RPU - 140

MINIMUM REQUIRED FIELD INTENSITIES FOR INTELLIGIBLE RECEPTION OF RADIOTELEPHONY IN PRESENCE OF ATMOSPHERICS OR RECEIVING SET NOISE

This report has been prepared under the direction of the Chief Signal Officer by the Radio Propagation Unit, (9463dTSU) Holabird Signal Depot, Baltimore, Maryland

RADIO PROPAGATION UNIT TECHNICAL REPORT

No. 5

DECEMBER 1945

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PREPARED BY

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RADIO PROPAGATION UNIT
HOLABIRD SIGNAL DEPOT
BALTIMORE 19, MARYLAND

PREVIOUS RADIO PROPAGATION UNIT TECHNICAL REPORTS

No. 1.- Investigation of Minimum Radio Frequency Voltage Required for Intelligible Reception of A-1, A-2, and A-3 Signals in Absence of Atmospherics.

No. 2.- Radiation from Antennas in the 1.5 to 20.0 Megacycle Band.

No. 3.- Ground-Wave Field Intensities.

No. 4.- Relative Sky-Wave Signal Strengths Required for Intelligible Reception of Various Types of Radio Communication Service.

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ATMOSPHERIC NOISE GRADE CURVES (CONTINUED) **Figure No.**

SKY-WAVE RECEPTION (CONTINUED)

MINIMUM REQUIRED FIELD INTENSITIES FOR INTELLIGIBLE RECEPTION OF RADIOTELEPHONY IN PRESENCE OF ATMOSPHERICS OR RECEIVING SET NOISE

I. PURPOSE AND SCOPE

This report has been prepared to show in graphical form the minimum required incident received field intensity for intelligible reception of radiotelephony in the presence of atmospheric or receiving set noise.

The curves showing required field in the presence of atmospheric noise are based upon noise measurements made throughout the world at different hours of the day and seasons of the year, and a knowledge of the locations of the important world atmospheric noise centers. The assumption that the receiving antenna responds equally to the desired signal and the atmospheric noise has been made in plotting these curves. When this is not the case the required field will be somewhat different, as discussed in a later section of this report.

Curves showing the required incident field intensities when set noise rather than atmospheric noise is the limiting factor have been prepared as a part of this report. These curves are based upon theoretical calculations for practical receiving antennas, and are plotted for various vertical angles of reception with various antennas.

II. CONSIDERATIONS IN DETERMINING REQUIRED SIGNAL INTENSITY

A. Atmospheric Noise

Most of the atmospheric noise in the world originates in thunderstorms. At a given receiving location the atmospheric noise is made up of noise from nearby centers of noise, such as local thunderstorms whose distance from the receiving location may vary from a few miles to hundreds of miles, plus noise which has been propagated from one or more of the principal centers of noise generation, such as the active thunderstorm areas in equatorial Africa, Central America, and the East Indies. The location and activity of the various noise centers vary with time of day and season. The determination of atmospheric noise at a given receiving location is thus a series of radio propagation problems, in which the noise originating in each center of storm activity produces a definite field intensity at the receiving location.

Figures 1 to 4, inclusive, are maps of the world divided into noise zones. It will be noted that these four noise maps correspond to four different periods of the year. Areas of the world in which thunderstorms are most frequent are indicated as zones 4 and 5. The areas most remote from the principal thunderstorm areas, and in which but little atmospheric radio noise may be expected, even by way of long distance sky-wave propagation, are indicated as zone 1. The other zones are intermediate in radio noise expectation. Corresponding to these noise zones are the required field intensity curves of Figures 5 to 23, inclusive. These curves for a particular noise grade are plotted as required incident field intensity vs. frequency for six different times of day. It will be noted that the night time noise curves have an almost constant slope, the noise intensity decreasing with increasing frequency. This represents roughly the frequency characteristic of the noise produced by the thunderstorms, as there is very little absorption by the ionosphere of sky-wave propagated signals during the hours of darkness. Above the maximum usable frequency for long distance transmission the noise can not be propagated by sky-wave transmission, and hence decreases very rapidly with increasing frequency. The variation in the magnitude of the required field intensity curves for various hours during darkness is due to the average variation of thunderstorm activity throughout the night, with the maximum usable frequency effect mentioned in the preceding sentence also a factor at the higher frequencies. During daylight hours the absorption of the sky-wave propagated noise increases, and is greatest in the frequency range of 1.5 to 2.5 megacycles. This is evident in the shape and magnitude of the noise curves for daylight hours. It is also pointed out that sky-wave propagated noise extends to higher frequencies in the daytime, because of the higher maximum usable frequencies occuring during these hours.

The required incident field intensity curves are plotted for 90% intelligibility of 100% modulated radiotelephone service, assuming the receiving antenna responds equally to the noise and the desired signal; for reception of other types of service the required field intensities are modified by an amount shown in Radio Propagation Unit Technical Report No. 4, "Relative Sky-Wave Signal Strengths Required for Intelligible Reception of Various Types of Radio Communication Service". It will be noted that noise curves for the lower noise grades are plotted for summer (May, June, and July), winter (November, December, and January), and equinox (February, March, April, and August, September, October) months. This variation with season is due to the variation in the length of daylight and darkness hours for north or south latitudes greater than 30 degrees, and the consequent effect on the propagation of the noise. When the receiving location is at a latitude of less than 30 degrees, the equinox months noise curves apply for all months of the year. These noise curves represent a signal to average noise ratio of approximately 15 decibels, with receiving set band-width of approximately 3 kilocycles each side of the carrier frequency.

When the receiving antenna discriminates either for or against the desired signal with respect to the atmospheric noise, the required incident field intensity for a particular type of service is modified accordingly. For instance assume that the majority of the noise is arriving from a noise center to the south of a particular receiving location, and that a signal is being received from the east on a directive antenna. Assume further that the response of the antenna in the direction of the arrival of the desired signal is 10 decibels greater than the response of of the antenna in the direction of the arrival of the noise. Then the required signal intensity to overcome the atmospheric noise is 10 decibels less than is indicated by the curves. It is to be remembered that the vertical angles of arrival of the signal and noise are to be considered, as well as the azimuth angles, in determining the relative response of an antenna to the signal and the noise. In this connection it is pointed out that little data are available on vertical angles of arrival of atmospheric noise, but an average angle of 20 degrees above the horizontal has frequently been assumed for the intermediate and low noise grades.

B. Receiving Set Noise

Experimental determination of the required receiver terminal voltage for typical army communication receivers has been found to be approximately 2 microvolts for 90% intelligibility of radiotelephony in presence of receiving set noise only. (See Radio Propagation Unit Technical Report No. 1.) This value is somewhat dependent on frequency, but is considered sufficiently accurate for all frequencies in the 1.5 to 20.0 megacycle band.

Figures 24 to 56, inclusive, are a set of curves showing required incident field intensity vs. frequency for various practical receiving antennas to deliver 2 microvolts across a 100 ohm load resistance. The average receiver input impedance has been assumed to be 100 ohms, and it is assumed that the antenna reactance, if any, will be tuned out. In the calculations for the rhombic antennas it has been assumed that a 600 to 100 ohm radio-frequency transformer will be used between the antenna and receiver, and that a voltage of 2 microvolts is required across the 100 ohm side. Transmission line and matching network losses have been neglected in these curves. If these losses are known, the loss in decibels should be added to the required incident field intensity as read from the curves. Thus these curves show the required incident field intensity for 90% intelligibility of radiotelephony with the various receiving antennas, when set noise is the limiting factor.

In computing these receiving antenna curves, advantage has been taken of the reciprocity theory for transmitting and receiving antennas, in that the directivity factors for a given antenna have been assumed to be the same in both cases. The formula used for the calculations is stated below:

$$E_{uv/m} = \frac{24.6 \times f_{mc}}{\sqrt{R_r} \times F} \times \frac{R_r + R_l + R_z}{R_z}$$, to produce 2 microvolts across R_z.

Where: R_r = antenna radiation resistance.
R_l = antenna loss resistance.
R_z = antenna load resistance
F = theoretical inverse distance field intensity

in millivolts per meter produced by antenna at one mile in desired direction when used as a transmitting antenna, with 1.0 kilowatt delivered to antenna, assuming zero antenna loss resistance.

f_{mc} = frequency in megacycles per second.

$E_{uv/m}$ = required incident field intensity in microvolts per meter.

It is to be noted that curves have been drawn for antennas located over both "good" and "poor" ground, and for various vertical angles of wave arrival.

III. USE OF THE CURVES

A. Determination of Minimum Required Field Intensity as Limited by Atmospheric Noise

To determine the required incident field intensity when atmospheric noise is limiting reception, first turn to the world noise map for the desired month, figures 1 to 4, inclusive, and find the noise grade applicable to the receiving location. Then turn to the noise chart for the particular noise grade and season and find the minimum required field intensity for radiotelephony at the frequency and time of day in question. If service other than radiotelephony is to be employed, the required field intensity should be modified by the amount shown in Radio Propagation Unit Technical Report No. 4. "Relative Sky-Wave Signal Strengths Required for Intelligible Reception of Various Types of Radio Communication Service".

The above determininination of required field intensity assumes that the receiving antenna responds equally to the noise and the desired signal. If this is not the case the required field intensity must be modified accordingly, as was mentioned in Section II of this report.

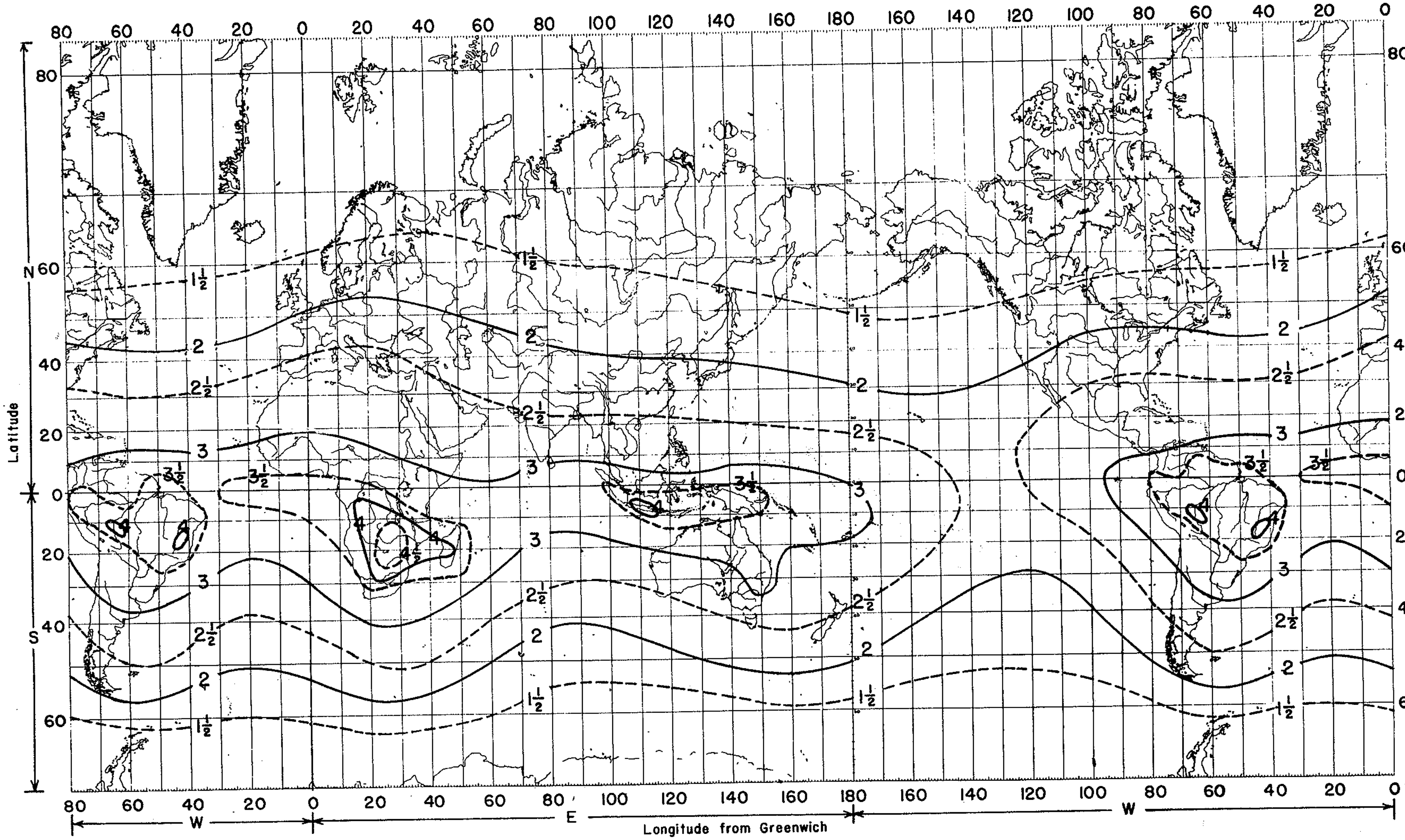
B. Determination of Minimum Required Field Intensity as Limited by Receiving Set Noise

When receiving set noise is limiting reception, the minimum required field intensity may be determined in the following manner. First, determine the wave arrival angle above the horizontal. This angle may be assumed to be the same as the angle of radiation when transmitting over the same path, and may be determined from the radiation angle vs. great circle distance chart for various ionosphere layer heights, contained in Radio Propagation Unit Technical Report No. 2, "Radiation from Antennas in the 1.5 to 20 Megacycle Band". Then turn to the curve sheet for the particular antenna and type of ground at the receiving location, and find the minimum required field intensity for the wave arrival angle and frequency in question. If service other than radiotelephony is to be used, the required fields are to be modified as in the atmospheric noise case by reference to Radio Propagation Unit Technical Report No. 4.

C. Minimum Required Field Intensity as Determined by both Atmospheric and Set Noise

The actual minimum required field intensity for a particular frequency, time of day, and receiving antenna is the higher of the two values determined as above for atmospheric and receiving set noise limitations. Thus, if desired, a composite curve of minimum required field intensity vs. frequency for a particular time of day may be drawn, plotting only the higher of the two values determined for atmospheric and receiving set noise.

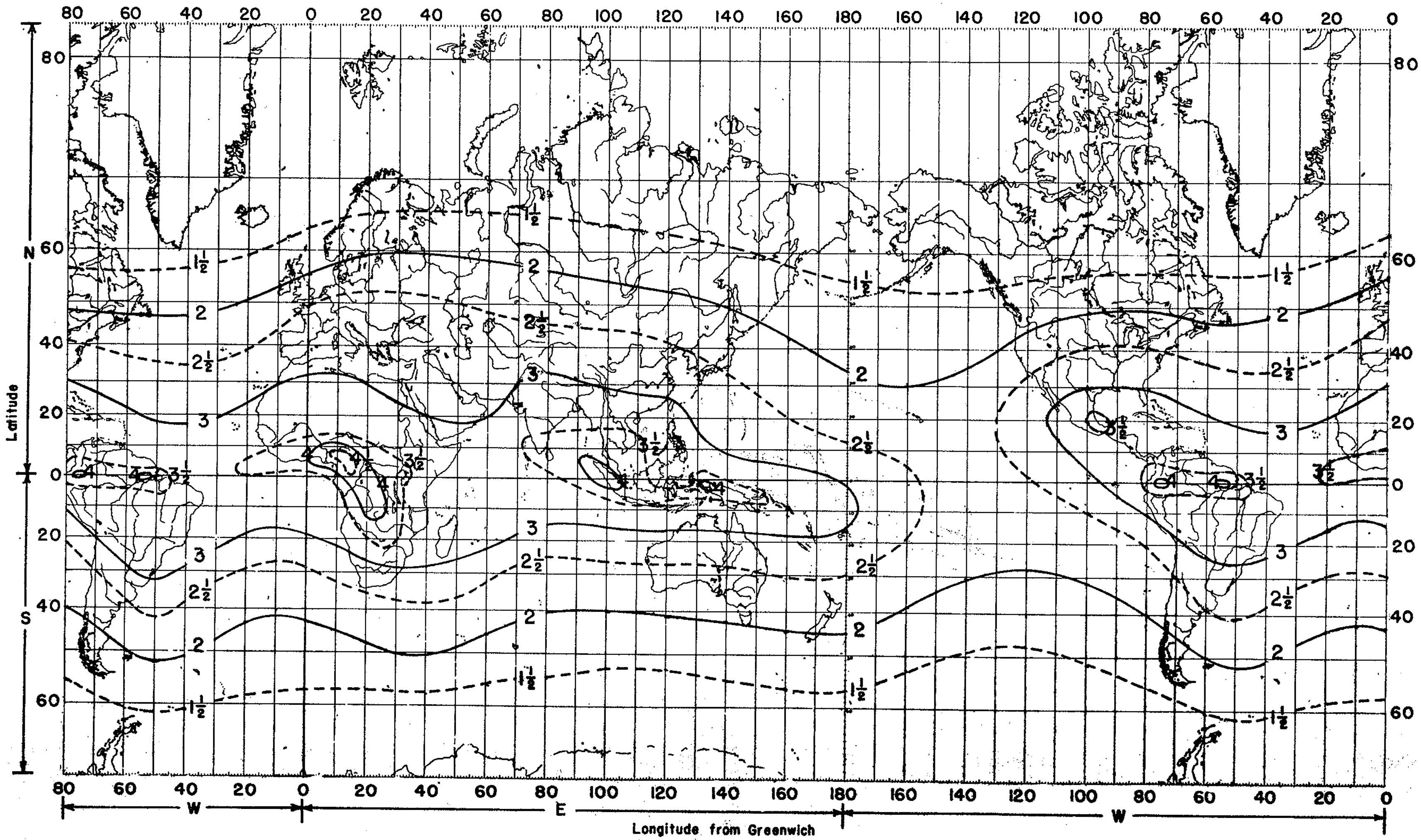
NOISE DISTRIBUTION FOR PERIOD
DECEMBER — JANUARY — FEBRUARY



Note:—Figures on contours correspond to numbered noise grade graphs.

Figure 1

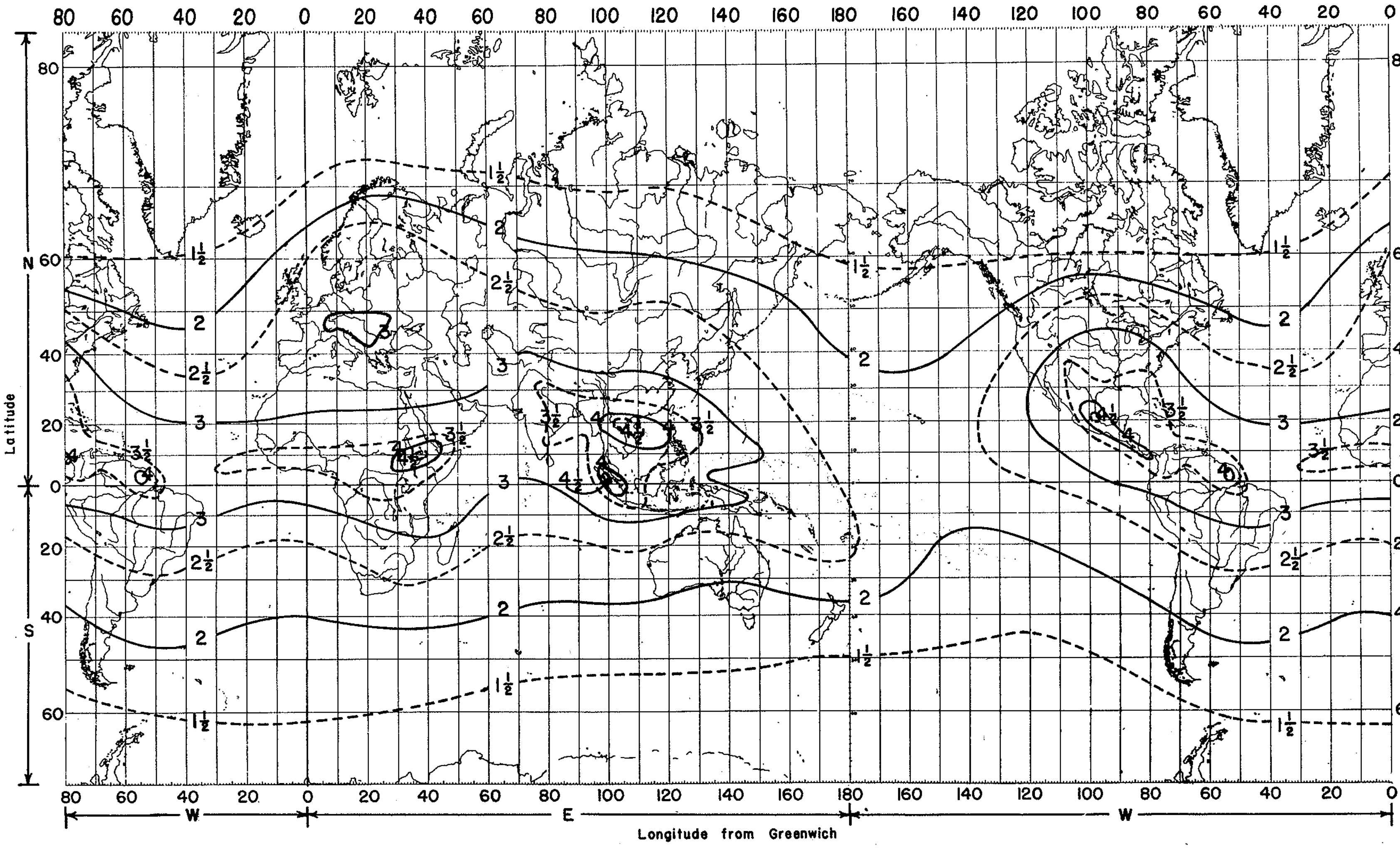
NOISE DISTRIBUTION FOR PERIOD
MARCH – APRIL – MAY



Note:— Figures on contours correspond to numbered noise grade graphs.

Figure 2

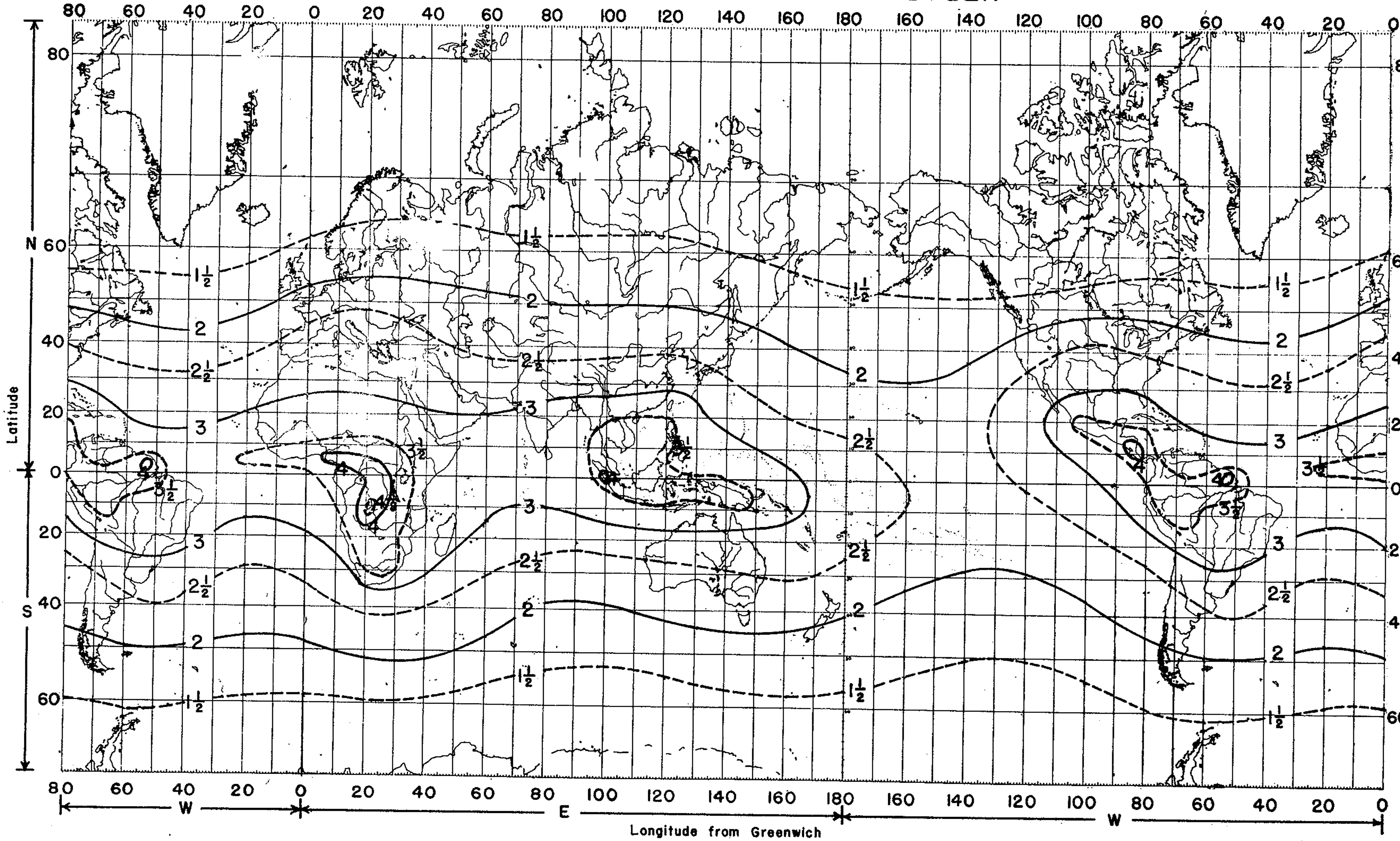
NOISE DISTRIBUTION FOR PERIOD
JUNE - JULY - AUGUST



Note:—Figures on contours correspond to numbered noise grade graphs.

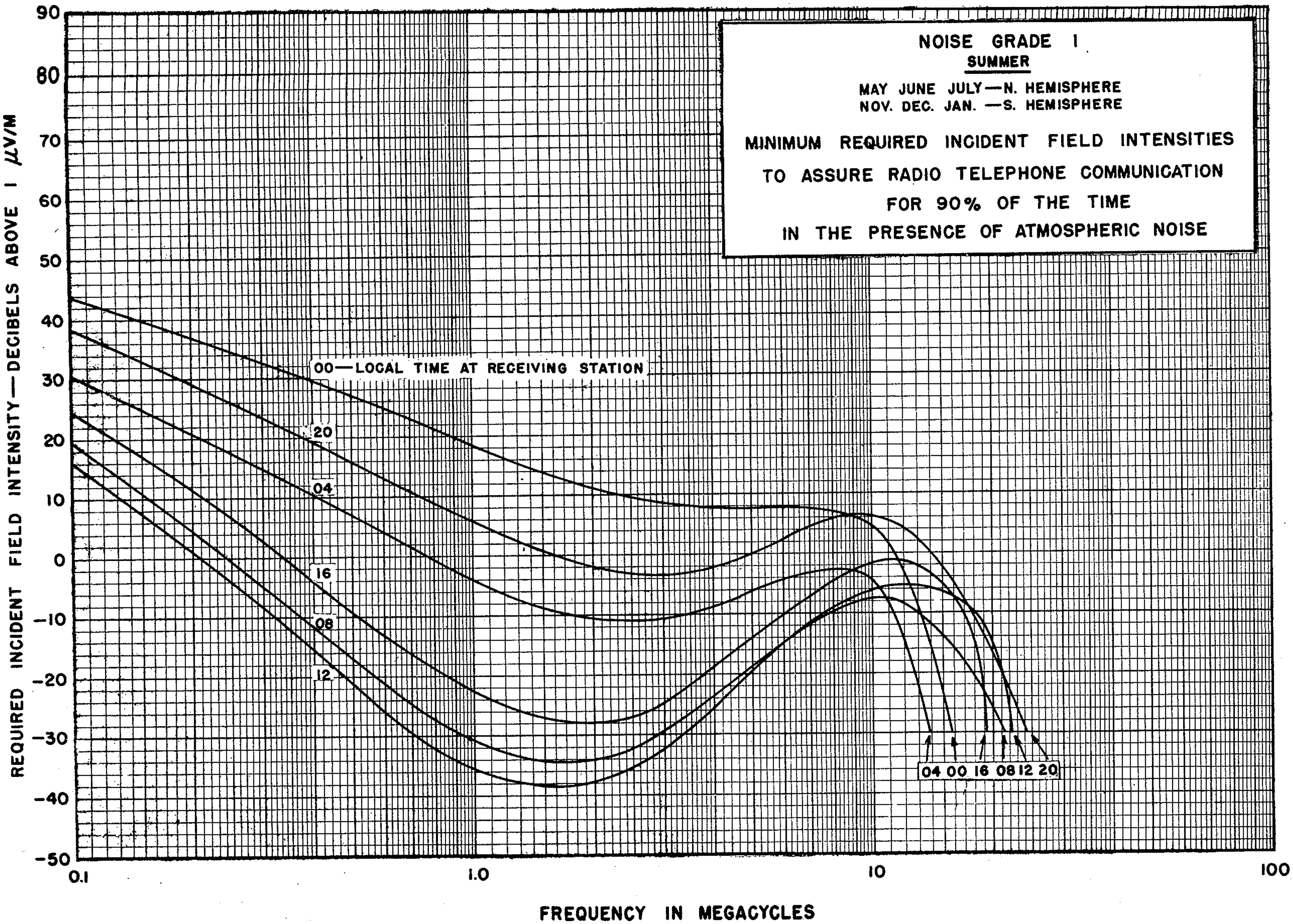
Figure 3

NOISE DISTRIBUTION FOR PERIOD SEPTEMBER - OCTOBER - NOVEMBER



Note:—Figures on contours correspond to numbered noise grade graphs.

Figure 4



NOISE GRADE 1
SUMMER
MAY JUNE JULY — N. HEMISPHERE
NOV. DEC. JAN. — S. HEMISPHERE
MINIMUM REQUIRED INCIDENT FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION
FOR 90% OF THE TIME
IN THE PRESENCE OF ATMOSPHERIC NOISE
00 — LOCAL TIME AT RECEIVING STATION
20
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04 00 16 08 12 20
REQUIRED INCIDENT FIELD INTENSITY — DECIBELS ABOVE 1 μV/M
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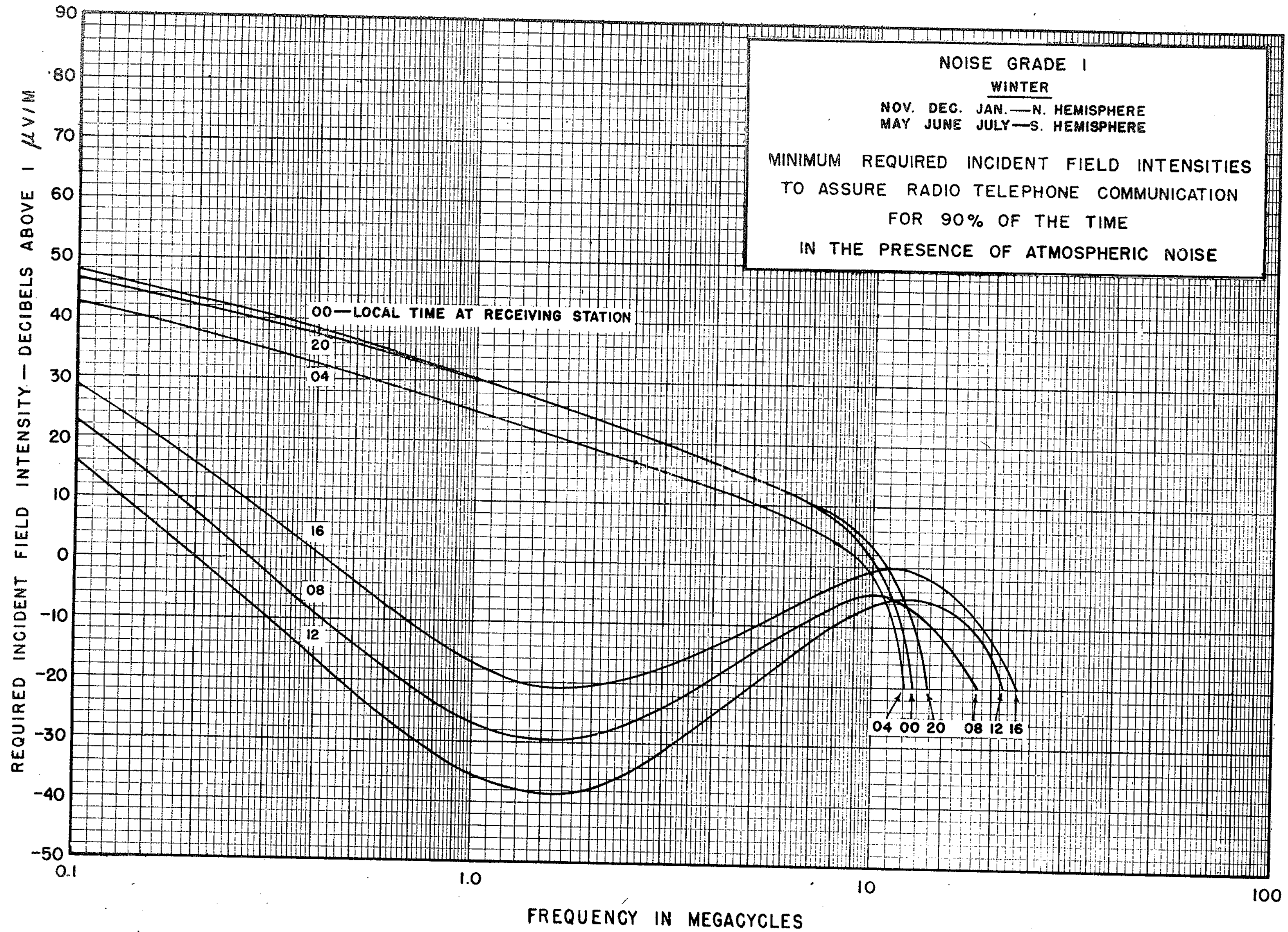
FREQUENCY IN MEGACYCLES

Fig. 5


NOISE GRADE I
WINTER
NOV. DEC. JAN.—N. HEMISPHERE
MAY JUNE JULY—S. HEMISPHERE
MINIMUM REQUIRED INCIDENT FIELD INTENSITIES
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FREQUENCY IN MEGACYCLES

Fig. 6

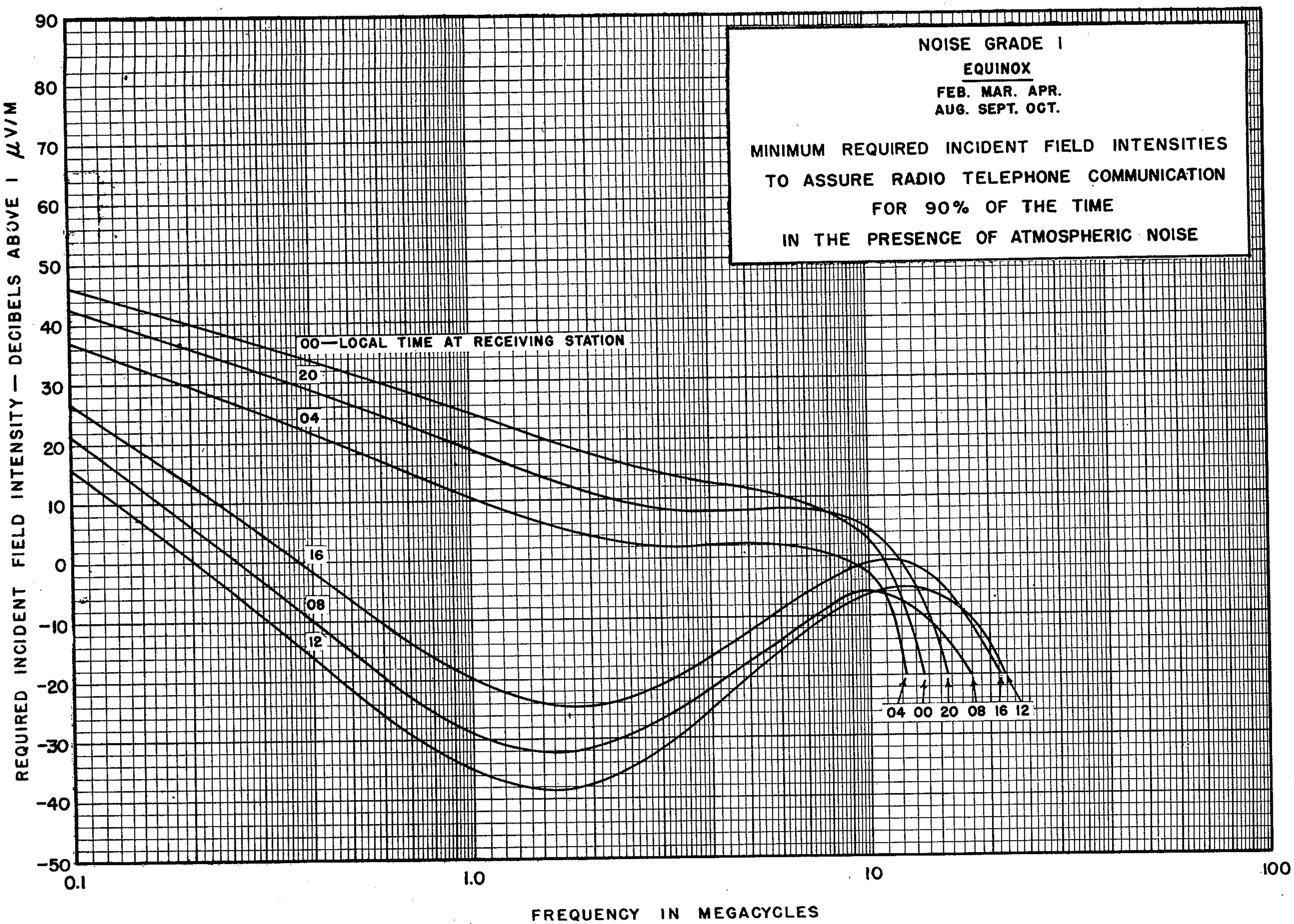
NOISE GRADE I
EQUINOX
FEB. MAR. APR.
AUG. SEPT. OCT.
MINIMUM REQUIRED INCIDENT FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION
FOR 90% OF THE TIME
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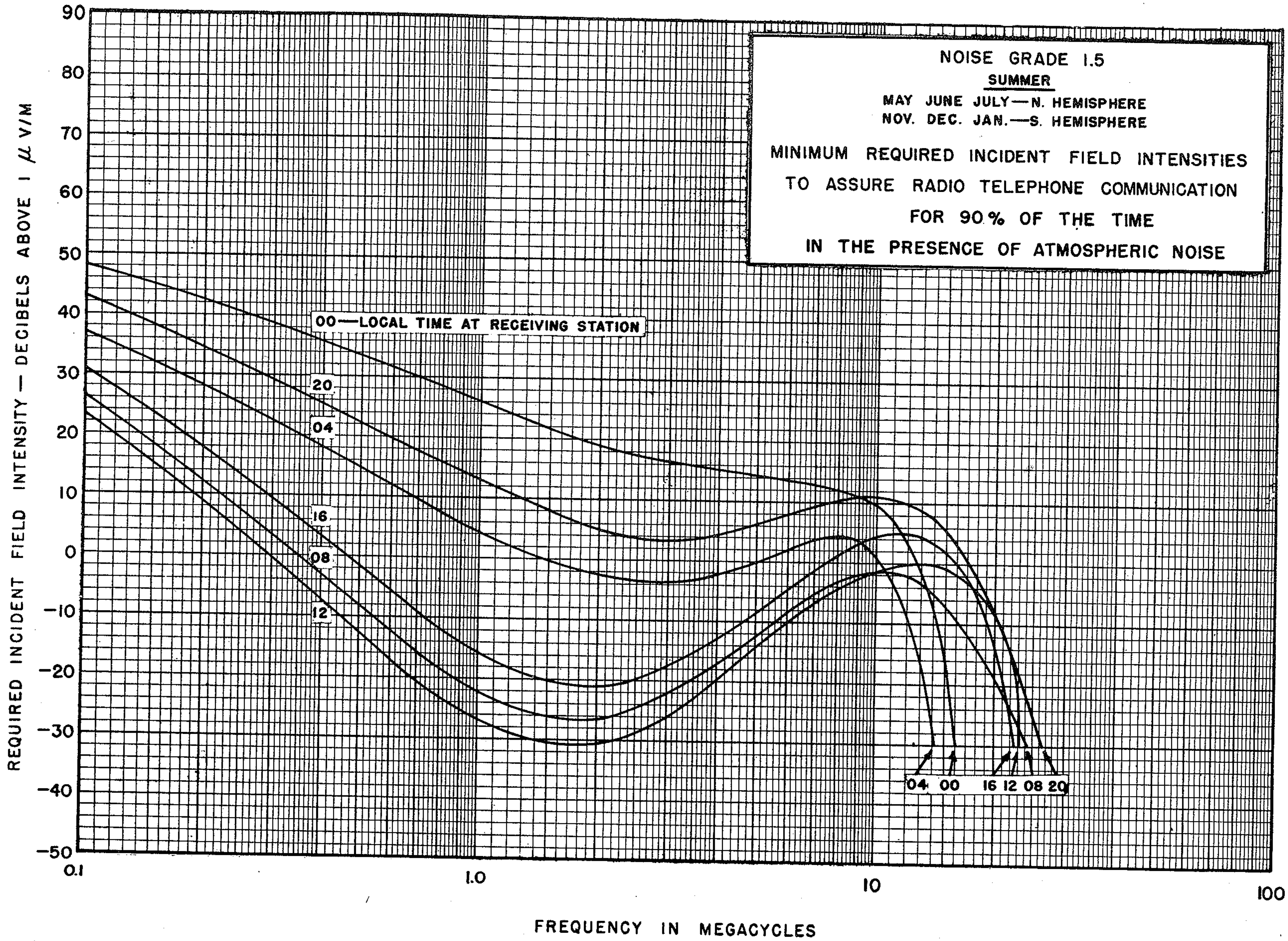
Fig. 7


NOISE GRADE 1.5
SUMMER
MAY JUNE JULY—N. HEMISPHERE
NOV. DEC. JAN.—S. HEMISPHERE
MINIMUM REQUIRED INCIDENT FIELD INTENSITIES
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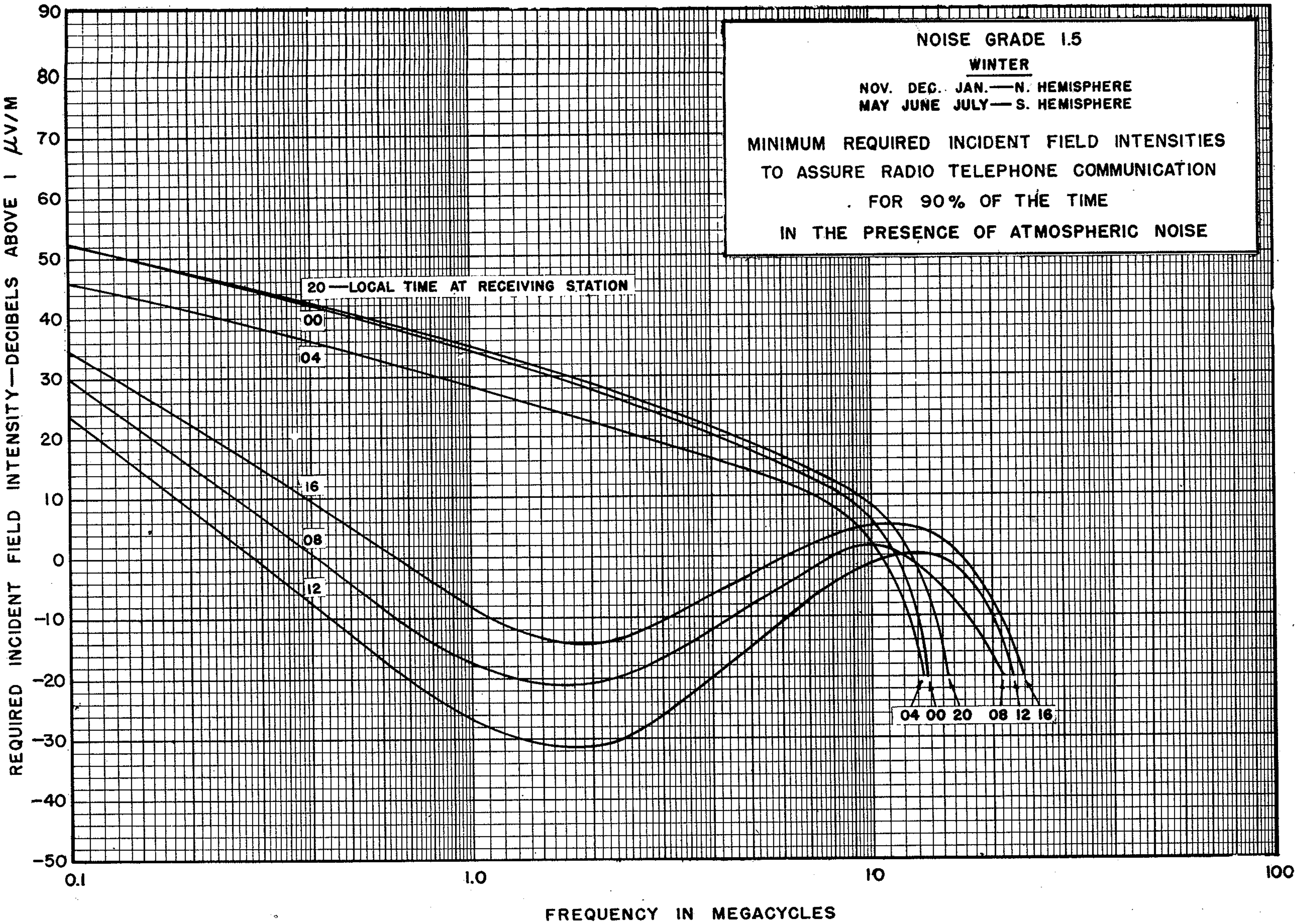
REQUIRED INCIDENT FIELD INTENSITY — DECIBELS ABOVE 1 μ V/M
FREQUENCY IN MEGACYCLES

Fig. 8


NOISE GRADE 1.5
WINTER
NOV. DEC. JAN.—N. HEMISPHERE
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FREQUENCY IN MEGACYCLES

Fig. 9

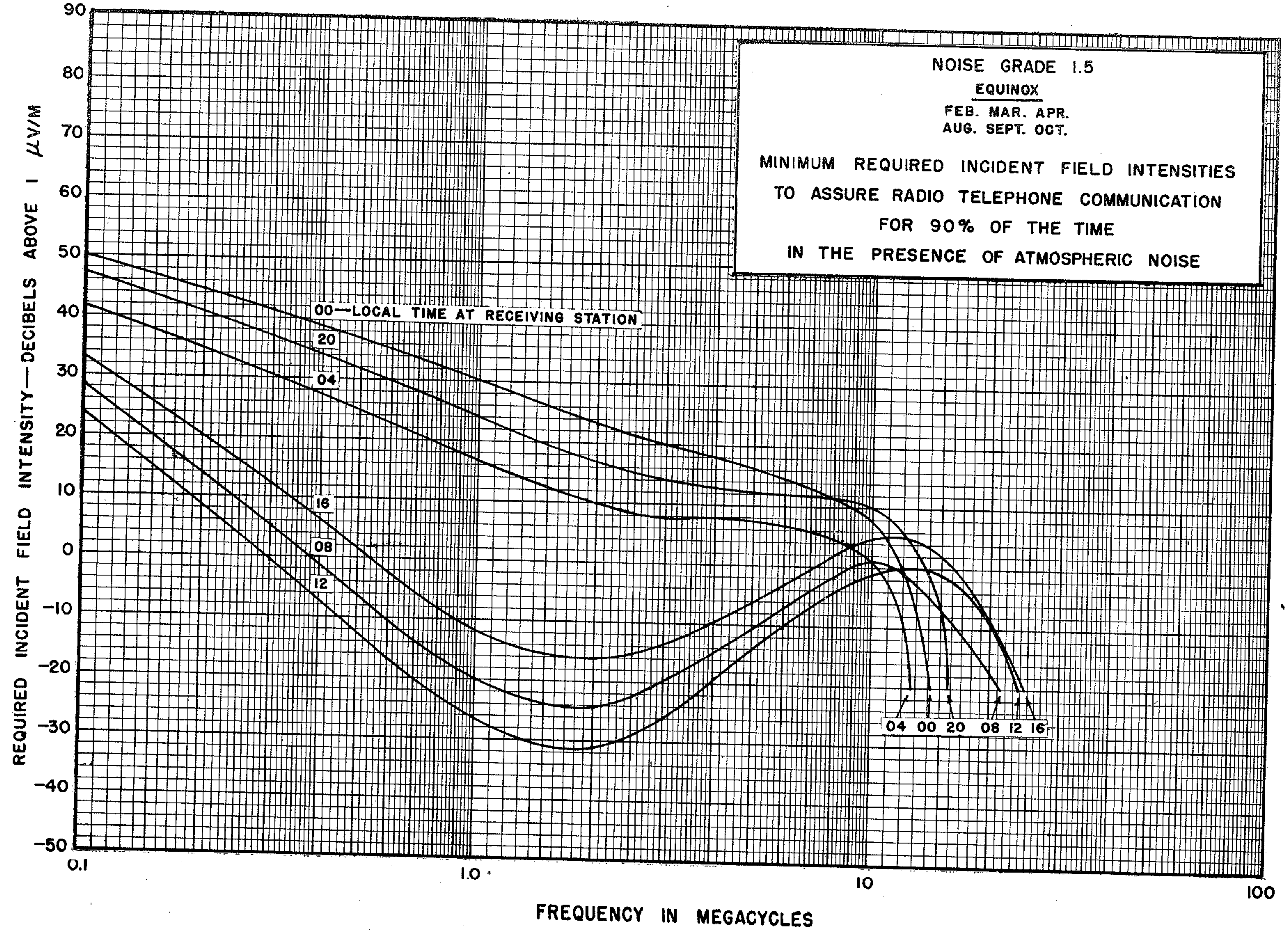
NOISE GRADE 1.5
EQUINOX
FEB. MAR. APR.
AUG. SEPT. OCT.
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Fig. 10

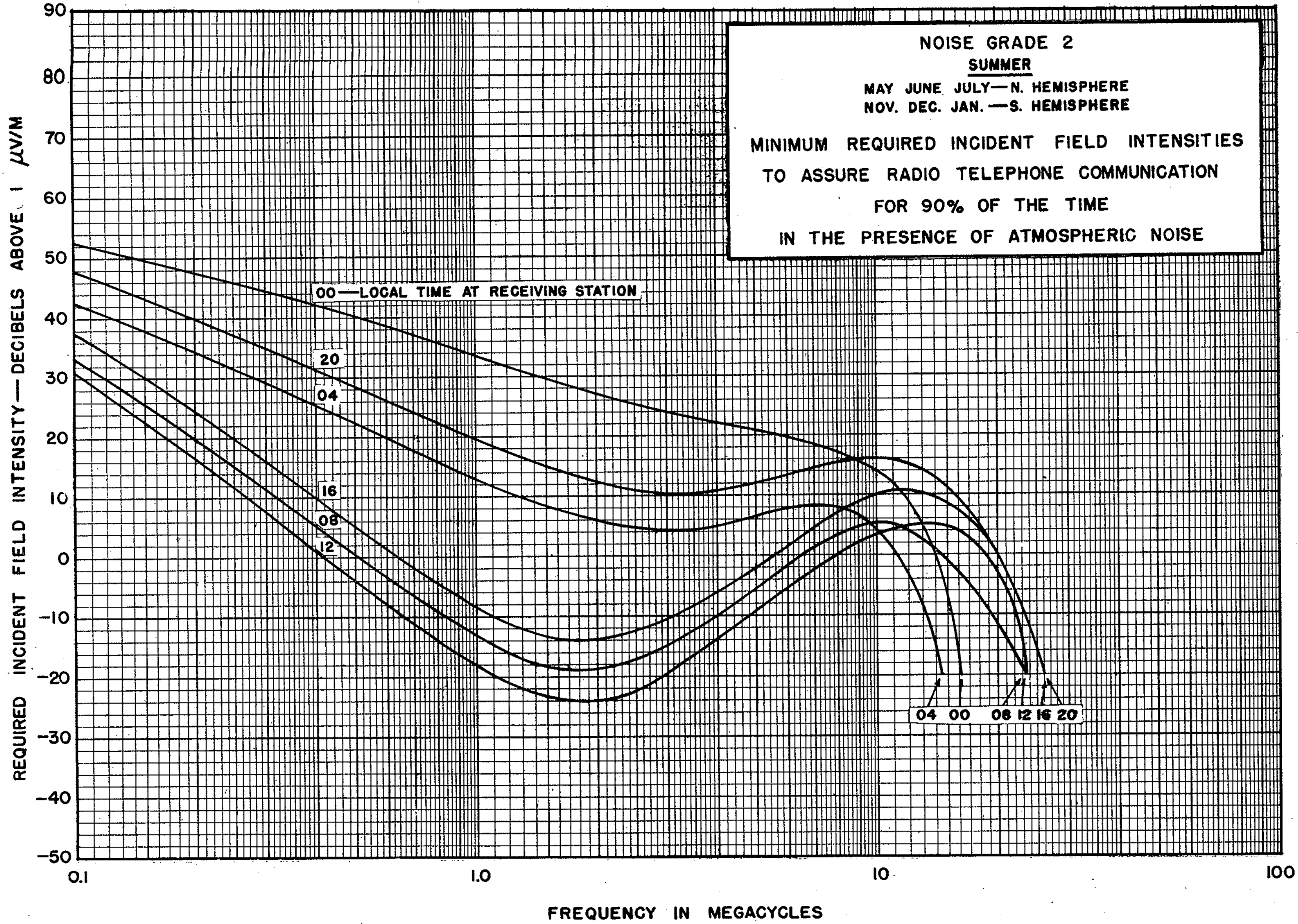
NOISE GRADE 2
SUMMER
MAY JUNE JULY—N. HEMISPHERE
NOV. DEC. JAN.—S. HEMISPHERE
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Fig. 11

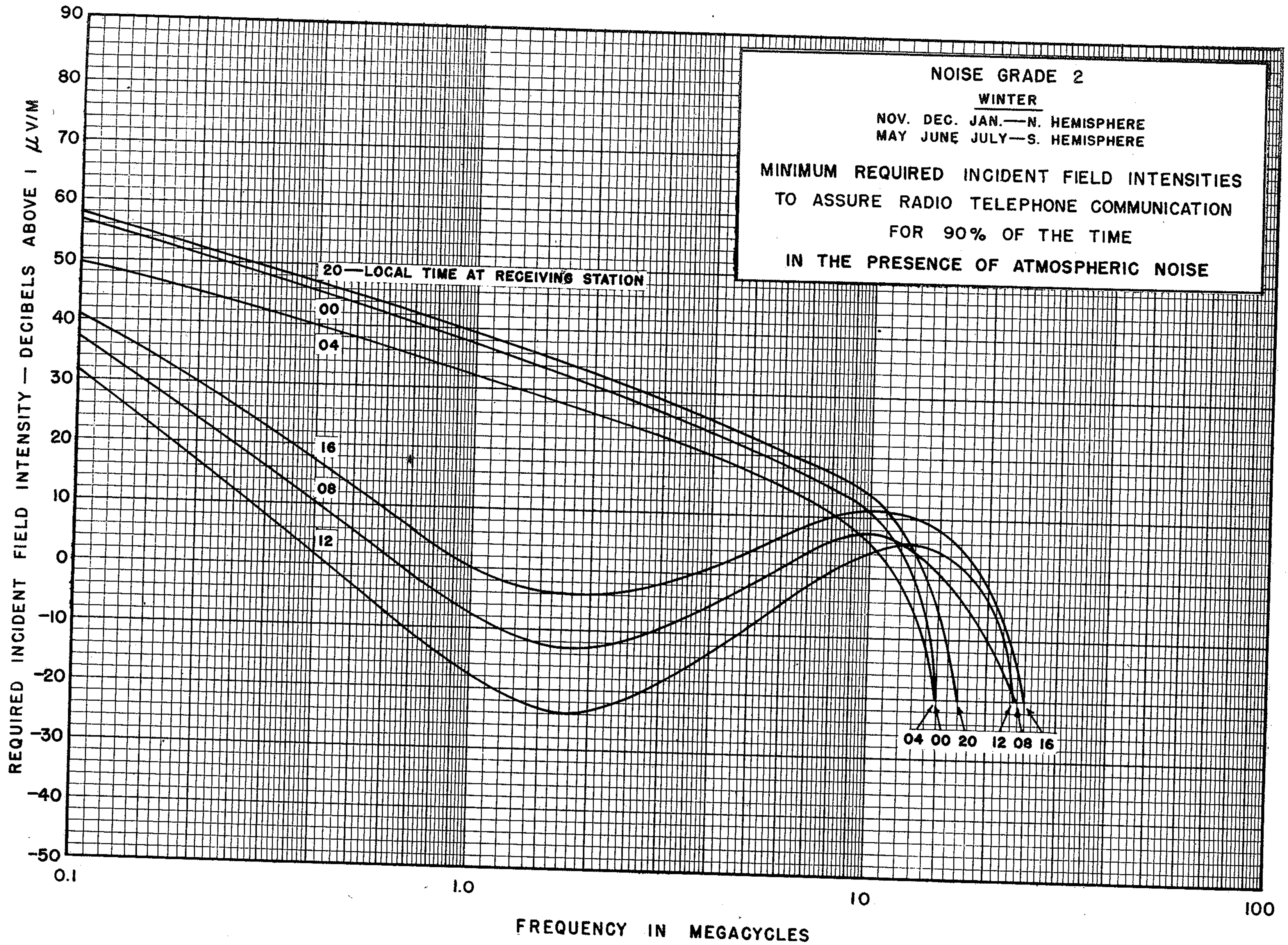
NOISE GRADE 2
WINTER
NOV. DEC. JAN.—N. HEMISPHERE
MAY JUNE JULY—S. HEMISPHERE
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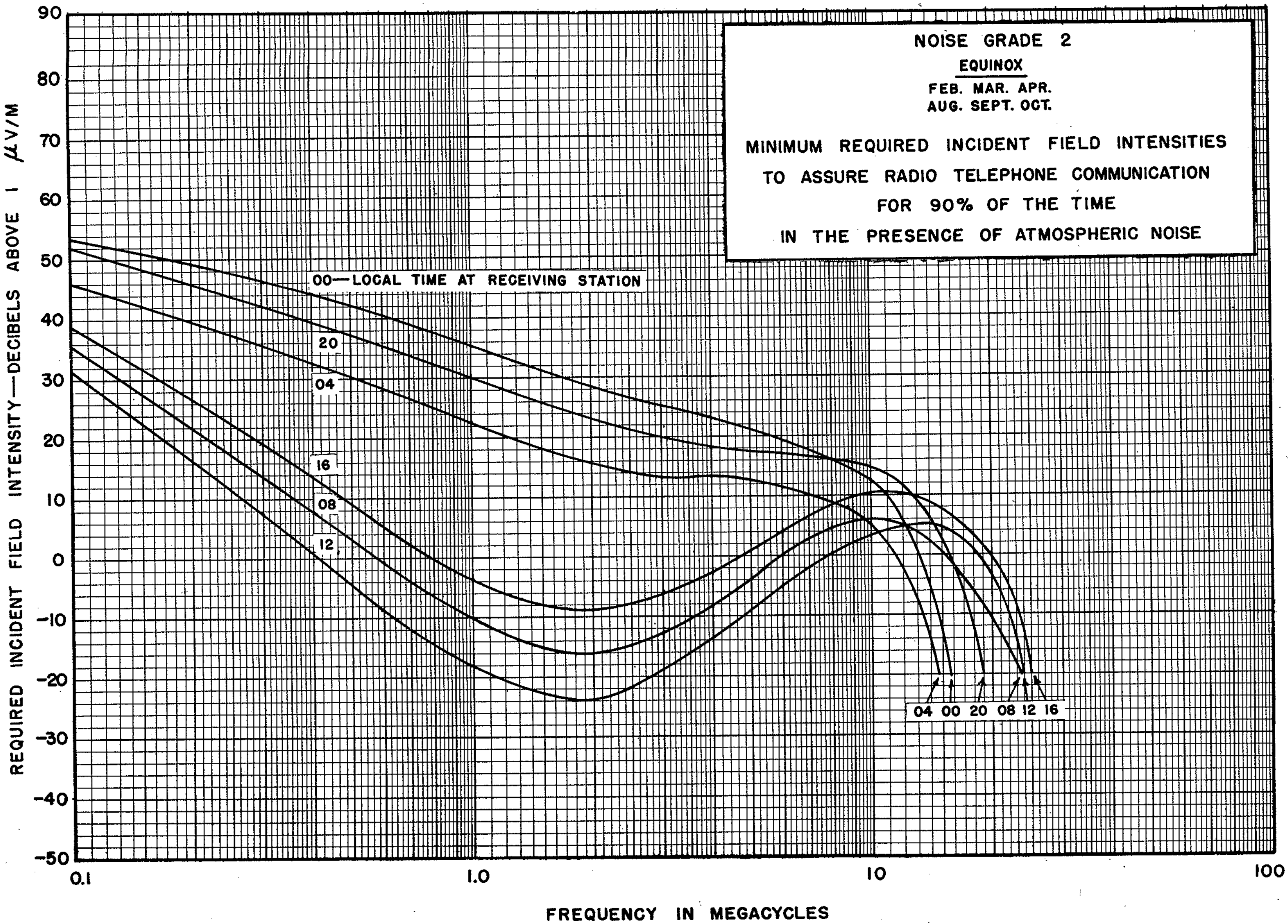
Fig. 12


NOISE GRADE 2
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AUG. SEPT. OCT.
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Fig. 13

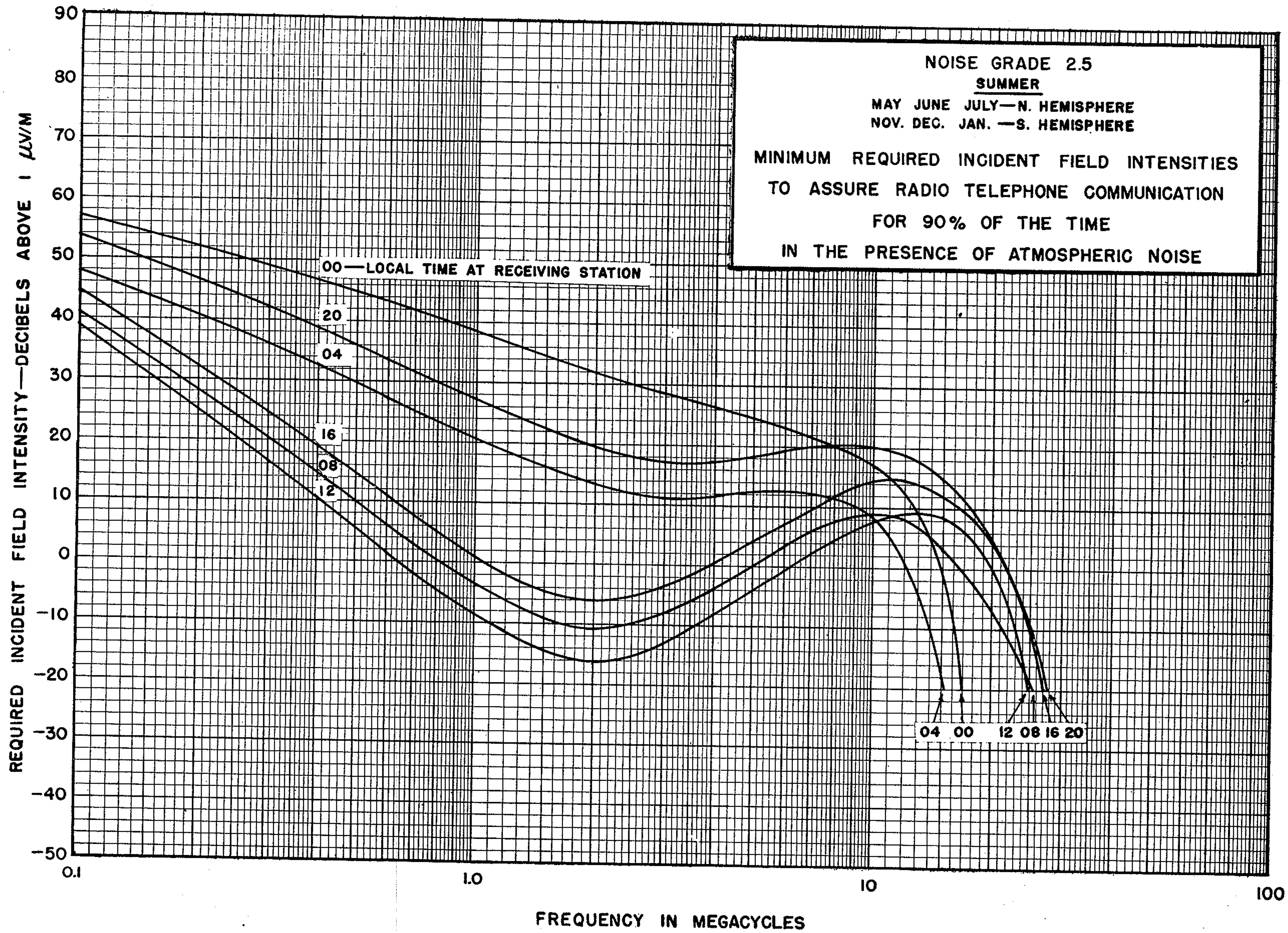
NOISE GRADE 2.5
SUMMER
MAY JUNE JULY—N. HEMISPHERE
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Fig. 14

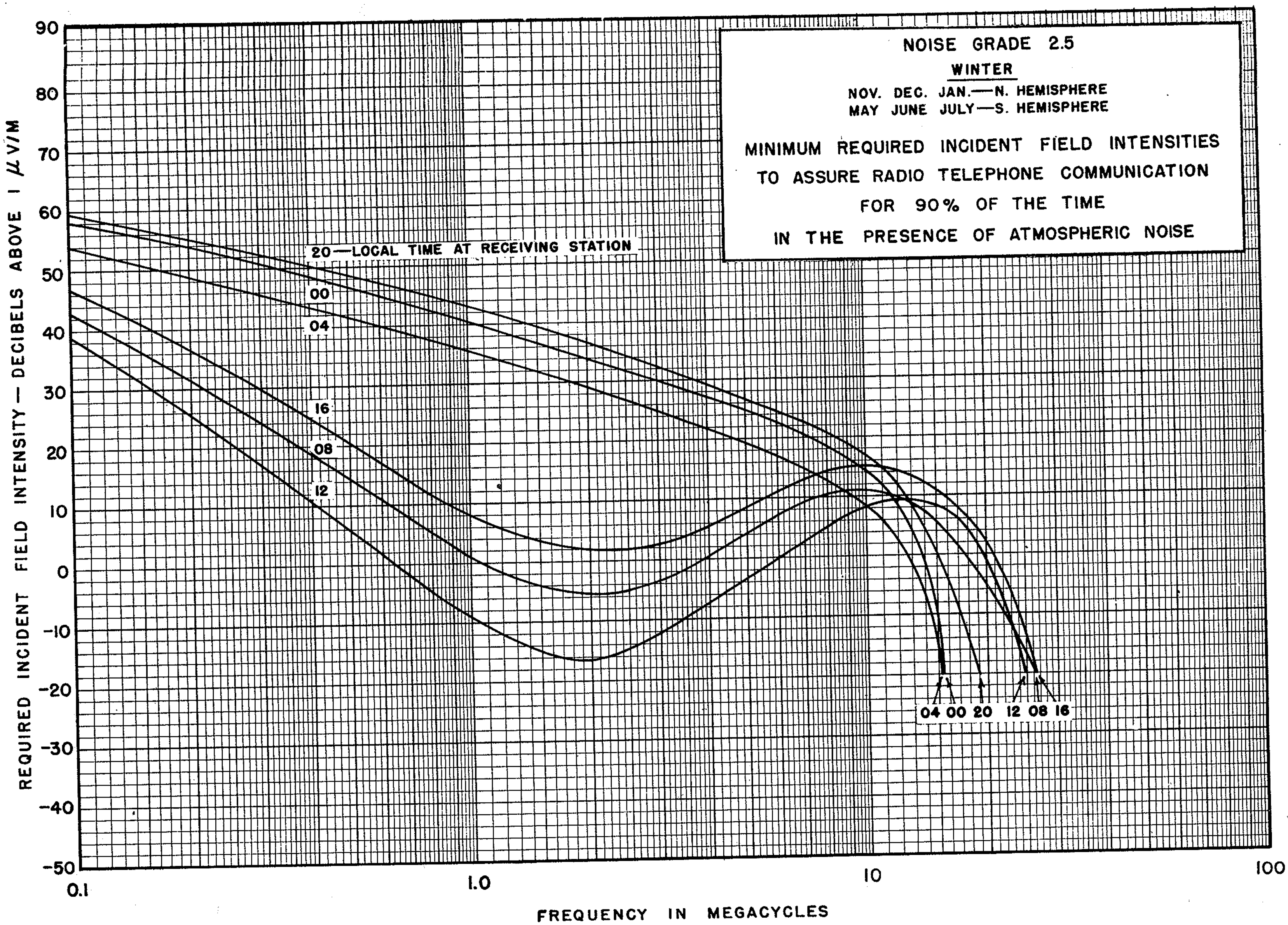
NOISE GRADE 2.5
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Fig. 15

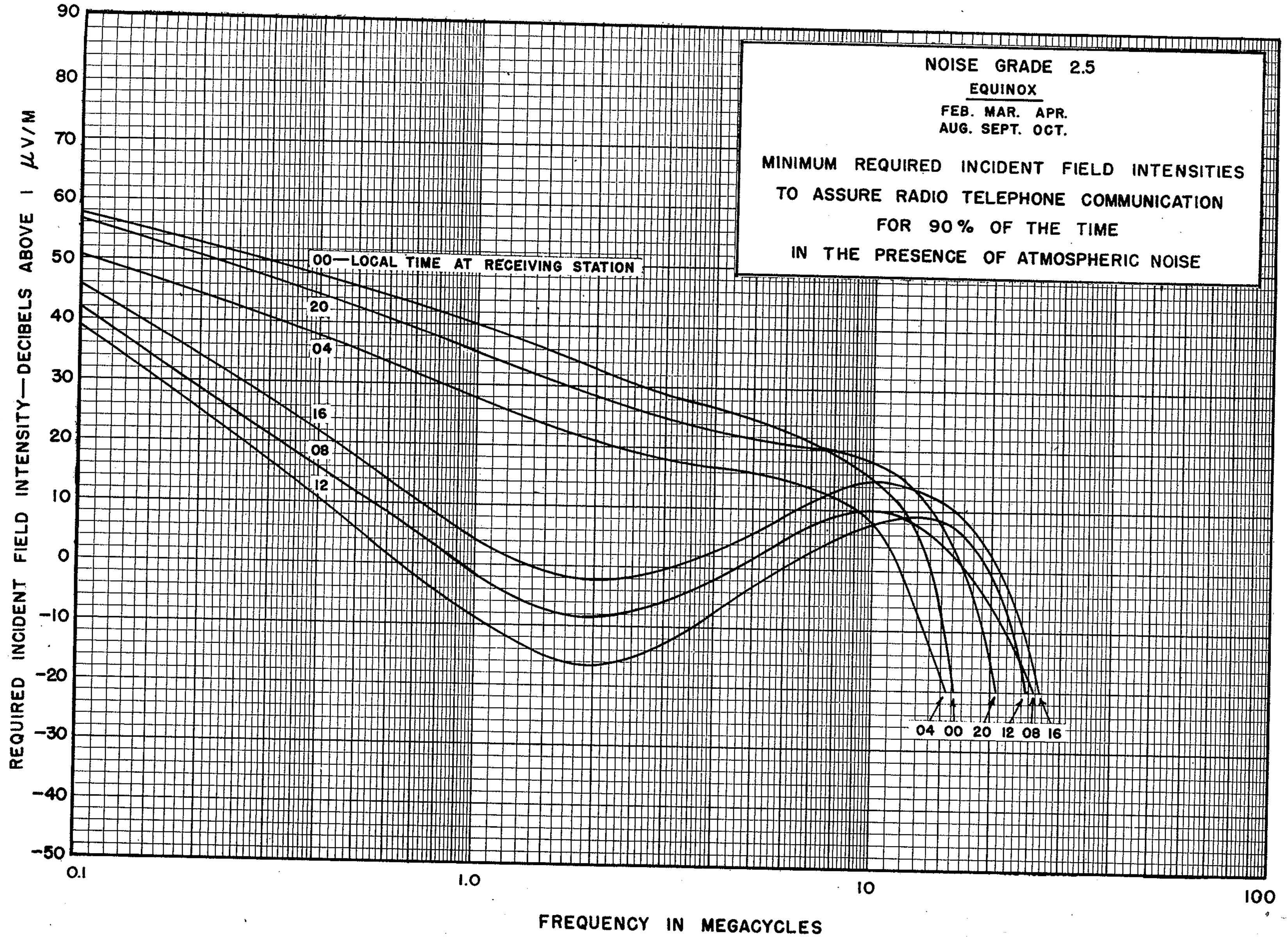
NOISE GRADE 2.5
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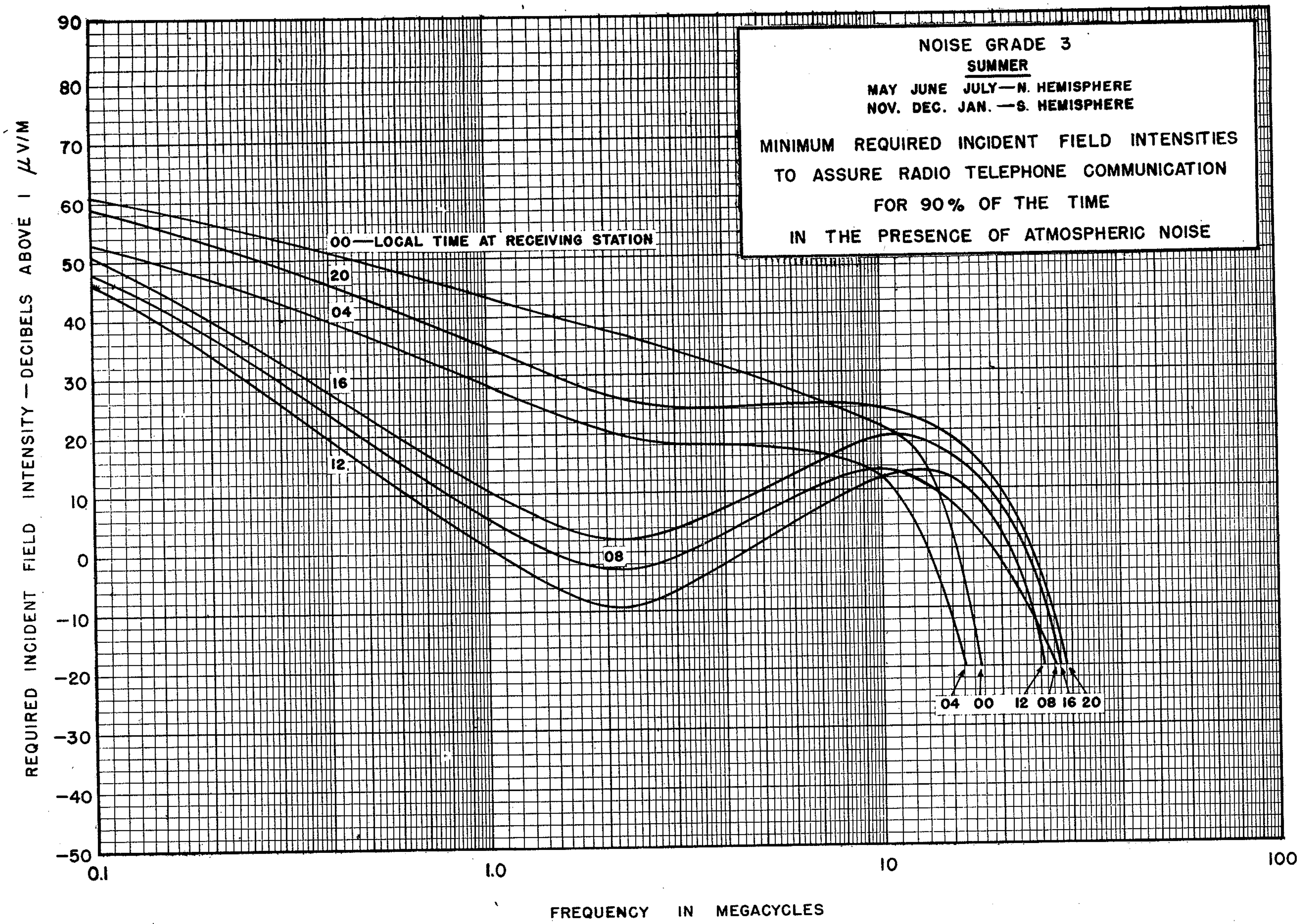
Fig. 16


NOISE GRADE 3
SUMMER
MAY JUNE JULY—N. HEMISPHERE
NOV. DEC. JAN. —S. HEMISPHERE
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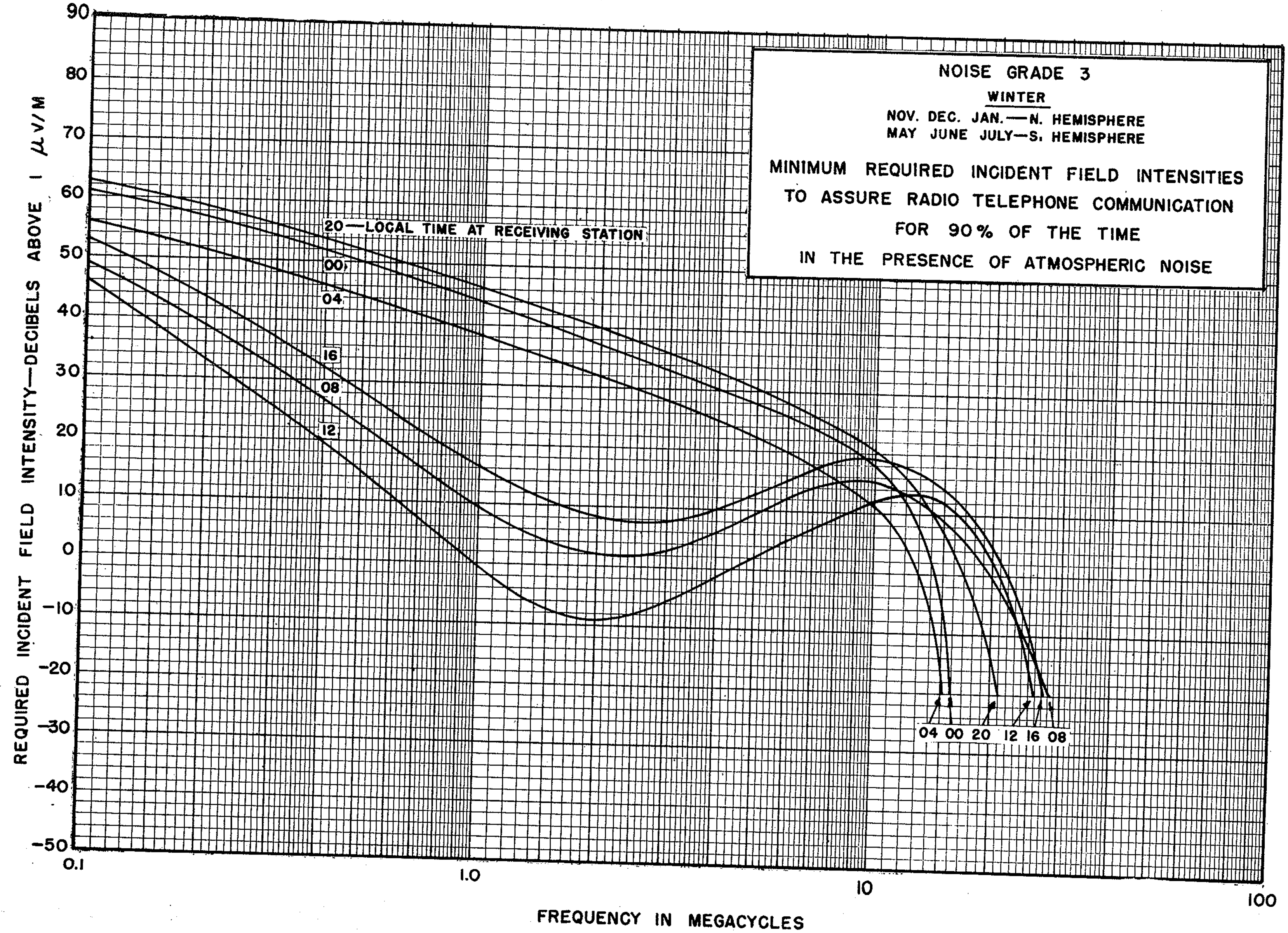
FREQUENCY IN MEGACYCLES

— Fig. 17


NOISE GRADE 3
WINTER
NOV. DEC. JAN.—N. HEMISPHERE
MAY JUNE JULY—S. HEMISPHERE
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REQUIRED INCIDENT FIELD INTENSITY—DECIBELS ABOVE 1 μV/M
FREQUENCY IN MEGACYCLES

Fig. 18

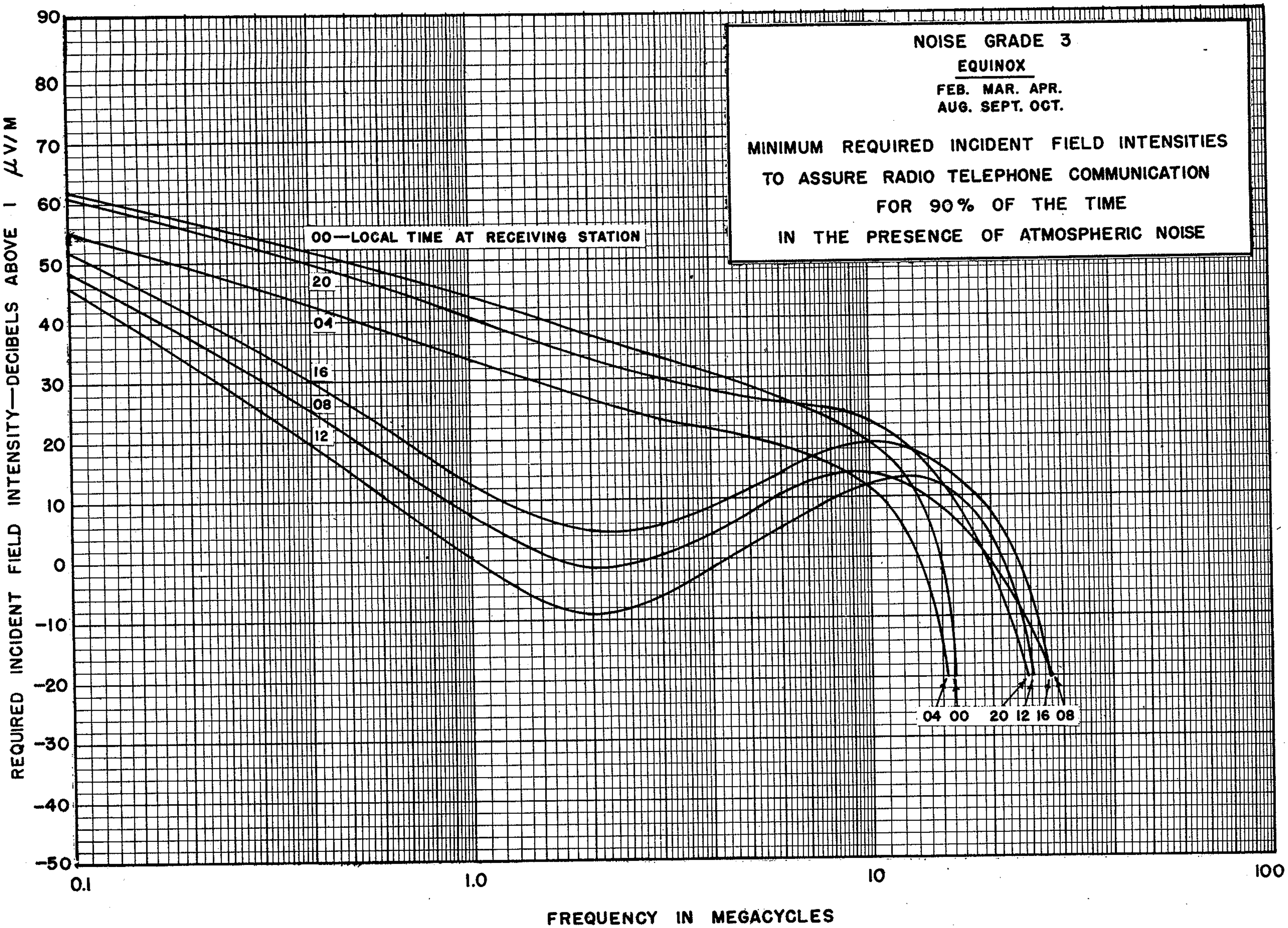

NOISE GRADE 3
EQUINOX
FEB. MAR. APR.
AUG. SEPT. OCT.
MINIMUM REQUIRED INCIDENT FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION
FOR 90% OF THE TIME
IN THE PRESENCE OF ATMOSPHERIC NOISE
00—LOCAL TIME AT RECEIVING STATION
20
04
16
08
12
04 00 20 12 16 08
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
0.1
1.0
10
100
REQUIRED INCIDENT FIELD INTENSITY—DECIBELS ABOVE 1 μV/M
FREQUENCY IN MEGACYCLES

Fig. 19

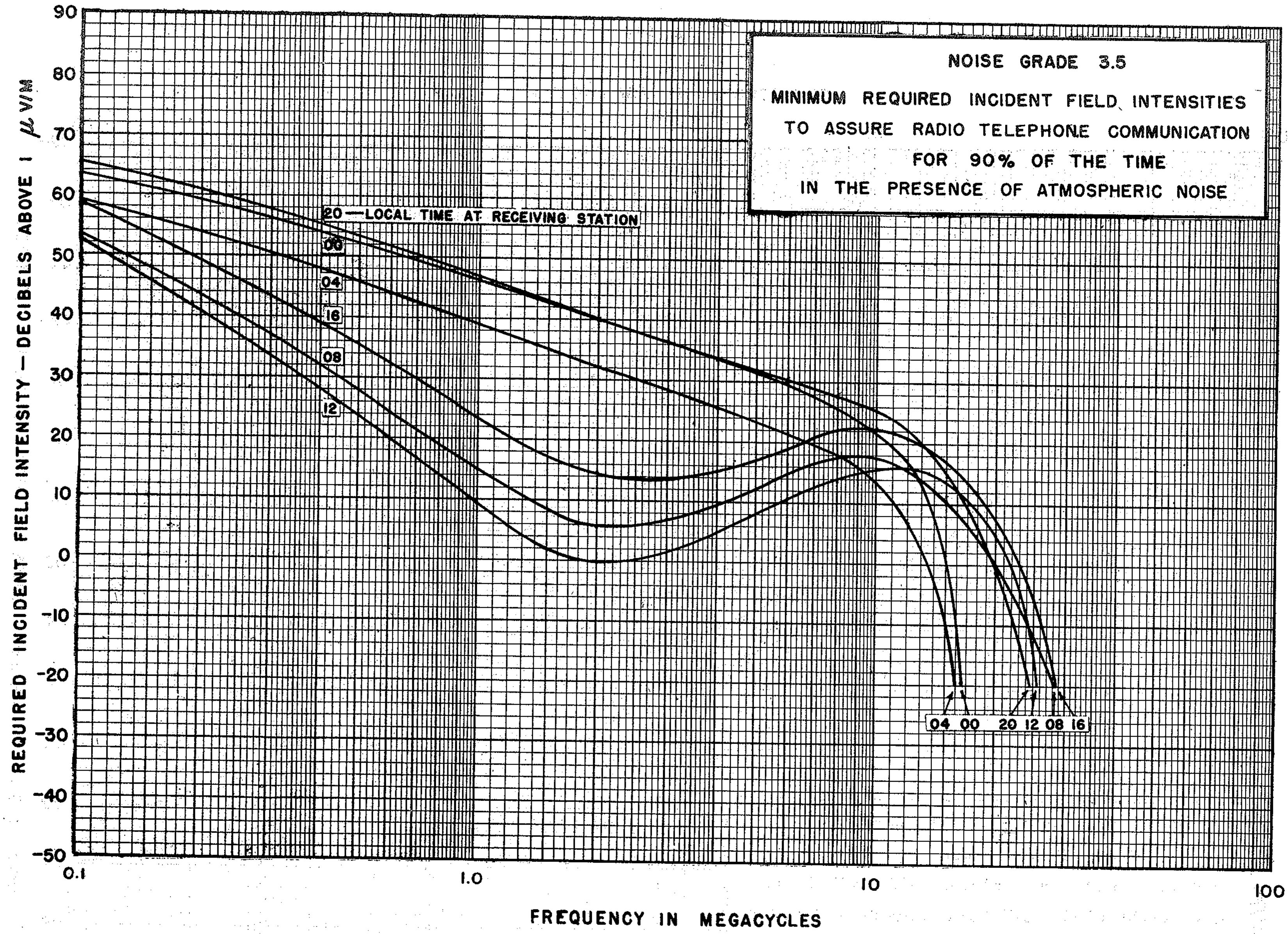

NOISE GRADE 3.5
MINIMUM REQUIRED INCIDENT FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION
FOR 90% OF THE TIME
IN THE PRESENCE OF ATMOSPHERIC NOISE
20 — LOCAL TIME AT RECEIVING STATION
00
04
16
08
12
04 00 20 12 08 16
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
0.1
1.0
10
100
REQUIRED INCIDENT FIELD INTENSITY — DECIBELS ABOVE 1 μV/M
FREQUENCY IN MEGACYCLES

Fig. 20

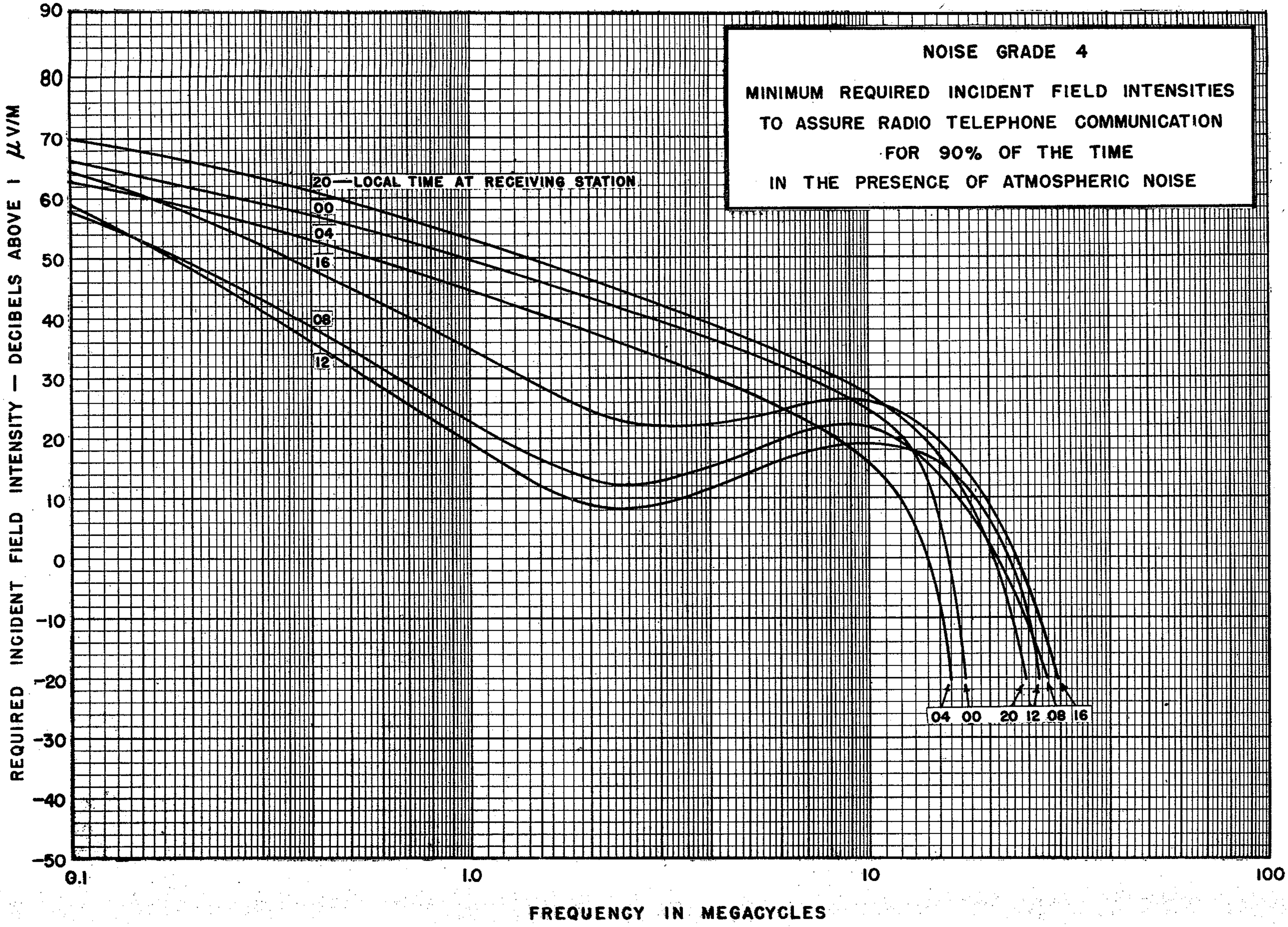

NOISE GRADE 4
MINIMUM REQUIRED INCIDENT FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION
FOR 90% OF THE TIME
IN THE PRESENCE OF ATMOSPHERIC NOISE
20—LOCAL TIME AT RECEIVING STATION
00
04
16
08
12
04 00 20 12 08 16
REQUIRED INCIDENT FIELD INTENSITY — DECIBELS ABOVE 1 μV/M
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
0.1
1.0
10
100
FREQUENCY IN MEGACYCLES

Fig. 21

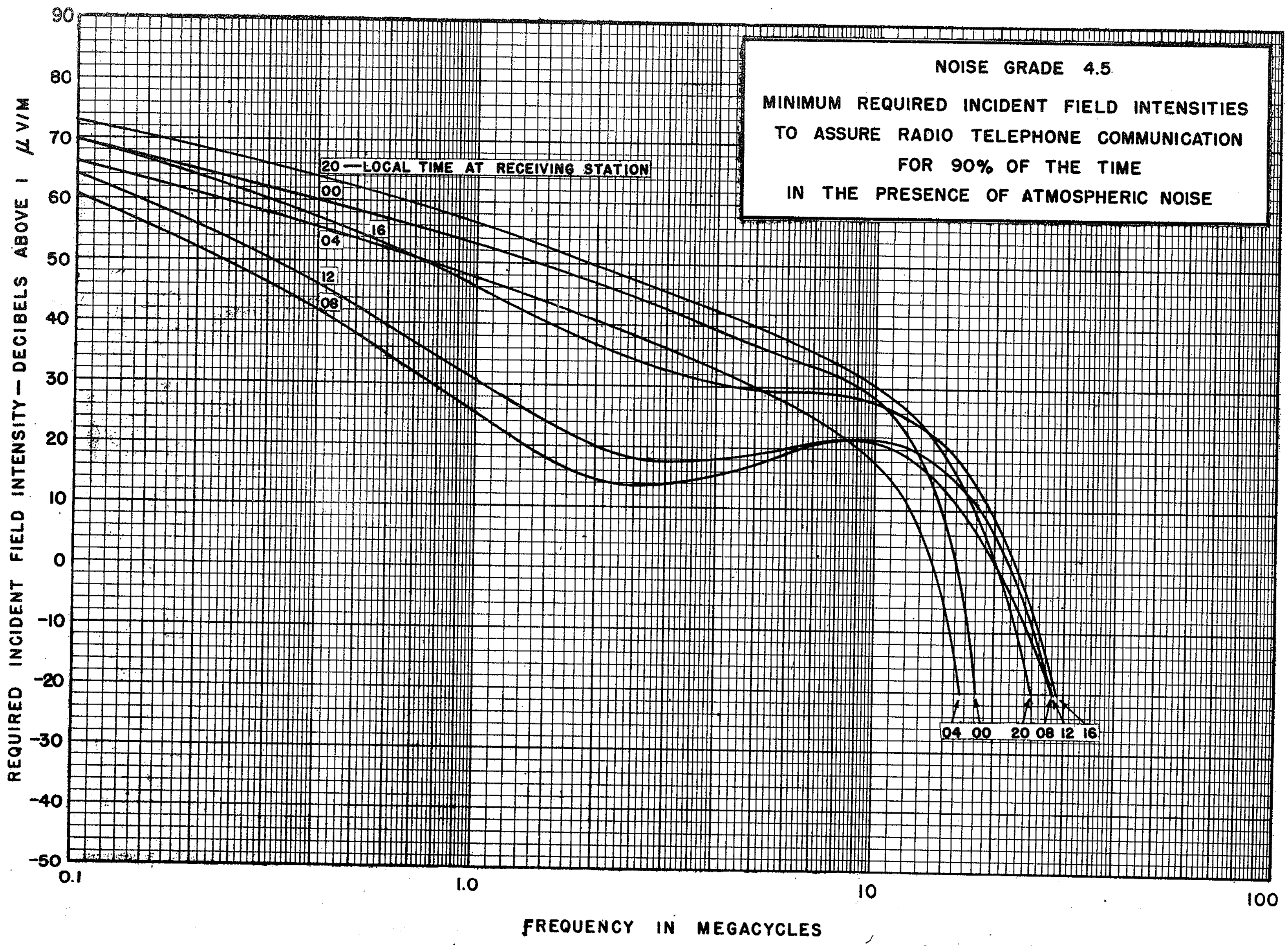

NOISE GRADE 4.5
MINIMUM REQUIRED INCIDENT FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION
FOR 90% OF THE TIME
IN THE PRESENCE OF ATMOSPHERIC NOISE
20 —LOCAL TIME AT RECEIVING STATION
00
04
16
12
08
04 00 20 08 12 16
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
REQUIRED INCIDENT FIELD INTENSITY — DECIBELS ABOVE 1 μV/M
0.1
1.0
10
100
FREQUENCY IN MEGACYCLES

Fig. 22

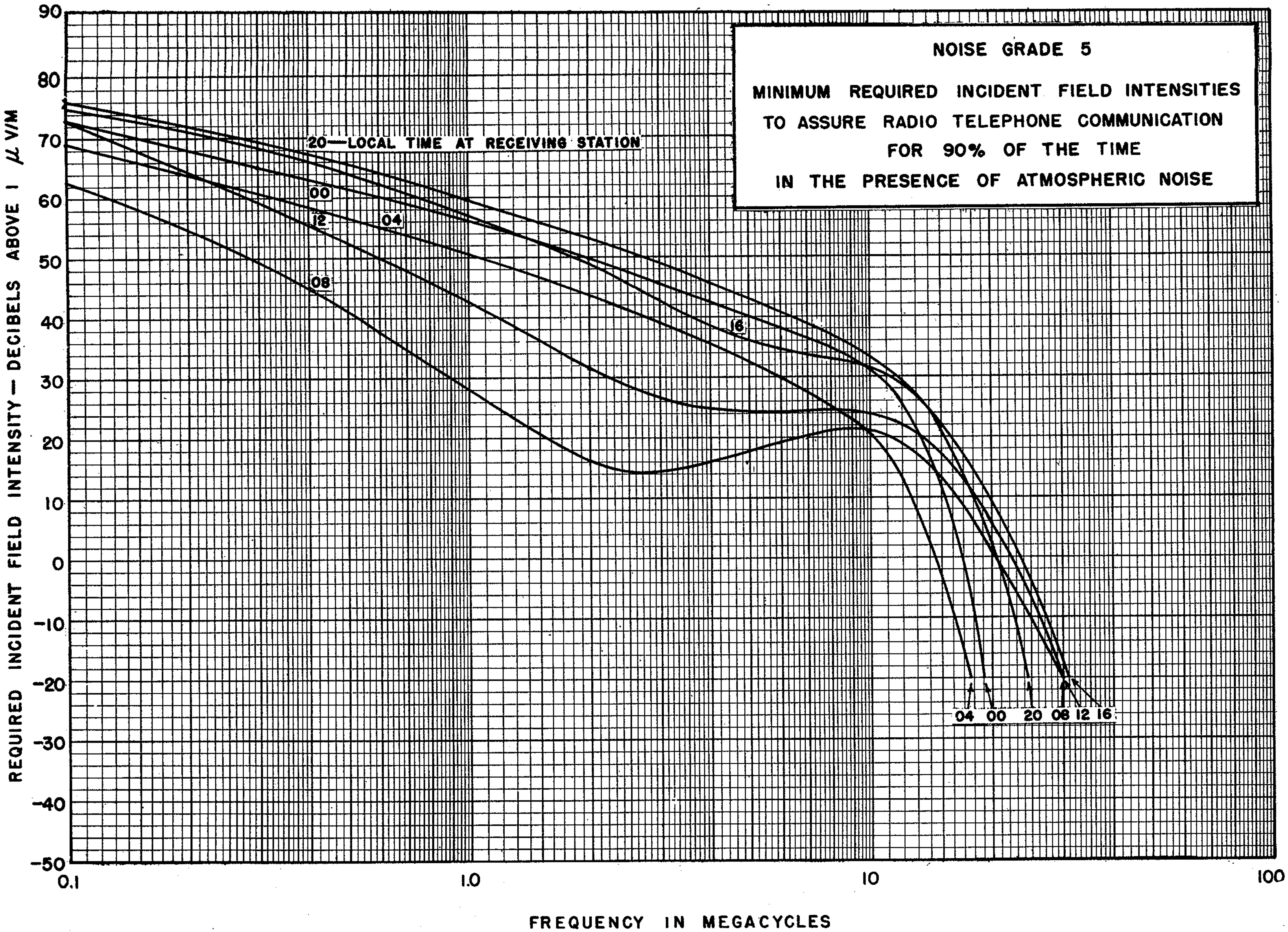

NOISE GRADE 5
MINIMUM REQUIRED INCIDENT FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION
FOR 90% OF THE TIME
IN THE PRESENCE OF ATMOSPHERIC NOISE
20—LOCAL TIME AT RECEIVING STATION
00
12
04
08
16
04 00 20 08 12 16
REQUIRED INCIDENT FIELD INTENSITY — DECIBELS ABOVE 1 μ V/M
FREQUENCY IN MEGACYCLES
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
0.1
1.0
10
100

Fig. 23

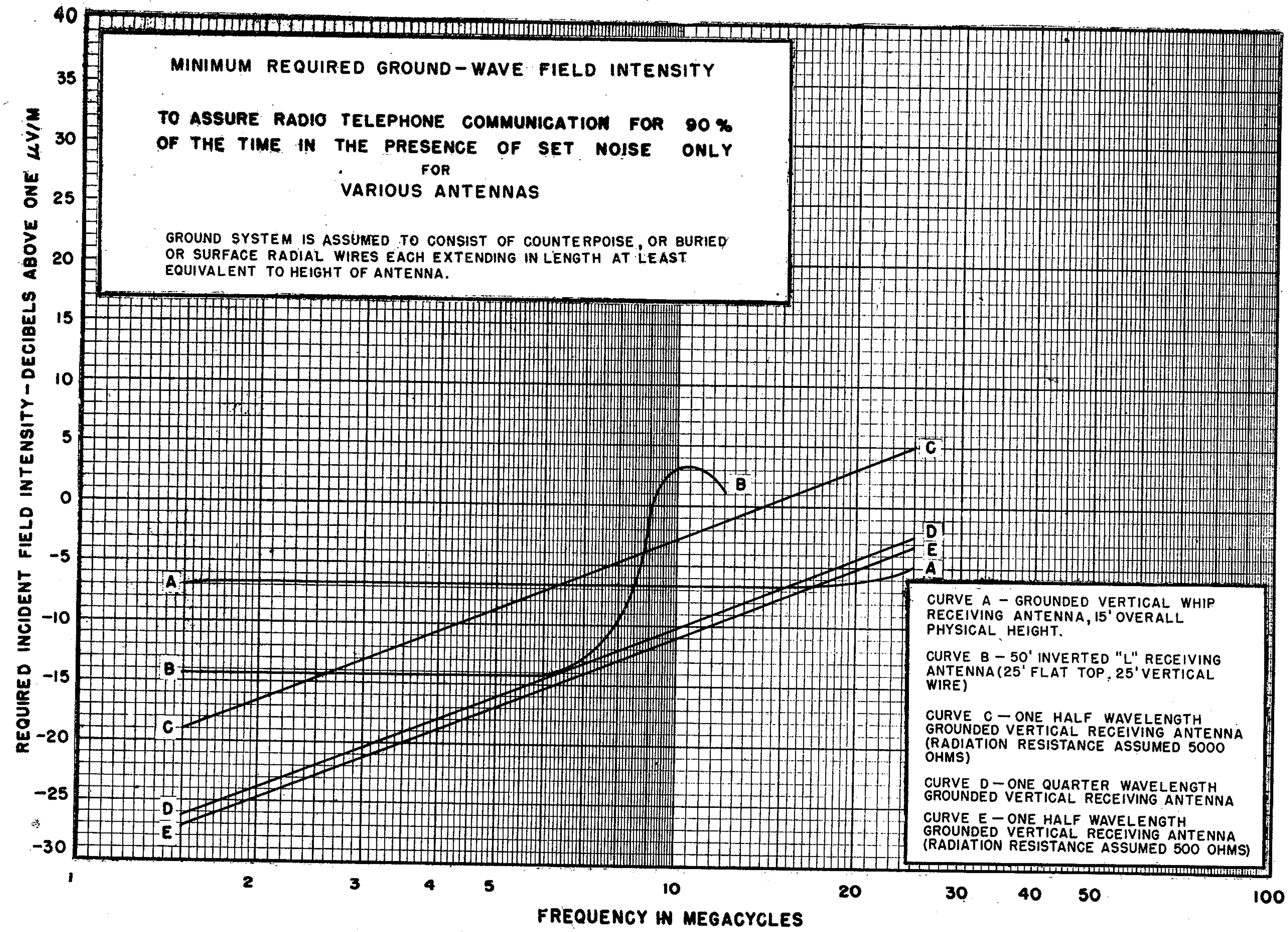

MINIMUM REQUIRED GROUND-WAVE FIELD INTENSITY
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 % OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
FOR
VARIOUS ANTENNAS
GROUND SYSTEM IS ASSUMED TO CONSIST OF COUNTERPOISE, OR BURIED OR SURFACE RADIAL WIRES EACH EXTENDING IN LENGTH AT LEAST EQUIVALENT TO HEIGHT OF ANTENNA.
CURVE A - GROUNDED VERTICAL WHIP RECEIVING ANTENNA, 15' OVERALL PHYSICAL HEIGHT.
CURVE B - 50' INVERTED "L" RECEIVING ANTENNA (25' FLAT TOP, 25' VERTICAL WIRE)
CURVE C - ONE HALF WAVELENGTH GROUNDED VERTICAL RECEIVING ANTENNA (RADIATION RESISTANCE ASSUMED 5000 OHMS)
CURVE D - ONE QUARTER WAVELENGTH GROUNDED VERTICAL RECEIVING ANTENNA
CURVE E - ONE HALF WAVELENGTH GROUNDED VERTICAL RECEIVING ANTENNA (RADIATION RESISTANCE ASSUMED 500 OHMS)
A
B
C
D
E
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE µV/M
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
1
2
3
4
5
10
20
30
40
50
100
FREQUENCY IN MEGACYCLES

Fig.. 24

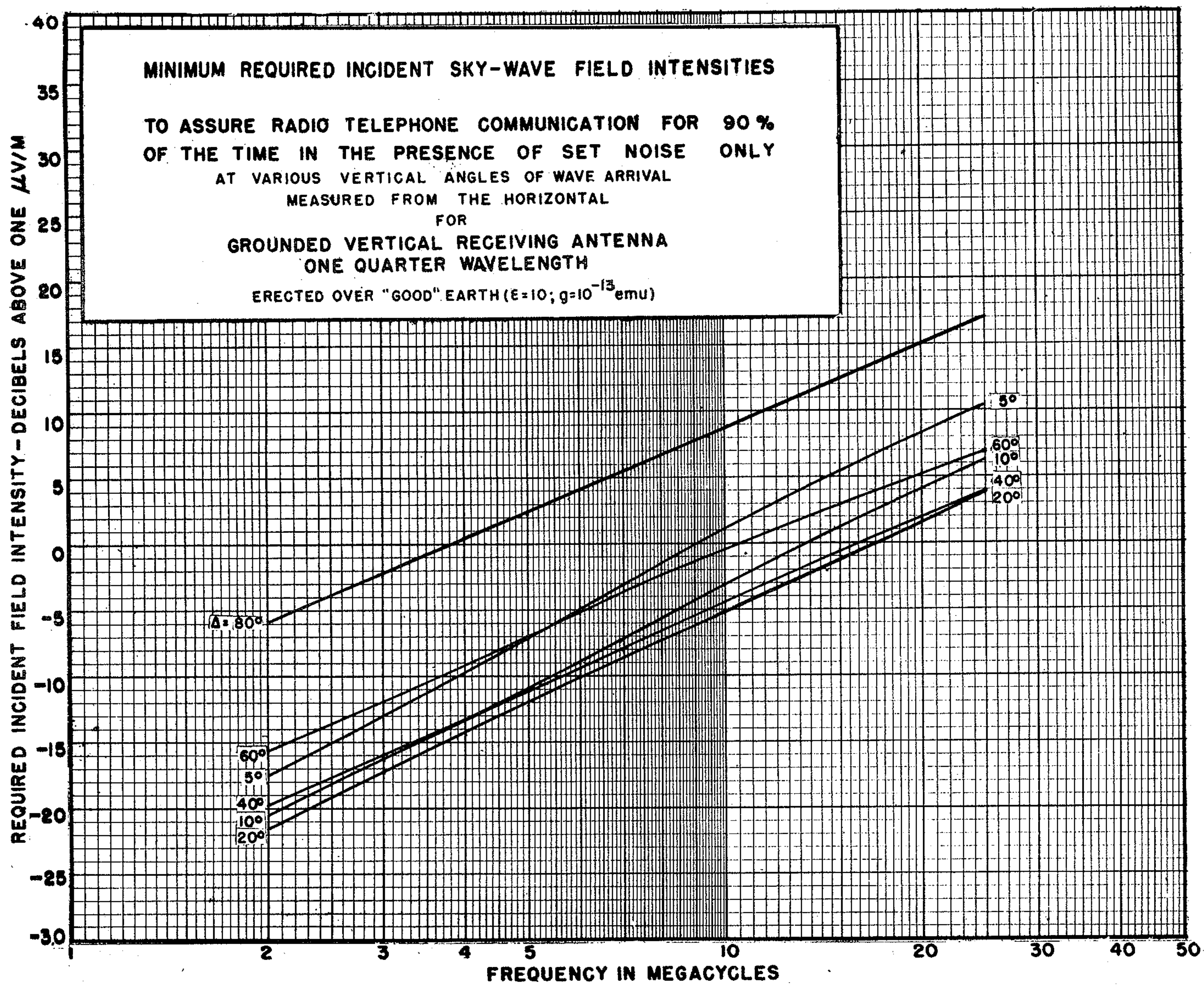

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 % OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL
MEASURED FROM THE HORIZONTAL
FOR
GROUNDED VERTICAL RECEIVING ANTENNA
ONE QUARTER WAVELENGTH
ERECTED OVER "GOOD" EARTH (ε=10; g=10^-13 emu)
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE μV/M
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
FREQUENCY IN MEGACYCLES
1
2
3
4
5
10
20
30
40
50
Δ= 80°
60°
5°
40°
10°
20°
5°
60°
10°
40°
20°

Fig. 25

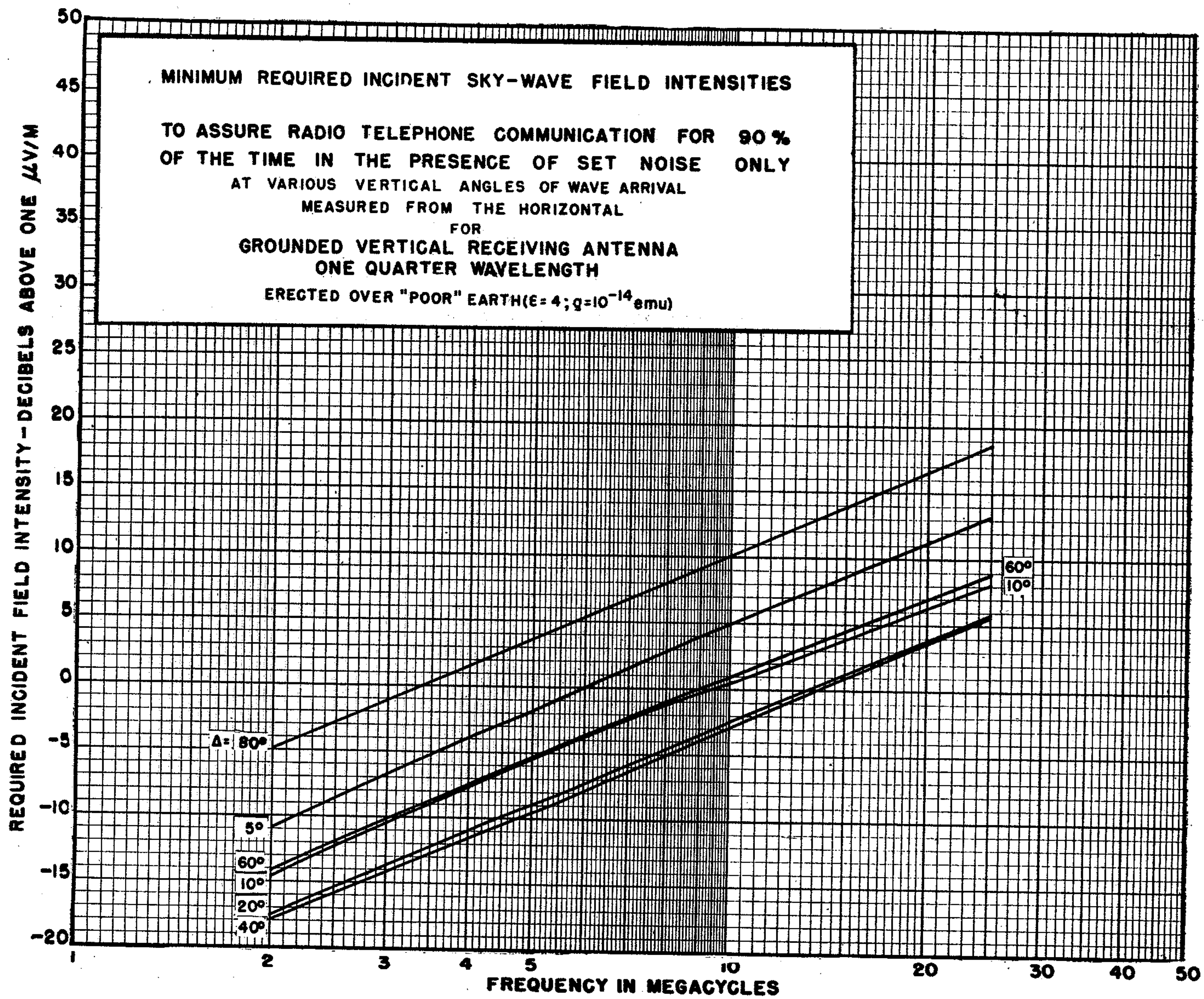
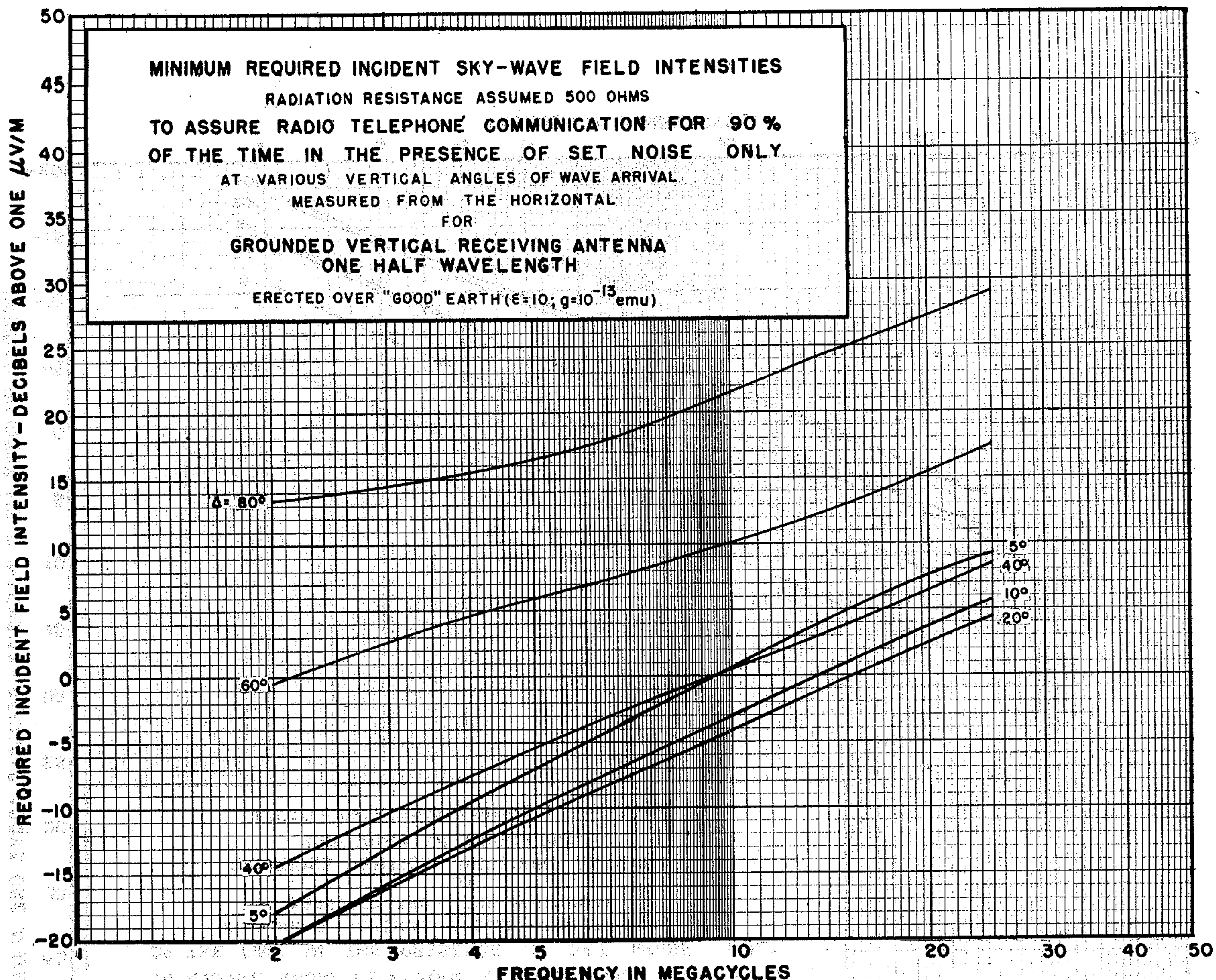

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 % OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM THE HORIZONTAL
FOR
GROUNDED VERTICAL RECEIVING ANTENNA ONE QUARTER WAVELENGTH
ERECTED OVER "POOR" EARTH(ε = 4; g=10^-14 emu)
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE μV/M
FREQUENCY IN MEGACYCLES
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
1
2
3
4
5
10
20
30
40
50
Δ= 80°
5°
60°
10°
20°
40°
60°
10°

Fig. 26



MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
RADIATION RESISTANCE ASSUMED 500 OHMS
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL
MEASURED FROM THE HORIZONTAL
FOR
GROUNDED VERTICAL RECEIVING ANTENNA
ONE HALF WAVELENGTH
ERECTED OVER "GOOD" EARTH (ε=10; g=10^-13 emu)
Δ= 80°
60°
40°
5°
5°
40°
10°
20°
REQUIRED INCIDENT FIELD INTENSITY-DECIBELS ABOVE ONE μV/M
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
1
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 27

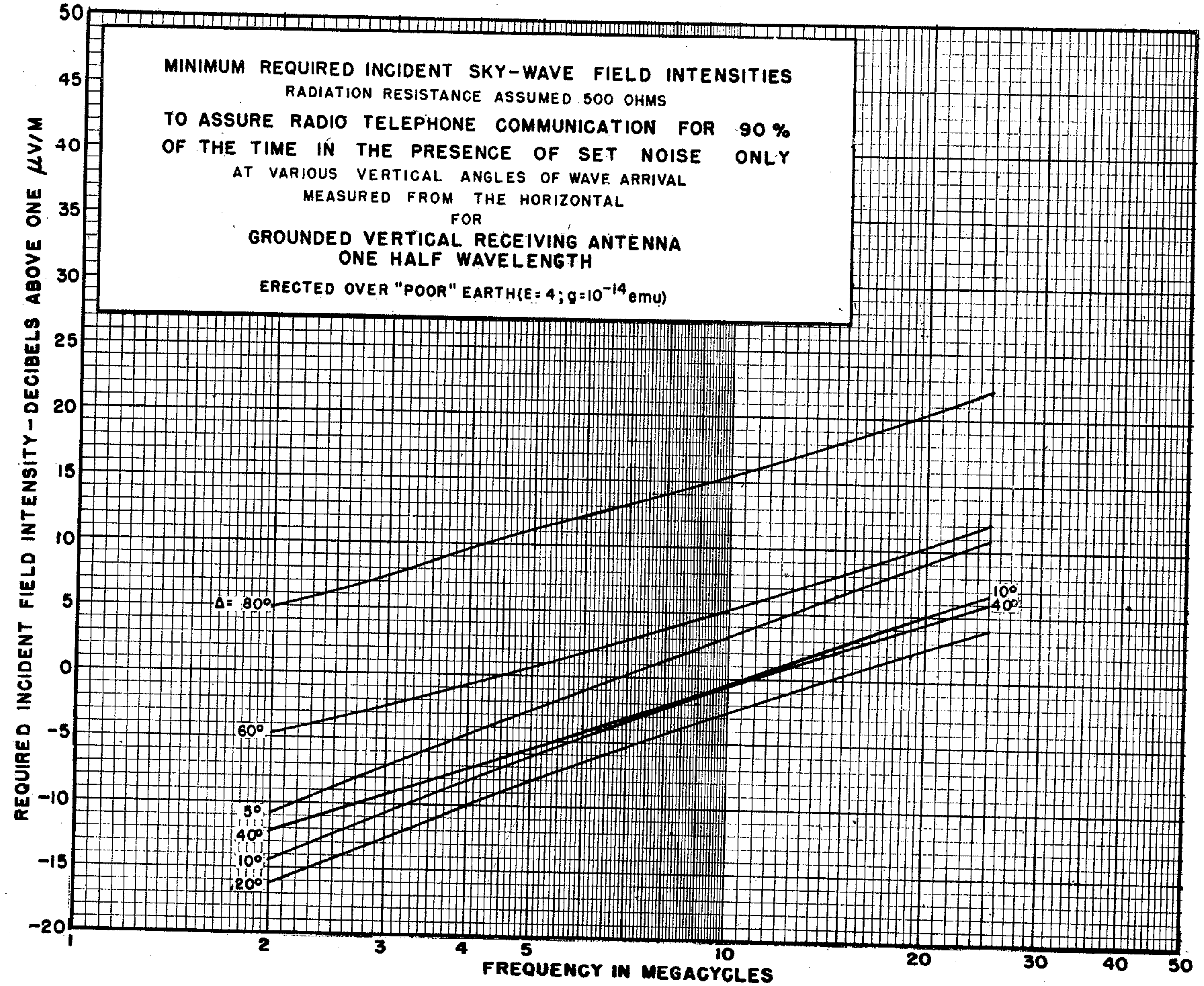
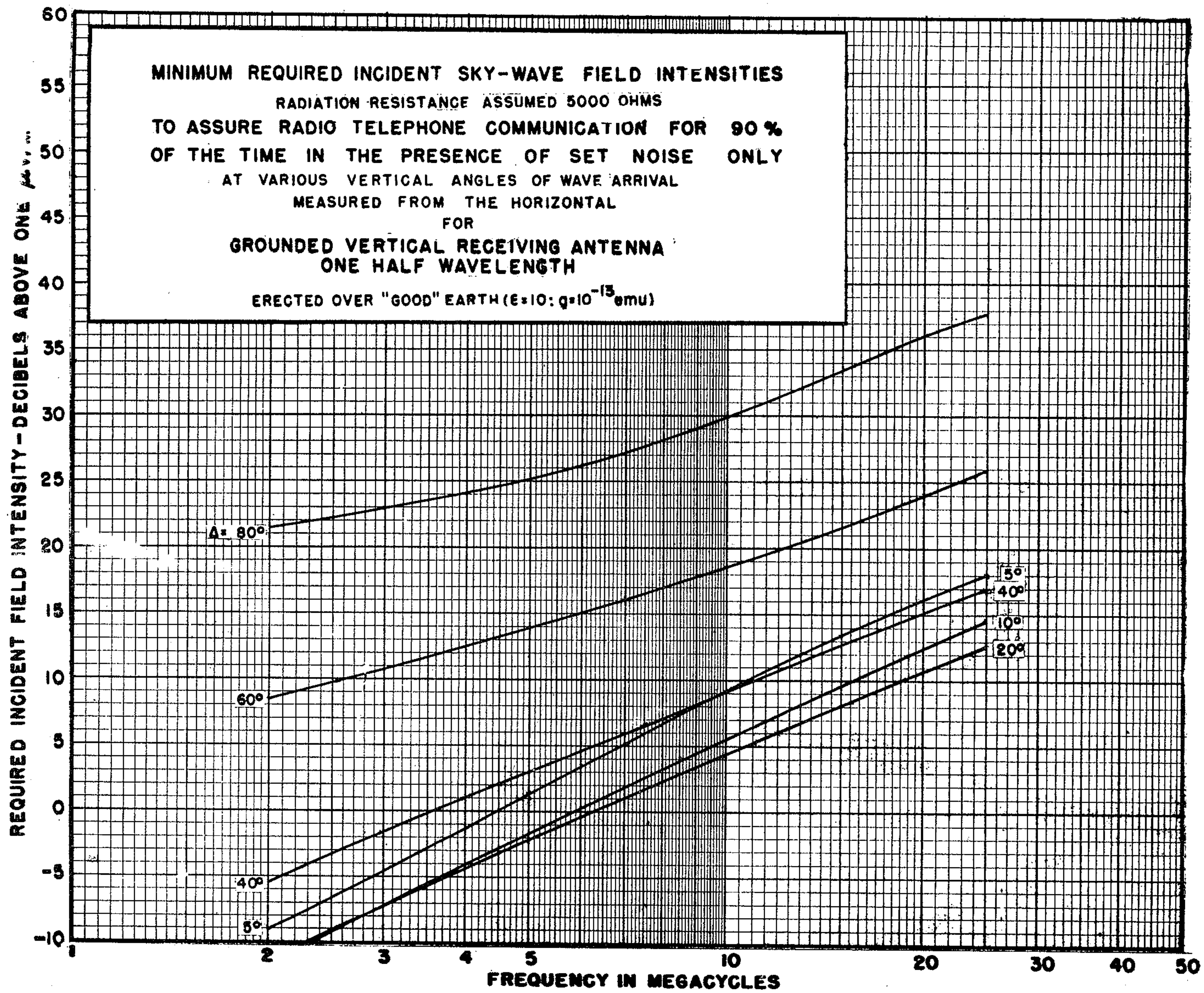

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
RADIATION RESISTANCE ASSUMED 500 OHMS
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL
MEASURED FROM THE HORIZONTAL
FOR
GROUNDED VERTICAL RECEIVING ANTENNA
ONE HALF WAVELENGTH
ERECTED OVER "POOR" EARTH(ϵ=4; g=10^{-14} emu)
Δ= 80°
60°
5°
40°
10°
20°
10°
40°
REQUIRED INCIDENT FIELD INTENSITY-DECIBELS ABOVE ONE µV/M
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
1
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 28



MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
RADIATION RESISTANCE ASSUMED 5000 OHMS
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL
MEASURED FROM THE HORIZONTAL
FOR
GROUNDED VERTICAL RECEIVING ANTENNA
ONE HALF WAVELENGTH
ERECTED OVER "GOOD" EARTH (ε=10: g=10⁻¹³ emu)
Δ= 80°
60°
40°
5°
5°
40°
10°
20°
REQUIRED INCIDENT FIELD INTENSITY-DECIBELS ABOVE ONE μv/m
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
1
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 29

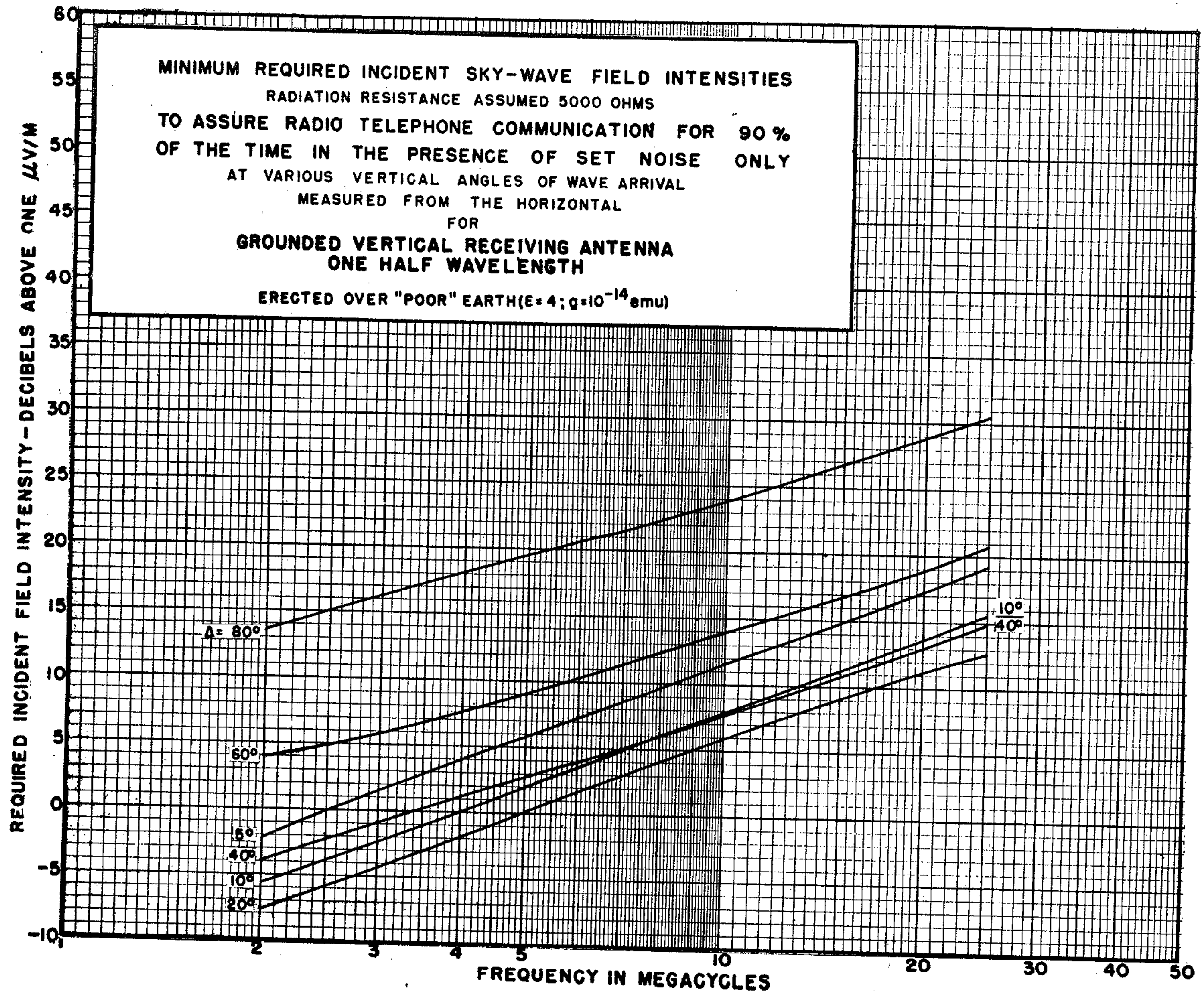

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
RADIATION RESISTANCE ASSUMED 5000 OHMS
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL
MEASURED FROM THE HORIZONTAL
FOR
GROUNDED VERTICAL RECEIVING ANTENNA
ONE HALF WAVELENGTH
ERECTED OVER "POOR" EARTH(ε = 4; g = 10^-14 emu)
Δ = 80°
60°
5°
40°
10°
20°
10°
40°
REQUIRED INCIDENT FIELD INTENSITY-DECIBELS ABOVE ONE μV/M
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
1
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 30

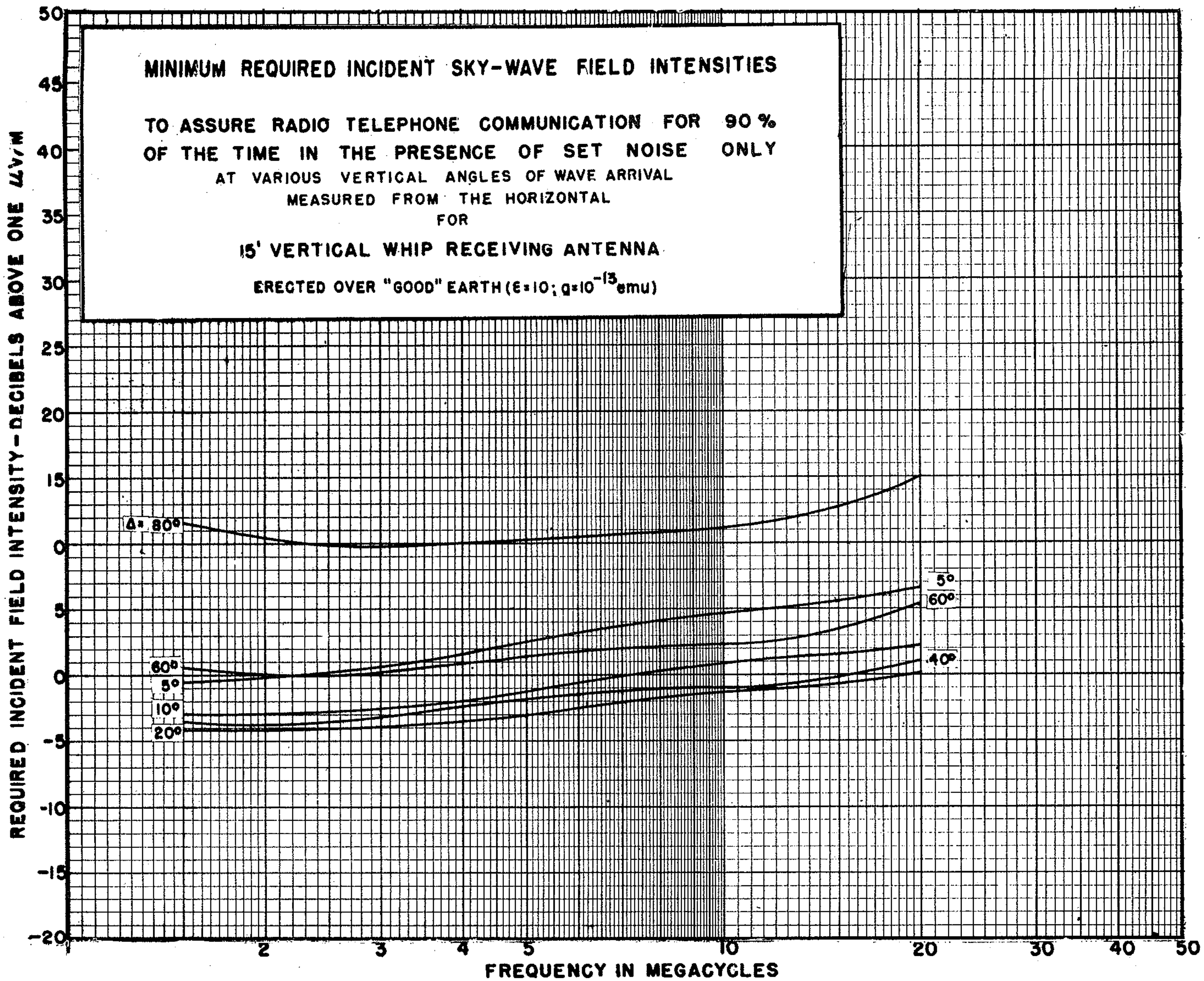

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 % OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM THE HORIZONTAL
FOR
15' VERTICAL WHIP RECEIVING ANTENNA
ERECTED OVER "GOOD" EARTH (ε=10; σ=10^-13 emu)
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE μV/M
FREQUENCY IN MEGACYCLES
Δ= 80°
60°
5°
10°
20°
5°
60°
40°
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
1
2
3
4
5
10
20
30
40
50

Fig. 31

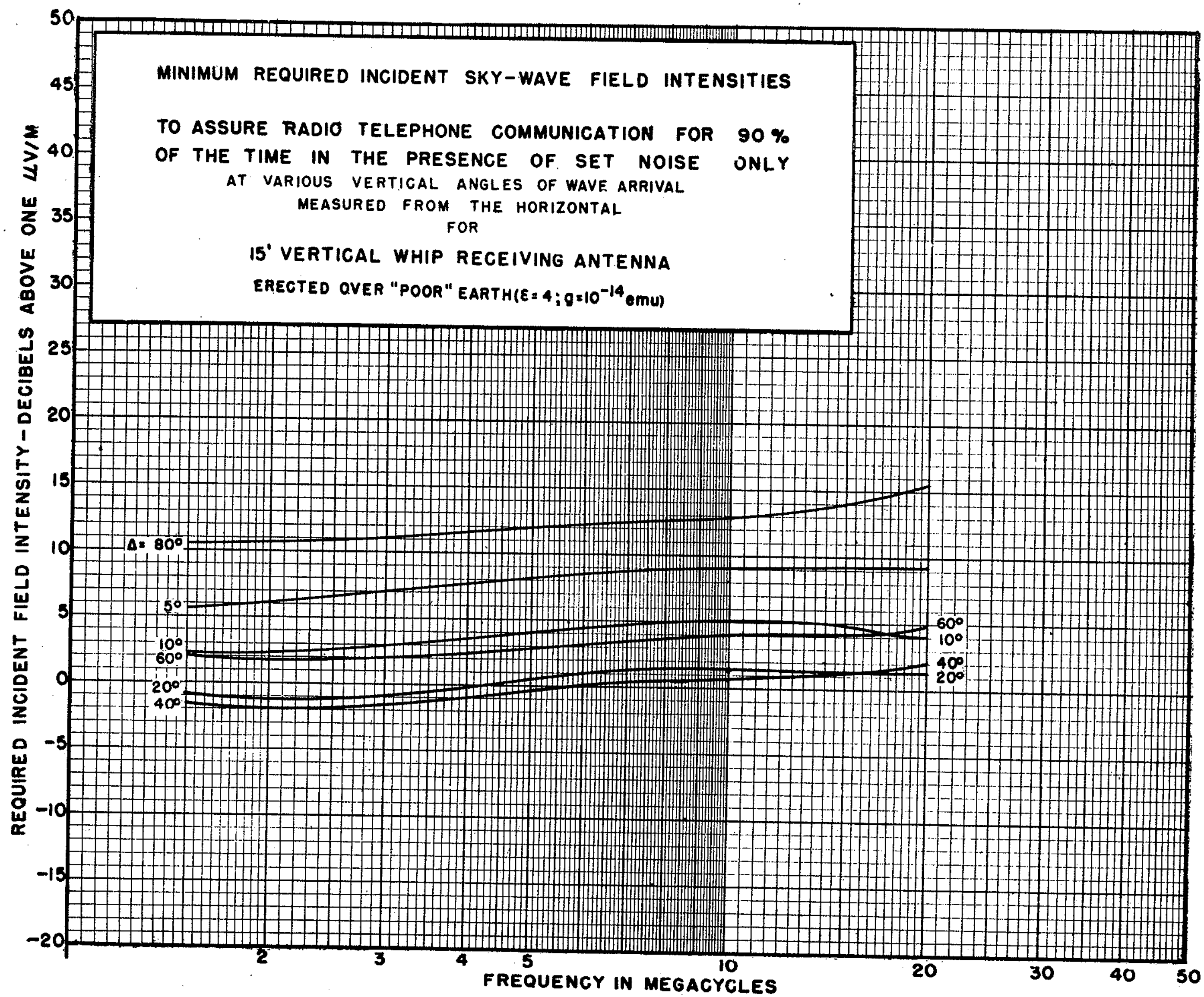

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 % OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM THE HORIZONTAL
FOR
15' VERTICAL WHIP RECEIVING ANTENNA
ERECTED OVER "POOR" EARTH(ε = 4; g = 10^-14 emu)
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE µV/M
FREQUENCY IN MEGACYCLES
Δ = 80°
5°
10°
60°
20°
40°
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
2
3
4
5
10
20
30
40
50

Fig. 32

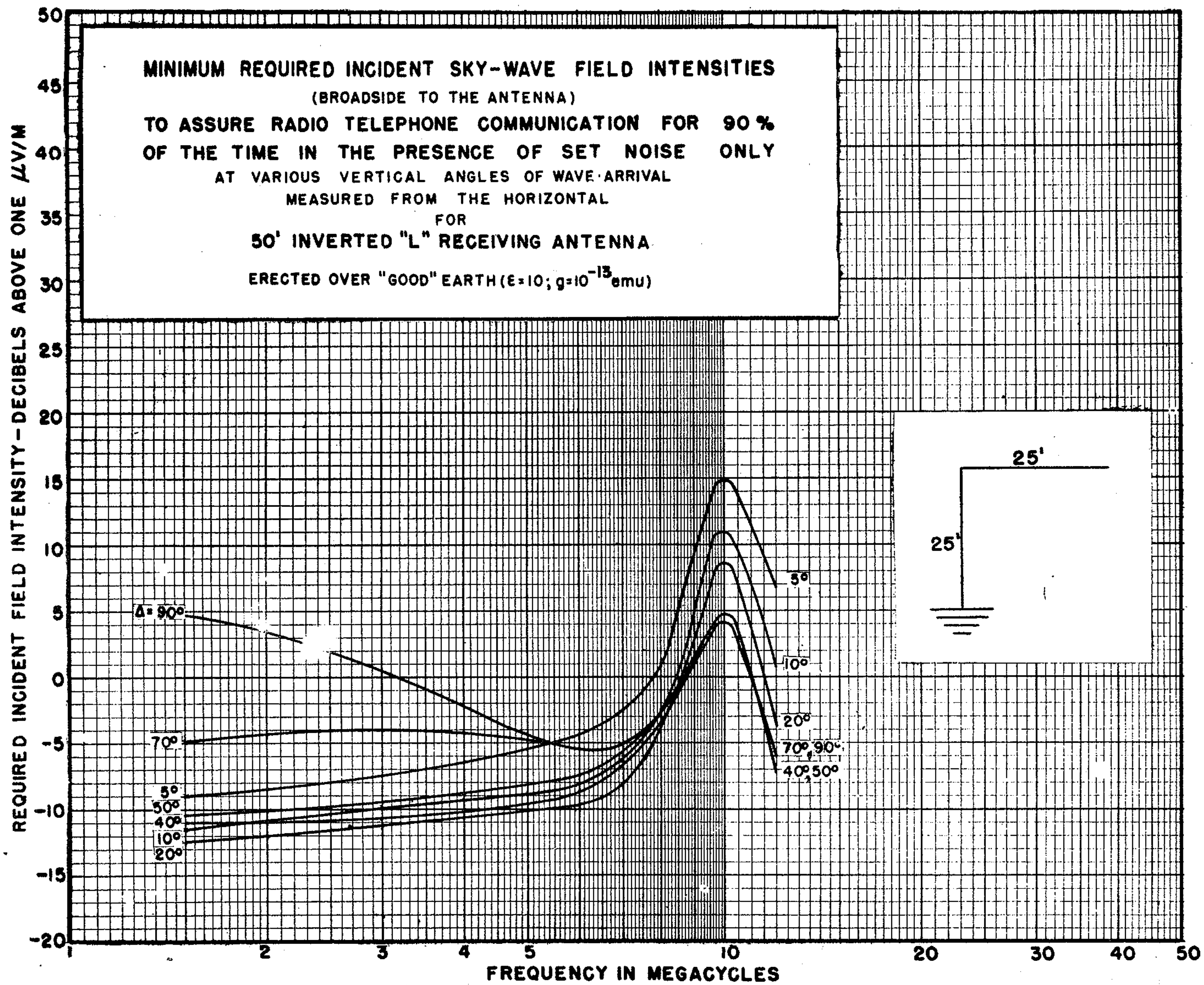

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
(BROADSIDE TO THE ANTENNA)
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL
MEASURED FROM THE HORIZONTAL
FOR
50' INVERTED "L" RECEIVING ANTENNA
ERECTED OVER "GOOD" EARTH (ε=10; g=10^-13 emu)
REQUIRED INCIDENT FIELD INTENSITY-DECIBELS ABOVE ONE μV/M
FREQUENCY IN MEGACYCLES
Δ=90°
70°
5°
50°
40°
10°
20°
70°,90°
40°,50°
25'
25'

Fig. 33

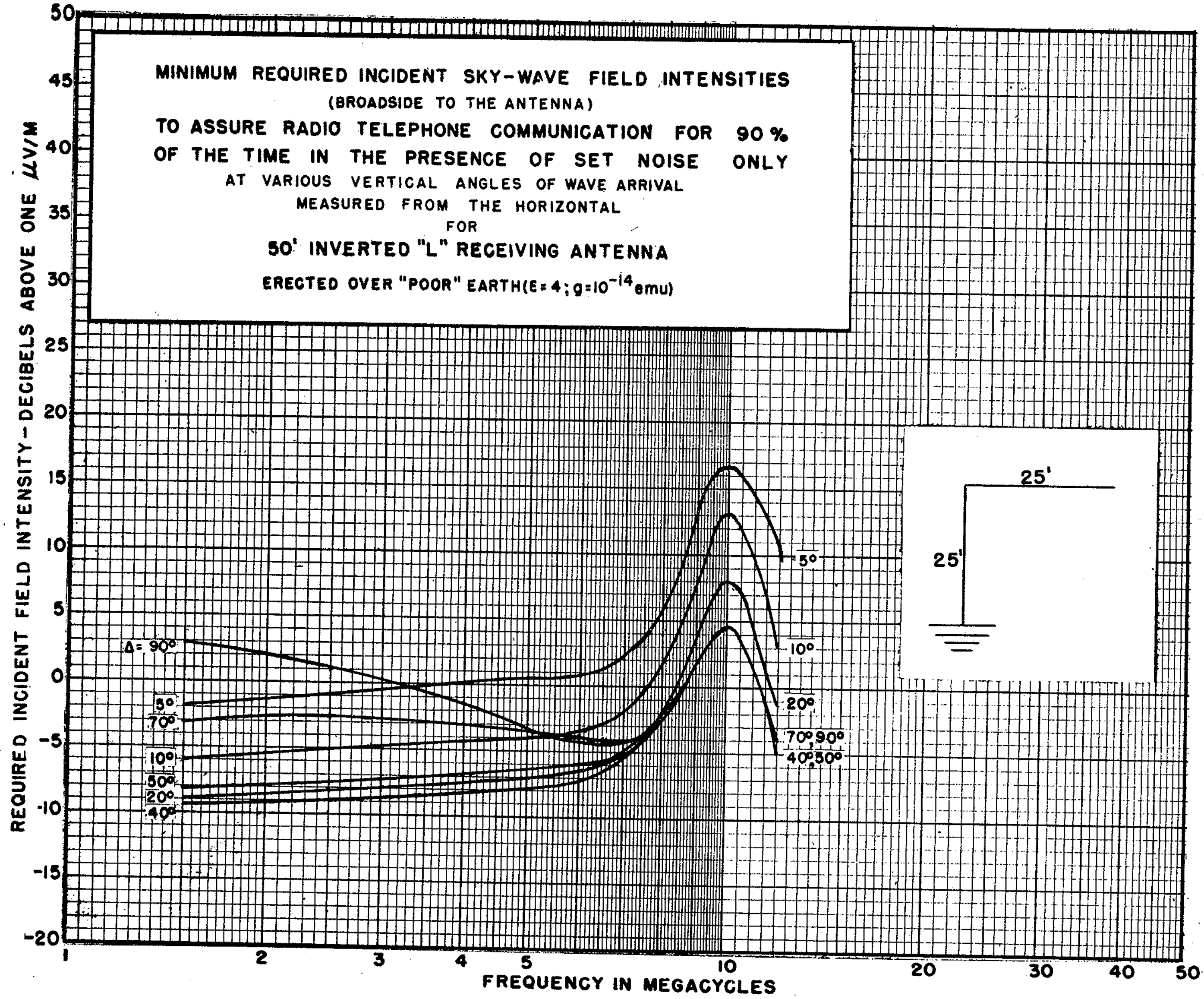
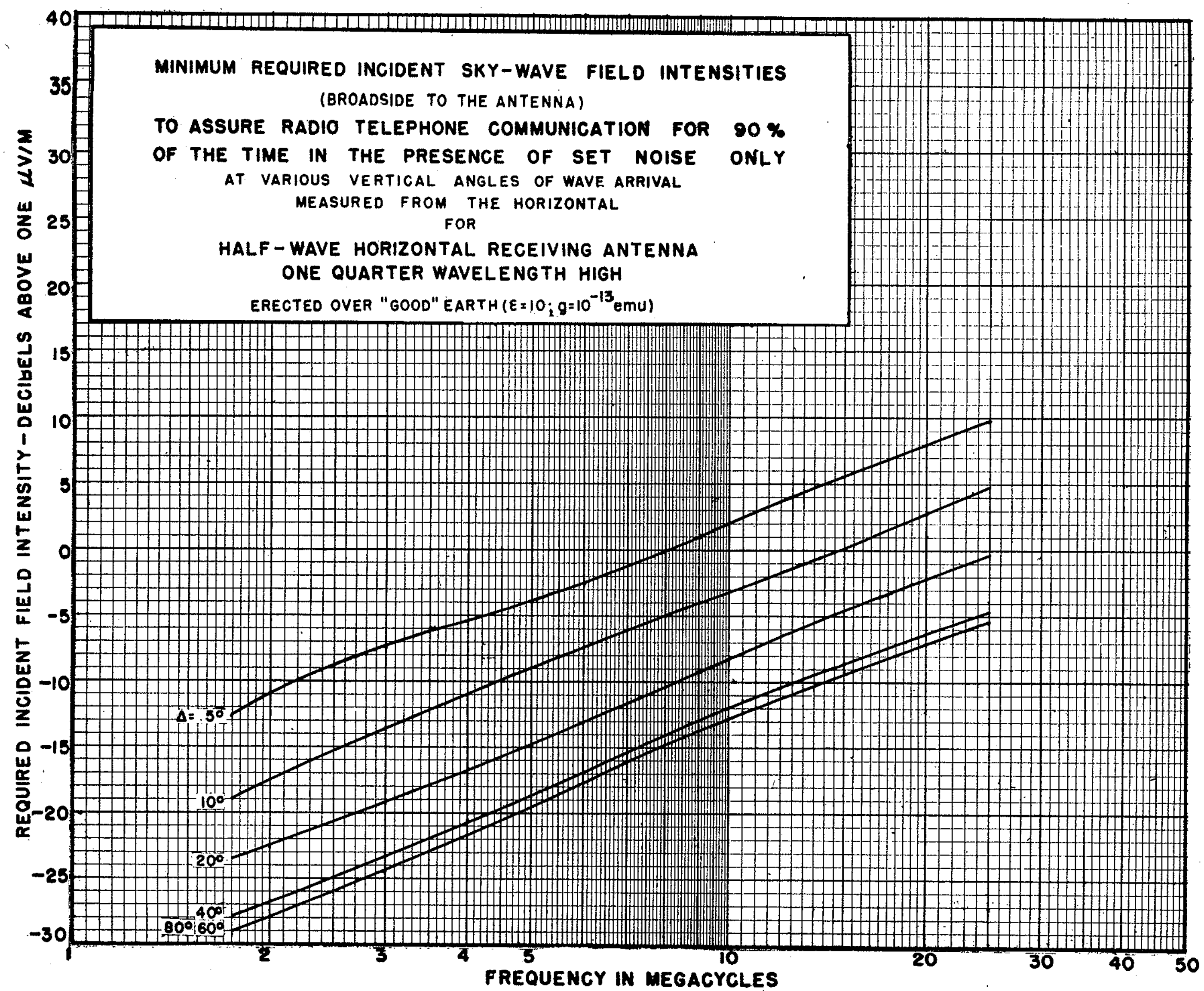

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
(BROADSIDE TO THE ANTENNA)
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL
MEASURED FROM THE HORIZONTAL
FOR
50' INVERTED "L" RECEIVING ANTENNA
ERECTED OVER "POOR" EARTH(ε = 4; g = 10⁻¹⁴ emu)
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE μV/M
FREQUENCY IN MEGACYCLES
Δ = 90°
5°
70°
10°
50°
20°
40°
5°
10°
20°
70°,90°
40°,50°
25'
25'

Fig. 34



MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
(BROADSIDE TO THE ANTENNA)
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL
MEASURED FROM THE HORIZONTAL
FOR
HALF-WAVE HORIZONTAL RECEIVING ANTENNA
ONE QUARTER WAVELENGTH HIGH
ERECTED OVER "GOOD" EARTH ($\varepsilon = 10$; $g = 10^{-13}$ emu)
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE μV/M
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
$\Delta = 5°$
10°
20°
40°
80° 60°
1
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 35

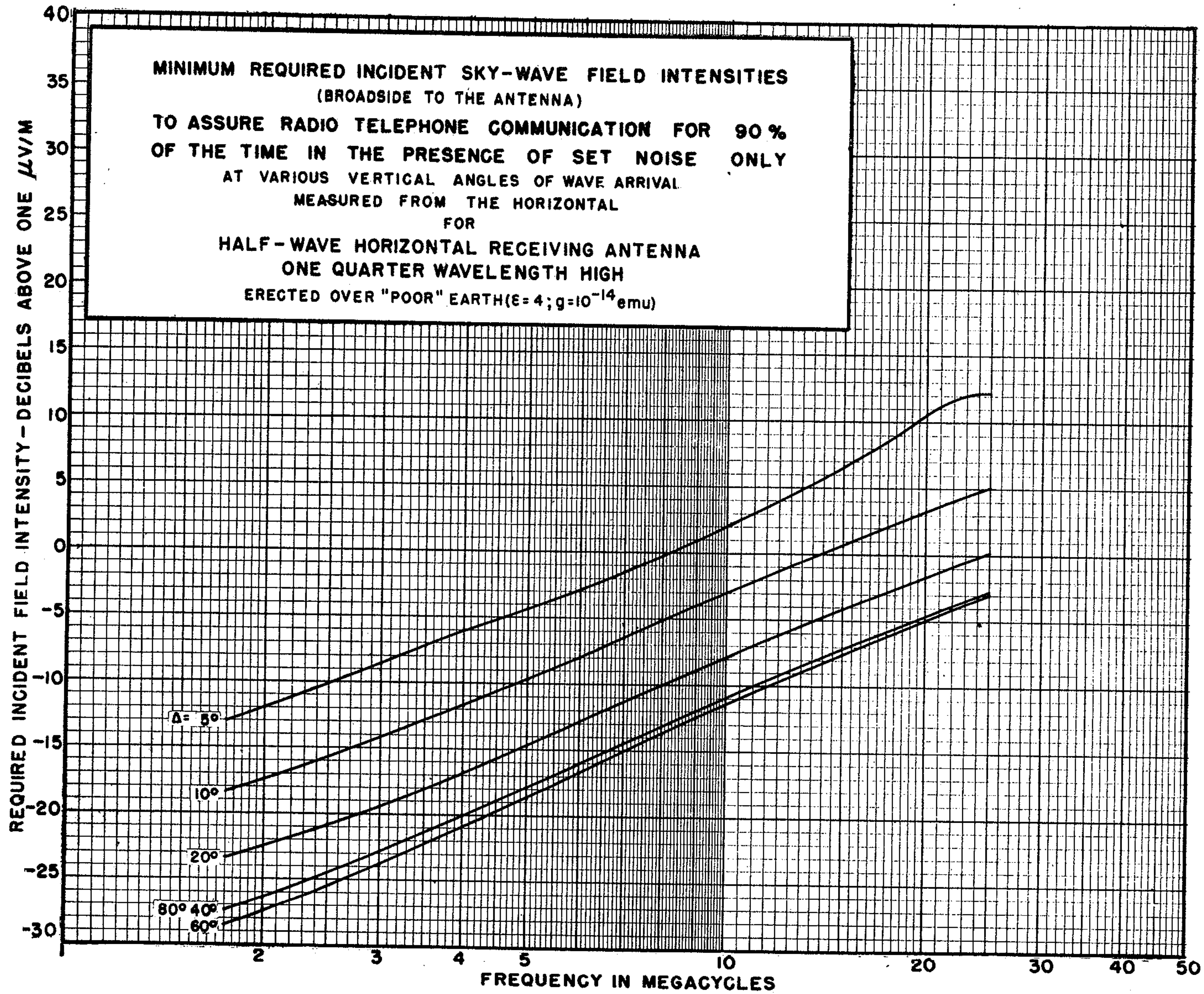

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
(BROADSIDE TO THE ANTENNA)
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL
MEASURED FROM THE HORIZONTAL
FOR
HALF-WAVE HORIZONTAL RECEIVING ANTENNA
ONE QUARTER WAVELENGTH HIGH
ERECTED OVER "POOR" EARTH(ϵ=4; g=10^{-14}emu)
Δ= 5°
10°
20°
80° 40°
60°
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
REQUIRED INCIDENT FIELD INTENSITY-DECIBELS ABOVE ONE µV/M
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 36

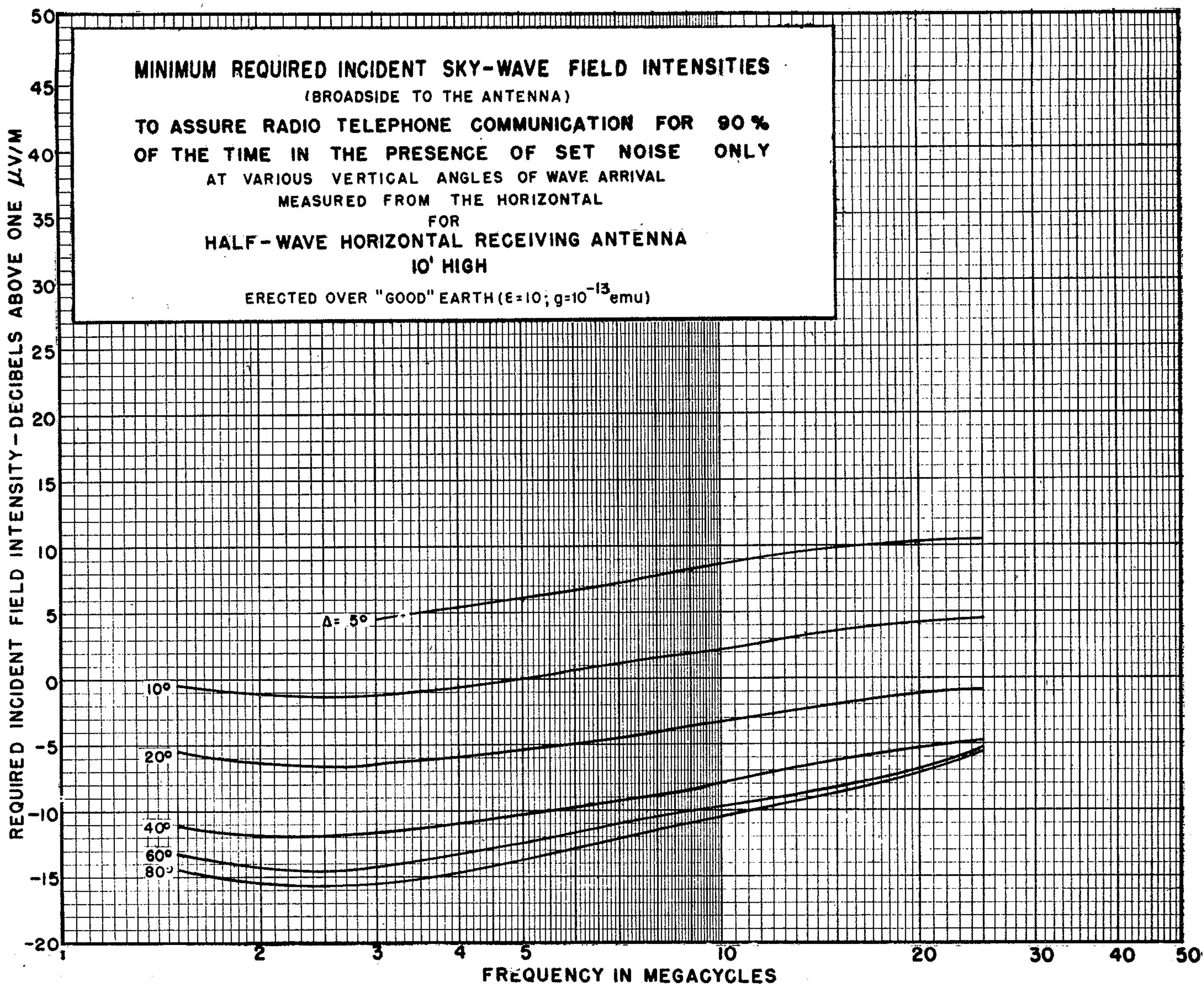

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
(BROADSIDE TO THE ANTENNA)
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL
MEASURED FROM THE HORIZONTAL
FOR
HALF-WAVE HORIZONTAL RECEIVING ANTENNA
10' HIGH
ERECTED OVER "GOOD" EARTH (ε=10; g=10^-13 emu)
Δ= 5°
10°
20°
40°
60°
80°
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE μV/M
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
1
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 37

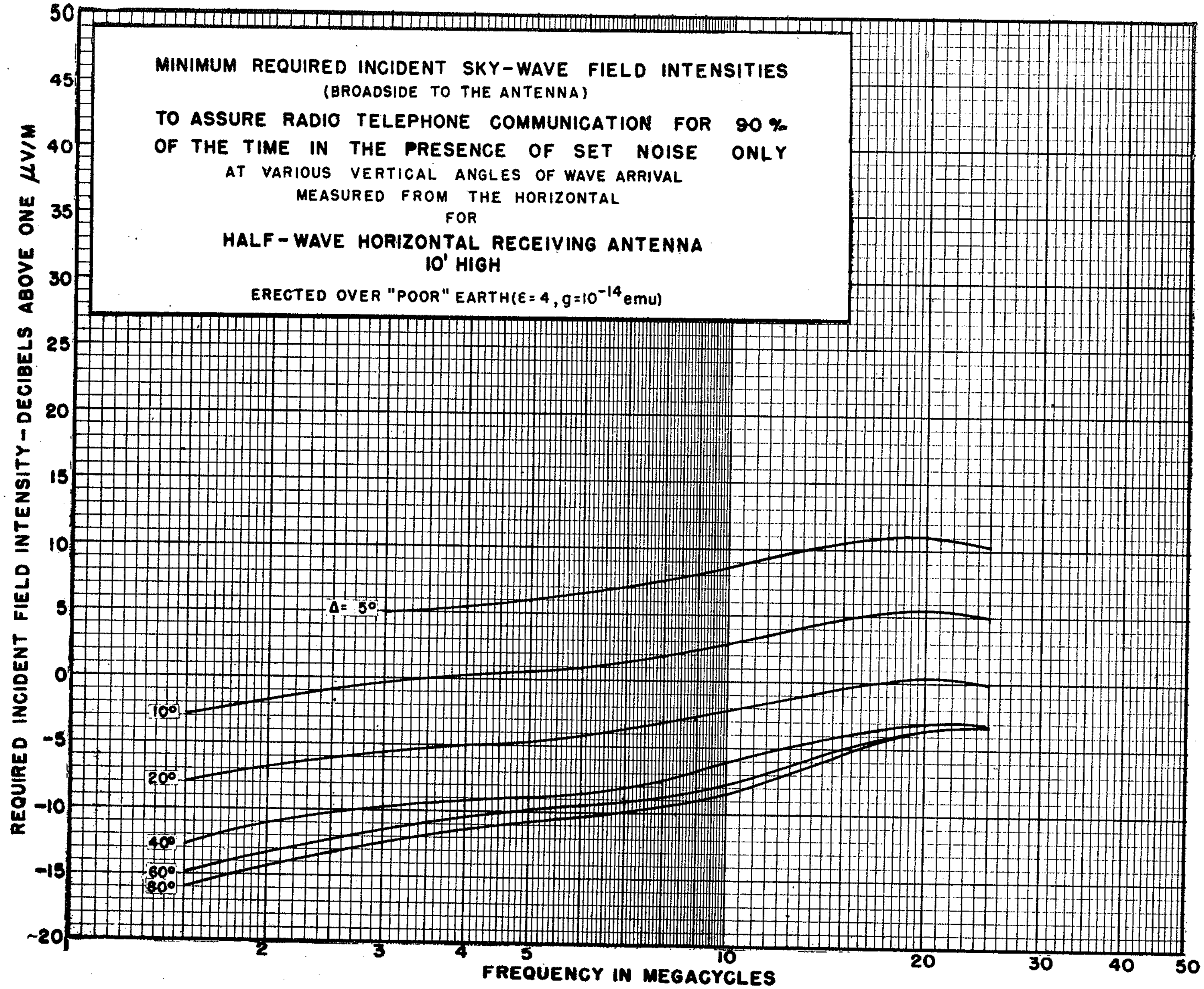

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
(BROADSIDE TO THE ANTENNA)
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL
MEASURED FROM THE HORIZONTAL
FOR
HALF-WAVE HORIZONTAL RECEIVING ANTENNA
10' HIGH
ERECTED OVER "POOR" EARTH(ε=4, g=10^-14 emu)
Δ= 5°
10°
20°
40°
60°
80°
REQUIRED INCIDENT FIELD INTENSITY-DECIBELS ABOVE ONE μV/M
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 38

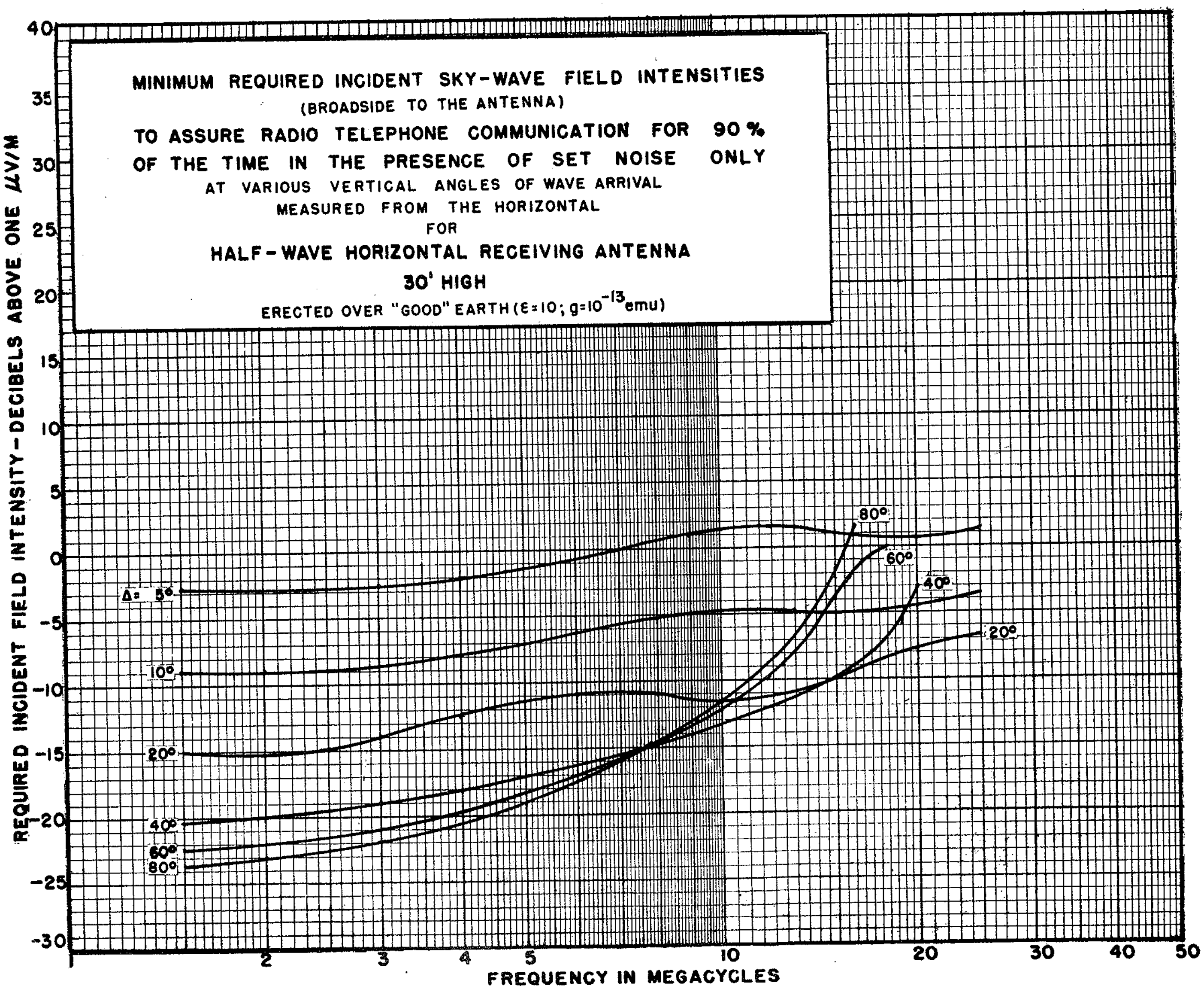

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
(BROADSIDE TO THE ANTENNA)
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL
MEASURED FROM THE HORIZONTAL
FOR
HALF-WAVE HORIZONTAL RECEIVING ANTENNA
30' HIGH
ERECTED OVER "GOOD" EARTH (ε=10; g=10^-13 emu)
REQUIRED INCIDENT FIELD INTENSITY-DECIBELS ABOVE ONE μV/M
FREQUENCY IN MEGACYCLES
Δ= 5°
10°
20°
40°
60°
80°
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
2
3
4
5
10
20
30
40
50

Fig. 39

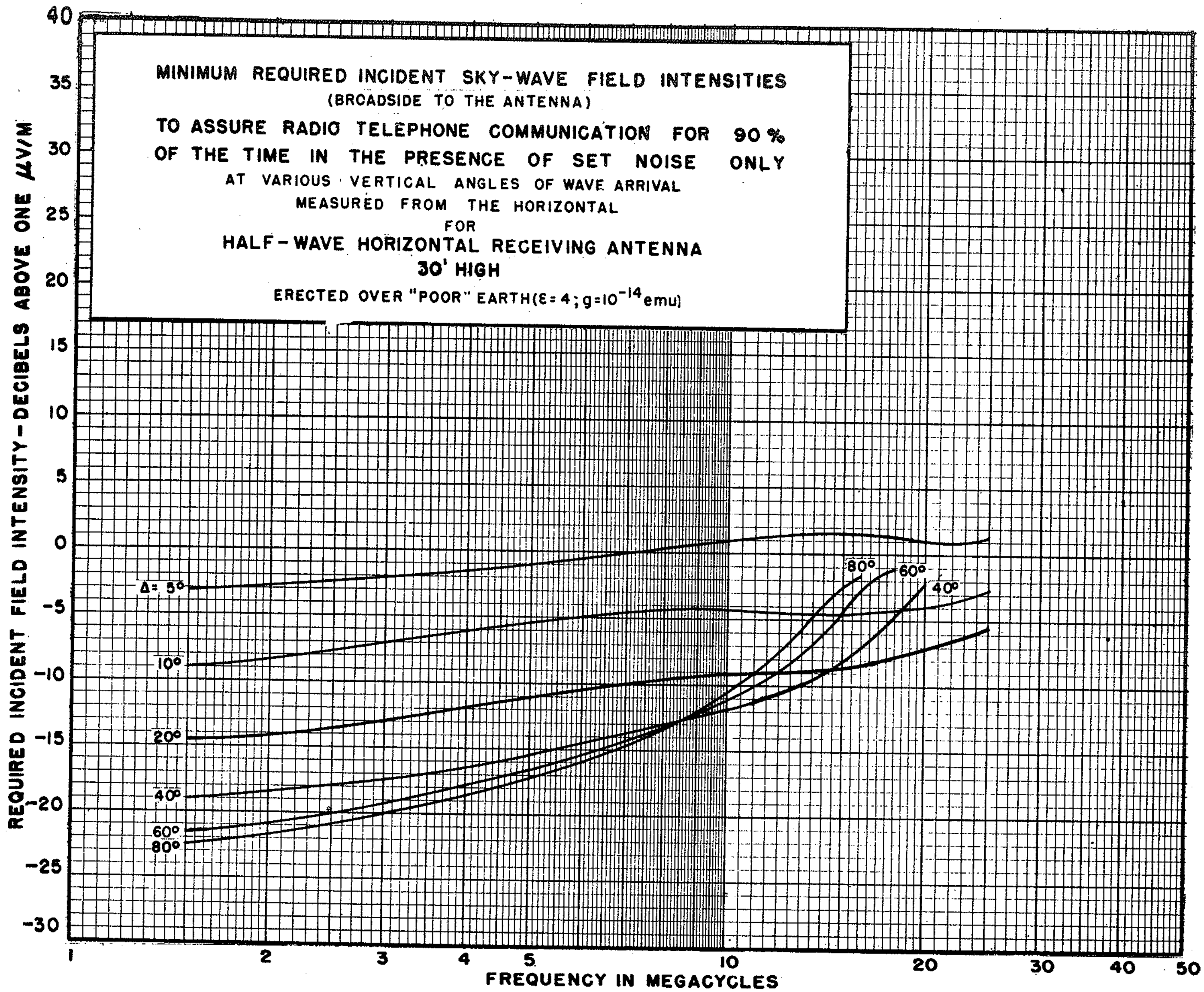

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
(BROADSIDE TO THE ANTENNA)
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL
MEASURED FROM THE HORIZONTAL
FOR
HALF-WAVE HORIZONTAL RECEIVING ANTENNA
30' HIGH
ERECTED OVER "POOR" EARTH(ε=4; g=10^-14 emu)
REQUIRED INCIDENT FIELD INTENSITY-DECIBELS ABOVE ONE μV/M
FREQUENCY IN MEGACYCLES
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
1
2
3
4
5
10
20
30
40
50
Δ= 5°
10°
20°
40°
60°
80°

Fig. 40

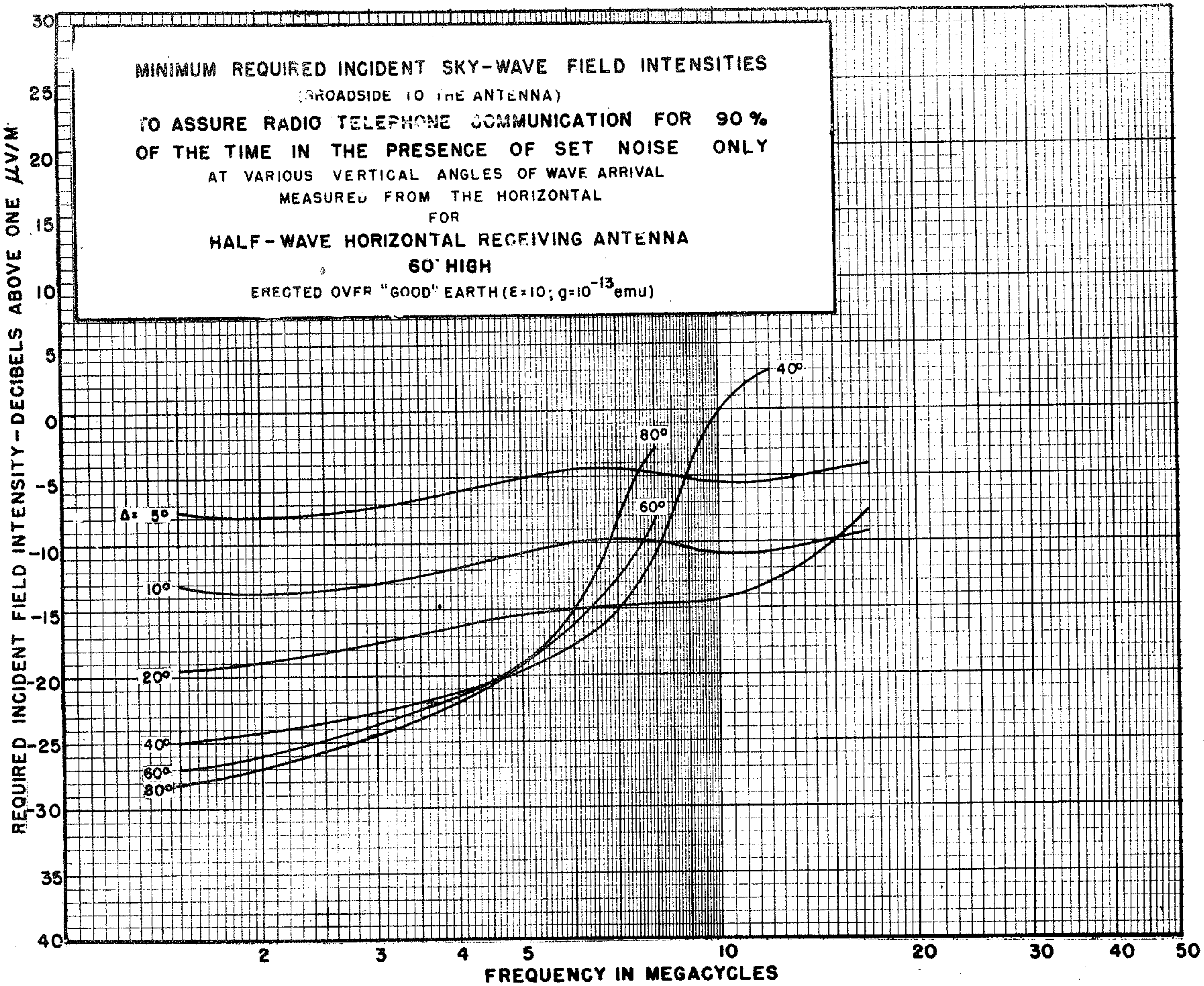

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
(BROADSIDE TO THE ANTENNA)
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 % OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL
MEASURED FROM THE HORIZONTAL
FOR
HALF-WAVE HORIZONTAL RECEIVING ANTENNA
60' HIGH
ERECTED OVER "GOOD" EARTH (ε=10; g=10^-13 emu)
Δ= 5°
10°
20°
40°
60°
80°
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE μV/M
FREQUENCY IN MEGACYCLES
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
35
40
2
3
4
5
10
20
30
40
50

Fig. 41

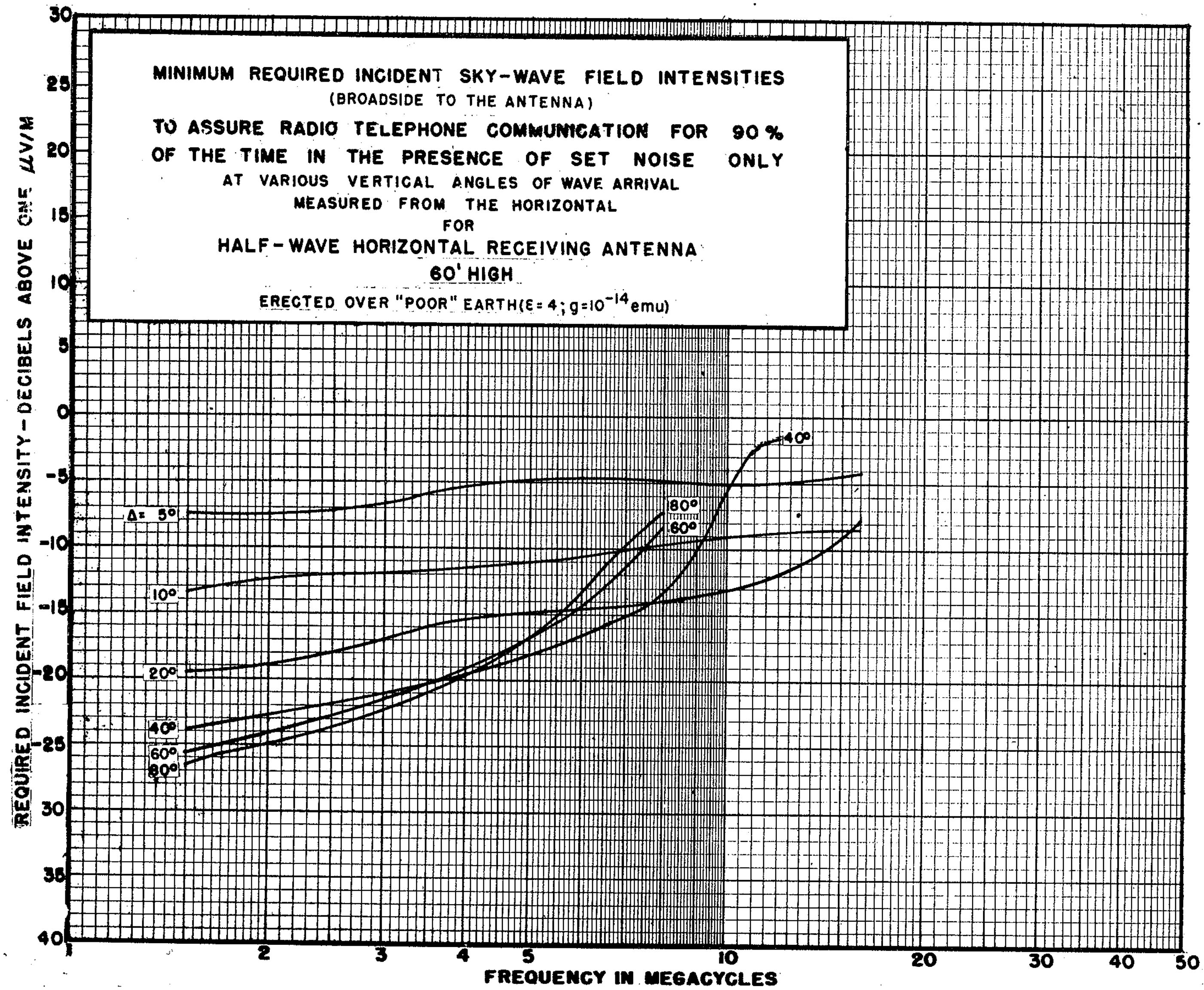

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
(BROADSIDE TO THE ANTENNA)
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL
MEASURED FROM THE HORIZONTAL
FOR
HALF-WAVE HORIZONTAL RECEIVING ANTENNA
60' HIGH
ERECTED OVER "POOR" EARTH(ε= 4; g=10^-14 emu)
Δ= 5°
10°
20°
40°
60°
80°
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE μV/M
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
30
35
40
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 42

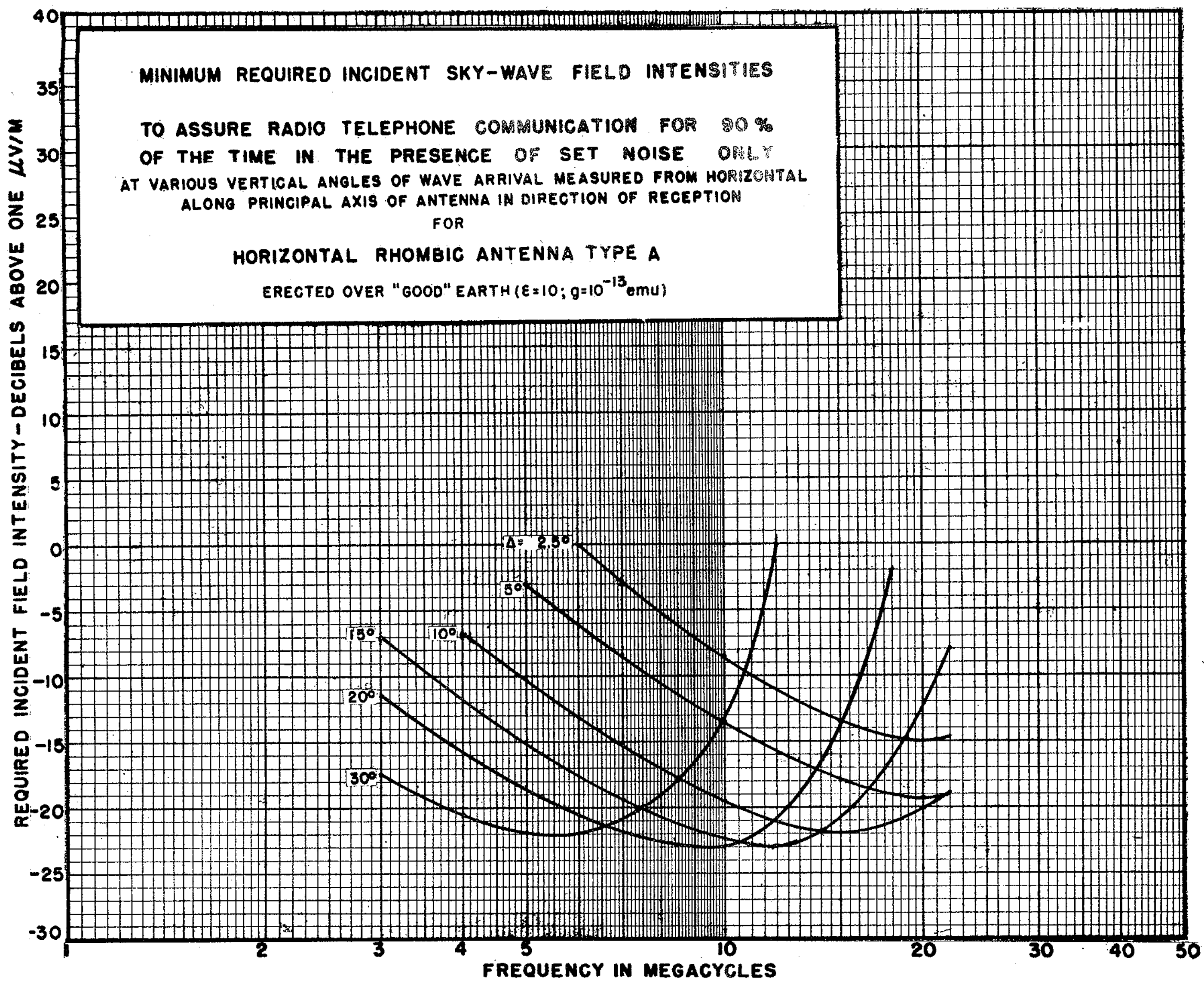

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM HORIZONTAL
ALONG PRINCIPAL AXIS OF ANTENNA IN DIRECTION OF RECEPTION
FOR
HORIZONTAL RHOMBIC ANTENNA TYPE A
ERECTED OVER "GOOD" EARTH (ε=10; g=10^-13 emu)
Δ= 2.5°
5°
10°
15°
20°
30°
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE μV/M
FREQUENCY IN MEGACYCLES
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
1
2
3
4
5
10
20
30
40
50

Fig. 43

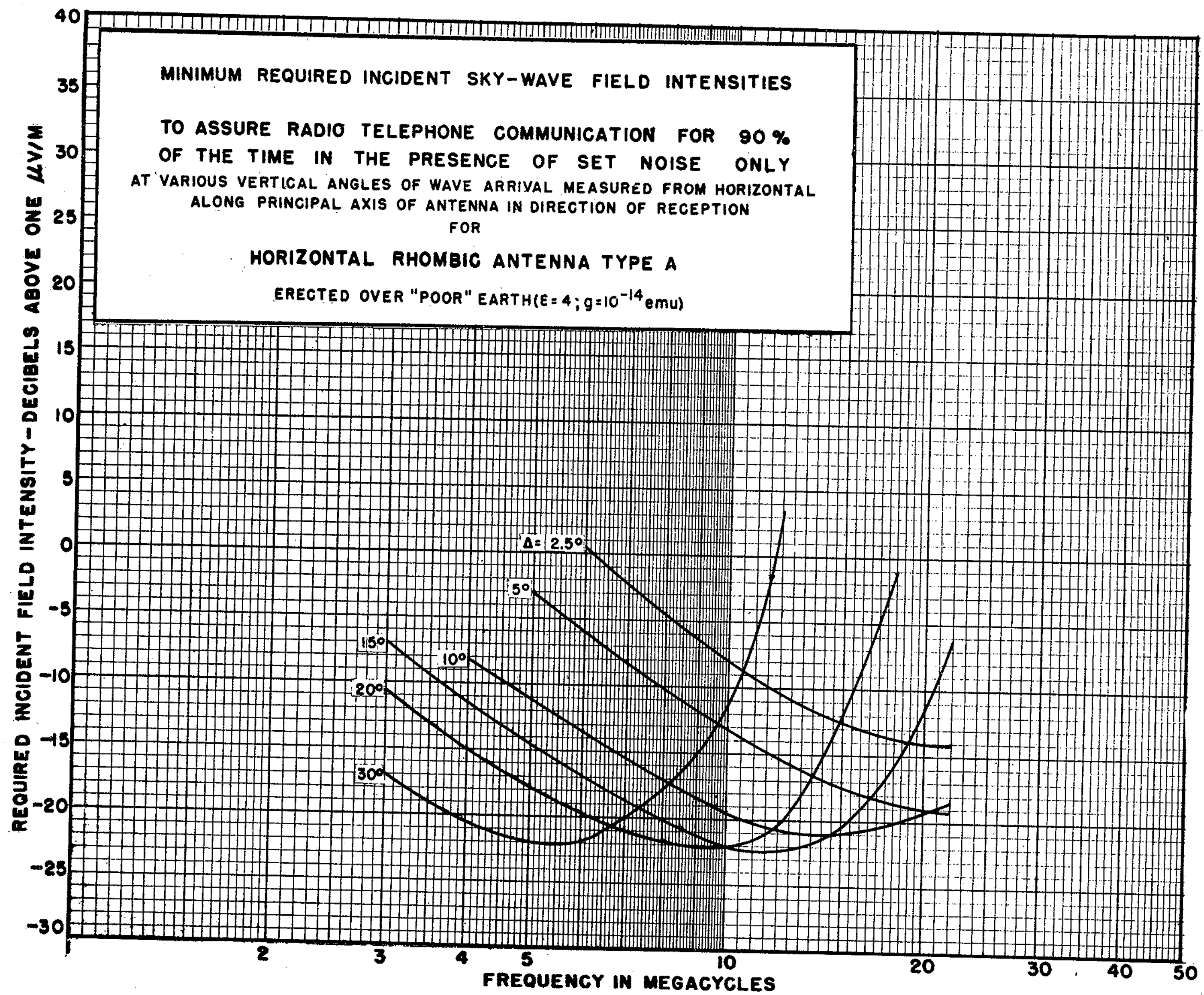
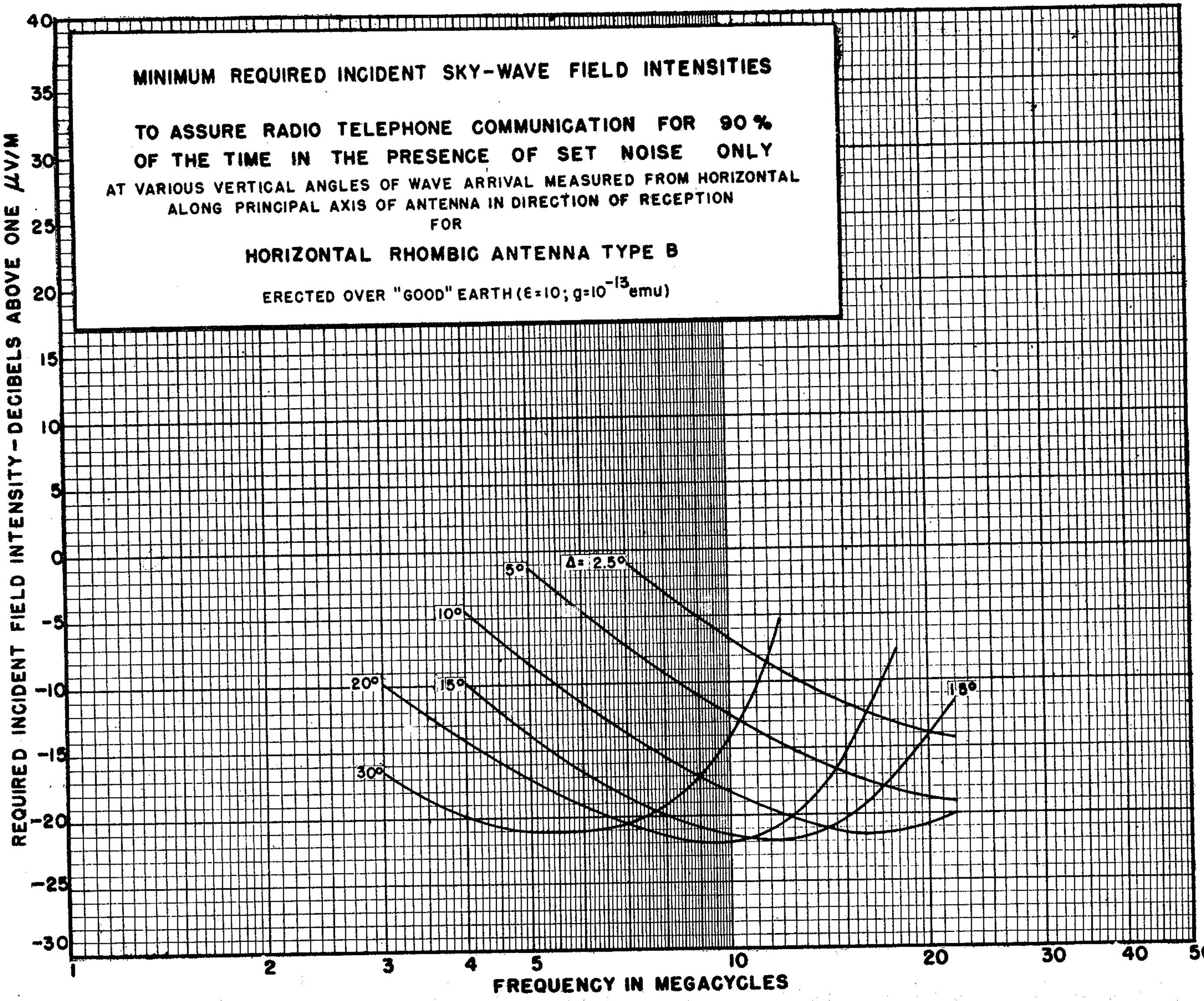

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 % OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM HORIZONTAL ALONG PRINCIPAL AXIS OF ANTENNA IN DIRECTION OF RECEPTION
FOR
HORIZONTAL RHOMBIC ANTENNA TYPE A
ERECTED OVER "POOR" EARTH(ε = 4; g = 10^-14 emu)
Δ = 2.5°
5°
10°
15°
20°
30°
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE μV/M
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
FREQUENCY IN MEGACYCLES
2
3
4
5
10
20
30
40
50

Fig. 44



MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM HORIZONTAL
ALONG PRINCIPAL AXIS OF ANTENNA IN DIRECTION OF RECEPTION
FOR
HORIZONTAL RHOMBIC ANTENNA TYPE B
ERECTED OVER "GOOD" EARTH (ε=10; g=10^-13 emu)
Δ= 2.5°
5°
10°
15°
20°
30°
18°
REQUIRED INCIDENT FIELD INTENSITY-DECIBELS ABOVE ONE μV/M
FREQUENCY IN MEGACYCLES
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
1
2
3
4
5
10
20
30
40
50

Fig. 45

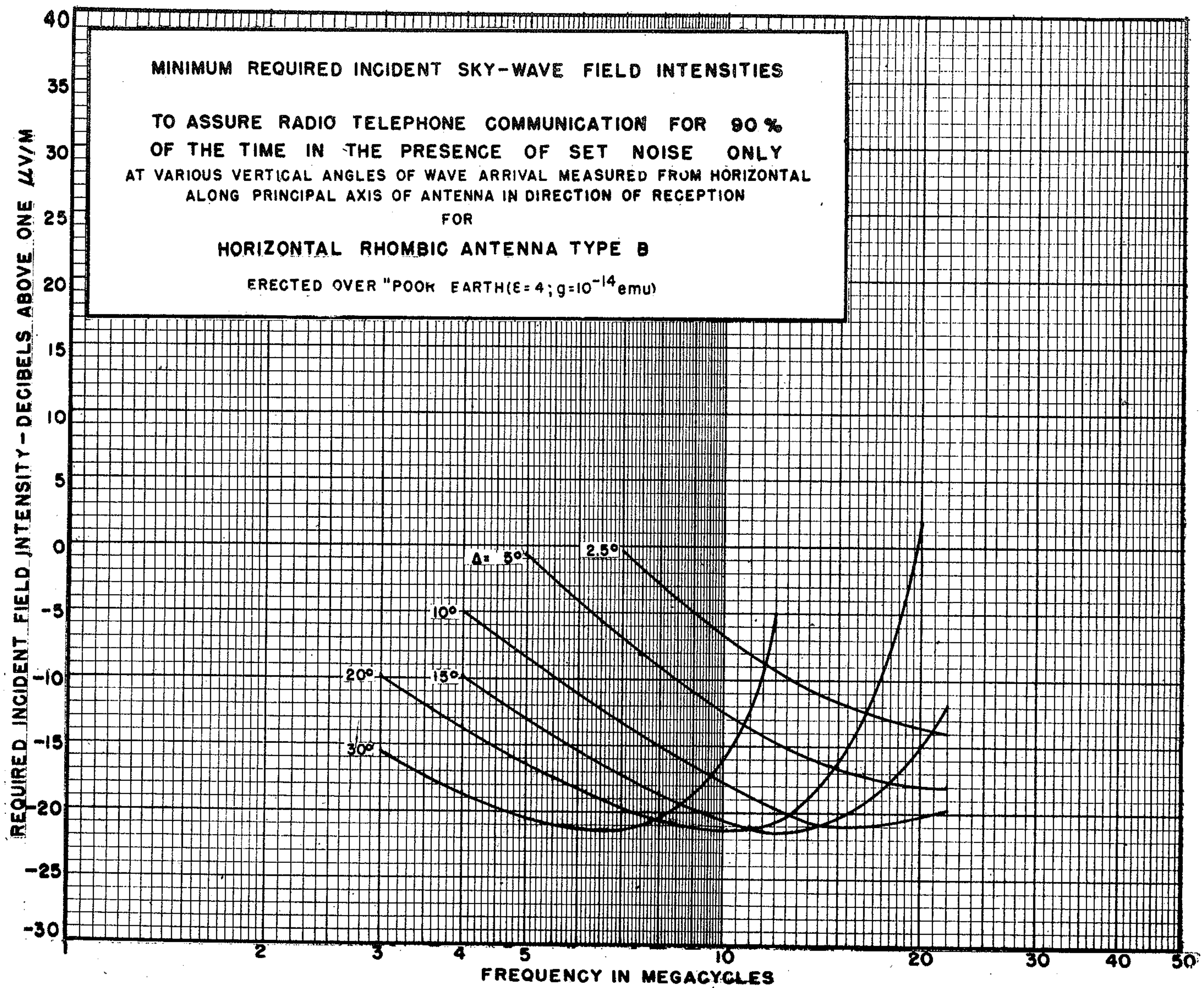

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM HORIZONTAL
ALONG PRINCIPAL AXIS OF ANTENNA IN DIRECTION OF RECEPTION
FOR
HORIZONTAL RHOMBIC ANTENNA TYPE B
ERECTED OVER "POOR EARTH(ε=4; g=10^-14 emu)
Δ= 5°
2.5°
10°
15°
20°
30°
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE μV/M
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
1
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 46

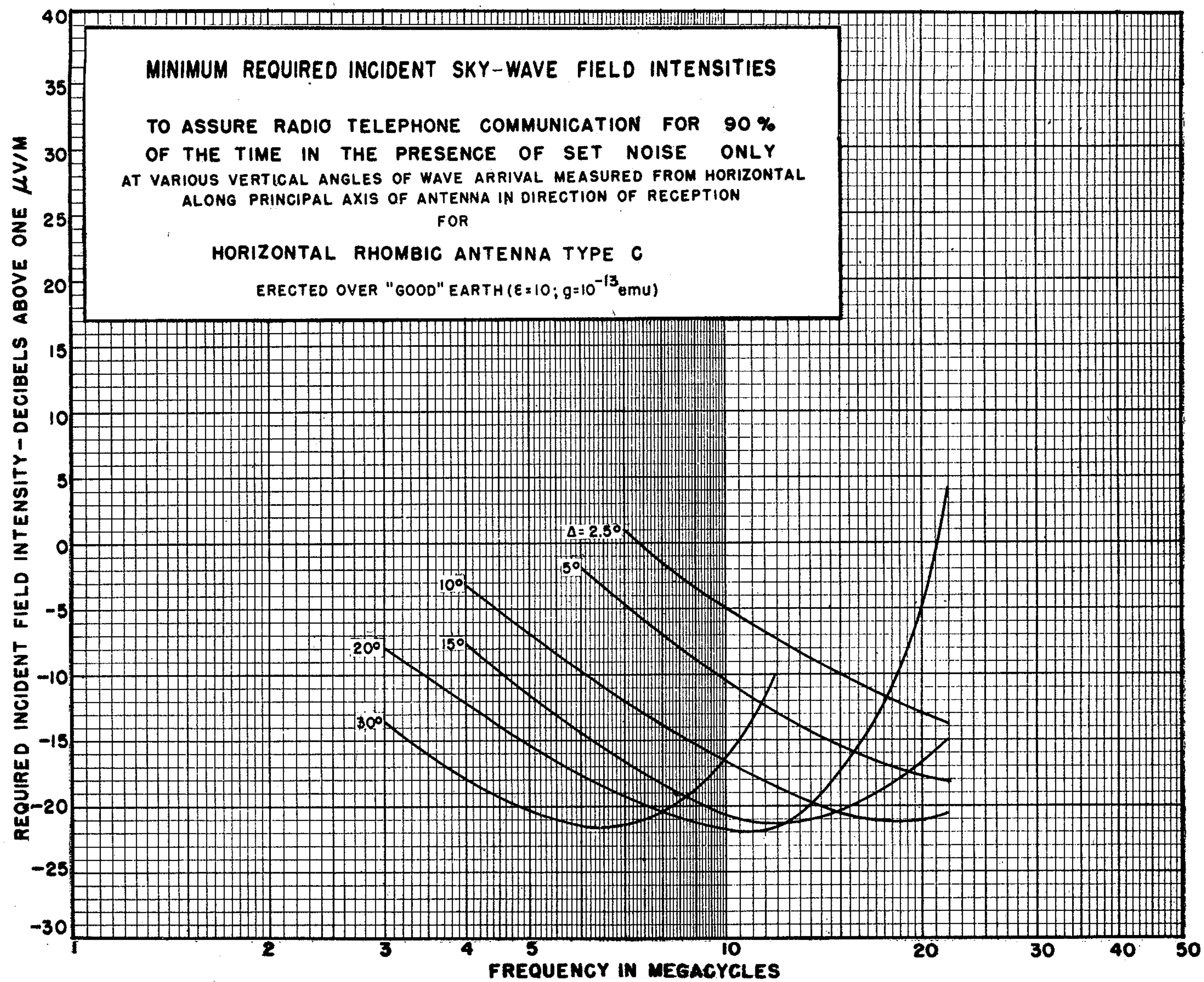

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM HORIZONTAL
ALONG PRINCIPAL AXIS OF ANTENNA IN DIRECTION OF RECEPTION
FOR
HORIZONTAL RHOMBIC ANTENNA TYPE C
ERECTED OVER "GOOD" EARTH (ε=10; g=10^-13 emu)
Δ=2.5°
5°
10°
15°
20°
30°
REQUIRED INCIDENT FIELD INTENSITY-DECIBELS ABOVE ONE μV/M
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
1
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 47

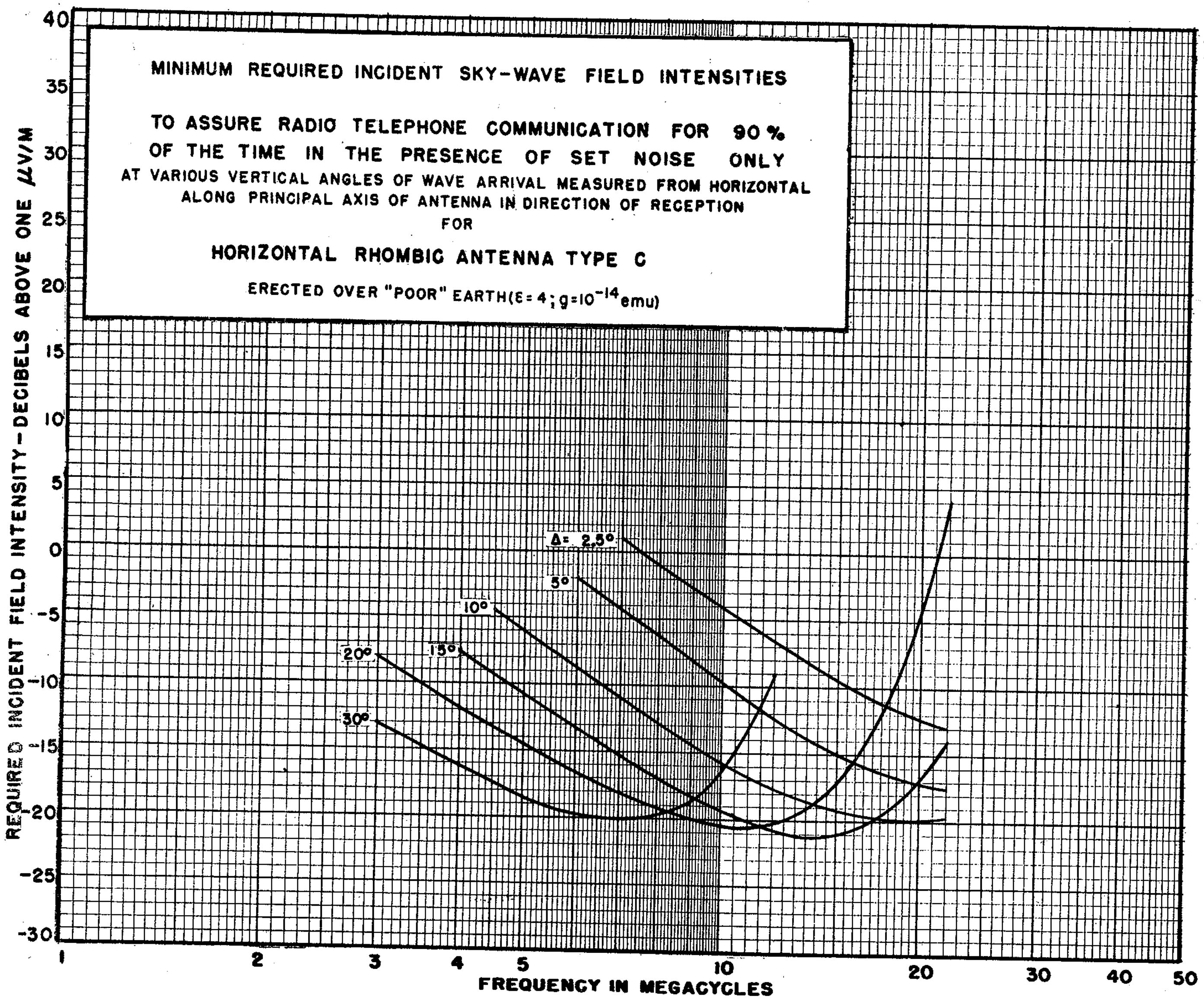

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM HORIZONTAL
ALONG PRINCIPAL AXIS OF ANTENNA IN DIRECTION OF RECEPTION
FOR
HORIZONTAL RHOMBIC ANTENNA TYPE C
ERECTED OVER "POOR" EARTH(ε = 4; g = 10^-14 emu)
REQUIRED INCIDENT FIELD INTENSITY-DECIBELS ABOVE ONE μV/M
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
Δ = 2.5°
5°
10°
15°
20°
30°
1
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 48

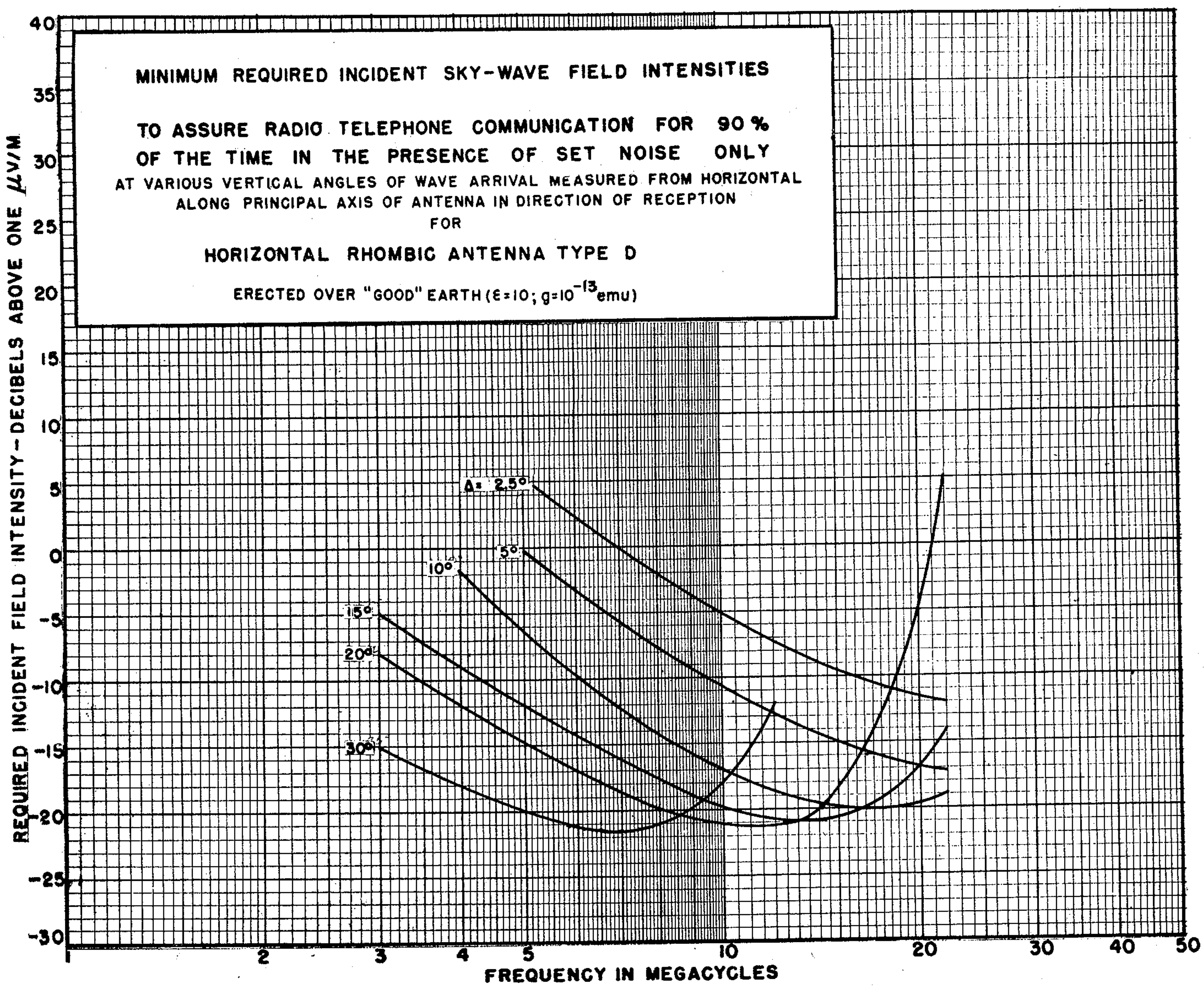

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM HORIZONTAL
ALONG PRINCIPAL AXIS OF ANTENNA IN DIRECTION OF RECEPTION
FOR
HORIZONTAL RHOMBIC ANTENNA TYPE D
ERECTED OVER "GOOD" EARTH (ε=10; g=10^-13 emu)
Δ= 2.5°
5°
10°
15°
20°
30°
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE μV/M
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
1
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 49

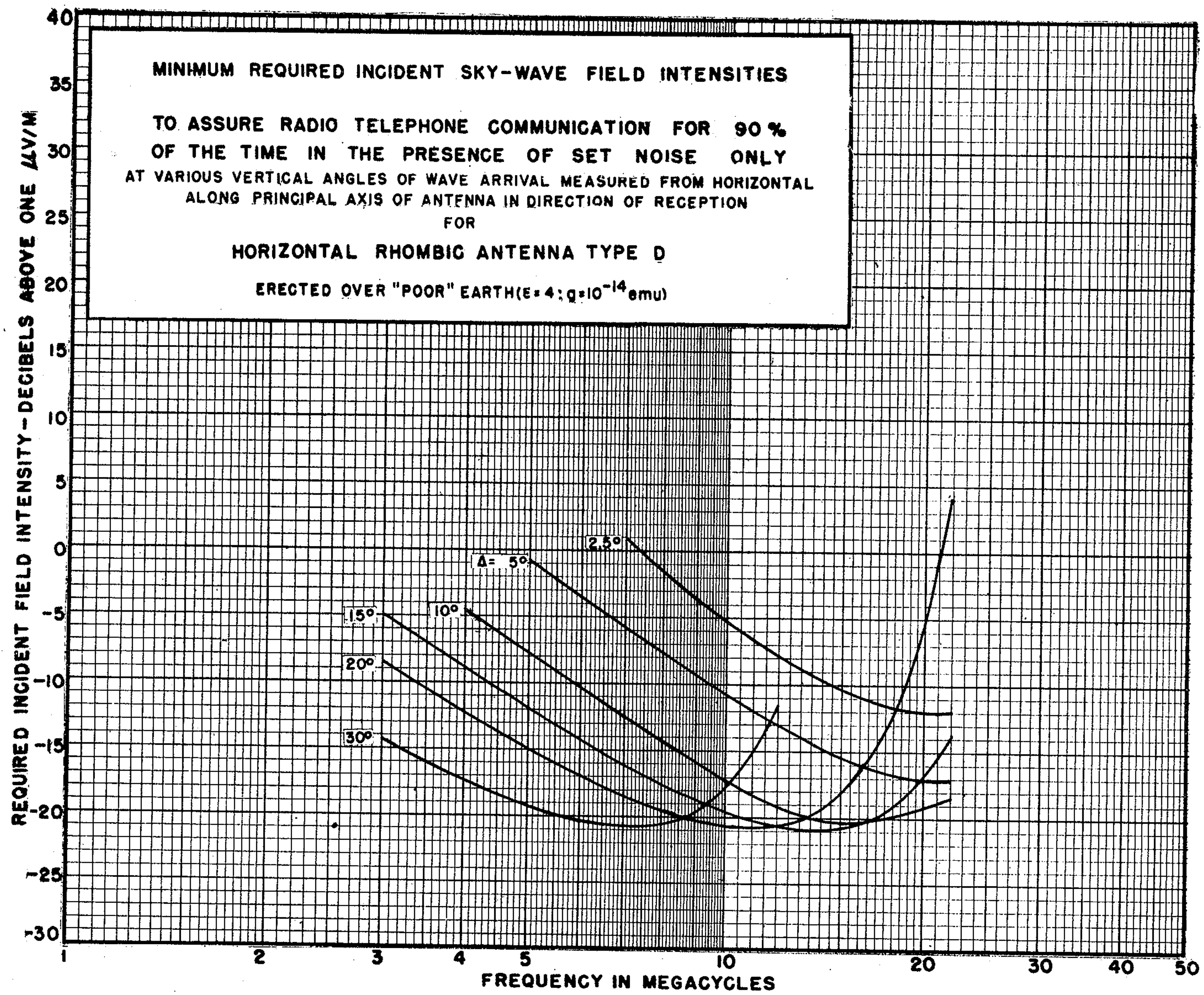

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM HORIZONTAL
ALONG PRINCIPAL AXIS OF ANTENNA IN DIRECTION OF RECEPTION
FOR
HORIZONTAL RHOMBIC ANTENNA TYPE D
ERECTED OVER "POOR" EARTH(ϵ=4; g=10^{-14} emu)
2.5°
Δ= 5°
10°
15°
20°
30°
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
REQUIRED INCIDENT FIELD INTENSITY–DECIBELS ABOVE ONE μV/M
1
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 50

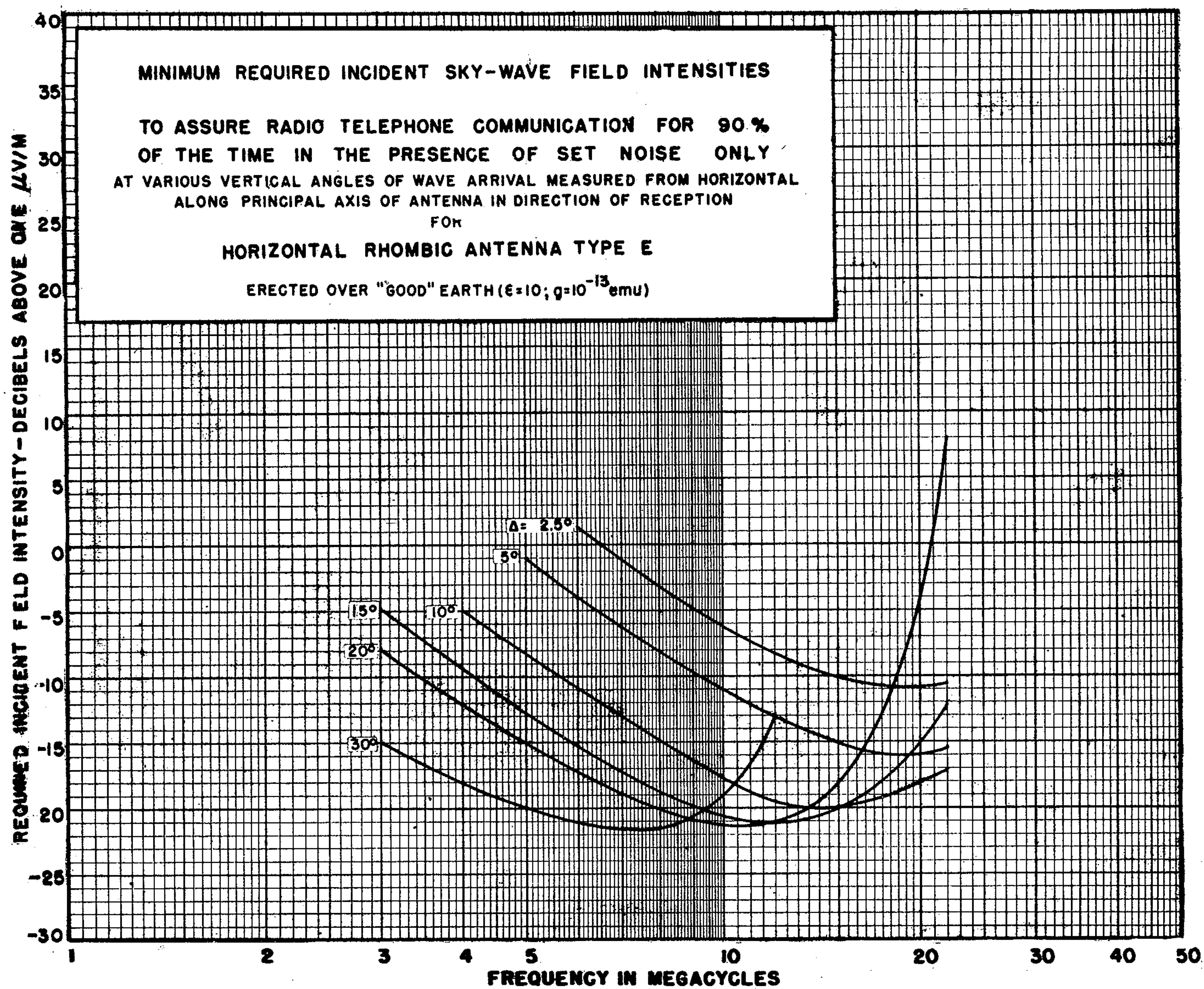

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM HORIZONTAL
ALONG PRINCIPAL AXIS OF ANTENNA IN DIRECTION OF RECEPTION
FOR
HORIZONTAL RHOMBIC ANTENNA TYPE E
ERECTED OVER "GOOD" EARTH (ε=10; g=10^-13 emu)
Δ= 2.5°
5°
10°
15°
20°
30°
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE μV/M
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
1
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 51

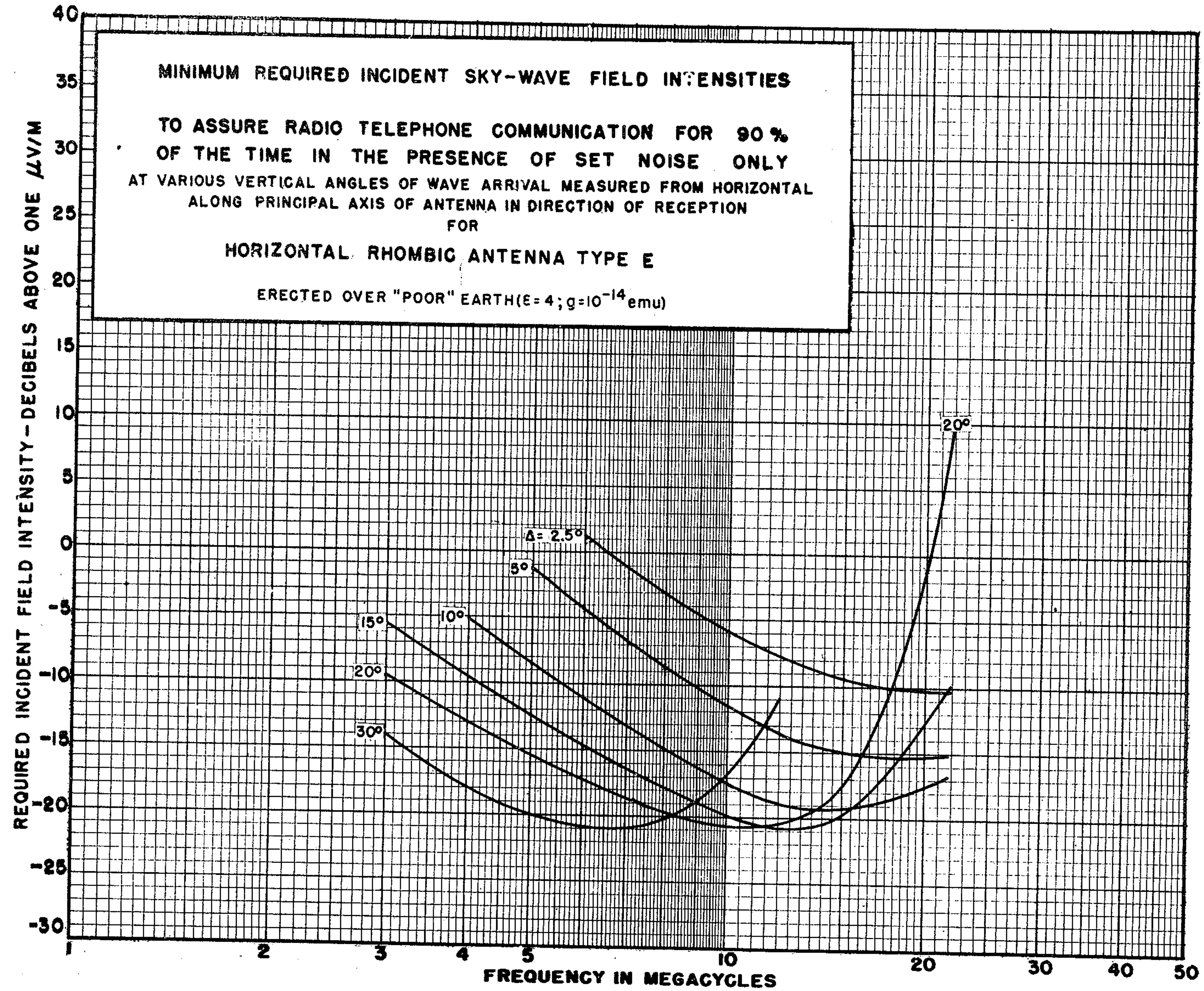

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM HORIZONTAL
ALONG PRINCIPAL AXIS OF ANTENNA IN DIRECTION OF RECEPTION
FOR
HORIZONTAL RHOMBIC ANTENNA TYPE E
ERECTED OVER "POOR" EARTH(ε=4; g=10^-14 emu)
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE µV/M
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
Δ= 2.5°
5°
10°
15°
20°
30°
20°
1
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 52

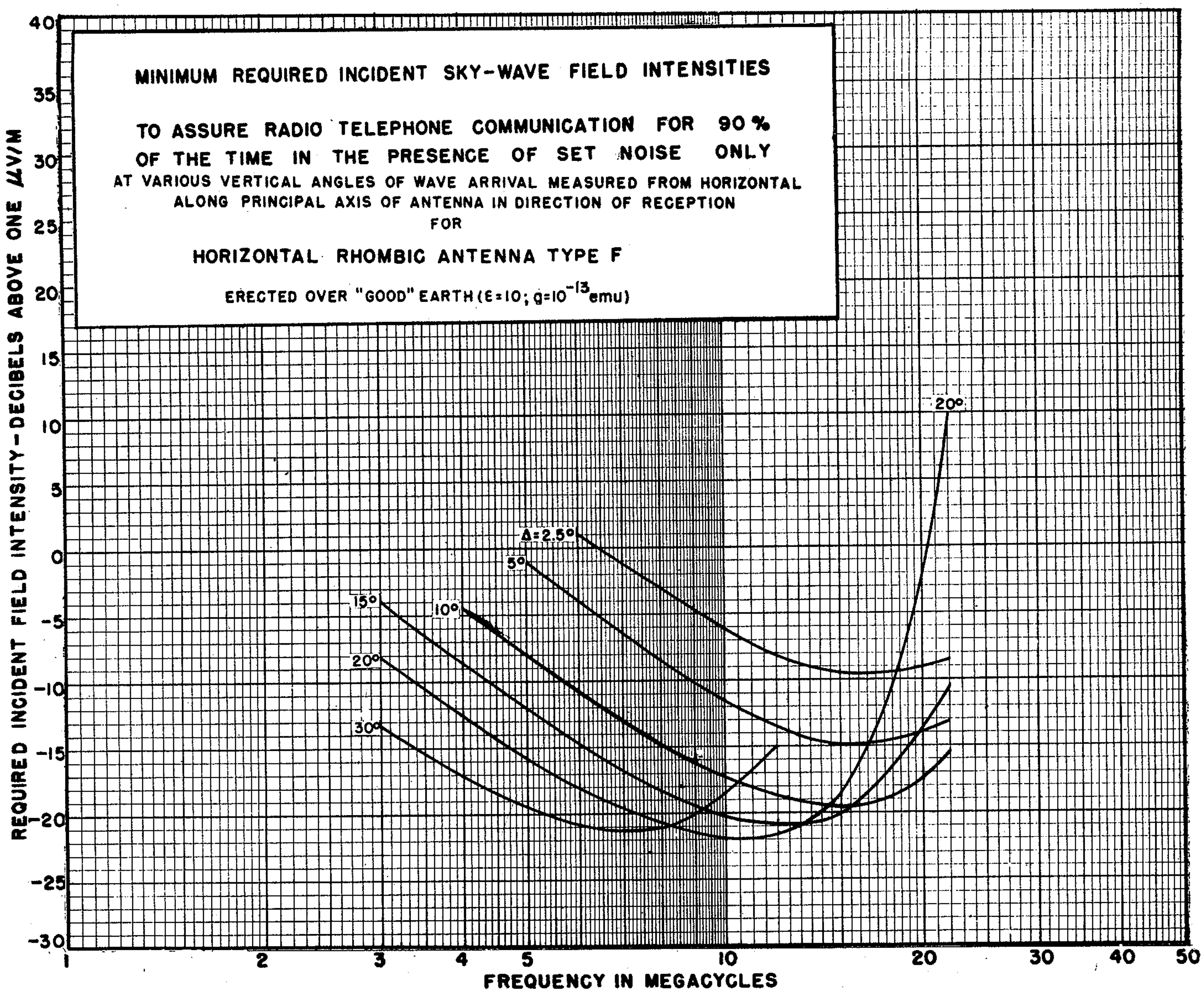

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM HORIZONTAL
ALONG PRINCIPAL AXIS OF ANTENNA IN DIRECTION OF RECEPTION
FOR
HORIZONTAL RHOMBIC ANTENNA TYPE F
ERECTED OVER "GOOD" EARTH (ϵ=10; g=10^{-13}emu)
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE μV/M
FREQUENCY IN MEGACYCLES
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
1
2
3
4
5
10
20
30
40
50
Δ=2.5°
5°
10°
15°
20°
30°
20°

Fig. 53

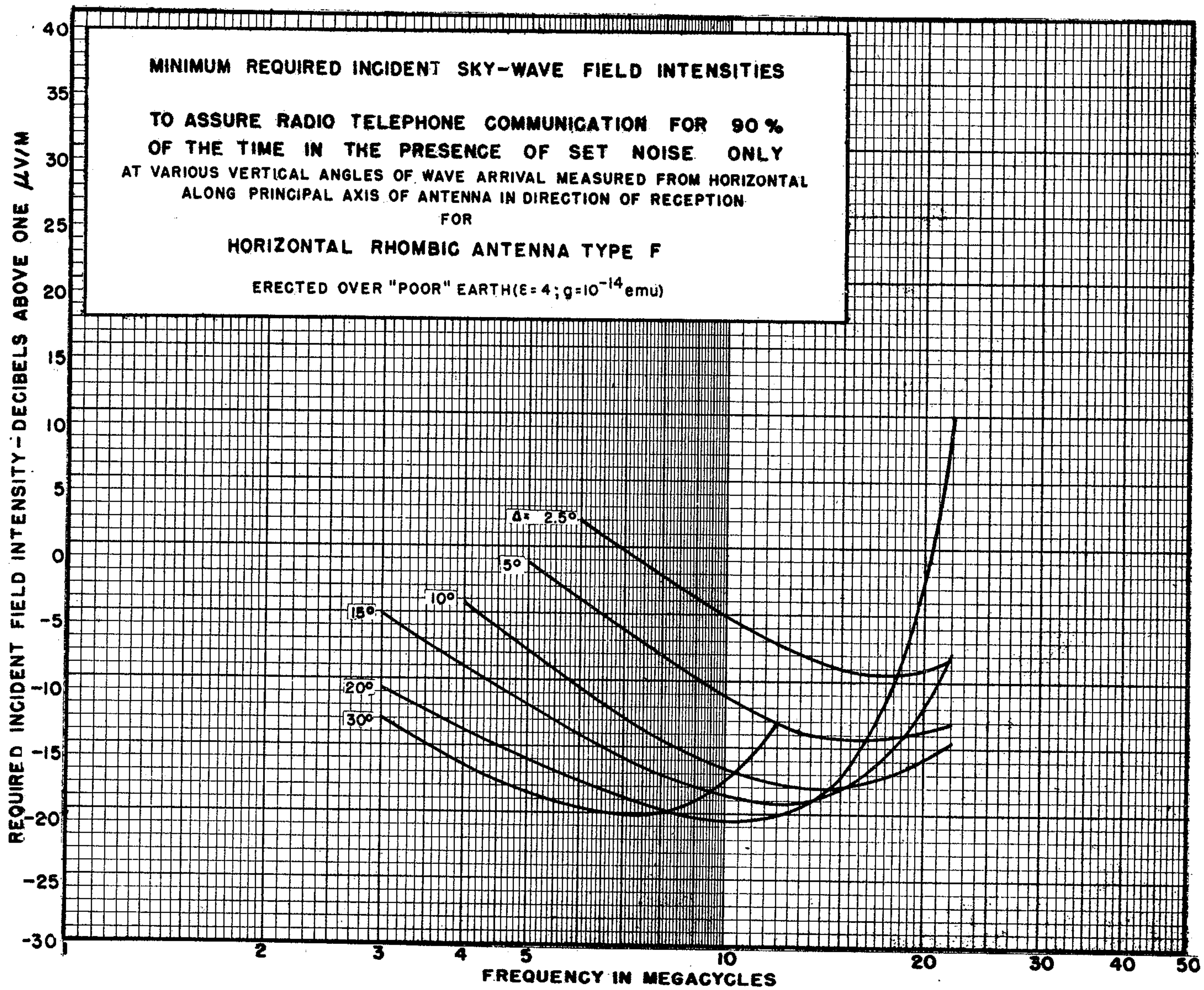

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM HORIZONTAL
ALONG PRINCIPAL AXIS OF ANTENNA IN DIRECTION OF RECEPTION
FOR
HORIZONTAL RHOMBIC ANTENNA TYPE F
ERECTED OVER "POOR" EARTH(ε= 4; g=10^-14 emu)
Δ= 2.5°
5°
10°
15°
20°
30°
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE μV/M
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
1
2
3
4
5
10
20
30
40
50
FREQUENCY IN MEGACYCLES

Fig. 54

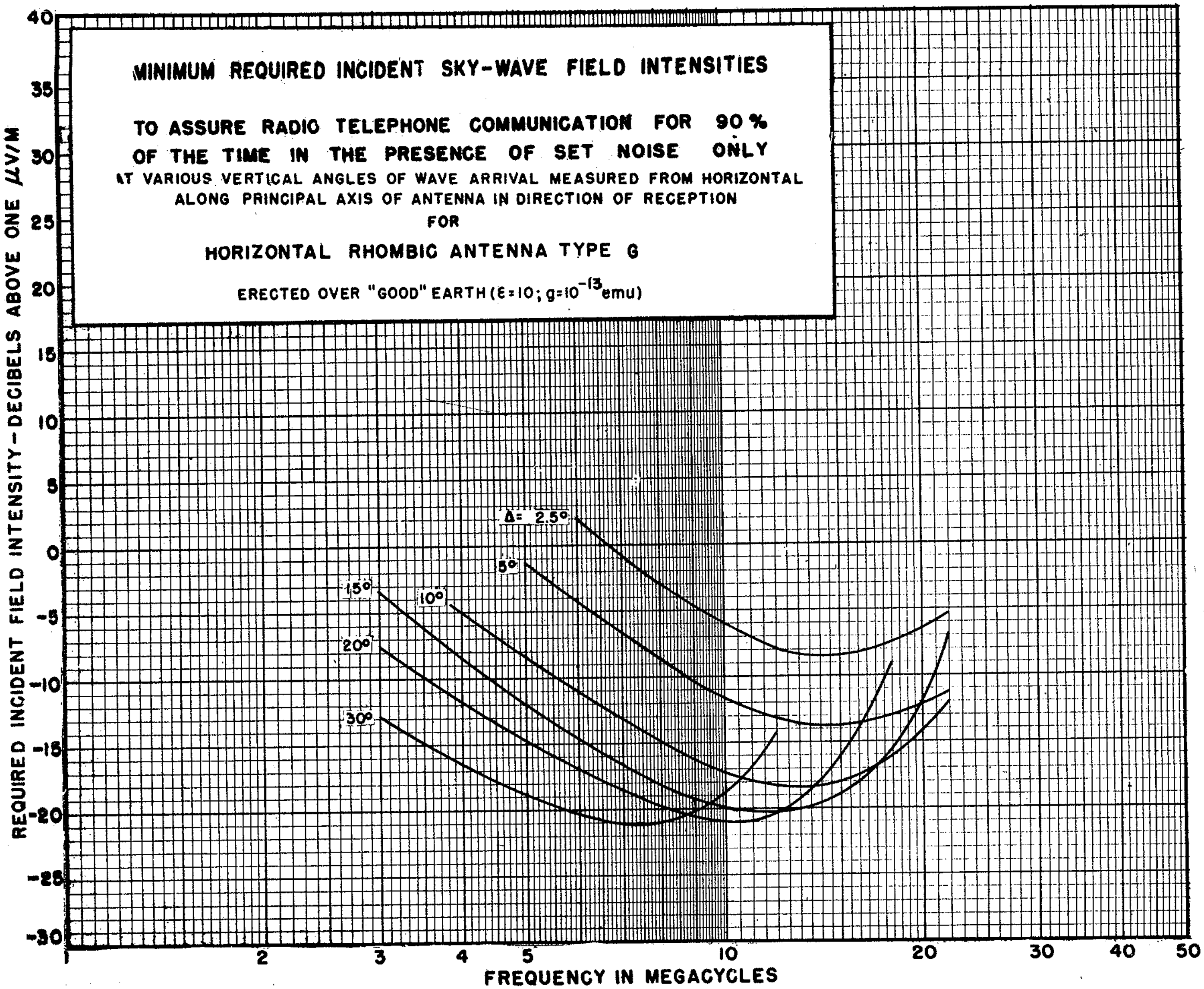

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 %
OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM HORIZONTAL
ALONG PRINCIPAL AXIS OF ANTENNA IN DIRECTION OF RECEPTION
FOR
HORIZONTAL RHOMBIC ANTENNA TYPE G
ERECTED OVER "GOOD" EARTH (ε=10; g=10^-13 emu)
Δ= 2.5°
5°
10°
15°
20°
30°
REQUIRED INCIDENT FIELD INTENSITY-DECIBELS ABOVE ONE μV/M
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
FREQUENCY IN MEGACYCLES
1
2
3
4
5
10
20
30
40
50

Fig. 55

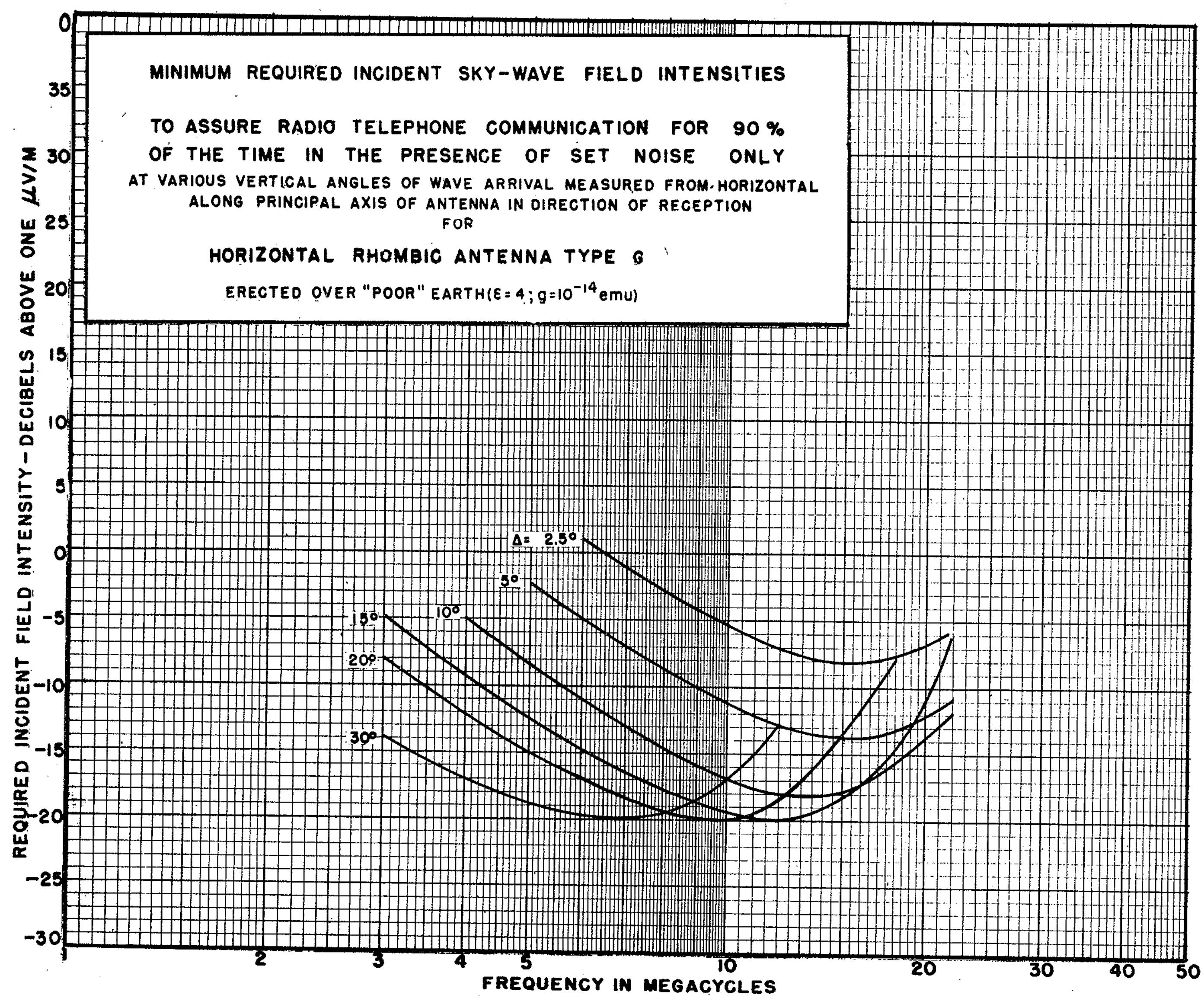

MINIMUM REQUIRED INCIDENT SKY-WAVE FIELD INTENSITIES
TO ASSURE RADIO TELEPHONE COMMUNICATION FOR 90 % OF THE TIME IN THE PRESENCE OF SET NOISE ONLY
AT VARIOUS VERTICAL ANGLES OF WAVE ARRIVAL MEASURED FROM HORIZONTAL ALONG PRINCIPAL AXIS OF ANTENNA IN DIRECTION OF RECEPTION
FOR
HORIZONTAL RHOMBIC ANTENNA TYPE G
ERECTED OVER "POOR" EARTH(ϵ = 4; g = 10^{-14} emu)
Δ = 2.5°
5°
10°
15°
20°
30°
REQUIRED INCIDENT FIELD INTENSITY - DECIBELS ABOVE ONE μV/M
0
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
FREQUENCY IN MEGACYCLES
2
3
4
5
10
20
30
40
50

Fig. 56