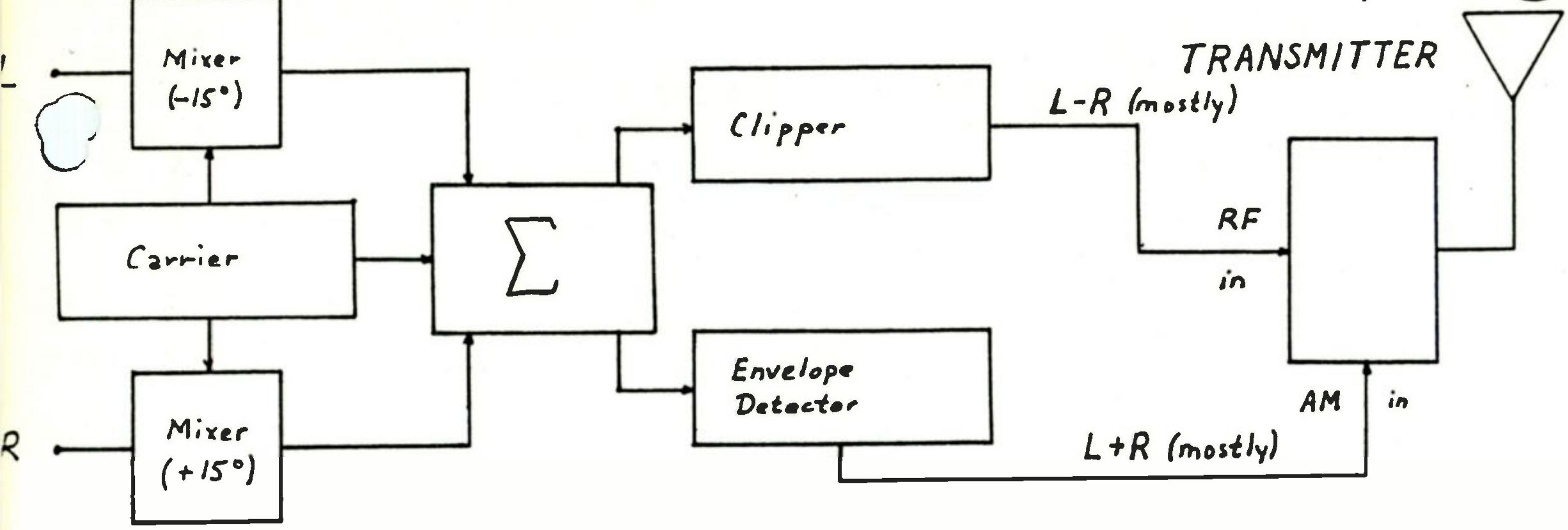
demodulator before the product detector provides a useable L-R output to the audio matrix. Kahn uses a 15 Hz tone decoder to provide any stereo switching desired.

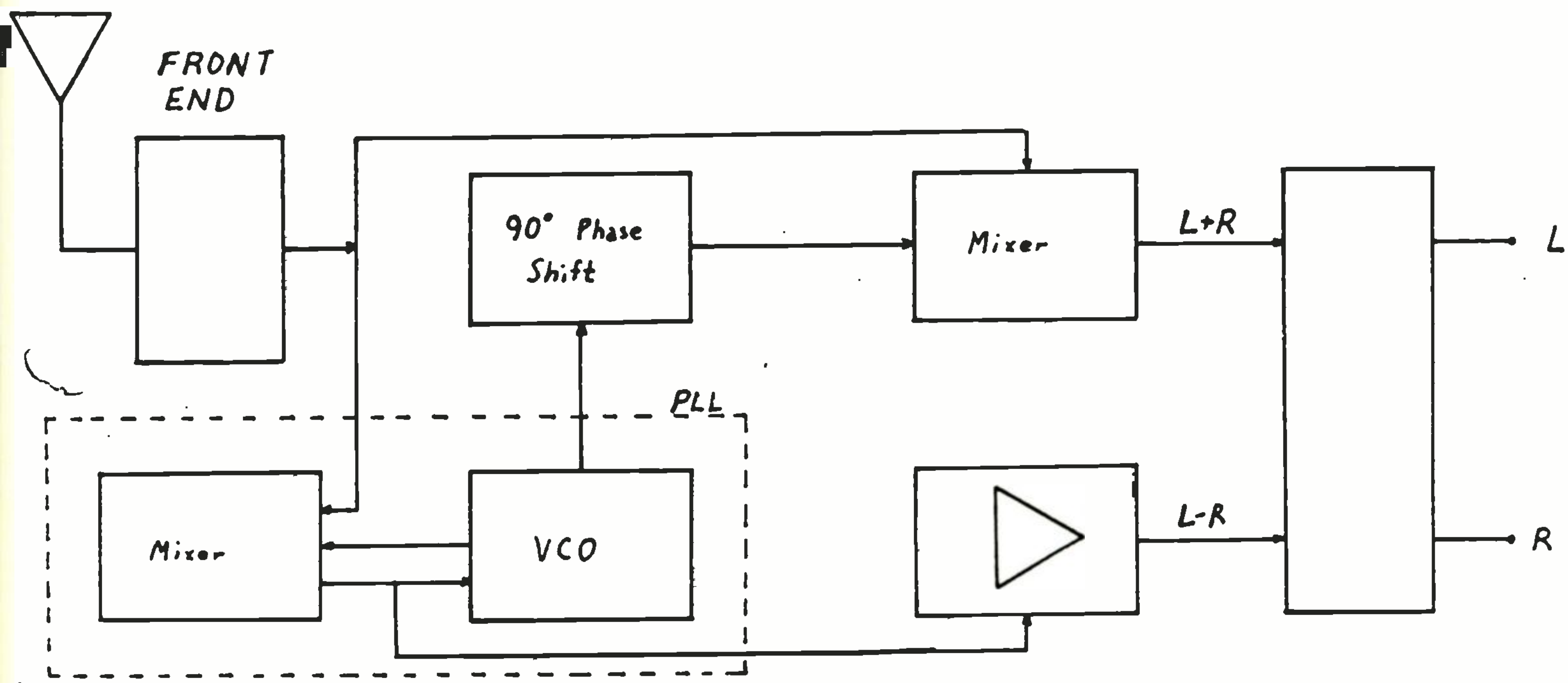
The primary difficulty inherent in this implementation stems from the numerous phase shift circuits, but a multiple IF stage design is conceivable with somewhat less phase manipulation.

The Kahn system is unique in providing independent sidebands. It has been claimed that the ISB system is relatively insensitive to ionospheric distortion, which theoretically makes it more DXable (are there any bodies out there who can substantiate this..???) and Kahn claims a relative insensitivity to full negative peak modulation, which allows those T-40 station to drive their transmitters hard and not splash onto neighbouring channels.... oretically.

Compatible Phase Multiplex (CPM) R-21

The Harris System (3)





The Harris Corporation of Quincy Illinois has implemented a system it calls compatible phase multiplex. Instead of using a distinct audio matrix, the L signal is modulated onto a carrier which lags the reference by 15 degrees and the R signal modulates a carrier which leads the reference by the same amount. The linear sum of all three, including the unshifted reference is said to provide something approaching a coherent L+R signal and reduced L-R signal quadrature signal. A stereo identification tone of 20 - 25 Hz is inserted onto the L-R signal at this point. When I look at the vagueness of this description I don't wonder that Harris has been experiencing some distortion problems, as far as the FCC is concerned. I must confess, I have never sat down and taken a good look at the math behind the system.

This is a modified quadrature system, similar to techniques used to transmit two chroma signal on a subcarrier in a television signal. A conventional AM transmitter cannot handle CPM in ths form, and the signal must be separated into its envelope and phase-modulated carrier components. These are then fed to the transmitter.

Receiver design is once again quite conventional until after the IF stages. The IF output is sent on the one hand to a phase locked loop consisting of a balanced mixer and a voltage controlled oscillator. The output of the PLL is sent to stereo tone identification circuits and to the audio

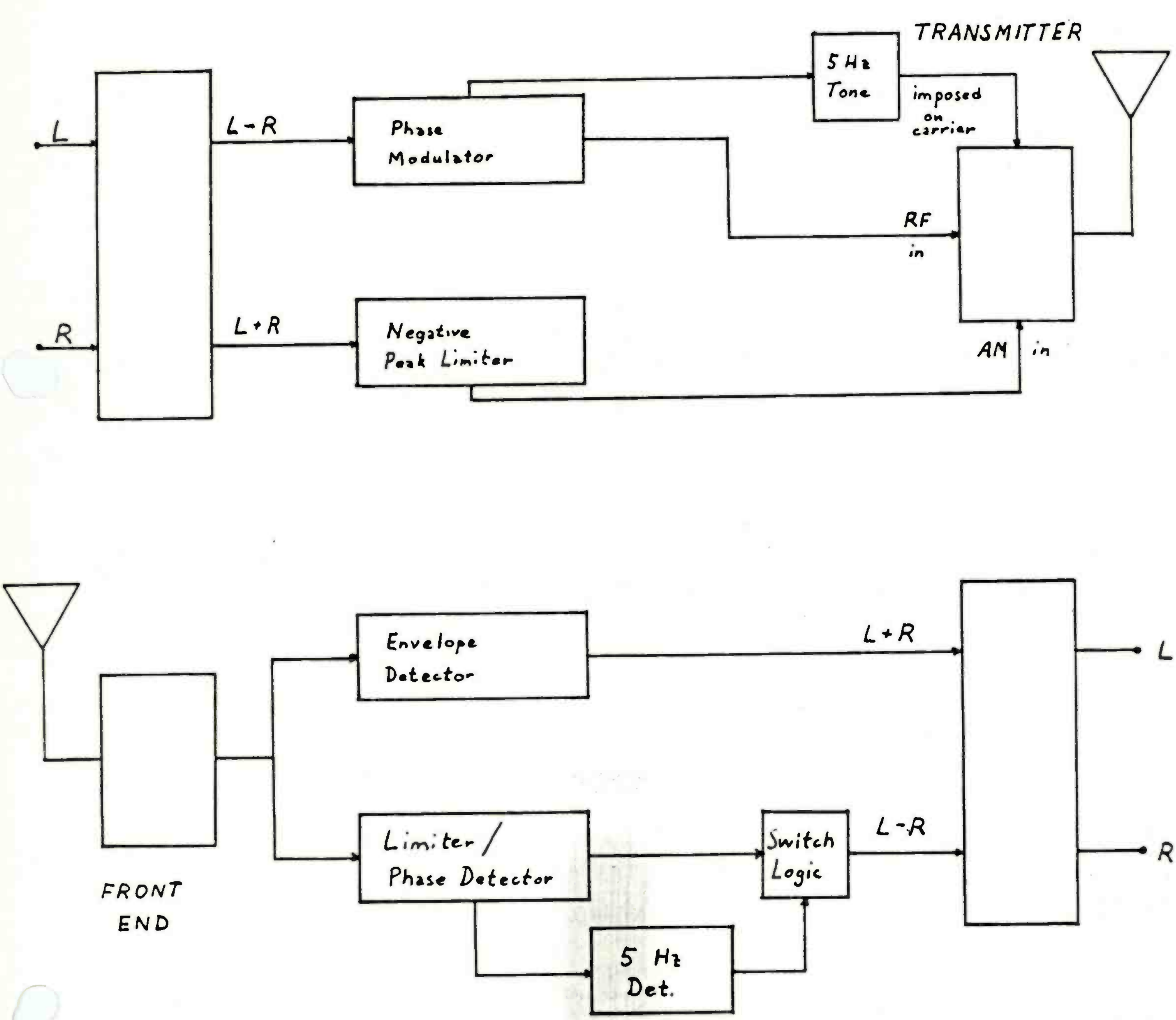
matrix. Another output of the PLL is phase- shifted +90 degrees and added to another signal coming directly from the IF stages. This L+R signal provides the other input for the audio matrix. (4)

Harris has placed an emphasis on compatibility and monaural signal quality. It has also been illustrated (by Harris) that the Harris system provides the least increase in spectrum width over a conventional signal. As it stands now, I believe the Harris system is the most popular in terms of the number of stations employing it. Correct me if I'm wrong.

AM/PM

Magnavox of Ft. Wayne Indiana came up with the system whereby the carrier is phase-modulated with the stereo (L-R) information and then amplitude modulated by the monaural (L+R) signal.

The Magnavox System



Firstly the L and R signals are matrixed to produce the requisite L+R and L-R signals. The stereo signal is time delayed and enters a phase modulator which imposes variations to a maximum of one radian (approximately 57 degrees) on the carrier. This signal is then modulated by the monaural signal. ⑤

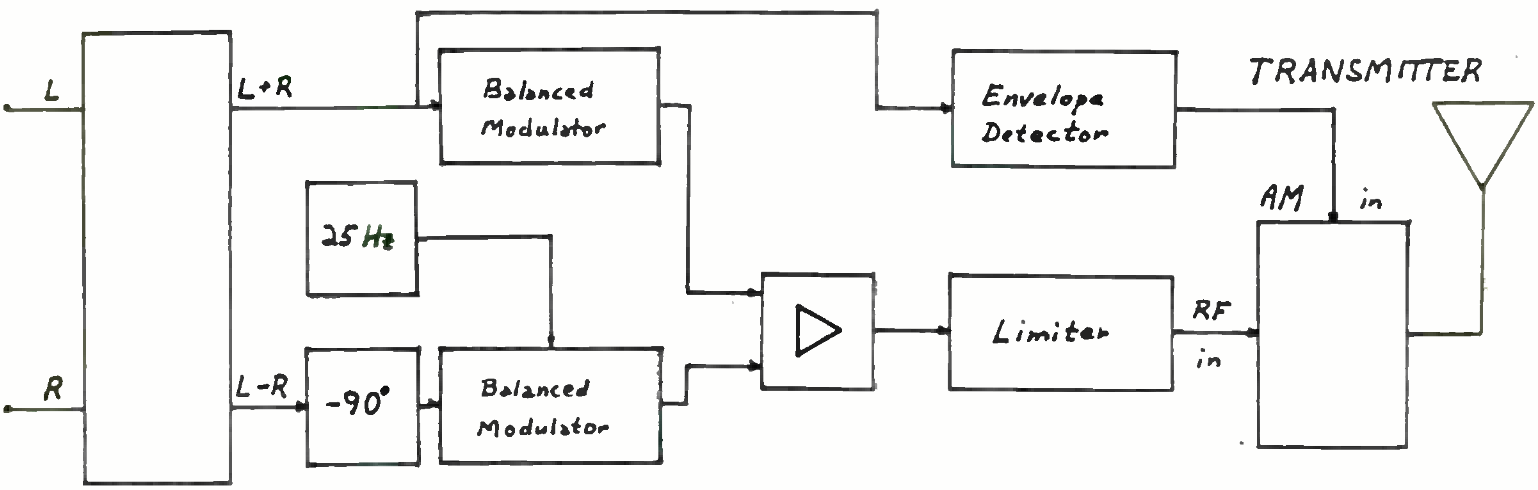
After a conventional front end and IF stages, the signal is sent to two destinations. The monaural information is detected conventionally in an elope detector. The stereo signal is limited and demodulated in a phase tector. Part of this is used for the 5 Hz stereo signal detector and the other portion is tailored for the audio matrix after having passed the stereo switching circuitry.

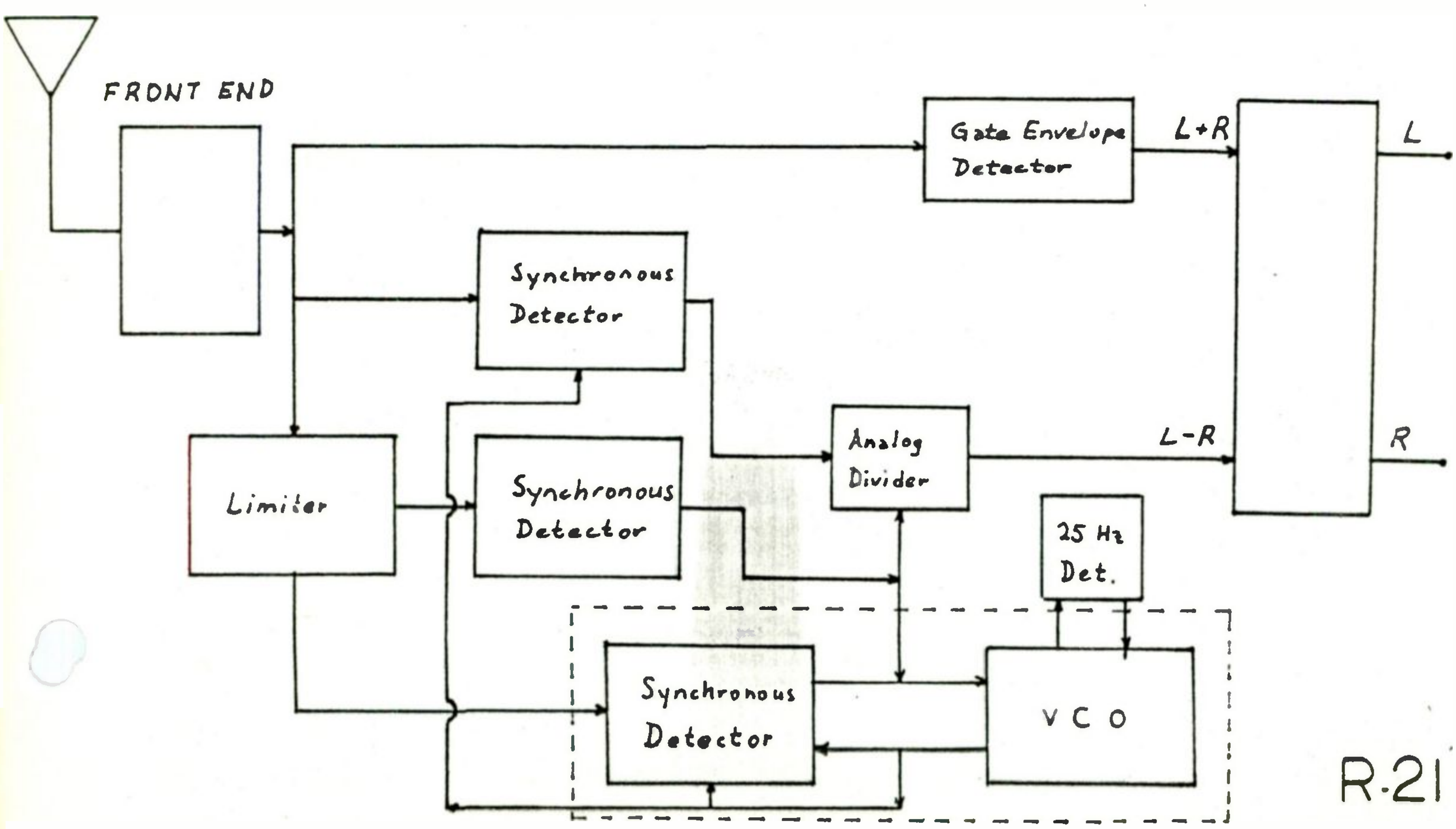
As is fairly apparent Magnavox has emphasized the simplicity of inplementation of the system. There is a problem with peaks of 100% negative modulation.

This was the system which the FCC decided on as the standard for the industry until the industry raised such a howl that the FCC relented and threw the market wide open.

C-QUAM

The Motorola System





R-21

Compatible quadrature amplitude modulation, as introduced by Motorola is a modified quadrature system also. ⑥

A straight quadrature system would, say, modulate the left channel 90 degrees ahead of the right. This would of course, not provide the necessary L+R compatibility to conventional monaural receiving systems. The modified quadrature system matrixes the L and R channels. The stereo signal is delayed by 90 degrees and summed to the monaural signal. The hard limiter produces a phase modulation and this is applied to the VCO of the transmitter, while the L+R provides the conventional amplitude modulation.

The decoding circuitry in the receiver is relatively complex. Naturally, up to the output of the IF stages, the receiver is of conventional design. A gated envelope detector provides the L+R signal to the matrix. Two synchronous detectors and an analog divider yield the L-R signal which is fed to the matrix also. The PLL and the 25 Hz detector extract the pilot tone which can once again be used to switch on an indicator lamp or drive the control logic to switch into stereo mode.

Although the receiver is complex, the quadrature system does have some noise advantages over its competitors. And te complexity of the receiver, and approach to AM stereo in general throws the responsibility of fidelity squarely onto the shoulders of the receivers, which might not be a bad thing in the long run.

Of course, now that the Japanese so wisely have brought out systems to receive all four of he competing methods of transmission, the need to choose a single system is made obsolete. For the average consumer it makes little or no difference as to which system is employed by the station which he or she listens to. For us within the DX faternity, the matter is not quite so clear cut, as the recent controversy with Harris points out.

Arnim Littek

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