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Project C-44
Communications Section
NATIONAL DEFENSE RESEARCH COMMITTEE

SUPPLEMENT TO RADIO TRANSMISSION HANDBOOK,

SUMMER, 1942

Prepared by
NATIONAL BUREAU OF STANDARDS
Washington, D.C.
June 1, 1942

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ERRATA IN

SUPPLEMENT TO RADIO TRANSMISSION HANDBOOK, SUMMER, 1942

Project C-44, Communications Section,
National Defense Research Committee.

Prepared by National Bureau of Standards.

Page 2. 2d paragraph, change last sentence to "In addition a Section (IV) is included, giving tables and nomograms for the rapid calculation of distance ranges and usable frequencies, for limited distances; in some cases even these give the data for transmission over almost the entire earth.".

Page 6, 3d paragraph, omit the second and third words, "sets of".

Page 6. 4th paragraph; the third and fourth sentences refer to use of Figs. 17-52 with the transparent maps Figs. 67 and 69 of the Handbook. Through an error in printing Figs. 17-52 do not match exactly in size Figs. 67 and 69 of the Handbook. Therefore when scaling the transparent maps must be shifted a proportional part of their total length, according to the distance to be measured.

Page 15, 3d paragraph, 5th line, change "table 5" to "table 4".

Page 16. Third line, under "VI. Sources" should read: "the following sources, whose effective cooperation has been most valuable". Add "Australian Government" to list under "(a) Ionosphere data".

Fig. 1. Add "Over or Near Land" to second line of legend. Add 0° just after "Azimuth" in third line of legend.

Fig. 23. The circle between 12 and 13 should also be labelled 13.

Fig. 53. In third line of legend replace 9 by the word "to".

November 1, 1942

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS
WASHINGTON

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How to Use the N.D.R.C.-N.B.S. Radio Transmission Handbook and Supplement for the Coming Year.

The Handbook and Supplement were prepared by the National Bureau of Standards for projects C-9 and C-44 respectively of the National Defense Research Committee. The Handbook gave predictions of usable transmission distances and frequencies for the winter (November through February) of 1941-42. The Supplement gave the same for the summer (May through August) of 1942. The predictions have been found by the experience of the past winter and summer to be reliable.

The two books have a certain amount of utility for the year ahead by the application of certain factors to the data given. For any specified set of conditions frequencies will be somewhat less and distances somewhat greater, in the year ahead than in the past year. The factors to be applied follow.

The graphs of distance ranges (Figs. 1 through 32 of the Handbook; Figs. 1 through 16 of the Supplement) and the maps of maximum usable frequencies and lowest useful high frequencies (Figs. 33 through 62 of the Handbook; Figs. 17 through 52 of the Supplement) may be used for the coming Winter (1942-3) and Summer (1943), by multiplying the maximum usable frequencies by 0.90 and the lowest useful high frequencies by 0.95.

For example, Fig. 15 in the Handbook gives, for 2000-mile reception at azimuth 180°, receiver about 40°N, at 1200 local time, Winter 1941-2, a maximum usable frequency of 25.2 Mc and a lowest useful high frequency for 1 kw of 13.0 Mc. Under these same conditions for Winter 1942-3 the maximum usable frequency will be 22.7 Mc and the 1-kw lowest useful high frequency will be about 12.3 Mc. The 1-kilowatt distance range for 13 Mc is, correspondingly, that given in the Handbook for 13 ÷ 0.95 = 13.7 Mc = 2200 miles; and the skip distance on, say, 12 Mc, is that shown in the Handbook for 12 ÷ 0.90 = 13.3 Mc, i.e., 650 miles. (The skip distance given in the Handbook for 12 Mc, Winter 1941-2, is 500 miles).

Note that the distance ranges, skip distances, maximum usable and lowest useful high frequencies given for 40°N are roughly good for receiving locations between 30°N and 50°N,

and those given for the equator are roughly good for receiving locations between 10°S and 10°N latitudes. Also, the values given in the Figs. referred to in the Handbook for Winter 1941-2, 40°N, may be used for receiving locations between 50°S and 30°S for May through August 1942, by multiplying the maximum usable frequency by 0.95 and the lowest useful high frequency by 0.98, and for May through Aug. 1943, by multiplying the maximum useful frequency in the Handbook by 0.85 and the lowest useful high frequency by 0.92. Also the values given in the Figs. referred to in the Supplement for Summer, 1942, 40°N, may be used for receiving locations between 50°S and 30°S for Nov. 1942 through Feb. 1943 by multiplying the maximum usable frequency by 0.95 and the lowest useful high frequency by 0.98.

The distance-range nomograms, Figs. 58 through 62, in the Supplement, may be used for the months of Nov. 1942 through Feb. 1943, in the opposite hemisphere (i.e. lat. 40°N, Summer, can be used for lat. 40°S, Winter) by multiplying the frequencies on the frequency scale by 0.98. The example shown in Fig. 61, then, would be for 50°S to 20°S, Nov. 1942 through Feb. 1943, 1 kw CW, time 0800, distance range 1500 miles, frequency 8.0 x 9.8 = 7.8 Mc.

Values of distance ranges, skip distances, lowest useful high frequencies and maximum usable frequencies for spring and autumn may be estimated by interpolation between the winter and summer data.

June 1, 1942

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SUPPLEMENT TO RADIO TRANSMISSION HANDBOOK, SUMMER, 1942

(Prepared by National Bureau of Standards, under sponsorship of Communications Section, National Defense Research Committee)

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I. INTRODUCTION

The "Radio Transmission Handbook", to which this is a supplement, gave predictions of usable transmission distances and frequencies (in the range from 1000 to 30,000 kilocycles) for the winter (November through February) of 1941-1942. Sixty-two Figures were included, giving the maximum usable frequency, lowest useful high frequency, distance range, and skip distance, for various radiated powers, times of day, azimuths, and places on the earth. Basic data were also included so that approximate calculations could be made for any transmission path anywhere on the earth.

This Supplement gives similar information for the summer (May through August) of 1942. In general, the distance-range graphs and usable-frequency maps cover the same ranges of latitudes, azimuths, powers, and local times as do the similar graphs and maps in the Handbook; the distance-range graphs do not show as many latitudes and times of day. There are also included the same basic kinds of data as in the Handbook Appendix. In addition a Section (IV) is included, giving tables and nomograms for the rapid calculation of distance ranges and usable frequencies, for transmission over distances not exceeding 4000 miles.

Comments and suggestions on the Handbook and this Supplement are desired, and should be sent to Radio Section, National Bureau of Standards, Washington, D.C. It is desired to make future supplements and revisions of maximum service to the users. In particular, comments are requested on the relative value of tables, graphs, "maps", nomograms, and other ways of presenting the data.

Errata in Handbook.- The following errors have been discovered in the original (Jan.1) Radio Transmission Handbook:

Page 34, in 15th line, insert "half" before "the logarithm".

In Figs. 22, 29, and 32, the 0.1 kw and 0.01 kw labels on the curves should be interchanged.

In Fig. 40, a label "8" was erroneously placed on the 12-Mc contour.

No mention was made in the Handbook of the sources of the data utilized. That oversight is corrected in this Supplement - see Sec. VI.

II. RAPID APPROXIMATE METHOD: - ALL DISTANCES.

The attached Figs. 1 through 16 are distance-range graphs of the same type as those (Figs. 1 to 32) in Sec. III of the Handbook. They show, for local noon and midnight, at a receiving station in any latitude between about 30°N and 50°N, the limits of distance over which practical radio communication is possible, for four azimuths and for five different values of radiated power. The curves are labelled "distance range" and "skip distance"; they also give maximum usable frequencies and lowest useful high frequencies, since:

(1) the maximum usable frequency for any distance is the frequency for which that distance is the skip distance, and

(2) the lowest useful high frequency, for any distance and power, is the frequency for which that distance is the distance range for the given power.

The distance-range graphs are averages for the period May through August, 1942, for quiet days (days when there is no ionosphere storm), and for transmission by way of the regular layers of the ionosphere (the E, F_1, and F or F_2 layers).* Conditions on a particular day may differ markedly from the average. The graphs were calculated by the methods given in the Appendix of the Handbook, and are based on the data given therein and Sec. V hereof. The maximum usable frequencies given here may be considerably exceeded during frequent irregular periods because of reflections from patches or clouds of "sporadic-E layer"; during periods of disturbance and ionospheric storminess, the skip distance may be considerably greater than, and the distance ranges considerably less than the values shown; see "Anomalies", pages 11-14 of the Handbook.

These graphs, like those in the Handbook, are only for frequencies greater than 1000 kilocycles. The solid-line curve in each graph represents the skip distance and also the maximum usable frequency; the dashed-line curves

*For more detailed information on the ionosphere and its effects on radio transmission than is given in the Handbook, see the pamphlet, "Radio transmission and the ionosphere", issued by the National Bureau of Standards.

represent the upper limit of useful distance (distance range), and also the lowest useful high frequency, for various powers radiated from the transmitter. These powers are for radiotelephone (phone) communication; for any given distance range, about 0.01 as much power would be required for radiotelegraph (CW) communication. For non-heterodyne reception of ICW (interrupted continuous wave) or MCW (modulated continuous wave) telegraph signals, the phone curves should be used. Non-directive transmission is assumed; a radiated power of 1 kw is taken as equivalent to a field intensity of 0.186 volt per meter measured at one mile from the transmitting antenna in the direction of the path from the transmitter to the receiver. If this field intensity is known to be F volts per meter, then the power to be used with the curves is $29F^2$.

The graphs are based on the lowest field intensity which permits practical reception in the presence of ordinary background interference or noise. As used here, practical reception does not mean, on the one hand, satisfactory broadcast program reception or, on the other hand, reception of extremely weak CW signals which would require much repetition and great effort to receive. The graphs also assume the use of a reasonably good receiving set and an operator of reasonably good ability. Each graph is labelled either "over open ocean" or "over or near land". This distinction is made because, when the receiving set is on shipboard far away from land in some latitudes the "static" is much less than when the receiving set is on or near land. The areas in which the "over or near land" graphs apply are shown cross-hatched in the map of Fig. 53; for receiving locations outside of the cross-hatched areas the "over open ocean" graphs apply.

For frequencies above the maximum usable frequency, the relatively short ground-wave distance range is shown, for a power of 1 kilowatt, by the lines made up of long dashes. There are two curves, one (marked "land") for transmission paths all or nearly all over land, the other (marked "ocean") for transmission paths all or nearly all over sea-water. As in the Handbook, the 1-kilowatt line is everywhere shown with long dashes.

Table 1 gives approximate factors by which the 1-kilowatt ground-wave distance range may be multiplied to obtain the distance range for other powers.

Table 1.
Factors for ground-wave distance ranges.

Radiated power, kilowatts		Land	Ocean
Phone	CW		
0.01	-	0.50	0.70
0.1	-	0.75	0.85
1.0	0.01	1.00	1.00
10.0	0.1	1.30	1.15
100.0	1.0	1.60	1.30
-	10.0	1.90	1.45
-	100.0	2.30	1.60

The high-frequency ground-wave calculations were made for antennas thirty feet high. The distance ranges given are for the ground wave alone, not considering the irregularly-reflected tropospheric wave. At frequencies above 10 megacycles, the tropospheric wave may sometimes produce fair transmission at distances as much as five times the "land" ground-wave range shown on the graphs.

For further information on the use of the distance-range graphs of Figs. 1 through 16, see pages 14-20 of the Handbook.

III. INTERMEDIATE METHOD: - ALL DISTANCES.

The attached Figs. 17 through 52 give the maximum usable frequencies and the lowest useful high frequencies for 1 kilowatt radiated power, for reception, at the time and latitude stated on each Fig., from a transmitter located anywhere in the world. They are "usable-frequency maps" of the same type as those (Figs. 33 to 62) in Sec. IV of the Handbook. The usable frequencies given in these Figs. are averages, for ionospherically quiet days, for transmission by way of the regular layers of the ionosphere. They are for the period from May through August, 1942, and were calculated by the methods given in the Appendix of the original Handbook, using the basic data given therein and in this Supplement.

The maximum usable frequencies may considerably exceed the values given in these Figs. during frequent irregular periods, because of reflections from clouds of "sporadic-E

layer"; during periods of disturbance and ionospheric storminess the maximum usable frequencies may be considerably less than, and the lowest useful high frequencies considerably greater than, the values shown; see "Anomalies", pages 11-14 of the Handbook.

In Figs. 17 through 52, as in the similar pseudo-maps in the Handbook, the ordinates are degrees of latitude, north and south of the equator, and the abscissas are the number of degrees of longitude that the transmitting location is east or west of the receiving location. The lines of longitude difference are spaced 15° because a longitude difference of 15° corresponds to one hour of time difference. The receiving location is always at the intersection of the vertical center line and the line of latitude for which the map is prepared. Thus if the transmitting location is 60° of longitude to the east of the receiving location and is at latitude 25°S, it is located on the map 4 squares to the right of the vertical center line (line of 0° longitude difference), and 2 1/2 squares below the horizontal 0° latitude line (equator).

Two sets of lowest-useful-high-frequency maps are given for each latitude and time of day, and are distinguished by the labels "over open ocean" and "over or near land". This distinction is the same as in the case of the distance-range graphs described above, and the areas to which each type of map applies are the same and are shown in Fig. 53.

Distances are not shown directly on these maps. The upper and lower limits of frequencies for transmission from any point in the world to the receiving points for which the maps are constructed may be obtained by reading off the frequencies on the curves which pass through the transmitting points. If desired, distance ranges and skip distances for any given frequency may be scaled from these maps by the use of the "great-circle maps" for latitudes 40° or 0° given as Figs. 67 and 69 in the Handbook. Thus, for a given great-circle path, determine the distances from the receiving point to the points where the great circle intersects the maximum-usable-frequency curves and the lowest-useful-high-frequency curve for the given frequency. The distances corresponding to the maximum-usable-frequency curves are the "skip distances", and the distance corresponding to the lowest-useful-high-frequency curve is the "distance range". Note that the distances on Figs. 67 and 69 of the Handbook are given in thousands of kilometers. One mile equals 1.6093 kilometers and one kilometer equals 0.6214 mile (see also discussion on p.33 of the Handbook).

As may be seen from Figs. 1 through 16, there are in most cases two skip distances for each frequency and great-circle path, an inner one which may be anywhere from 0 to 2500 miles from the receiving location, and an outer one which is generally more distant than 2500 miles from the receiving location. Within the region bounded by these two distances the radio waves will be transmitted and will not penetrate through the ionosphere; elsewhere they will not be transmitted because of penetration through the ionosphere. Usually, the distance range determines the upper, and the skip distance the lower, limit of distance for transmission.

The band of useful frequencies for transmission over any path may be determined by using these maps according to the procedure outlined on page 21 of the Handbook.

Procedure for Powers Other than One Kilowatt.- As stated on page 22 of the Handbook, the maximum usable frequency is independent of radiated power, but the lowest useful high frequency is not, and therefore correction must be made for a radiated power different from one kilowatt. The following procedure is suggested to replace the procedure outlined on page 22 of the Handbook. It is based on the fact that the distance range with a given power on a given frequency is the same as that with a lower power on a somewhat higher frequency, or with a higher power on a somewhat lower frequency. This is only an approximation; for precise distance-range determinations it is necessary to follow in detail the procedure of calculation outlined in the Appendix of the Handbook, and it would be necessary to construct a separate map for each value of radiated power.

The maps of lowest useful high frequency are given for a radiated power of 1 kilowatt, radiotelephone (phone) transmission. For other radiated powers, or for CW transmission (heterodyne reception), for which only 0.01 of the radiated power is required as for phone transmission of equal intelligibility, the following procedure may be used:

(a) Determine the lowest useful high frequency (for 1-kilowatt phone) from the maps,

(b) Use the nomogram, Fig. 54, (for method of use, see example shown on nomogram)* to determine the lowest useful high frequency for the power actually used, or

*A nomogram is a graphical device for rapid calculation by means of aligning straightedges with numbers on two or more scales and reading the answer on another scale.

(c) Add to or subtract from the 1-kw phone value of lowest useful high frequency in megacycles the appropriate number taken from Table 2 below, but bear in mind that the lowest frequency considered here is 2 megacycles. If the l.u.h.f. calculated is less than 2 megacycles the value to be taken is 2 megacycles.

Table 2

Factors for Lowest Useful High Frequency

Radiated power, kilowatts		
Phone	CW	
0.01	-	Add 5.2 Mc to the l.u.h.f.
0.1	-	Add 2.2 Mc to the l.u.h.f.
1.0	0.01	Use the l.u.h.f. as given
10.0	0.1	Subtract 1.7 Mc from the l.u.h.f.
100.0	1.0	Subtract 2.9 Mc from the l.u.h.f.
-	10.0	Subtract 3.8 Mc from the l.u.h.f.
-	100.0	Subtract 4.5 Mc from the l.u.h.f.

Range of Usefulness of the Maps.- The maps are given for two latitudes of receiving station and for six times of day. The maps labelled 40°N may be used for receiving stations located between latitudes 30°N and 50°N, while those labeled 0° may be used for receiving stations located between 10°S and 10°N. Their accuracy becomes less, the greater the difference between the receiving stations latitude and the latitude for which the map is constructed. For other latitudes and for times of day other than those specified on the maps, usable frequencies may be determined by interpolation.

For further remarks on the use of the maps, interpolation, variation, etc., see the discussion on pages 20-23 of the Handbook. The distance ranges and lowest useful high frequencies in the summer of 1943 will probably be but little different from the values given here for the summer of 1942; the distance ranges will probably be slightly greater, and the lowest useful high frequencies slightly lower, for the summer of 1943 than for the summer of 1942. The maximum usable frequencies for May through August 1943 will probably be about 10% less than those given in this supplement for the period May through

August 1942; the skip distances will thus be somewhat greater. If these variations are kept in mind, the distance-range graphs and the usable-frequency maps given here may be used for the summer of 1943. Conditions for November 1942 through February 1943 are discussed in the Handbook, page 23. Equinoctial conditions are quite different from summer or winter conditions.

IV. MORE EXACT METHODS: - SHORT DISTANCES.

The methods in this Section are slightly more complicated than those of Secs. II and III, but less so than the basic calculations given in Sec. V. Some users may find it easier to use the tables and nomograms of this Section than to use graphs, especially where there are a large number of graphs to be examined and chosen from. No single series of graphs can represent all the possible variations of the factors involved in distance-range or usable-frequency determination. More comprehensive data may be given by a small number of tables and nomograms than by a large number of graphs.

There is no practical way of simplifying the picture of radio transmission over distances of 4000 miles or more. For such long-distance transmission, the paths must be individually examined and analyzed in some such way as in the Appendix of the Handbook. Hence, for great distances, the distance-range graphs and the usable-frequency maps in the Handbook and in this Supplement are to be used, supplemented when necessary by calculations according to the Handbook Appendix.

For distances less than about 4000 miles, however, this Section provides a rapid means of determining distance ranges and usable frequencies for a wide variety of conditions which are met in practice. The data are given in the form of tables and nomograms. Some of the data are given in both tabular and nomographic form; each person may use the form most convenient for him. A detailed description of the tables and nomograms follows.

Maximum Usable Frequency.- The regular-layer maximum usable frequency for any distance up to 4000 miles is determined by multiplying a certain frequency, dependent on latitude and time of day, by a factor dependent on the distance. It has nothing to do with radiated power or noise level at the receiver.

The basic data are the maximum usable frequencies for transmission by way of the E layer for a path 1000 miles in

in length, and by way of the F or F_2 layer for a path 2200 miles in length. For transmission paths of lengths other than these, maximum usable frequencies are different and must be calculated. These frequencies are given for every point in the world in the maps of Figs. 68 and 69, the direct use of which in more accurate computations is described in the next Section. For the purposes of this Section, however, these frequencies are listed numerically in Table 3 (pages 17-18) for every two hours during the day and for every 20° of latitude, for reception from the north, east, south, and west.

The first step is to select the frequency numbers which most nearly represent conditions over the transmission path. For example, for a receiver at 55°N, 0800 local time, receiving from the east, the 2200-mile m.u.f. would be 13.9 Mc, and the 1000-mile m.u.f. would be 14.5 Mc, as determined from Table 3. These frequencies can be determined more precisely, for the midpoint of the transmission path, from the maps, using the method described in the Appendix of the Handbook, but the values obtained from the table are accurate enough for most purposes.

The maximum usable frequency is the greater of the two values obtained by multiplying the 1000-mile E m.u.f. and the 2200-mile F m.u.f. by their respective factors for the given distance from table 4, or alternatively, the greater of the two values obtained by entering the distance and the frequency in the two nomograms Figs. 55 and 56.* The skip distance for a given frequency may also be calculated at the given time, location, and azimuth, by using the fact that the maximum usable frequency for any distance is the frequency for which that distance is the skip distance.

*This procedure takes into account F_1-layer transmission also. Detailed consideration of this is outside the scope of the discussion in this Handbook Supplement.

Table 4

Distance Factors for Maximum Usable Frequency

(Maximum usable frequency for a given distance is the greater of the two values obtained by multiplying the 1000-mile E m.u.f. and the 2200-mile F m.u.f. (from Table 3 or from Figs. 68 and 69) by the factors in this Table for the given distance).

Distance in miles	For E-layer transmission	For F- or F_2-layer transmission
0	0.23	0.37
200	0.33	0.38
400	0.54	0.41
600	0.72	0.47
800	0.89	0.57
1000	1.00	0.67
1200	1.05	0.75
1400	1.07	0.82
1600	1.08	0.88
1800	1.08	0.94
2000	1.07	0.98
2200	1.05	1.00
2400	1.00	1.02
2500	0.95	1.03

In the example above, where the 1000-mile E m.u.f. is 14.5 Mc and the 2200-mile F m.u.f. is 13.9 Mc, suppose the transmission path is 600 miles long. From table 4 the factors for 600 miles are 0.72 for E-layer transmission, and 0.47 for F- or F_2-layer transmission. The maximum usable frequency is thus the greater of the two frequencies obtained by multiplying 0.72 x 14.5 Mc = 10.4 Mc and 0.47 x 13.9 Mc = 6.5 Mc. The maximum usable frequency is thus determined by E-layer transmission, and is 10.4 Mc for the example given; conversely the skip distance for 10.4 Mc is 600 miles. The same result could be obtained also by using the nomograms.

If desired, it could be determined whether E-layer or F-layer calculations would be necessary by the use of the nomogram of Fig. 57, or by taking the ratio of the 1000-mile E m.u.f. to the 2200-mile F m.u.f. and consulting Table 5.

Table 5

Distances for Which to Use Tables, Maps, and Nomograms

Ratio $\frac{\text{1000-mi.E m.u.f.}}{\text{2200-mi.F m.u.f.}}$	Use F, F_2-layer tables, map, nomogram	Use E-layer tables, map, nomogram	Use F, F_2-layer tables, map, nomogram
2.50	0 to 100 mi.	100 to beyond 2500 mi.	-
1.50	0 to 170 mi.	170 to beyond 2500 mi.	-
1.00	0 to 270 mi.	270 to beyond 2500 mi.	-
0.90	0 to 310 mi.	310 to 2200 mi.	2200 to beyond 2500 mi.
0.80	0 to 400 mi.	400 to 1200 mi.	1200 to beyond 2500 mi.
0.70	0 to 520 mi.	520 to 910 mi.	910 to beyond 2500 mi.
0.65	0 to beyond 2500 mi.	-	-

Lowest Useful High Frequency.- Five nomograms are given for determining the lowest useful high frequency for any time of day, for stations located between 50°S and 50°N. These are based on predicted average conditions, for quiet days, for transmission by way of the regular layers. They also give distance ranges, since the lowest useful high frequency for a given distance and power is the frequency for which that distance is the distance range for the given power.

The method of use of the nomograms is illustrated by the examples shown thereon. The frequency range covered is 2 to 30 megacycles; and the range of radiated power is from 0.1 kilowatt (phone) to 1000 kilowatts (CW). Fig. 58, labelled 40°S, may be used for receiving locations between 50°S and 20°S. No distinction is made between land and ocean locations, because at this time of year static conditions are not bad in these latitudes. Figs. 59 and 61, labelled 0°, may be used for receiving locations between 20°S and 20°N, and Figs. 60 and 62, labelled 40°N, may be used for receiving locations between 20°N and 50°N.

The sky-wave distance range and skip distance, and the range of useful frequencies, are completely determined by the procedure outlined above (pages 9-12).

Ground-Wave Distance Ranges.- The distance range of the ground wave over land or sea may be determined by use of the two nomograms of Figs. 63 and 64. Because of the wide variety of receiving conditions which may be encountered, a "field intensity factor A" is used instead of the radiated power. This factor is taken as $A = 4 + \log_{10} F^2/P$ where F is the required field intensity in microvolts per meter and P is the radiated power in kilowatts. The field intensity factor "A" thus includes not only radiated power, but also the type of receiving set and noise conditions, the latter two of which have elsewhere been included jointly as an average "required field intensity". For example, an insensitive receiving set in a mobile army unit where the noise level is high would correspond to a large field intensity factor, while a sensitive receiving set in a relatively noise-free location would correspond to a low field intensity factor.

Table 6 gives approximate values of the field intensity factor for various types of receiving sets, noise conditions, and values of radiated power. The nomogram of Fig. 65 gives a more precise determination of the factor, provided the required field intensity and the radiated power are known.

Table 6

Estimated Values of Field Intensity Factor "A"

(To be used with ground-wave nomograms of Figs. 63 and 64).

Power		Good receiving set			Average receiving set			Poor receiving set		
		Quiet	Mod. noise	Bad noise	Quiet	Mod. noise	Bad noise	Quiet	Mod. noise	Bad noise
Phone	low	6	9	12	8	11	14	10	12	14
	medium	4	7	10	6	9	12	8	10	12
	high	2	5	8	4	7	10	6	8	10
CW	low	4	7	10	6	9	12	8	10	12
	medium	2	5	8	4	7	10	6	8	10
	high	0	3	6	2	5	8	4	6	8

Given the field intensity factor A, the ground-wave distance range for any frequency may be determined directly from the nomograms of Figs. 63 and 64. These are for vertical antennas 30 feet high, and for average ground and sea water, respectively. They are for the ground wave alone, and do not take into account the irregularly reflected tropospheric wave, which can considerably increase the distance range on high frequencies. In fact, on frequencies of 10 megacycles or greater the distance range due to this tropospheric wave may occasionally exceed five times the distance range of the ground wave over land.

Low-Frequency Distance Ranges.- Two nomograms are given for the rapid estimation of sky-wave distance ranges on frequencies below 1000 kilocycles. These are Figs. 66 and 67. They are given only for the range of latitudes 10°S to 50°N, and for two times of day: "day", or the period from about sunrise to sunset, and "night", or the period from a little after sunset to a little before sunrise.

V. PRECISE METHODS USING BASIC DATA.

This Section gives information similar to that in the Appendix of the Handbook. Figs. 68 and 69 give the basic data from which to calculate maximum usable frequencies; they show directly maximum usable frequencies over the entire world, for any latitude and local time, for 2200-mile F- or F_2-layer, and for 1000-mile E-layer transmission. They are similar to Fig. 63 of the Handbook, which, however, shows only the F- and F_2-layer values. In this Supplement Fig. 69 shows E-layer frequencies for the parts of the world for which the E layer determines the maximum usable frequency for some distance. The number on each curve of Fig. 68 is the 2200-mile F m.u.f. in megacycles. The curves of Fig. 69 are similarly for the 1000-mile E m.u.f. These maps are for average ionosphere conditions during quiet days, May through August, 1942, for transmission by way of the regular ionosphere layers. On days of ionosphere storms the maximum usable frequencies may differ greatly from the values shown. The maximum usable frequencies may, at frequent irregular intervals, considerably exceed the values calculated from these maps, because of reflections from clouds of sporadic-E layer (see "Variations and Irregularities", pp.19-20 of the Handbook).

The method of using these maps for transmission distances greater than 2500 miles has been outlined on pages 35 and 36 of the Handbook. Only the F-layer-frequency map need be used for these paths. Briefly, this method consists of superposing a plot of the great-circle path from

the transmitting station to the receiving station on the map of Fig. 68 at the correct local times, and noting the lowest frequency curve which the path encounters. If this occurs at either end of the path, the maximum usable frequency for the path is the value at a point 1200 miles from that end toward the middle of the path; if it occurs somewhere along the path, the maximum usable frequency is the lower of the two values at points on the path 600 miles either way from the point where the lowest value occurs.

To determine the maximum usable frequency for paths shorter than 2500 miles, determine first the approximate latitude and local time of the midpoint of the path. Obtain from the maps of Figs. 68 and 69 the 1000-mile E m.u.f. and the 2200-mile F m.u.f. at this place (if the place lies in a part of the map where no E-layer curves are shown, E-layer transmission does not have to be considered). Using the nomograms of Figs. 55 and 56 (or the factors in Table 4) calculate maximum usable frequencies for the desired distance for the two modes of transmission (E- and F-layer). The greater of these two values is the actual maximum usable frequency for the path. The skip distance may then also be calculated, since the maximum usable frequency for a given distance is also the frequency for which the given distance is the skip distance.

For example, consider the maximum usable frequency for a 750-mile path whose midpoint is at latitude 40°N, at 1100 local time. The 2200-mile F m.u.f. is 15.7 megacycles, and the 1000-mile E m.u.f. is 16.1 megacycles. Multiplying by the factors for 750 miles from table 5 gives, for F_2-layer transmission 8.6 megacycles, and, for E-layer transmission 13.7 megacycles. The maximum usable frequency is thus 13.7 megacycles, and, conversely, the skip distance for 13.7 megacycles is 750 miles.

Note that the maximum usable frequency thus obtained is independent of radiated power or of noise conditions at the receiving point. It is the same in both directions over the same path.

Fig. 70 is the absorption-index map of the world for the months of May through August. It is similar to the map of Fig. 64 in the Handbook, and is to be used in exactly the same way as described on pages 30-35 of the Handbook. In so using it, the great-circle maps of Figs. 65 through 69 of the Handbook are to be used, and also the "absorption constant" curve and the "unabsorbed field intensity" curve, Figs. 70 and 71 of the original Handbook. The "required

field intensity" curves to be used for the months of May through August are, however, different from those in the Handbook. They are given, for stations between 50°S and 20°S in Fig. 71, and for stations between 20°S and 50°N, located at sea or on or near land, in Figs. 72 and 73.

Fig. 53 gives a map of the world showing the areas in which "static" is likely to be severe and for which the "over or near land" curves and graphs are to be used.

VI. SOURCES

Ionosphere and field-intensity data used in the preparation of the Handbook and this Supplement were obtained from the following sources:

(a) Ionosphere data:

National Bureau of Standards, Washington, D.C.
University of Puerto Rico, San Juan, P.R.
1941 Louise A. Boyd Expedition to waters west of Greenland.
Leland Stanford University, Calif.
College, Alaska, observatory of Carnegie Institution of Washington.
Huancayo, Peru, observatory of Carnegie Institution of Washington.
Watheroo, Western Australia, observatory of Carnegie Institution of Washington.
Canadian Government.
British Government.

(b) Field intensity data:

National Bureau of Standards, Washington, D.C.
University of Puerto Rico, San Juan, P.R.
1941 Louise A. Boyd Expedition to waters west of Greenland.
Louisiana State University, Baton Rouge, La.
Leland Stanford University, California.
College, Alaska, observatory of Carnegie Institution of Washington.
Federal Communications Commission, Washington, D.C.

The first five sources under (a) and the first six sources under (b) are associated in a cooperative project of radio transmission measurements under sponsorship of Communications Section, National Defense Research Committee.

Table 3

Maximum Usable Frequencies
(for 1000-mile E-layer and 2200-mile F- or F_2-layer transmission. See text for computation of other distances).
In Megacycles. May through August, 1942.

Local time of day		00	02	04	06	08	10	12	14	16	18	20	22
70°N to N.Pole													
F	North	13.4	13.5	13.6	13.5	13.2	13.0	13.0	13.0	13.1	13.2	13.5	13.5
	East	12.4	13.0	13.4	14.0	14.8	15.0	14.9	14.1	13.5	12.7	12.1	12.1
	South	11.8	11.5	12.0	12.6	13.3	14.6	15.7	16.2	16.0	15.0	13.7	12.8
	West	12.9	12.3	12.1	12.3	12.9	13.3	13.9	14.7	15.0	14.9	14.3	13.6
E	North	12.6	12.6	12.5	12.5	12.5	12.4	12.4	12.4	12.5	12.5	12.5	12.6
	East	11.0	12.1	12.8	13.5	13.7	13.7	13.5	12.8	12.0	11.0	10.6	10.8
	South	9.0	9.6	10.6	12.1	13.4	14.2	14.3	14.2	13.4	12.1	10.6	9.6
	West	11.0	10.8	10.6	11.0	12.0	12.8	13.5	13.7	13.7	13.5	12.8	12.1
50°N to 70°N													
F	North	11.9	11.7	12.2	13.0	13.5	14.6	15.7	16.1	15.5	15.6	13.5	12.7
	East	11.0	10.7	11.5	12.5	13.9	15.0	15.2	15.2	15.1	14.6	13.7	12.3
	South	12.2	9.7	8.9	11.0	12.8	14.8	15.2	15.2	15.2	15.7	16.0	14.5
	West	12.8	11.3	10.4	11.1	12.1	13.4	14.8	15.1	15.2	15.2	15.1	14.2
E	North	10.0	10.1	11.1	12.4	13.4	14.0	14.0	14.0	13.4	12.4	11.0	10.7
	East	-	9.0	11.3	13.2	14.5	15.0	15.1	15.0	14.5	10.5	-	-
	South	-	-	8.1	11.5	13.8	15.1	15.9	15.1	13.8	11.5	-	-
	West	-	-	8.0	10.5	12.6	14.1	15.1	14.1	12.6	13.2	11.1	-
30°N to 50°N													
F	North	12.2	9.8	9.5	11.3	12.8	14.6	14.9	14.7	14.7	15.2	15.5	13.9
	East	11.9	8.7	9.5	11.9	14.4	15.8	16.9	17.0	17.2	17.9	17.0	14.8
	South	15.5	12.8	10.0	11.6	14.0	17.0	19.7	20.5	20.5	20.5	20.3	18.5
	West	14.7	12.0	8.8	9.3	11.8	14.3	15.8	16.8	17.0	17.1	17.9	17.0
E	North	4.0	5.0	8.6	11.6	13.7	15.0	15.7	15.0	13.75	11.6	8.2	5.0
	East	-	-	8.9	12.5	14.7	16.05	16.05	14.7	12.6	8.7	-	-
	South	-	-	-	10.4	13.6	15.6	16.4	15.7	13.6	10.5	-	-
	West	-	-	-	8.9	12.5	14.6	16.1	16.1	14.7	12.6	8.8	-
10°N to 30°N													
F	North	15.4	12.0	9.0	11.3	13.7	15.9	18.9	19.5	19.5	20.0	19.8	17.7
	East	17.6	14.0	12.2	14.1	17.4	20.9	23.3	23.8	23.2	22.4	21.6	20.0
	South	21.0	17.6	13.9	15.1	17.9	20.5	22.3	23.0	23.4	23.6	23.3	22.5
	West	19.9	16.9	13.5	12.5	14.8	18.2	21.7	23.7	23.8	23.2	22.2	21.3
E	North	-	-	4.8	10.6	13.7	15.5	16.3	15.6	13.6	10.6	-	-
	East	-	-	6.5	11.6	14.4	16.1	16.2	14.9	12.2	6.9	-	-
	South	-	-	-	7.6	13.1	15.3	16.2	15.4	13.1	9.0	-	-
	West	-	-	-	-	12.1	15.0	16.3	16.1	14.3	11.8	5.0	-

Table 3. Maximum Usable Frequencies, May through August 1942
(continued)

Local time of day		00	02	04	06	08	10	12	14	16	18	20	22
10°S to 10°N													
F	North	20.5	17.3	13.7	15.2	17.9	20.6	23.0	24.3	24.0	23.7	23.3	22.4
	East	19.8	16.0	12.3	15.6	19.5	19.0	20.0	20.0	20.2	21.0	21.2	20.9
	South	17.3	14.2	11.7	12.2	19.5	17.0	16.5	16.5	16.5	16.6	17.0	17.0
	West	20.6	18.8	14.75	12.0	16.6	19.0	19.0	19.8	20.0	20.4	21.2	21.2
E	North	-	-	-	9.1	13.3	15.4	16.2	15.5	13.4	9.0	-	-
	East	-	-	-	10.1	13.8	15.6	15.7	14.4	11.4	-	-	-
	South	-	-	-	4.5	12.1	14.6	15.3	14.4	11.9	5.5	-	-
	West	-	-	-	-	11.5	14.3	15.7	15.5	13.7	10.0	-	-
10°S to 30°S													
F	North	18.0	16.0	1[illegible].0	12.6	19.3	16.9	16.5	16.8	16.8	17.0	18.6	17.6
	East	13.0	11.4	9.0	14.8	19.1	18.5	18.3	18.9	19.0	17.0	13.1	13.2
	South	8.0	8.0	8.2	8.2	17.0	21.1	22.4	22.0	22.3	16.0	9.6	8.0
	West	13.5	13.0	10.9	8.9	16.5	19.0	18.4	21.9	18.9	18.9	16.0	13.0
E	North	-	-	-	5.2	12.3	14.6	15.3	14.5	12.1	6.5	-	-
	East	-	-	-	8.0	12.9	14.5	14.6	13.1	9.2	-	-	-
	South	-	-	-	-	10.0	13.0	13.9	13.1	10.0	-	-	-
	West	-	-	-	-	9.4	13.1	14.6	14.5	12.8	8.4	-	-
30°S to 50°S													
F	North	9.0	9.2	8.6	8.3	18.2	21.5	21.5	22.1	21.4	18.0	10.2	8.9
	East	6.4	7.3	7.0	8.5	19.0	21.9	22.5	21.8	17.0	8.2	6.4	5.8
	South	4.7	5.6	6.6	5.9	8.5	16.0	19.3	19.5	16.3	8.0	5.2	4.5
	West	5.0	6.4	7.3	6.9	8.5	19.0	21.9	22.4	21.9	18.0	8.8	6.4
E	North	-	-	-	-	10.4	13.2	14.2	13.3	10.3	-	-	-
	East	-	-	-	-	11.2	13.0	13.1	11.1	4.5	-	-	-
	South	-	-	-	-	4.6	10.9	11.8	11.0	6.7	-	-	-
	West	-	-	-	-	-	11.1	13.1	13.0	11.1	-	-	-
50°S to 70°S													
F	North	4.8	5.8	6.7	5.9	9.5	18.0	20.1	20.4	17.8	9.5	5.6	4.7
	East	5.0	6.0	5.7	6.0	13.0	17.2	18.0	15.8	8.9	5.0	4.0	4.2
	South	4.3	5.0	5.5	5.5	5.8	8.0	12.5	13.0	9.0	5.8	4.0	3.7
	West	4.0	4.7	5.6	6.0	5.8	8.5	15.7	18.0	17.0	13.2	5.7	4.4
E	North	-	-	-	-	6.5	11.3	12.1	11.3	7.1	-	-	-
	East	-	-	-	-	9.0	11.1	10.5	6.5	-	-	-	-
	South	-	-	-	-	-	6.0	7.1	6.0	-	-	-	-
	West	-	-	-	-	-	6.5	10.5	11.1	8.3	-	-	-
70°S to S.Pole													
F	North	4.9	5.0	5.7	5.6	5.9	9.8	14.2	14.5	10.5	6.0	4.1	3.5
	East	5.5	5.5	5.8	6.1	10.5	13.0	10.0	7.0	4.7	3.8	3.9	4.6
	South	6.0	6.0	5.9	5.6	5.0	4.9	4.8	5.1	5.5	4.7	5.8	5.9
	West	3.9	3.9	4.9	5.3	5.5	5.7	6.0	9.7	12.9	11.0	7.2	5.0
E	North	-	-	-	-	-	6.8	8.9	7.5	-	-	-	-
	East	-	-	-	-	7.0	6.1	-	-	-	-	-	-
	South	-	-	-	-	-	-	-	-	-	-	-	-
	West	-	-	-	-	-	-	-	6.1	6.8	-	-	-

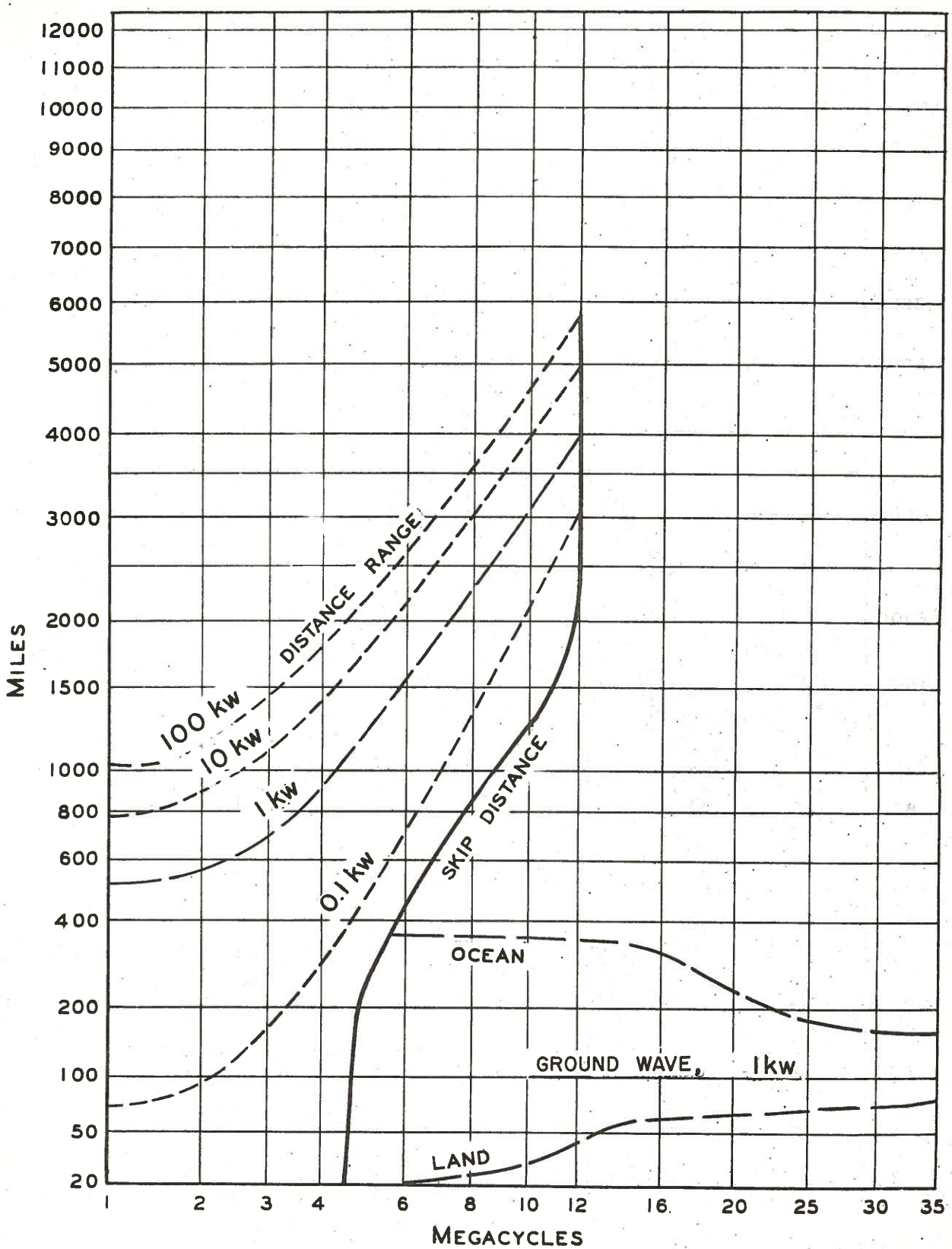


FIG. 1. RADIO DISTANCE RANGES.

MAY THROUGH AUG. 1942.

LATITUDE 40° N. 0000 LOCAL TIME. AZIMUTH

(POWERS SHOWN ON CURVES ARE FOR PHONE TRANSMISSION. POWERS FOR CW TRANSMISSION ARE 0.01 AS GREAT.)

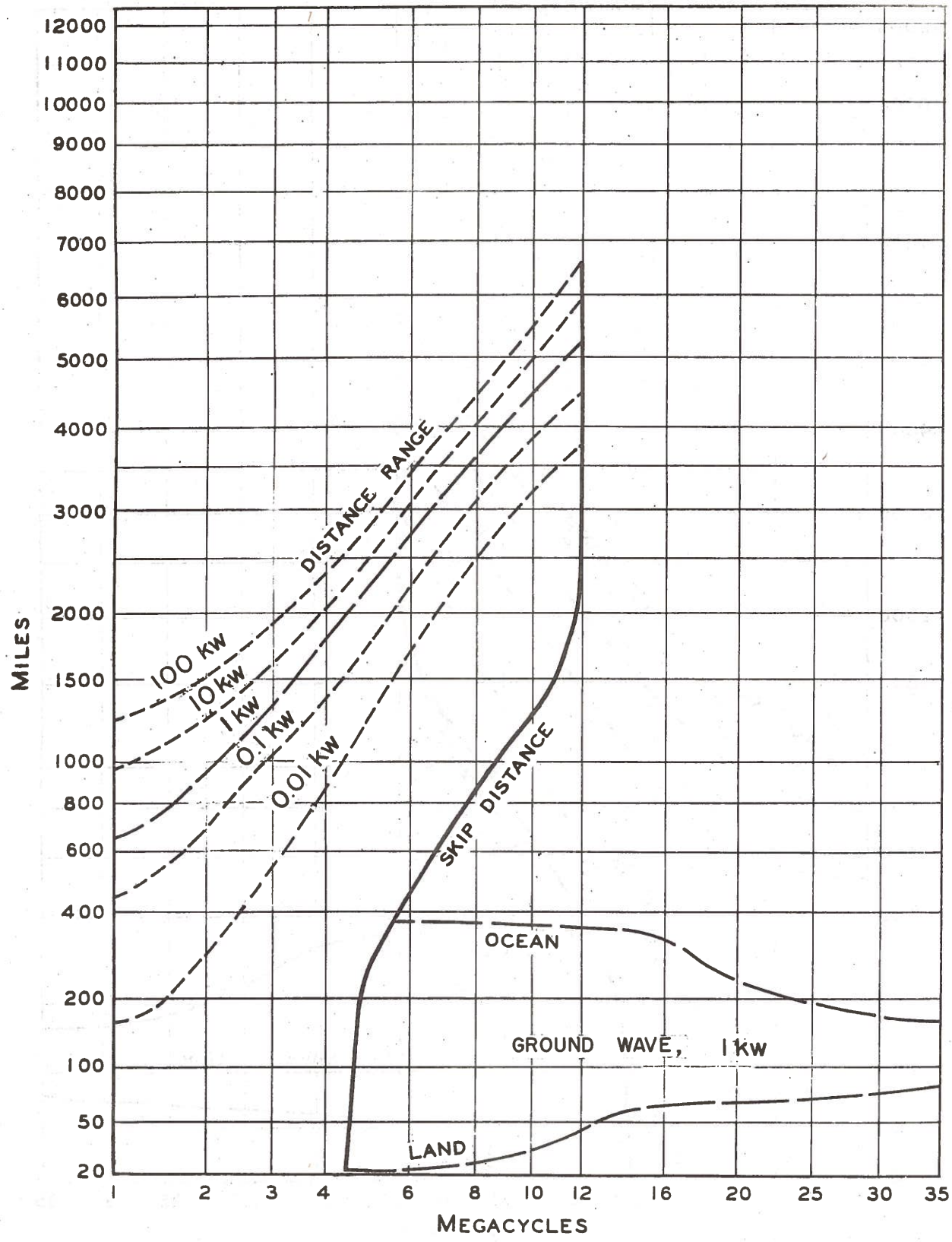


FIG 2. RADIO DISTANCE RANGES.

MAY THROUGH AUG. 1942 OVER OPEN OCEAN.
LATITUDE 40° N. 0000 LOCAL TIME AZIMUTH 0°.

(POWERS SHOWN ON CURVES ARE FOR PHONE TRANSMISSION.
POWERS FOR CW TRANSMISSION ARE 0.01 AS GREAT.)

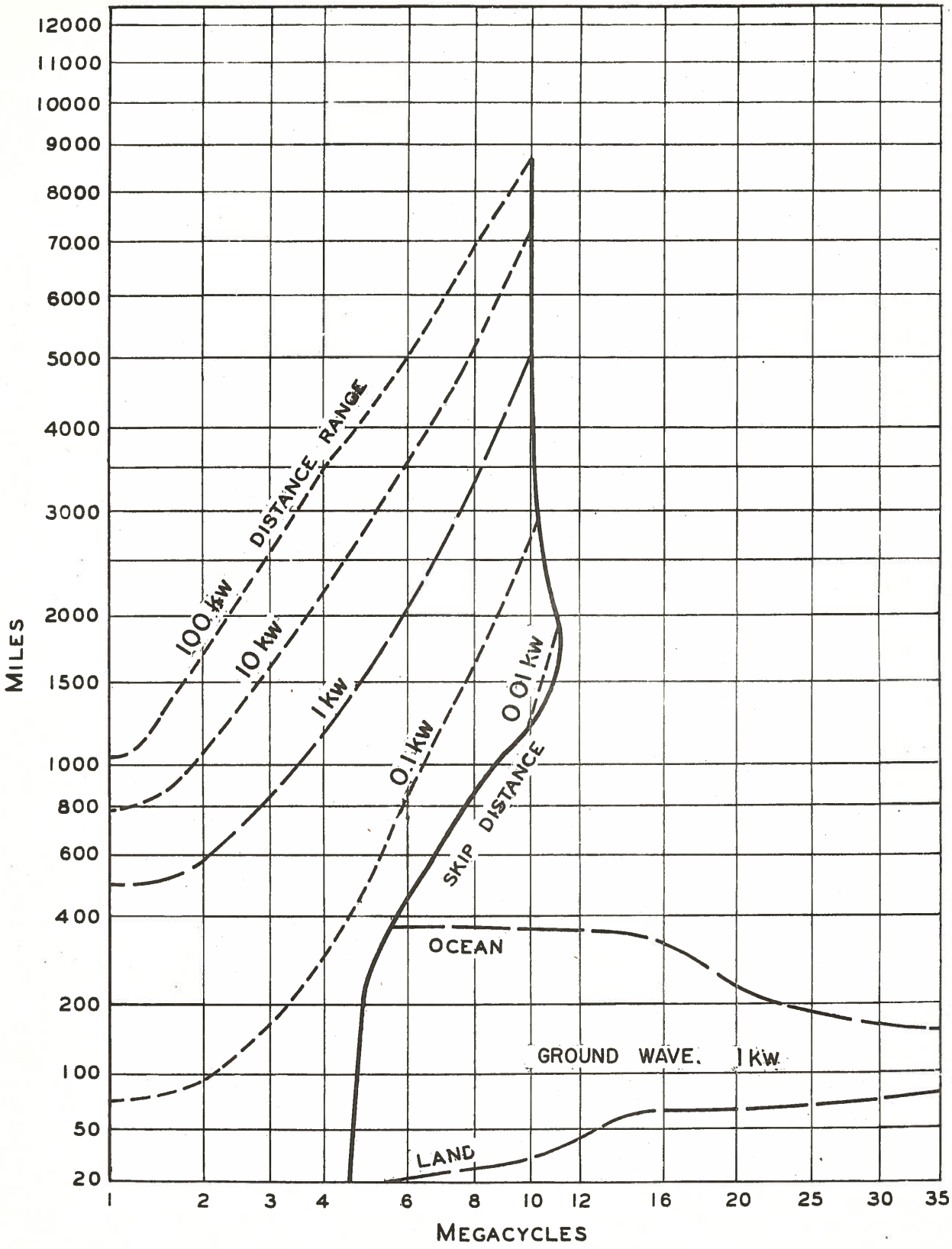


FIG. 3. RADIO DISTANCE RANGES.

MAY THROUGH AUG. 1942. OVER OR NEAR LAND.

LATITUDE 40° N. 0000 LOCAL TIME. AZIMUTH 90°.

(POWERS SHOWN ON CURVES ARE FOR PHONE TRANSMISSION
POWERS FOR CW TRANSMISSION ARE 0.01 AS GREAT.)

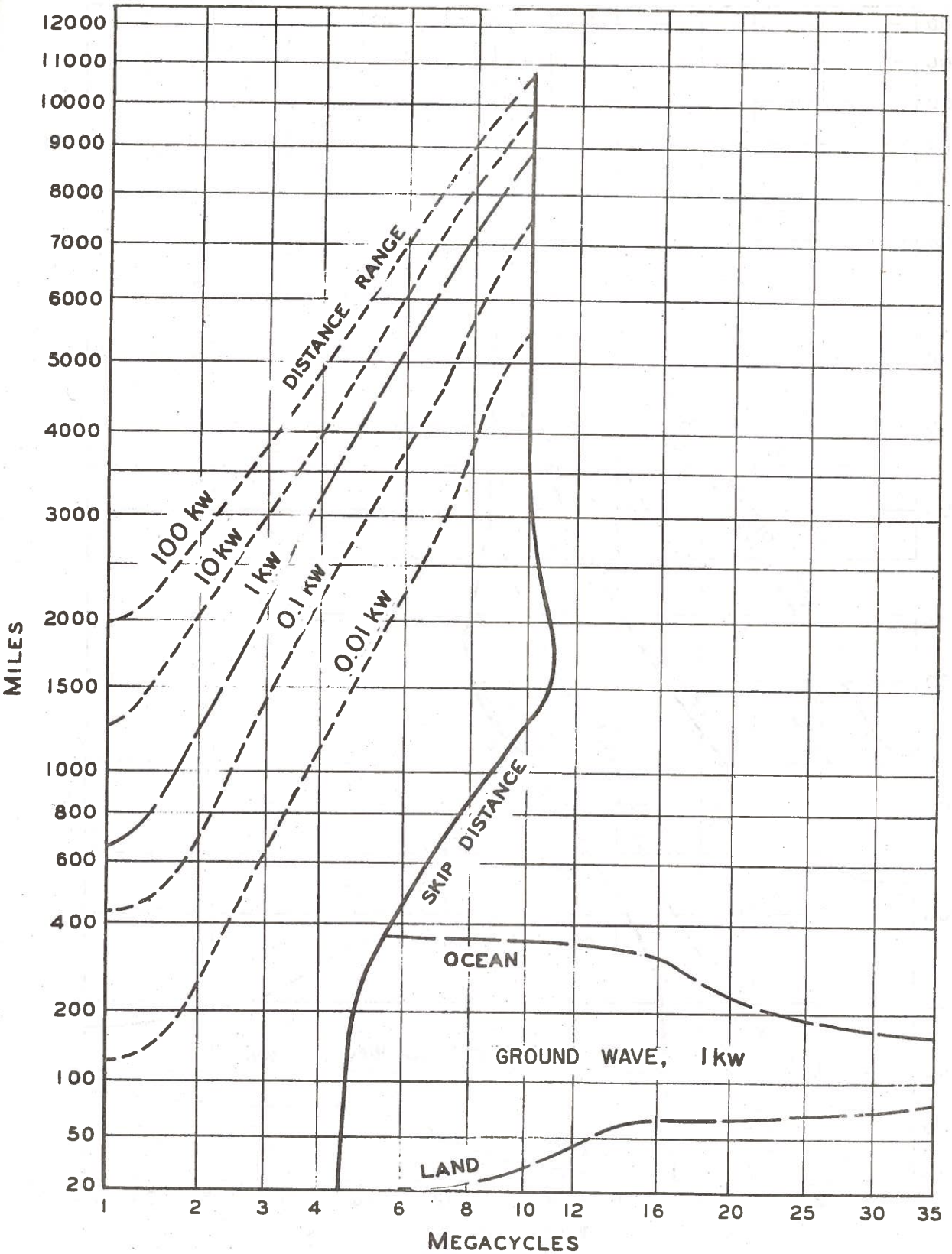


FIG. 4. RADIO DISTANCE RANGES

MAY THROUGH AUG. 1942. OVER OPEN OCEAN.
LATITUDE 40° N. 0000 LOCAL TIME. AZIMUTH 90°.

(POWERS SHOWN ON CURVES ARE FOR PHONE TRANSMISSION.
POWERS FOR CW TRANSMISSION ARE 0.01 AS GREAT.)

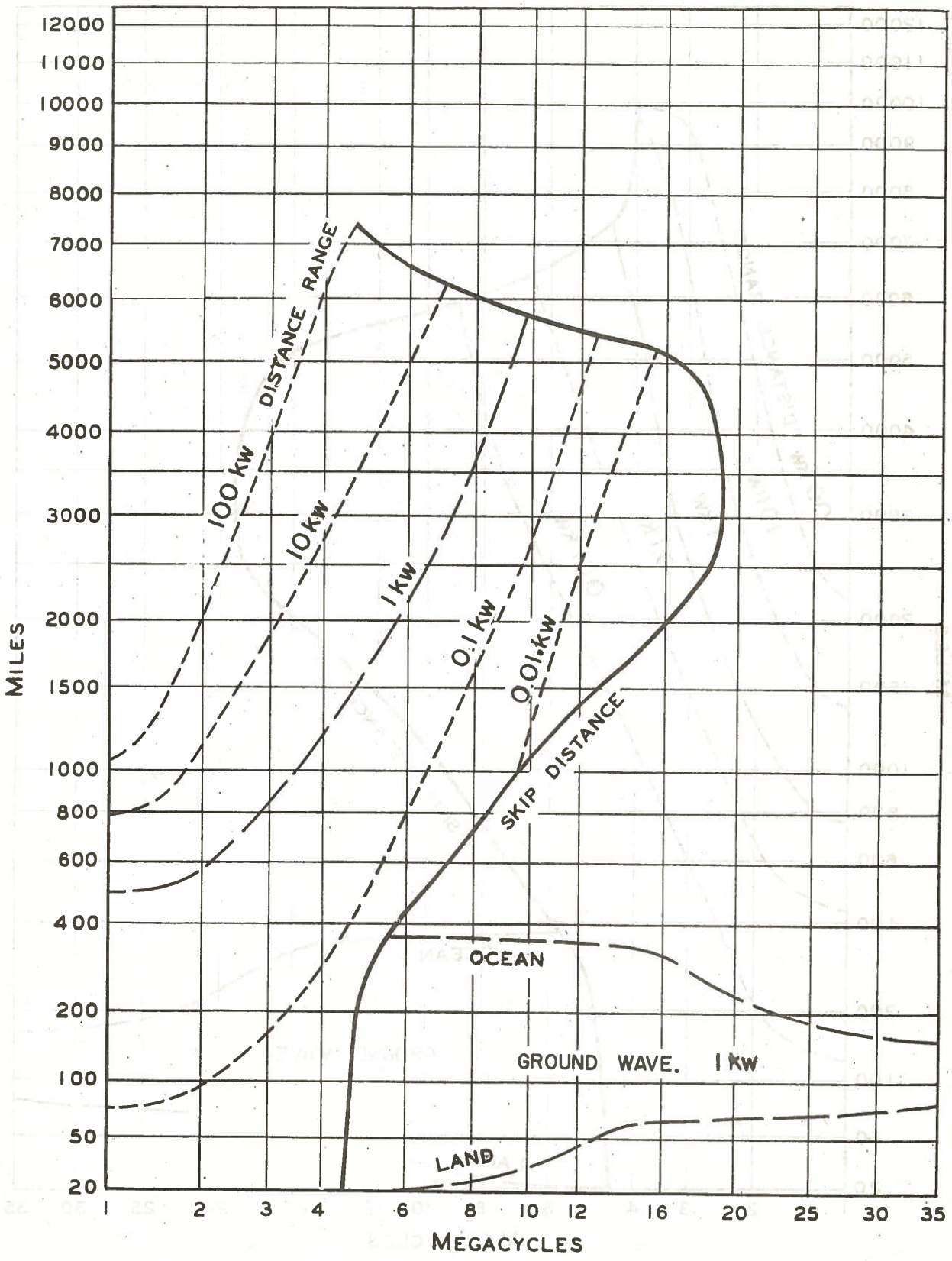


FIG. 5. RADIO DISTANCE RANGES.

MAY THROUGH AUG. 1942. OVER OR NEAR LAND.
LATITUDE 40° N. 0000 LOCAL TIME. AZIMUTH 180°.

(POWERS SHOWN ON CURVES ARE FOR PHONE TRANSMISSION.
POWERS FOR CW TRANSMISSION ARE 0.01 AS GREAT.)

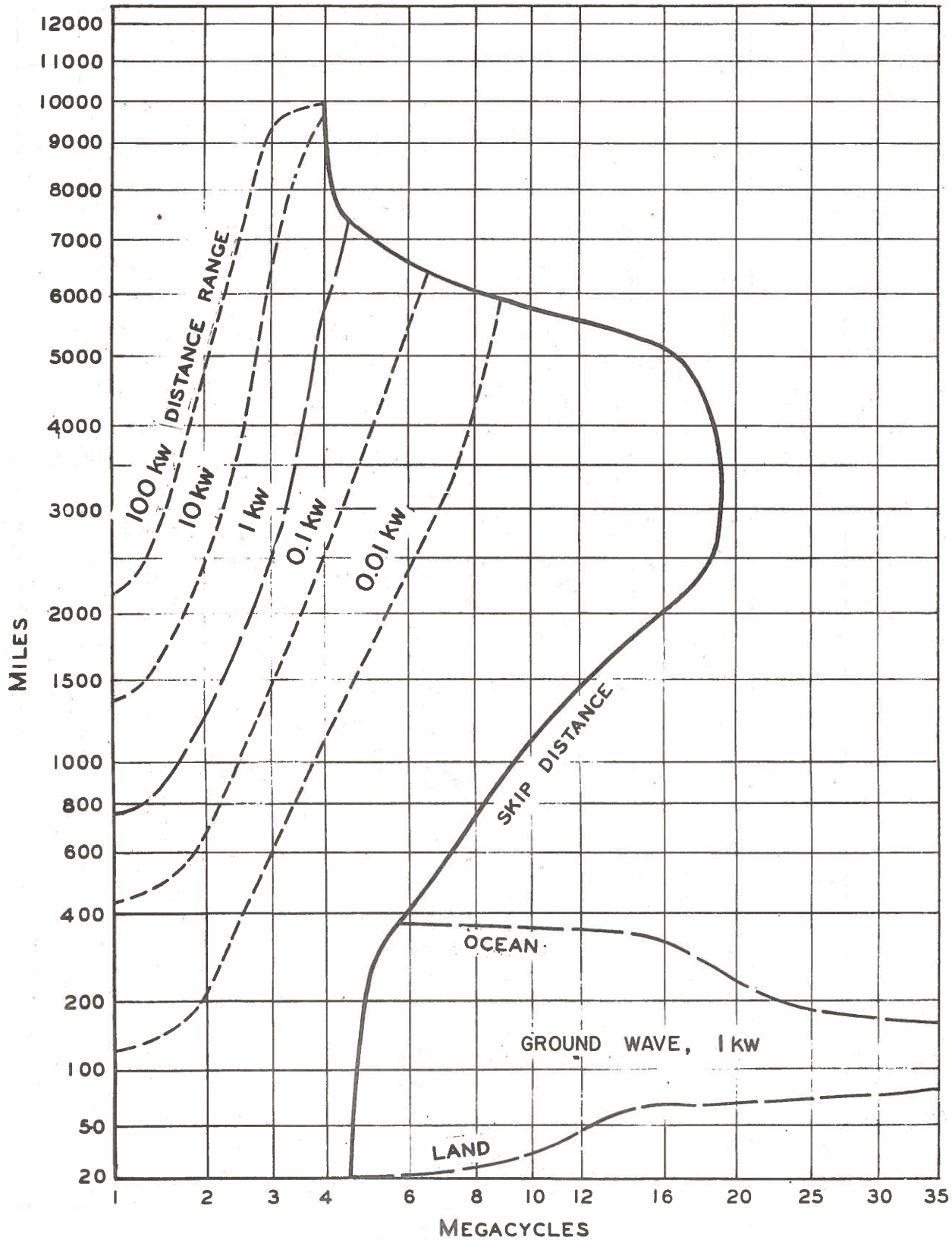


FIG. 6. RADIO DISTANCE RANGES.

MAY THROUGH AUG. 1942. OVER OPEN OCEAN.
LATITUDE 40° N. 0000 LOCAL TIME. AZIMUTH 180°.

(POWERS SHOWN ON CURVES ARE FOR PHONE TRANSMISSION.
POWERS FOR CW TRANSMISSION ARE 0.01 AS GREAT.)

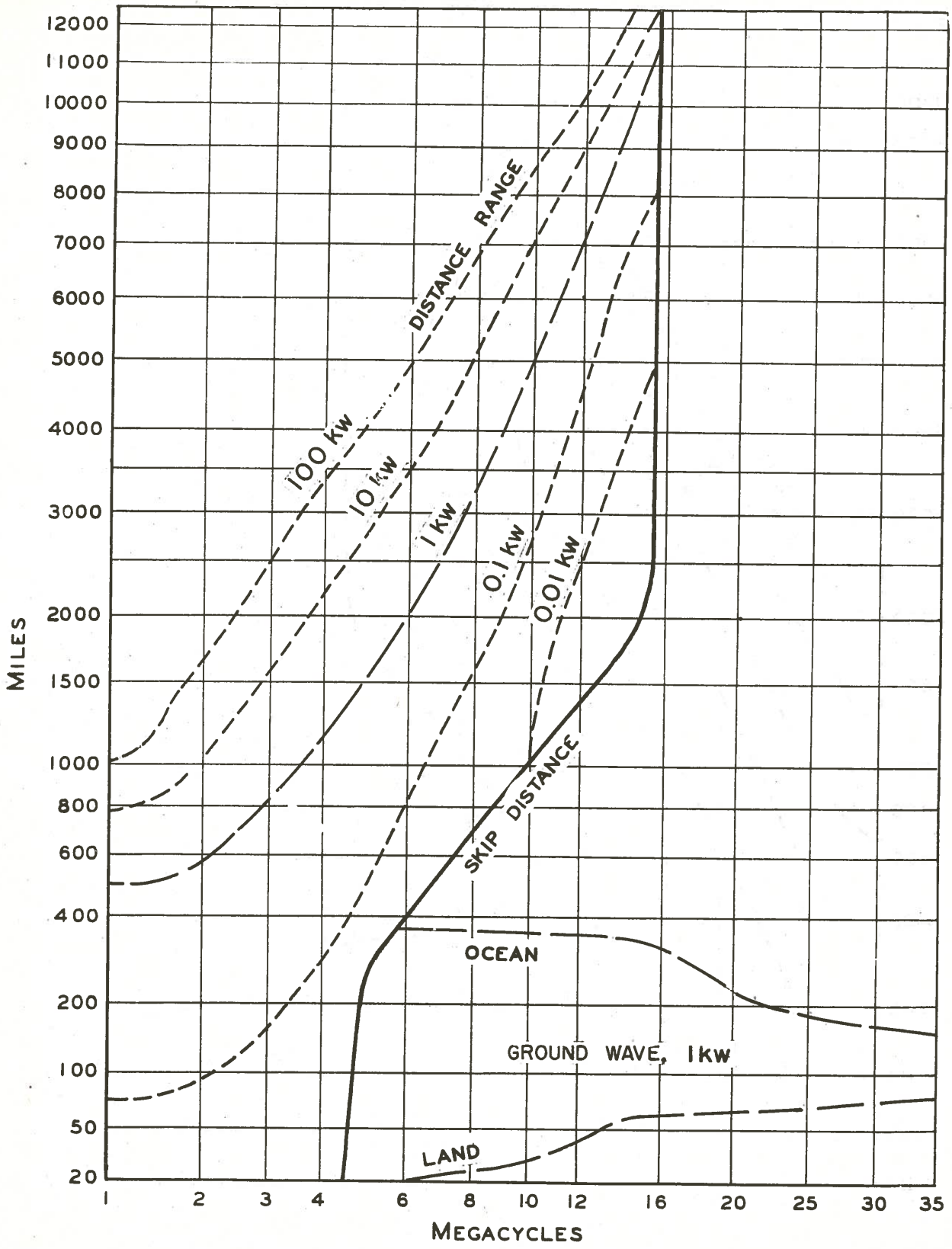


FIG. 7 RADIO DISTANCE RANGES.

MAY THROUGH AUG. 1942. OVER OR NEAR LAND.
LATITUDE 40° N. 0000 LOCAL TIME. AZIMUTH 270°.

(POWERS SHOWN ON CURVES ARE FOR PHONE TRANSMISSION.
POWERS FOR CW TRANSMISSION ARE 0.01 AS GREAT.)

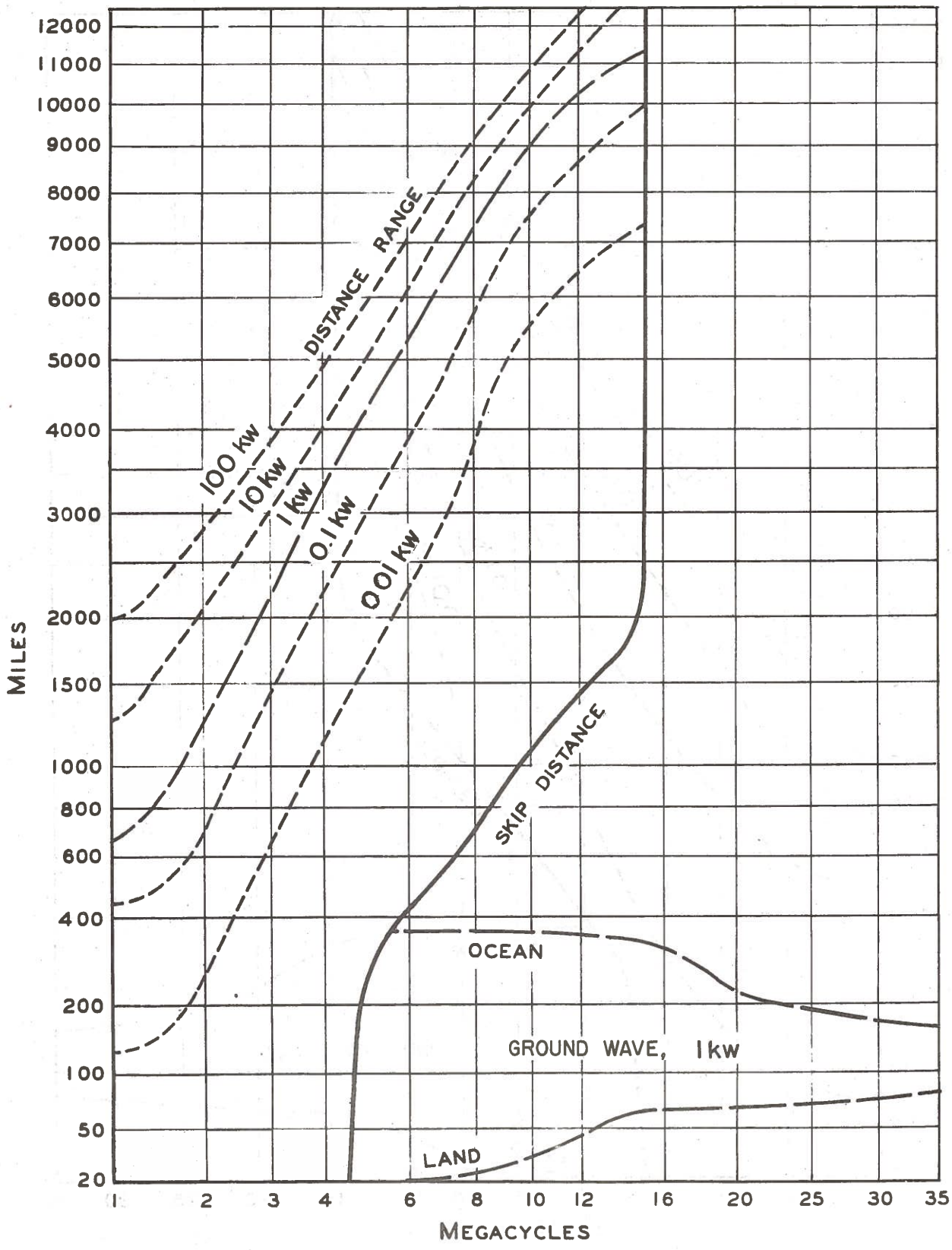


FIG. 8. RADIO DISTANCE RANGES.

MAY THROUGH AUG. 1942. OVER OPEN OCEAN.

LATITUDE 40° N. 0000 LOCAL TIME. AZIMUTH 270°.

(POWERS SHOWN ON CURVES ARE FOR PHONE TRANSMISSION. POWERS FOR CW TRANSMISSION ARE 0.01 AS GREAT.)

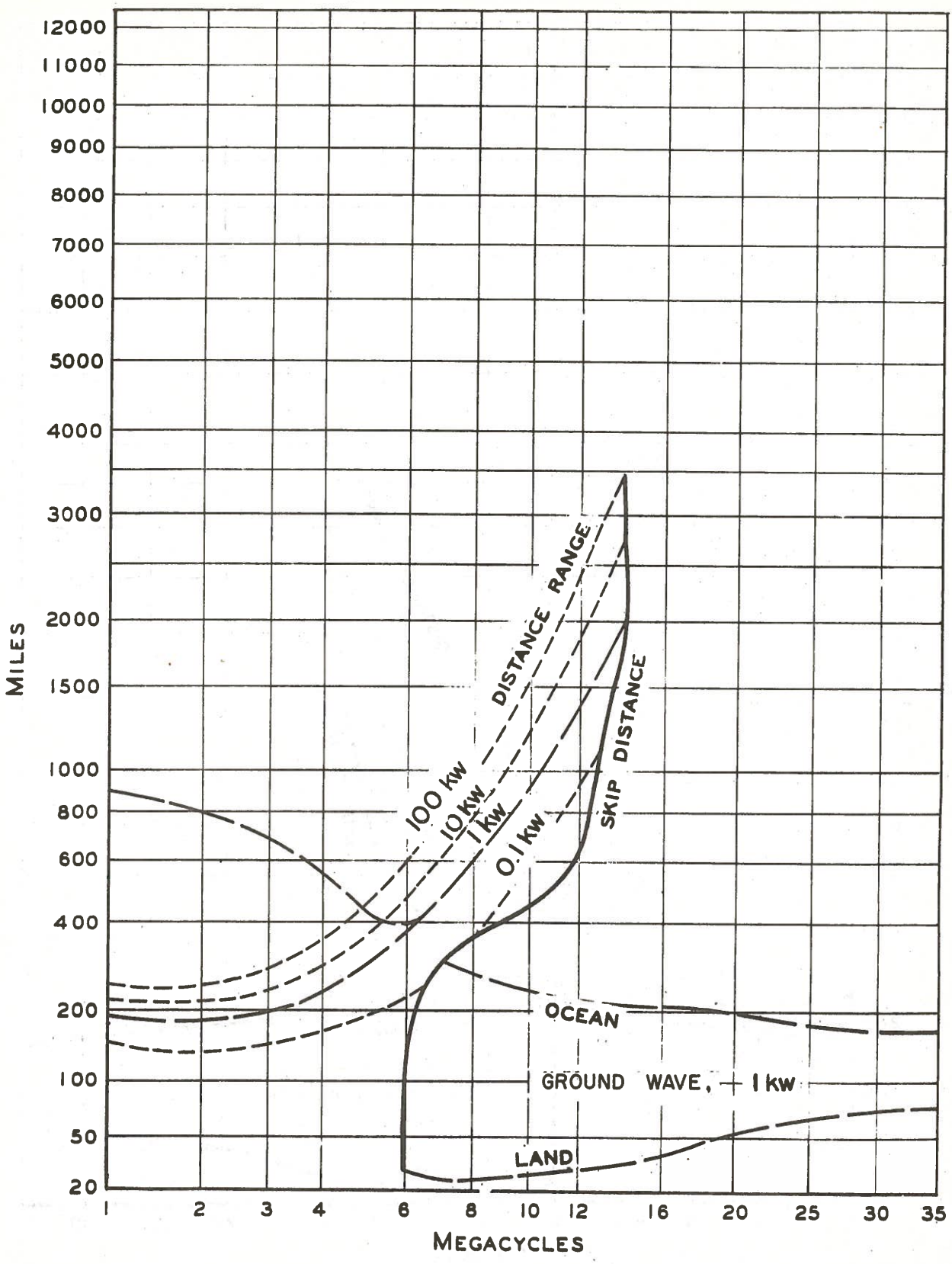


FIG. 9. RADIO DISTANCE RANGES.

MAY THROUGH AUG. 1942. OVER OR NEAR LAND
LATITUDE 40 N. 1200 LOCAL TIME. AZIMUTH 0°

(POWERS SHOWN ON CURVES ARE FOR PHONE TRANSMISSION.
POWERS FOR CW TRANSMISSION ARE 0.01 AS GREAT.)

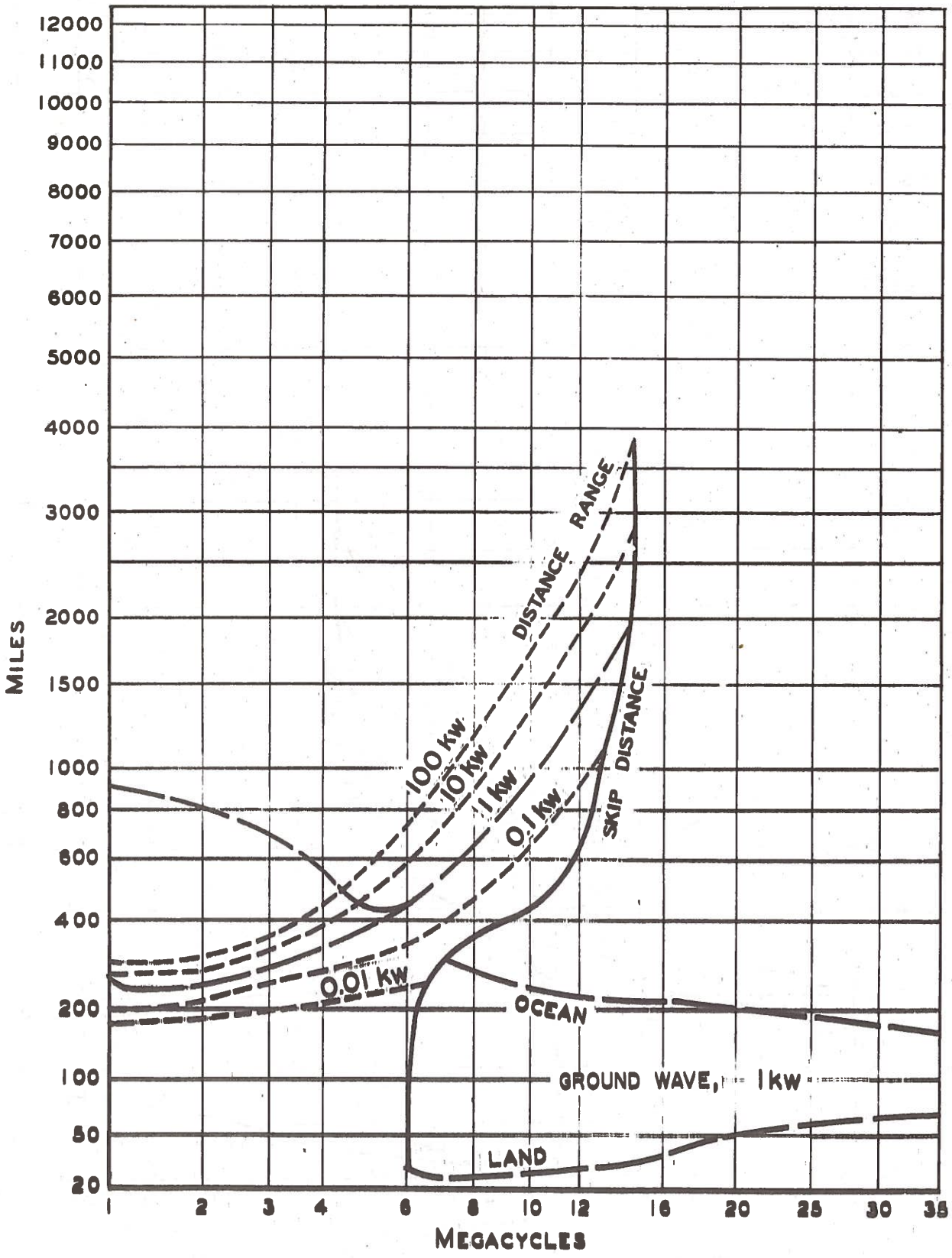


FIG. 10. RADIO DISTANCE RANGES.

MAY THROUGH AUG. 1942. OVER OPEN OCEAN.
LATITUDE 40° N. 1200 LOCAL TIME. AZIMUTH 0°.

(POWERS SHOWN ON CURVES ARE FOR PHONE TRANSMISSION.
POWERS FOR CW TRANSMISSION ARE 0.01 AS GREAT.)

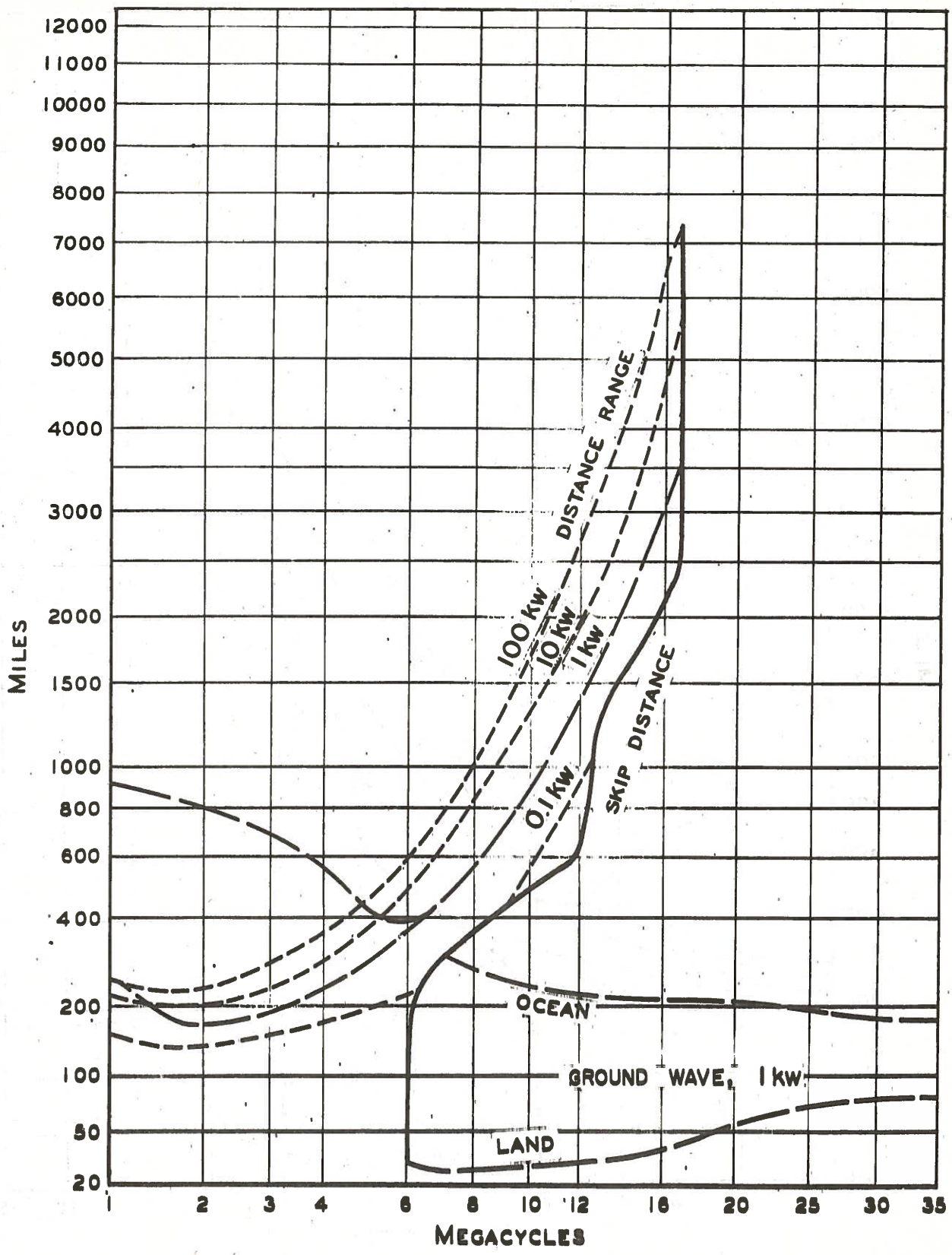


FIG. 11 RADIO DISTANCE RANGES.

MAY THROUGH AUG. 1942. OVER OR NEAR LAND.

LATITUDE 40° N. 1200 LOCAL TIME. AZIMUTH 90°.

(POWERS SHOWN ON CURVES ARE FOR PHONE TRANSMISSION. POWERS FOR CW TRANSMISSION ARE 0.01 AS GREAT.)

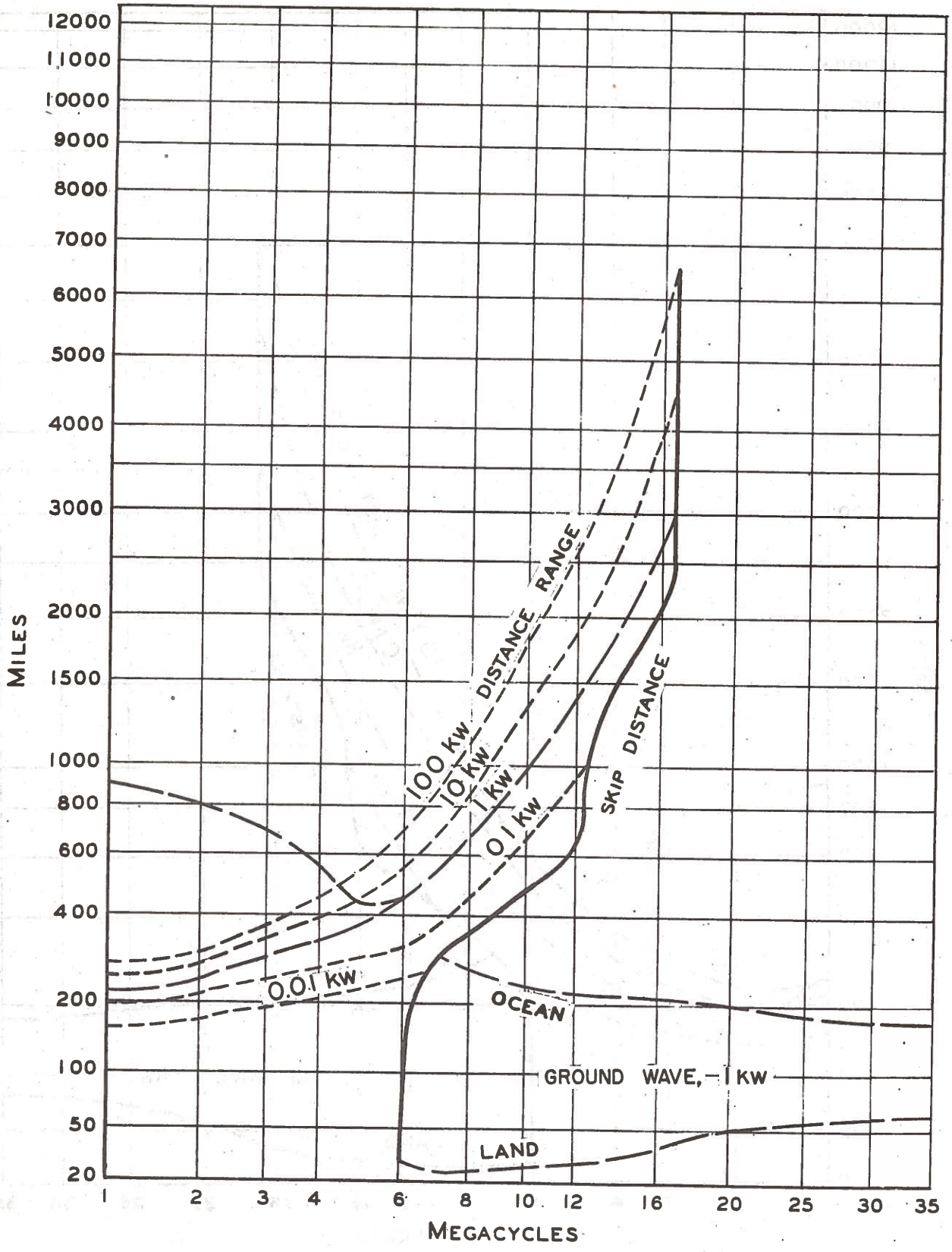


FIG. 12. RADIO DISTANCE RANGES.

MAY THROUGH AUG. 1942. OVER OPEN OCEAN.
LATITUDE 40° N. 1200 LOCAL TIME. AZIMUTH 90°.

(POWERS SHOWN ON CURVES ARE FOR PHONE TRANSMISSION.
POWERS FOR CW TRANSMISSION ARE 0.01 AS GREAT.)

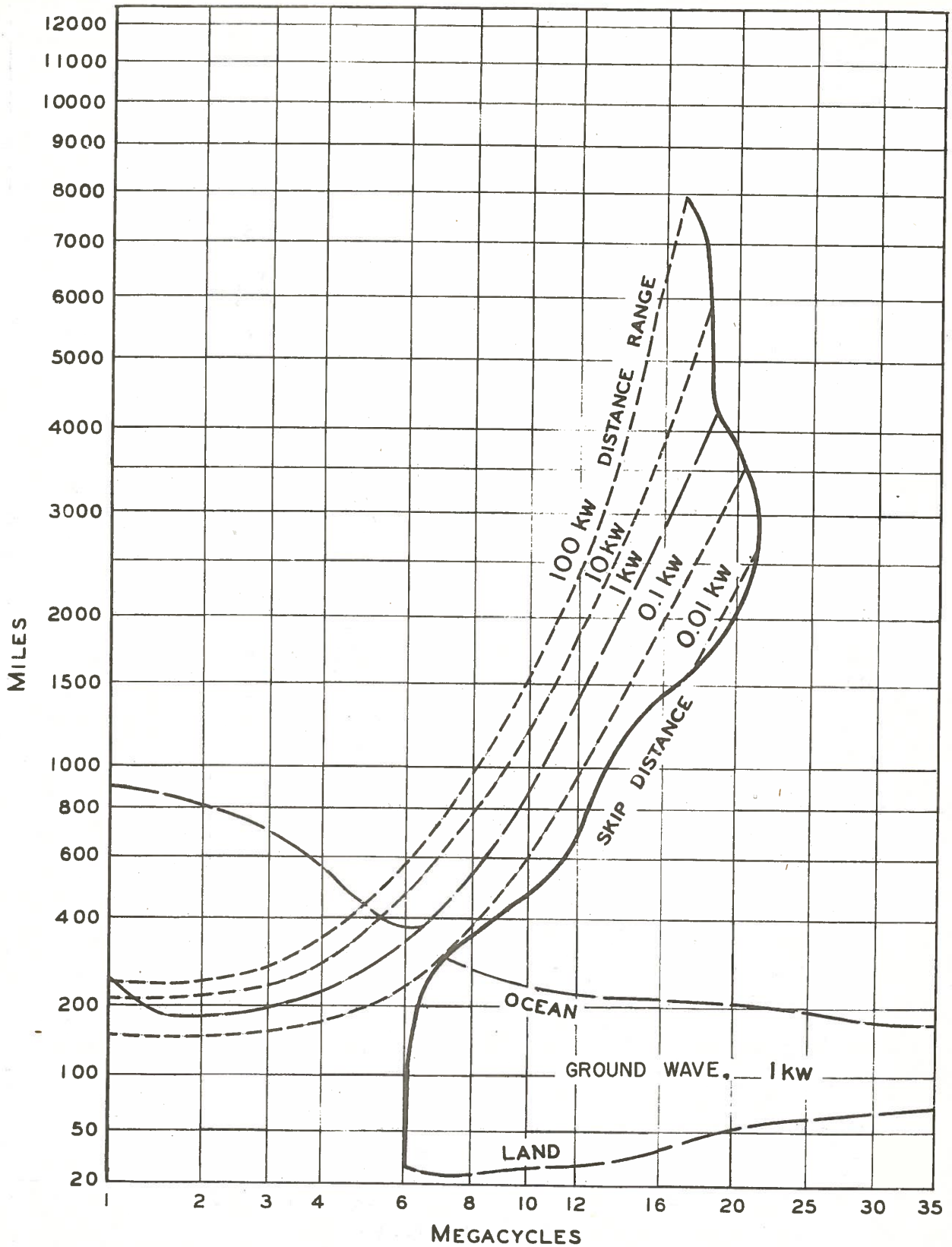


FIG. 13 RADIO DISTANCE RANGES.

MAY THROUGH AUG. 1942. OVER OR NEAR LAND.

LATITUDE 40° N. 1200 LOCAL TIME. AZIMUTH 180°.

(POWERS SHOWN ON CURVES ARE FOR PHONE TRANSMISSION. POWERS FOR CW TRANSMISSION ARE 0.01 AS GREAT.)

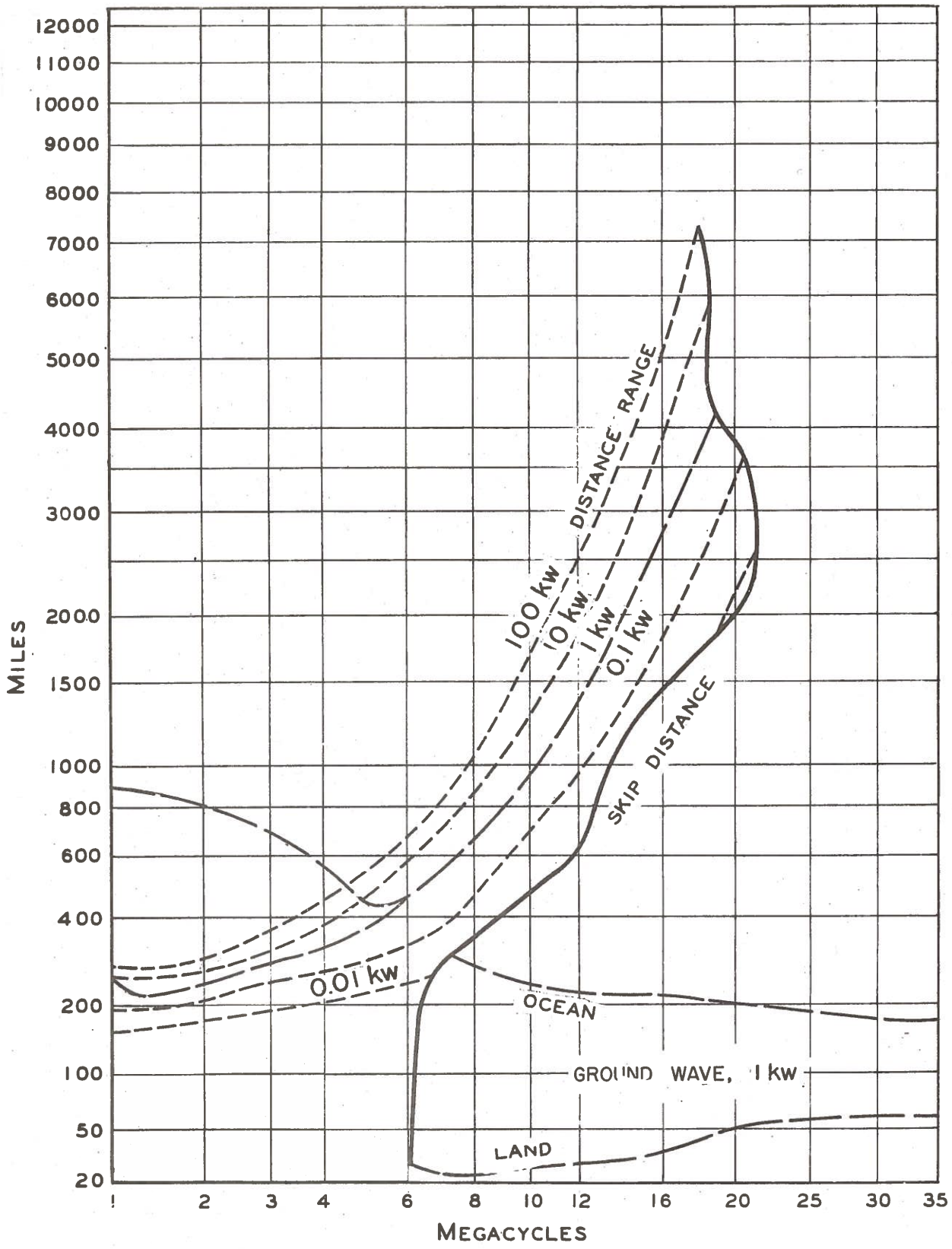


FIG. 14. RADIO DISTANCE RANGES.

MAY THROUGH AUG. 1942. OVER OPEN OCEAN.
LATITUDE 40° N. 1200 LOCAL TIME. AZIMUTH 180°.

(POWERS SHOWN ON CURVES ARE FOR PHONE TRANSMISSION.
POWERS FOR CW TRANSMISSION ARE 0.01 AS GREAT.)

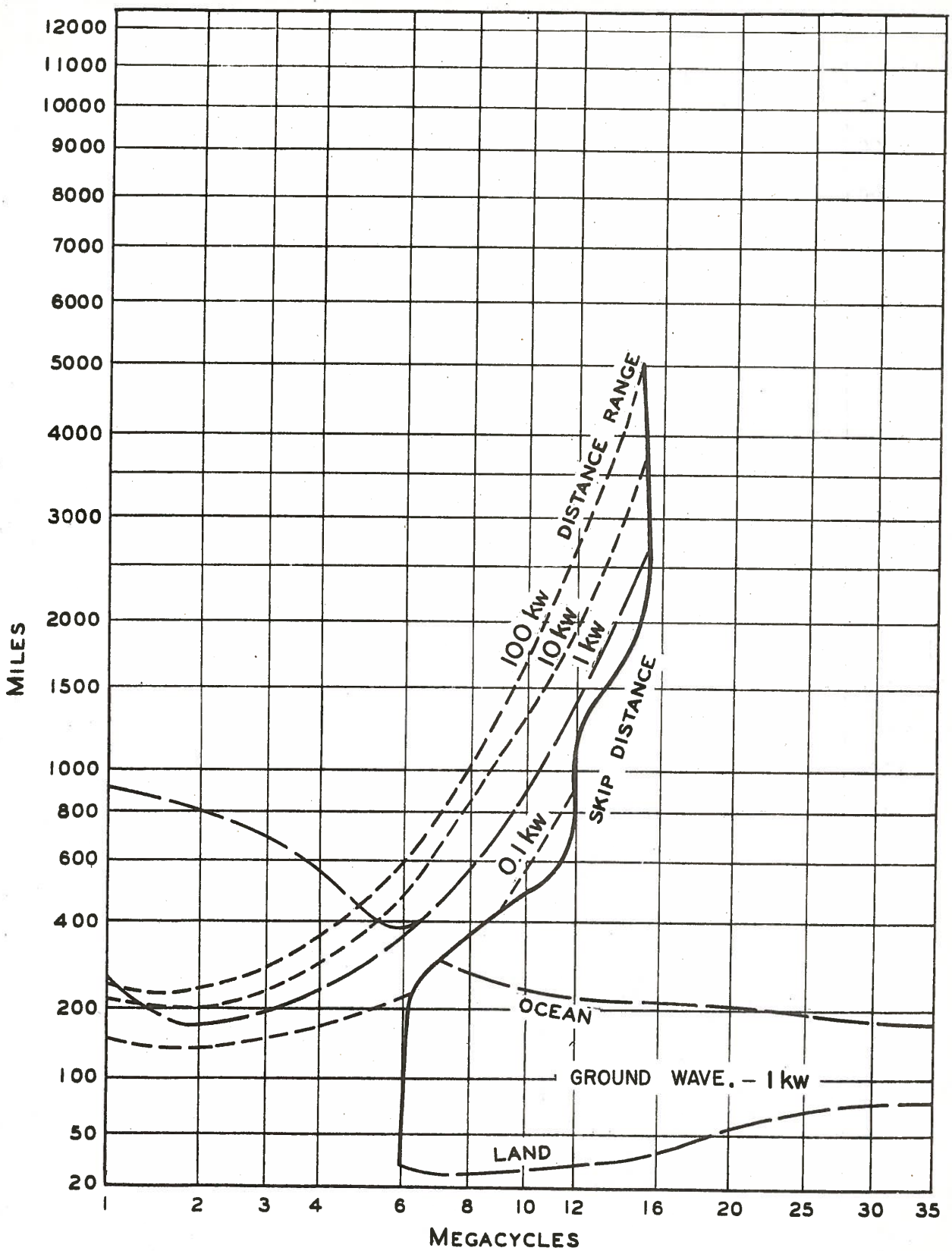


FIG. 15. RADIO DISTANCE RANGES.

MAY THROUGH AUG. 1942. OVER OR NFAR LAND.

LATITUDE 40° N. 1200 LOCAL TIME. AZIMUTH 270°

(POWERS SHOWN ON CURVES ARE FOR PHONE TRANSMISSION. POWERS FOR CW TRANSMISSION ARE 0.01 AS GREAT.)

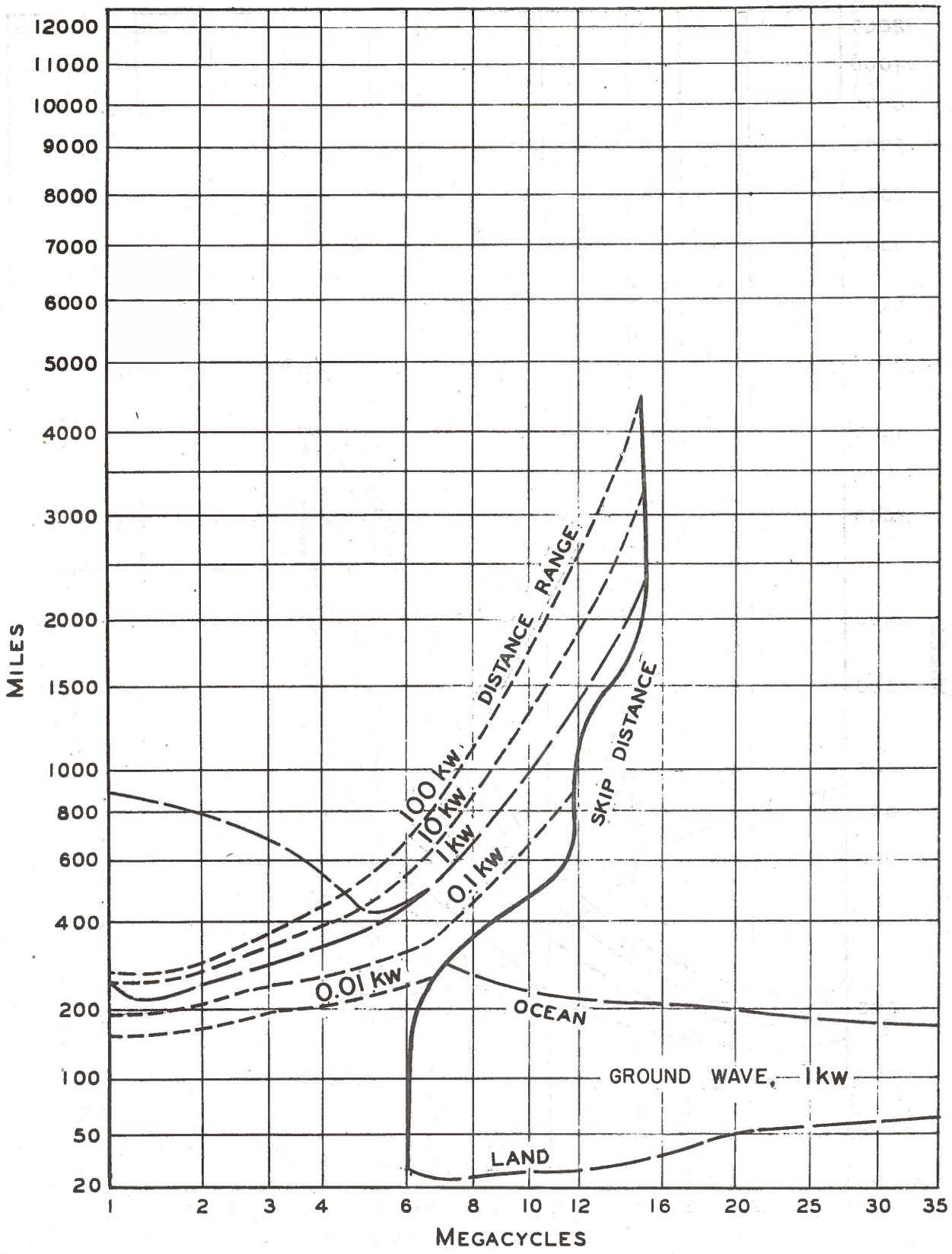


FIG. 16. RADIO DISTANCE RANGES.

MAY THROUGH AUG. 1942. OVER OPEN OCEAN.
LATITUDE 40° N. 1200 LOCAL TIME. AZIMUTH 270°

(POWERS SHOWN ON CURVES ARE FOR PHONE TRANSMISSION.
POWERS FOR CW TRANSMISSION ARE 0.01 AS GREAT.)

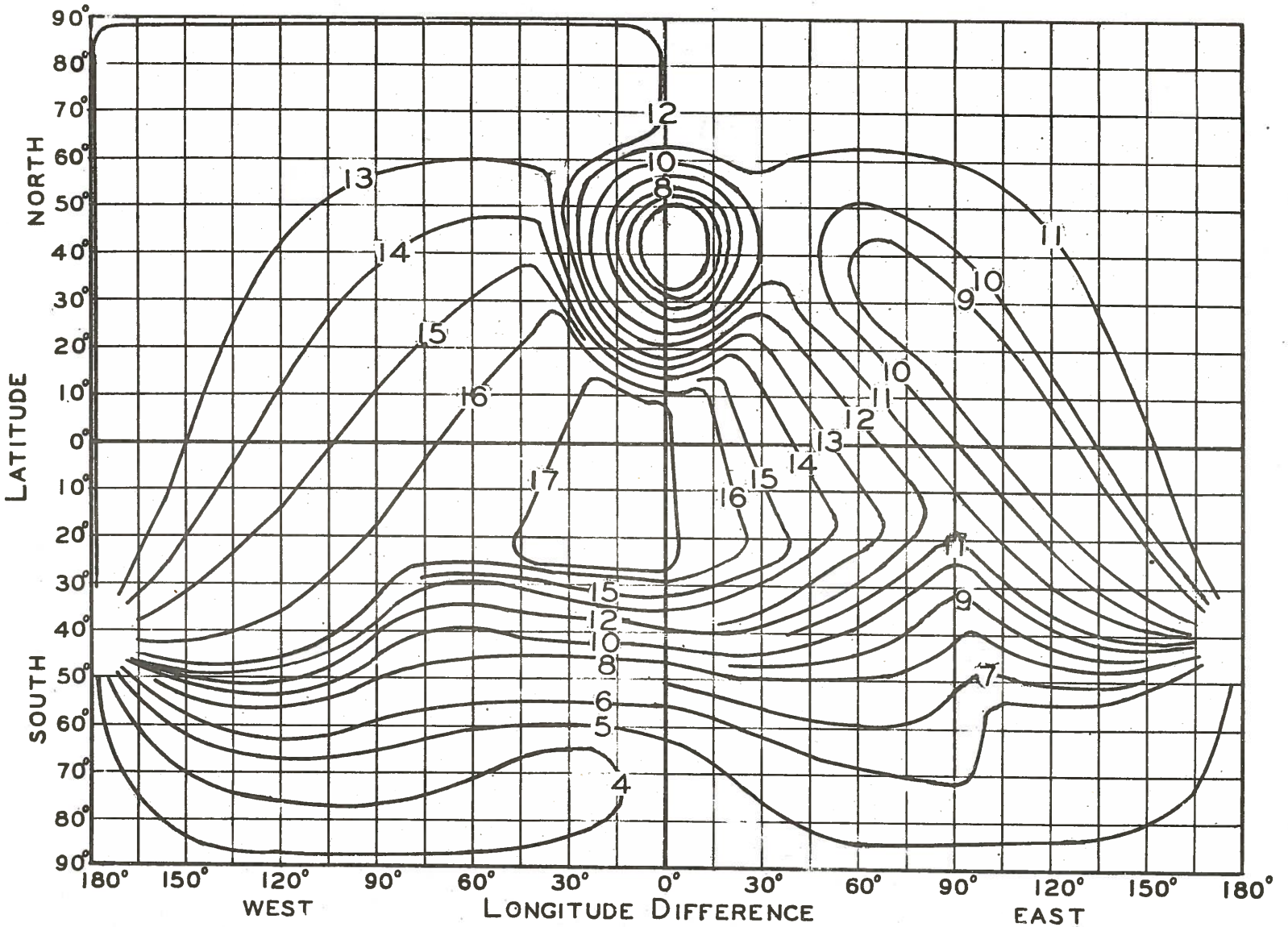


FIG. 17. MAXIMUM USABLE FREQUENCY.

MAY THROUGH AUG. 1942.

LATITUDE 40° N. 0000 LOCAL TIME.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

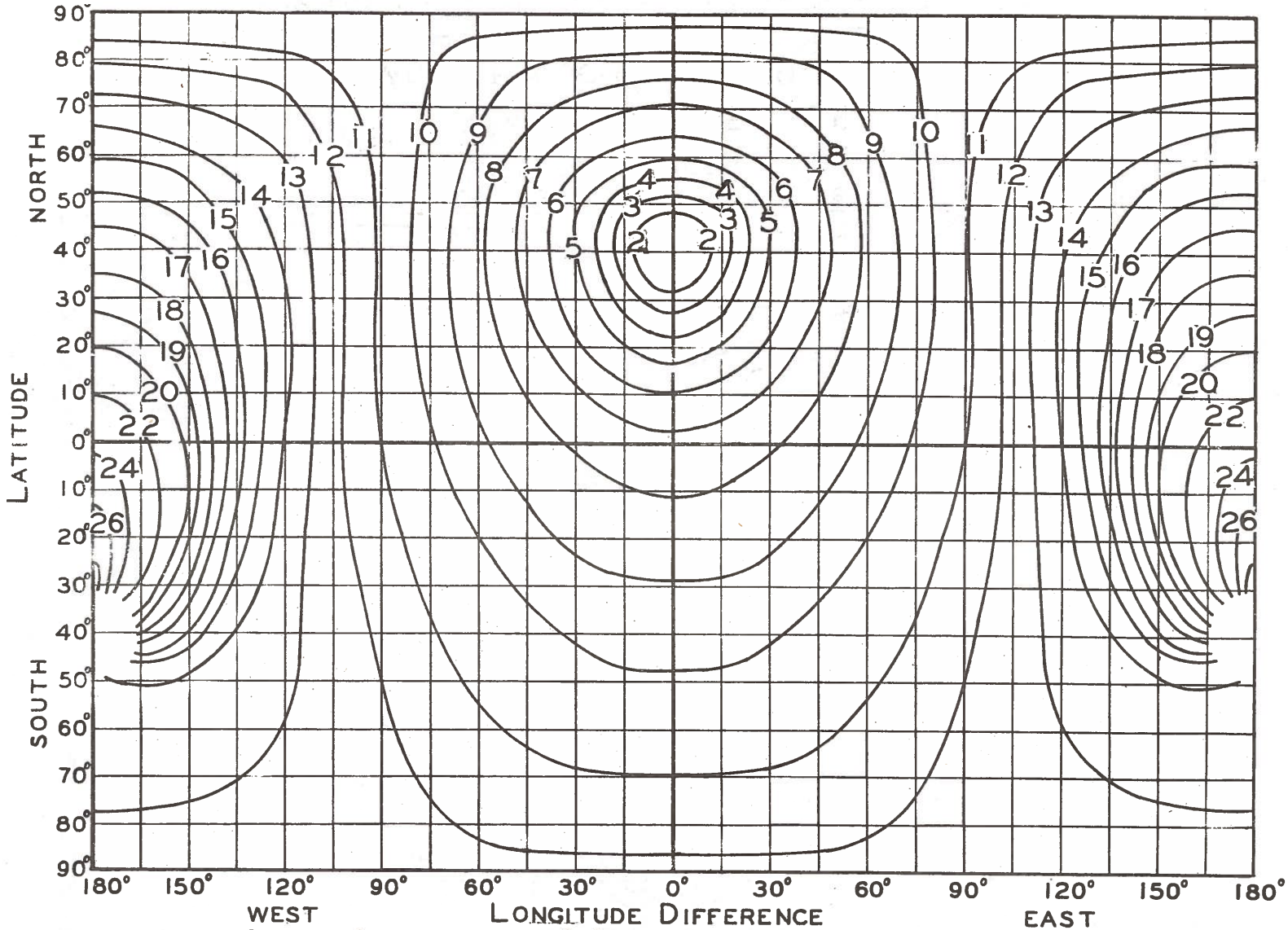


FIG. 18. LOWEST USEFUL HIGH FREQUENCY (1 kw).

MAY THROUGH AUG. 1942.

LATITUDE 40°N. 0000 LOCAL TIME. OVER OR NEAR LAND.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

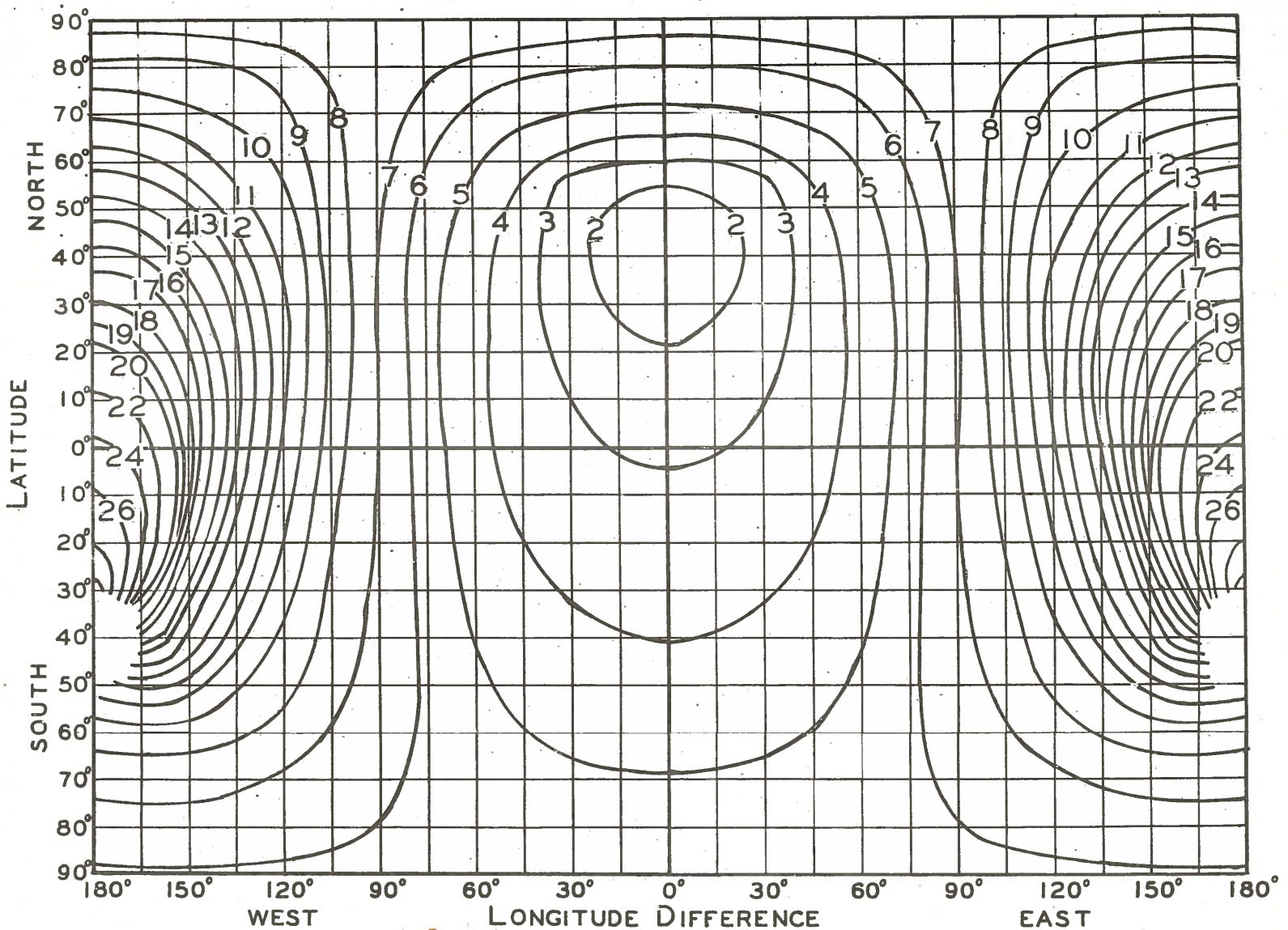


FIG. 19. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 40° N. 0000 LOCAL TIME. OVER OPEN OCEAN.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

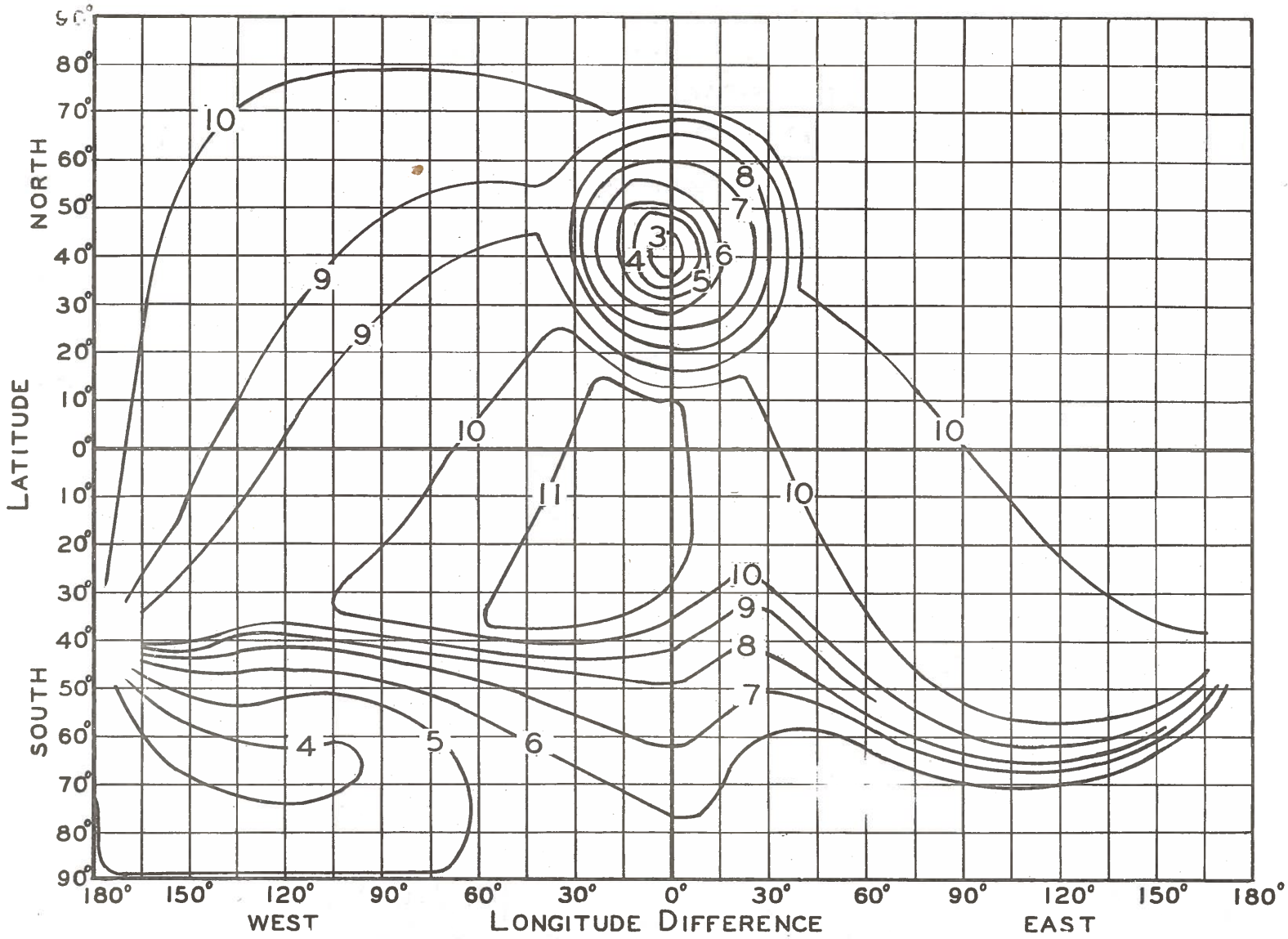


FIG. 20. MAXIMUM USABLE FREQUENCY.

MAY THROUGH AUG 1942.

LATITUDE 40° N. 0400 LOCAL TIME.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

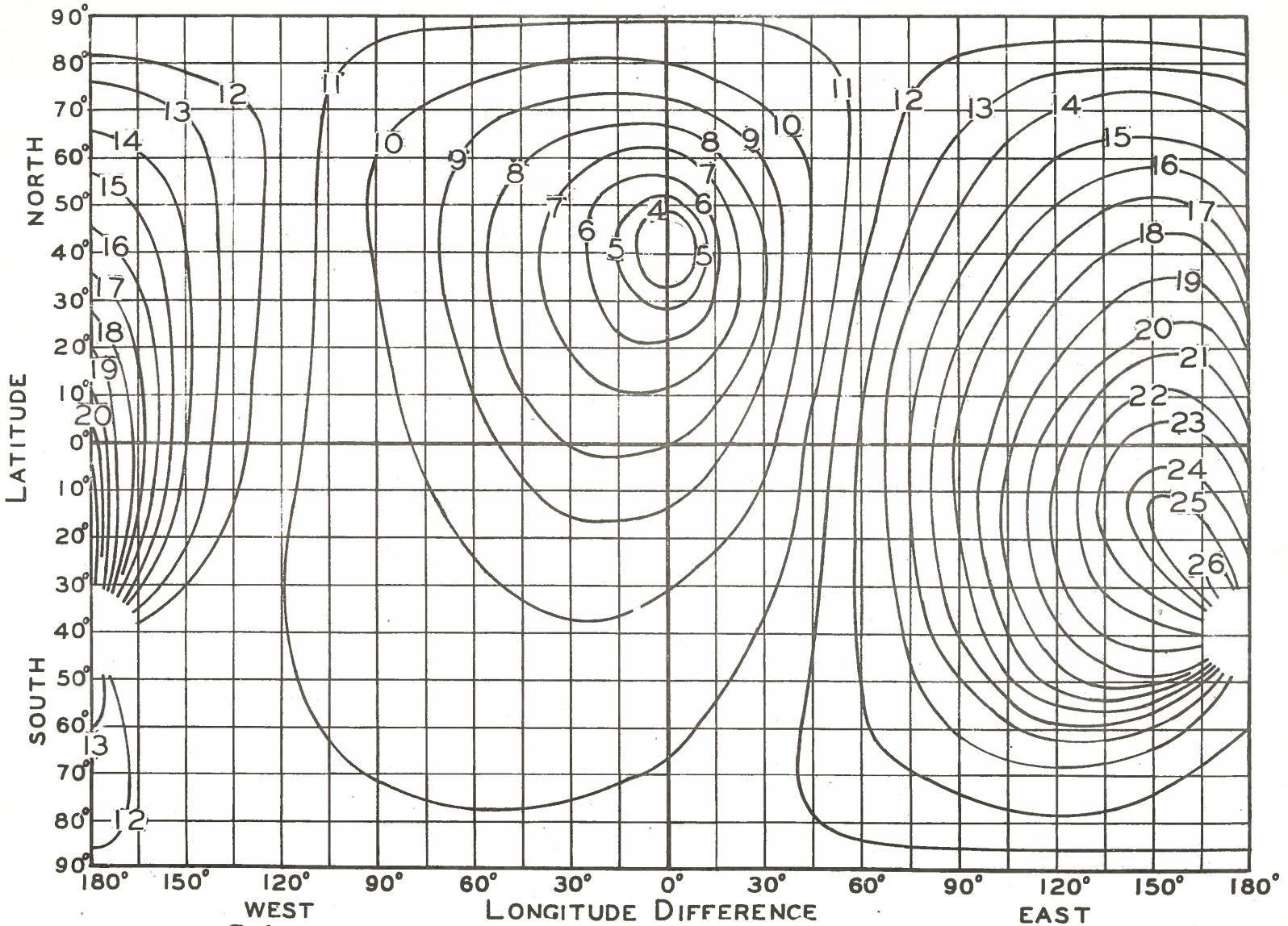


FIG. 21. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 40° N. 0400 LOCAL TIME. OVER OR NEAR LAND.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

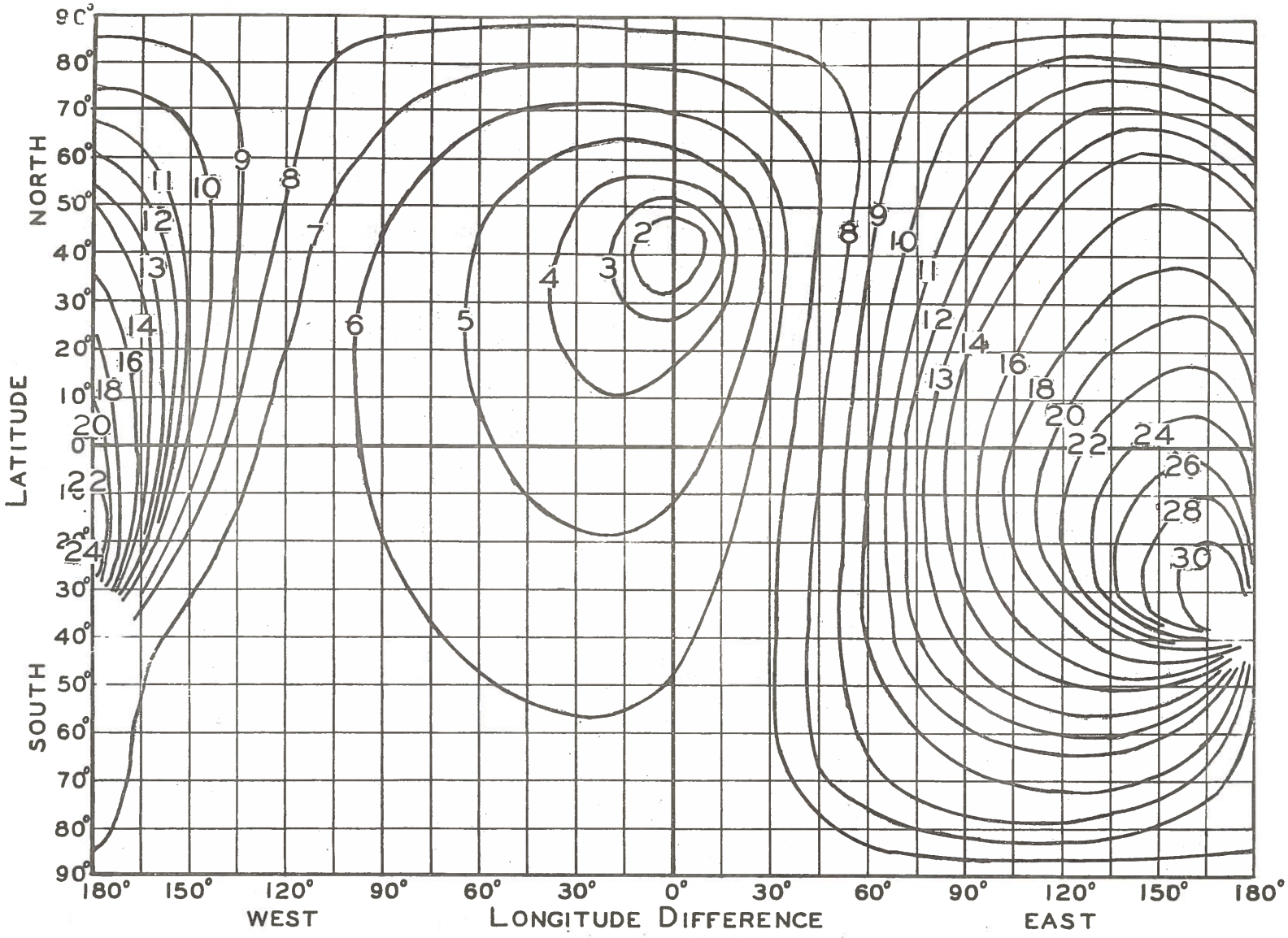


FIG. 22. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 40° N. 0400 LOCAL TIME. OVER OPEN OCEAN.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

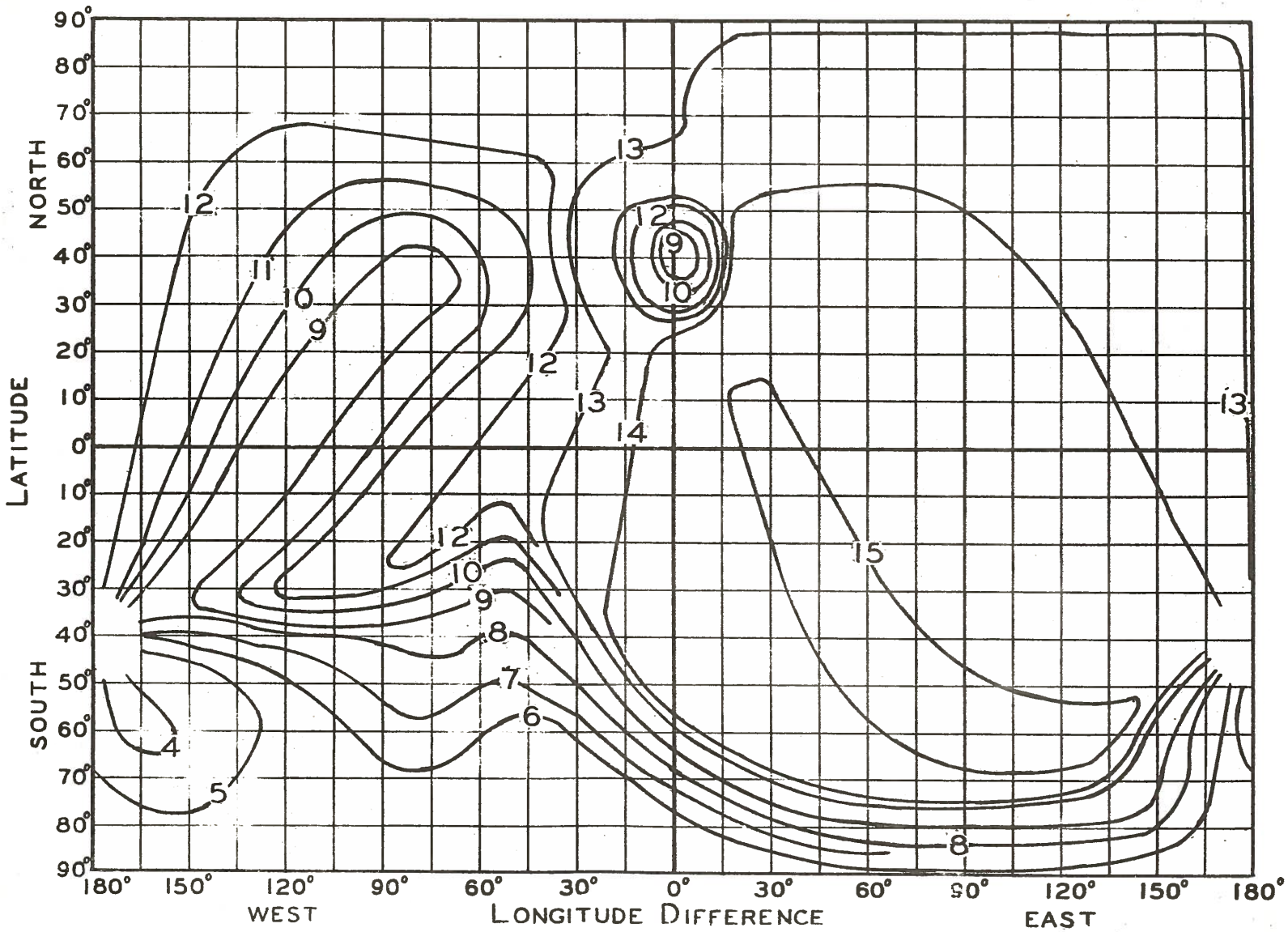


FIG. 23. MAXIMUM USABLE FREQUENCY.

MAY THROUGH AUG. 1942.

LATITUDE 40° N. 0800 LOCAL TIME.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

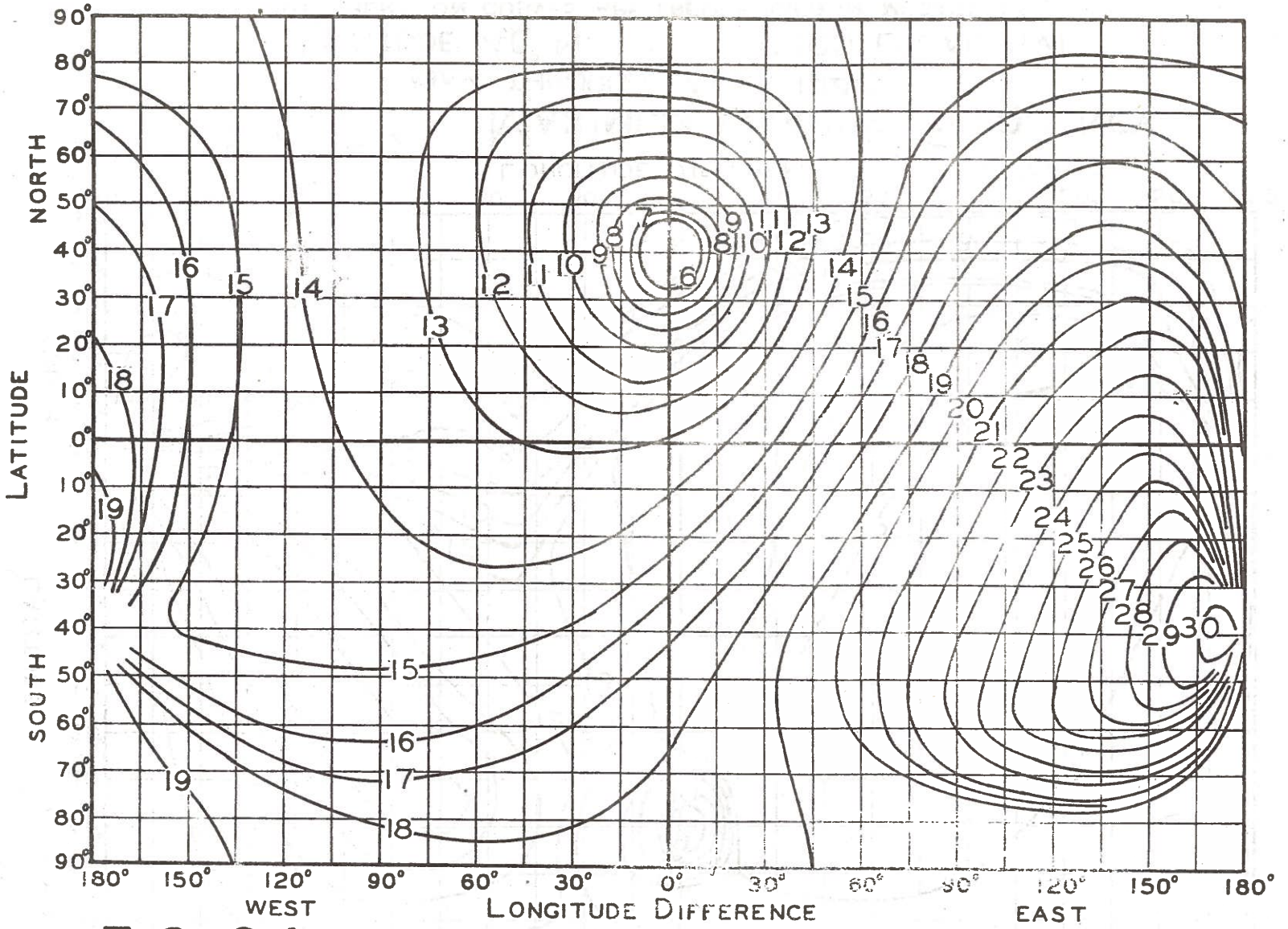


FIG. 24. LOWEST USEFUL HIGH FREQUENCY (1 kW).

MAY THROUGH AUG. 1942.

LATITUDE 40° N. 0800 LOCAL TIME. OVER OR NEAR LAND.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

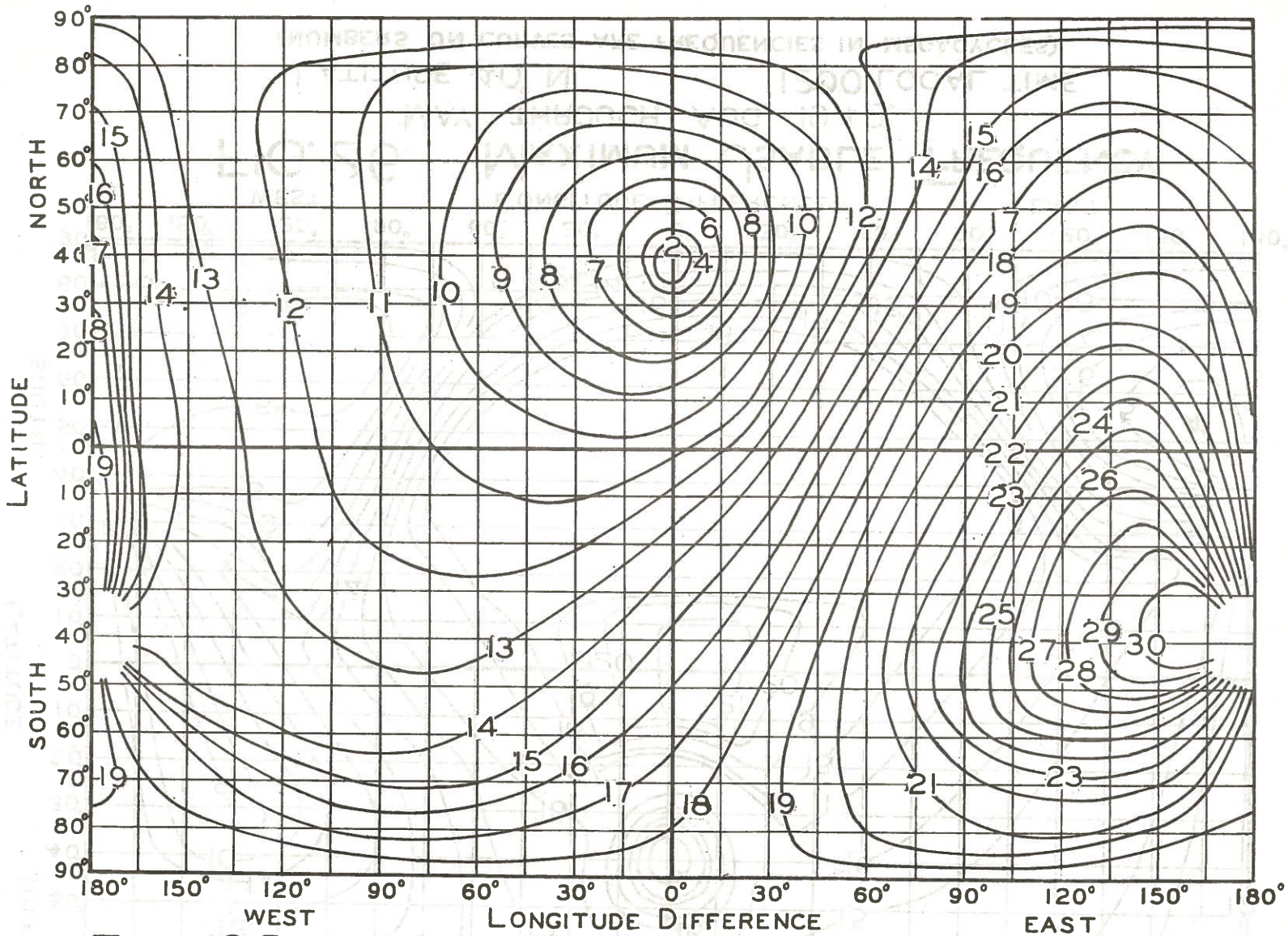


FIG. 25. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 40° N. 0800 LOCAL TIME. OVER OPEN OCEAN.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

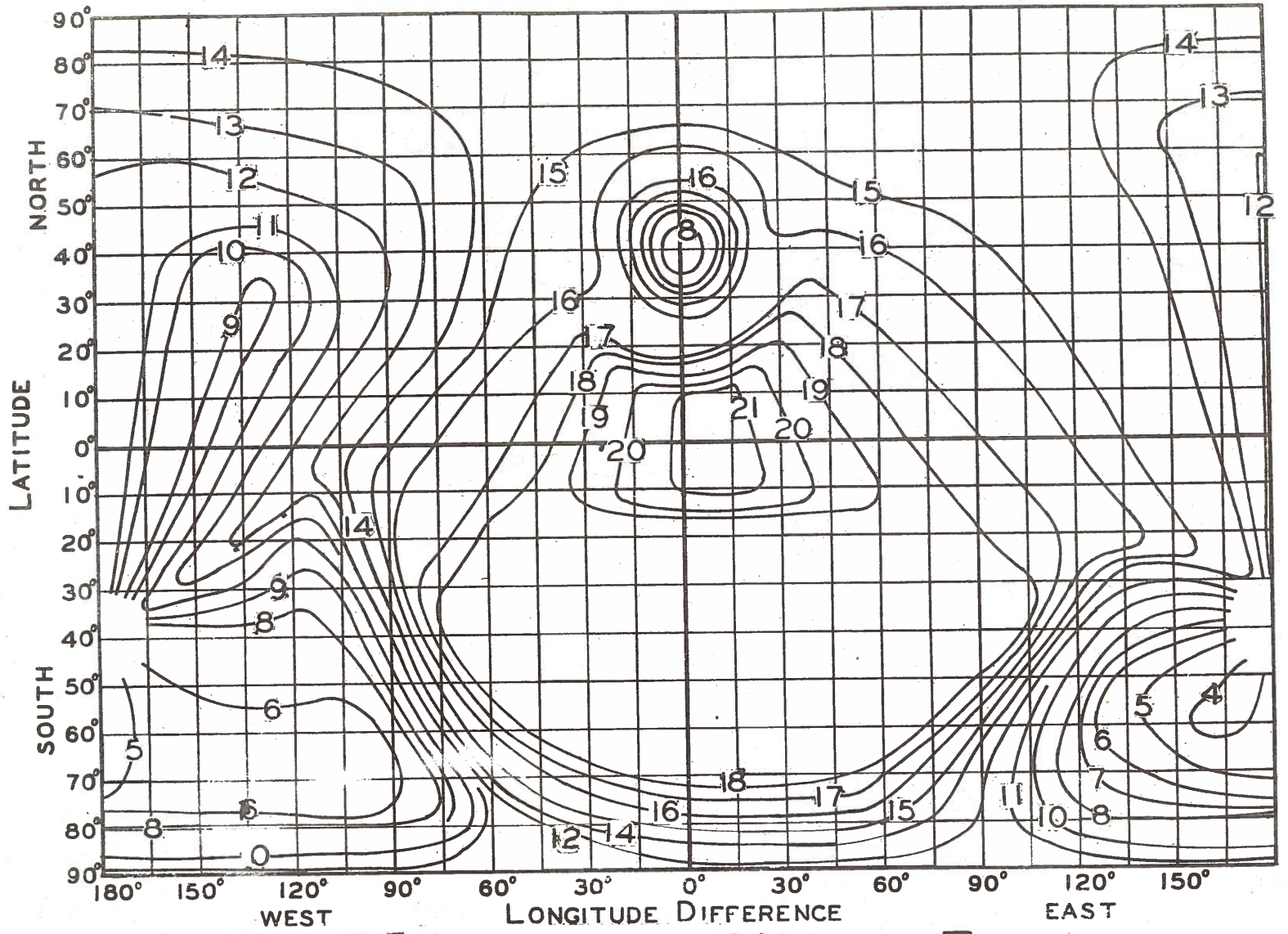


FIG. 26. MAXIMUM USABLE FREQUENCY

MAY THROUGH AUG. 1942.

LATITUDE 40° N. 1200 LOCAL TIME

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

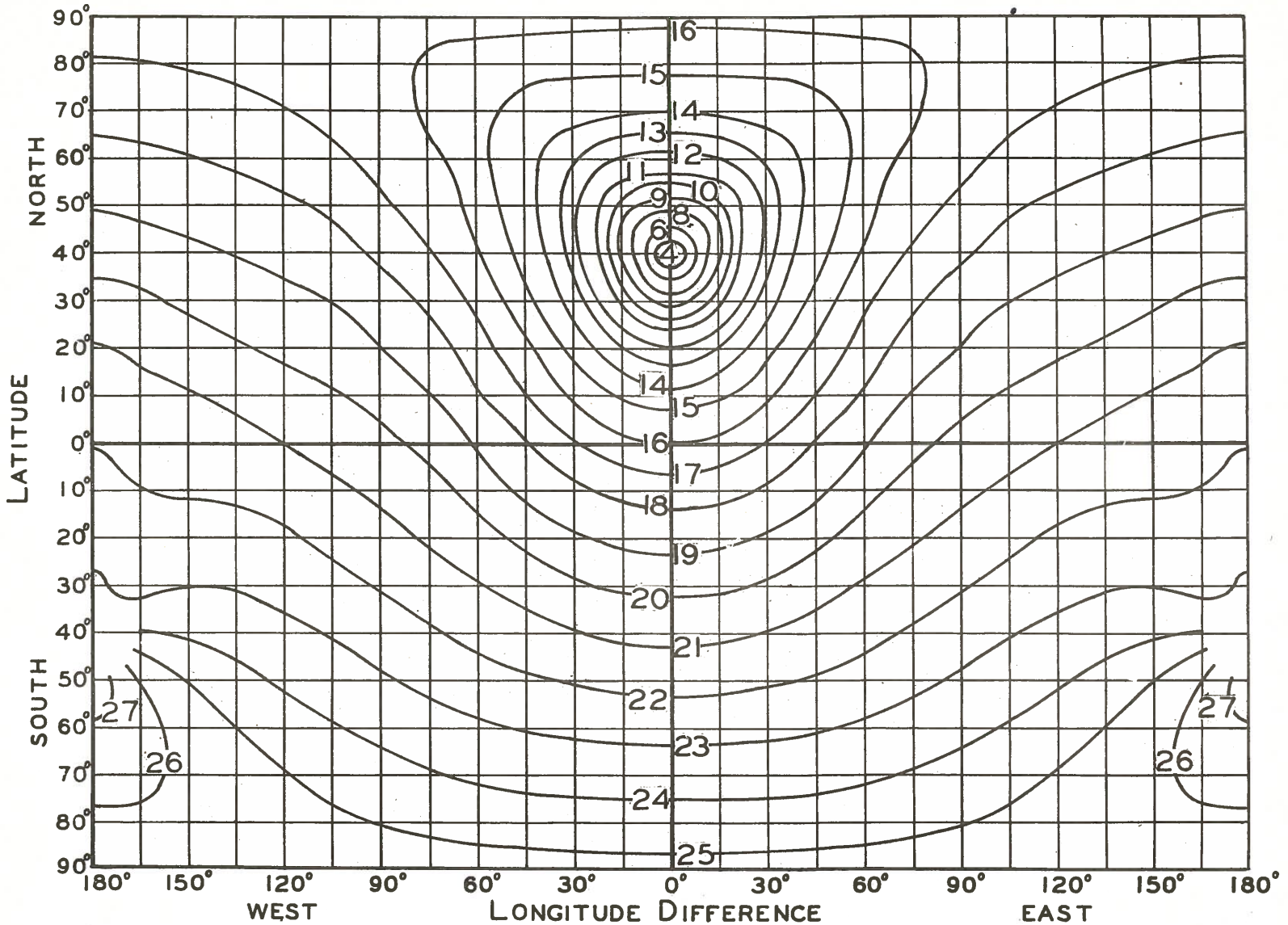


FIG. 27. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 40° N. 1200 LOCAL TIME. OVER OR NEAR LAND.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

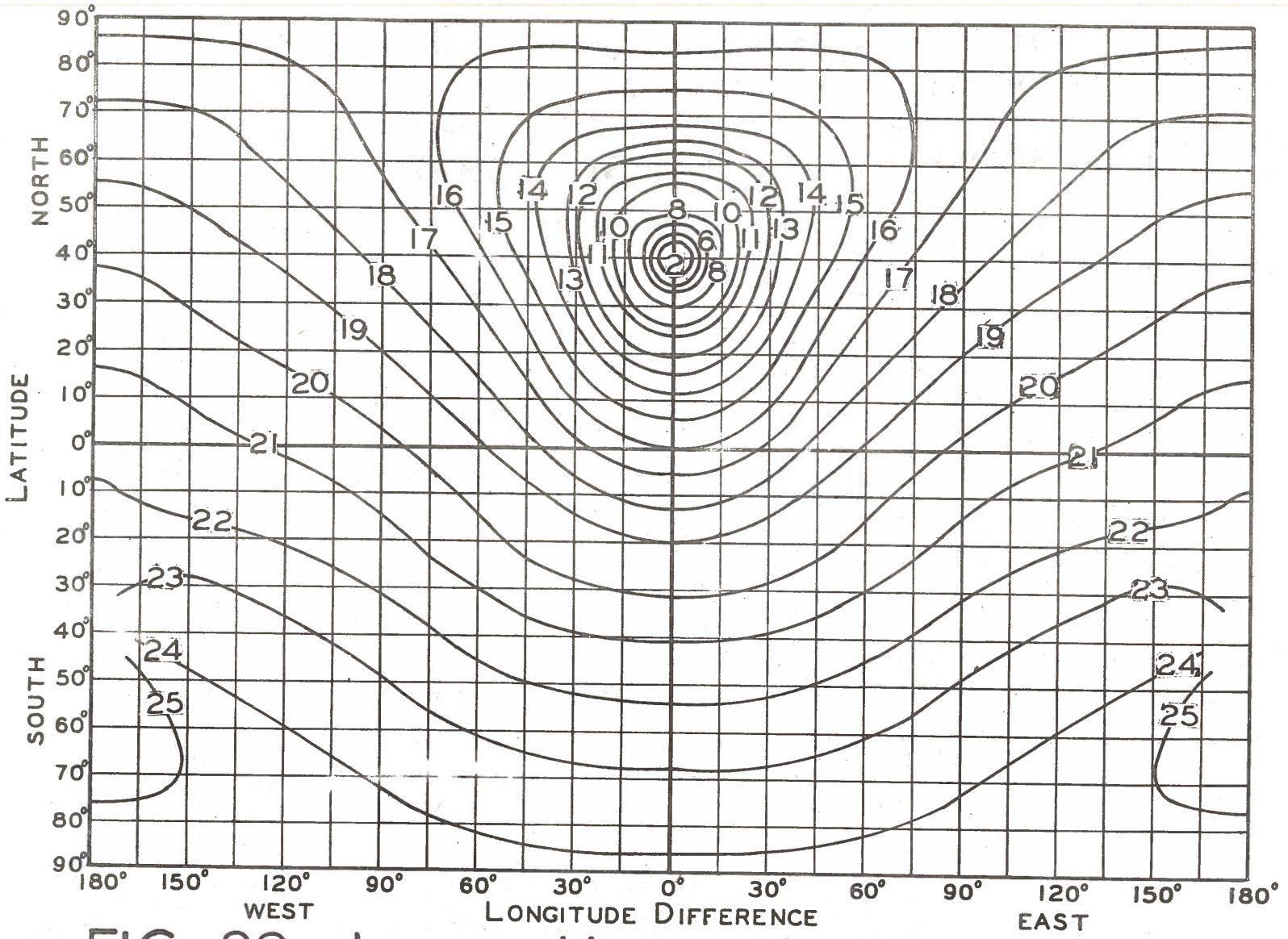


FIG. 28. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 40° N. 1200 LOCAL TIME. OVER OPEN OCEAN.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

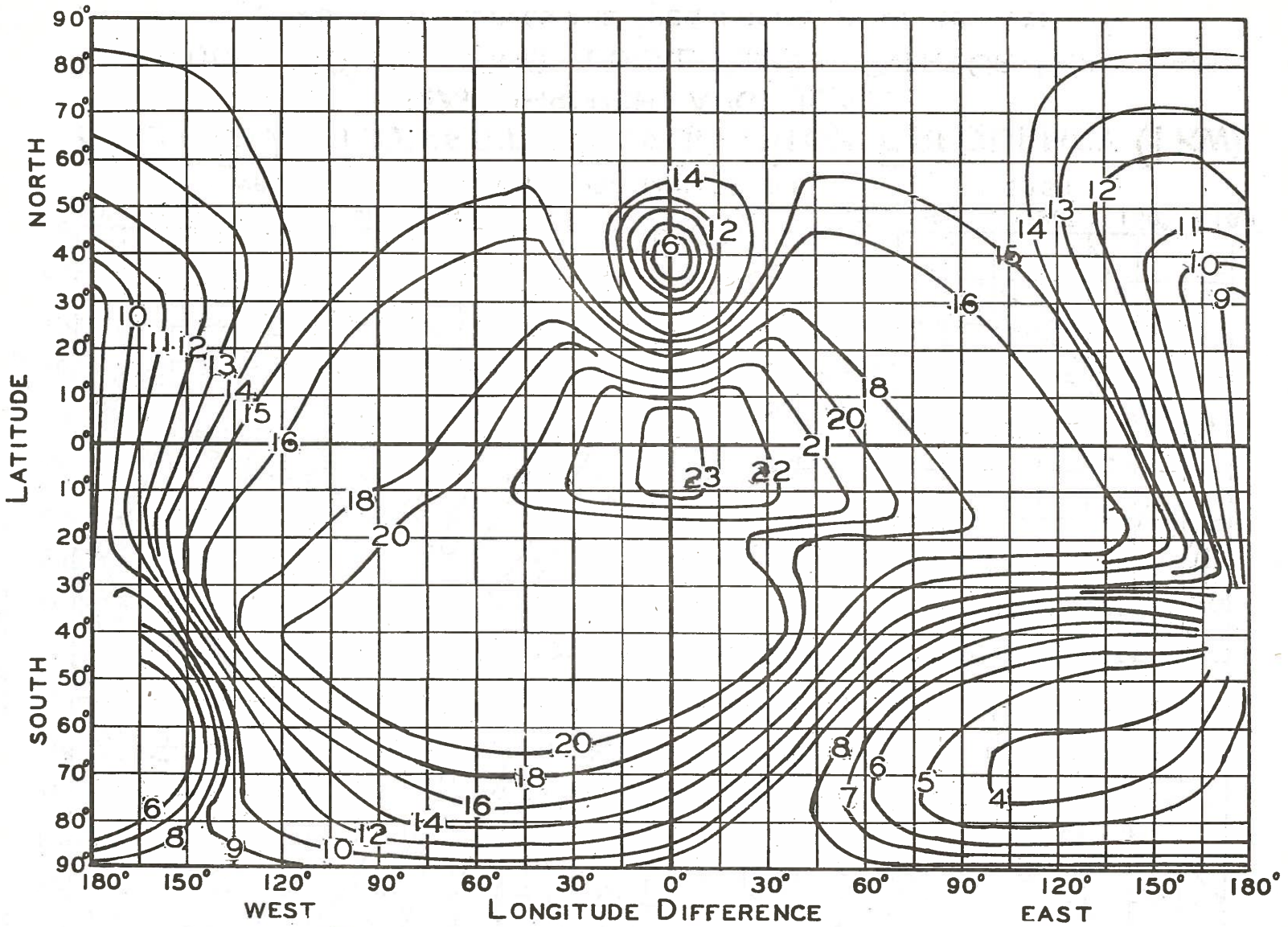


FIG. 29. MAXIMUM USABLE FREQUENCY.

MAY THROUGH AUG. 1942.

LATITUDE 40° N. 1600 LOCAL TIME.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

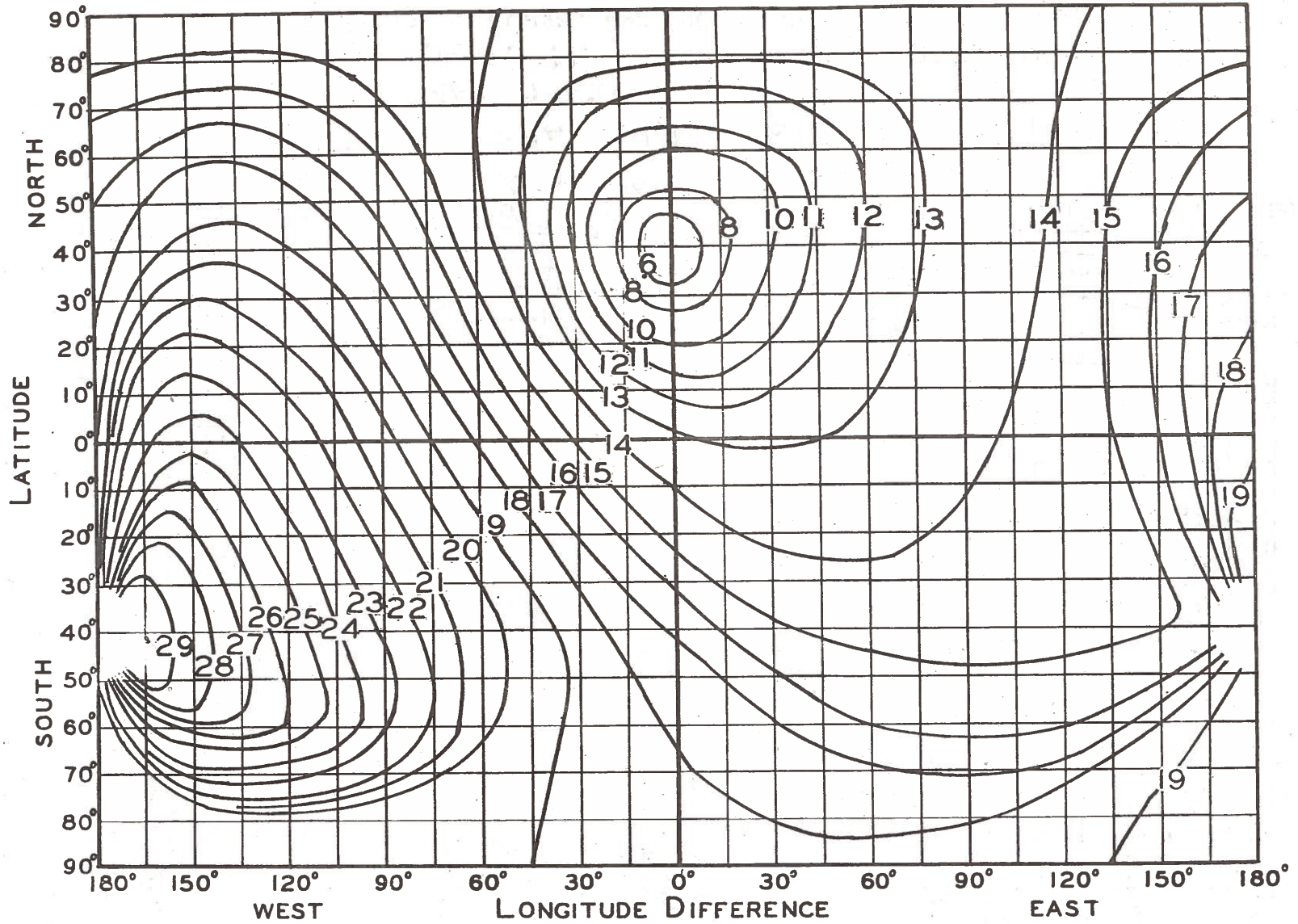


FIG. 30. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 40° N. 1600 LOCAL TIME. OVER OR NEAR LAND.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

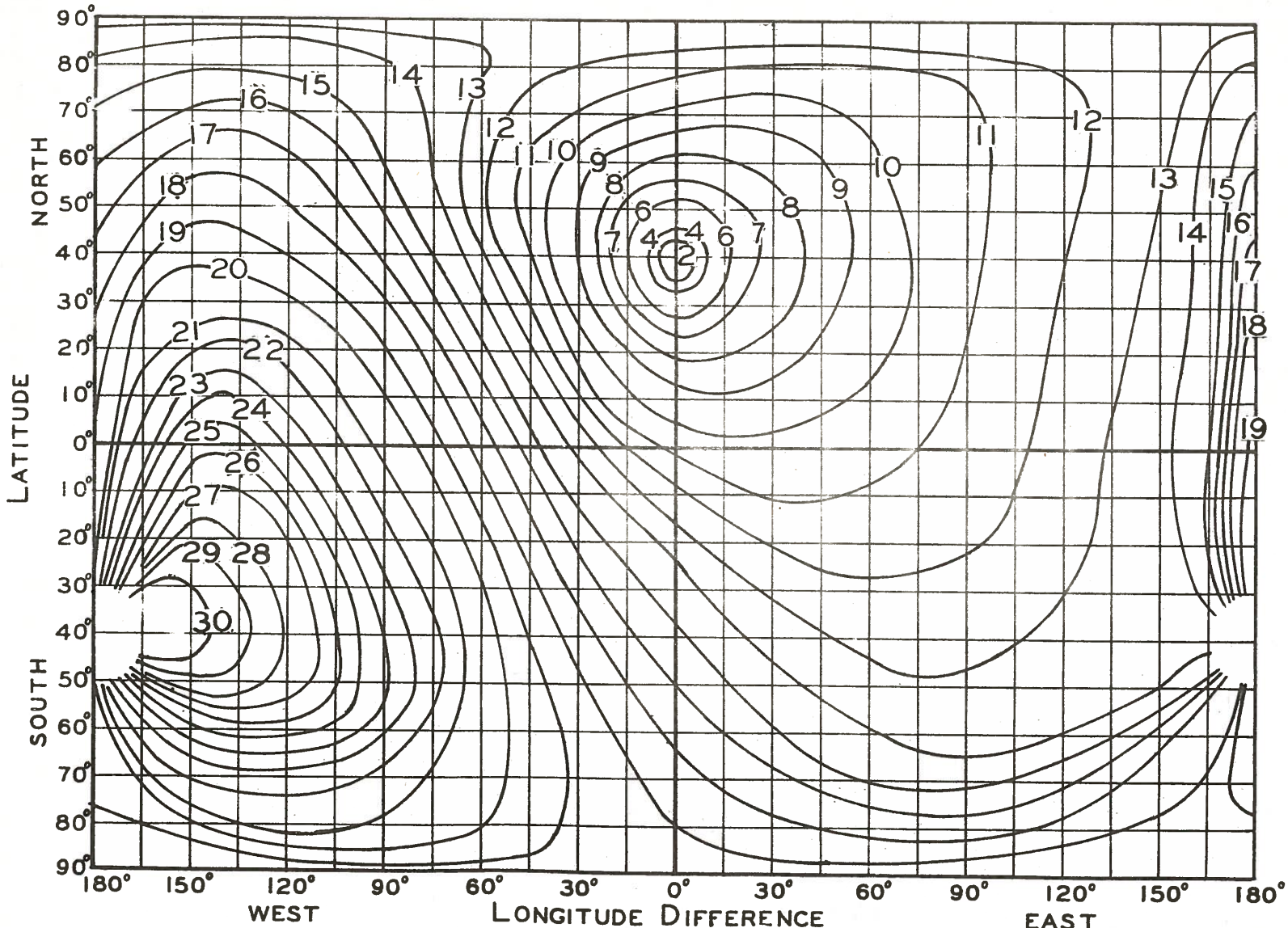


FIG. 31. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 40° N. 1600 LOCAL TIME. OVER OPEN OCEAN

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

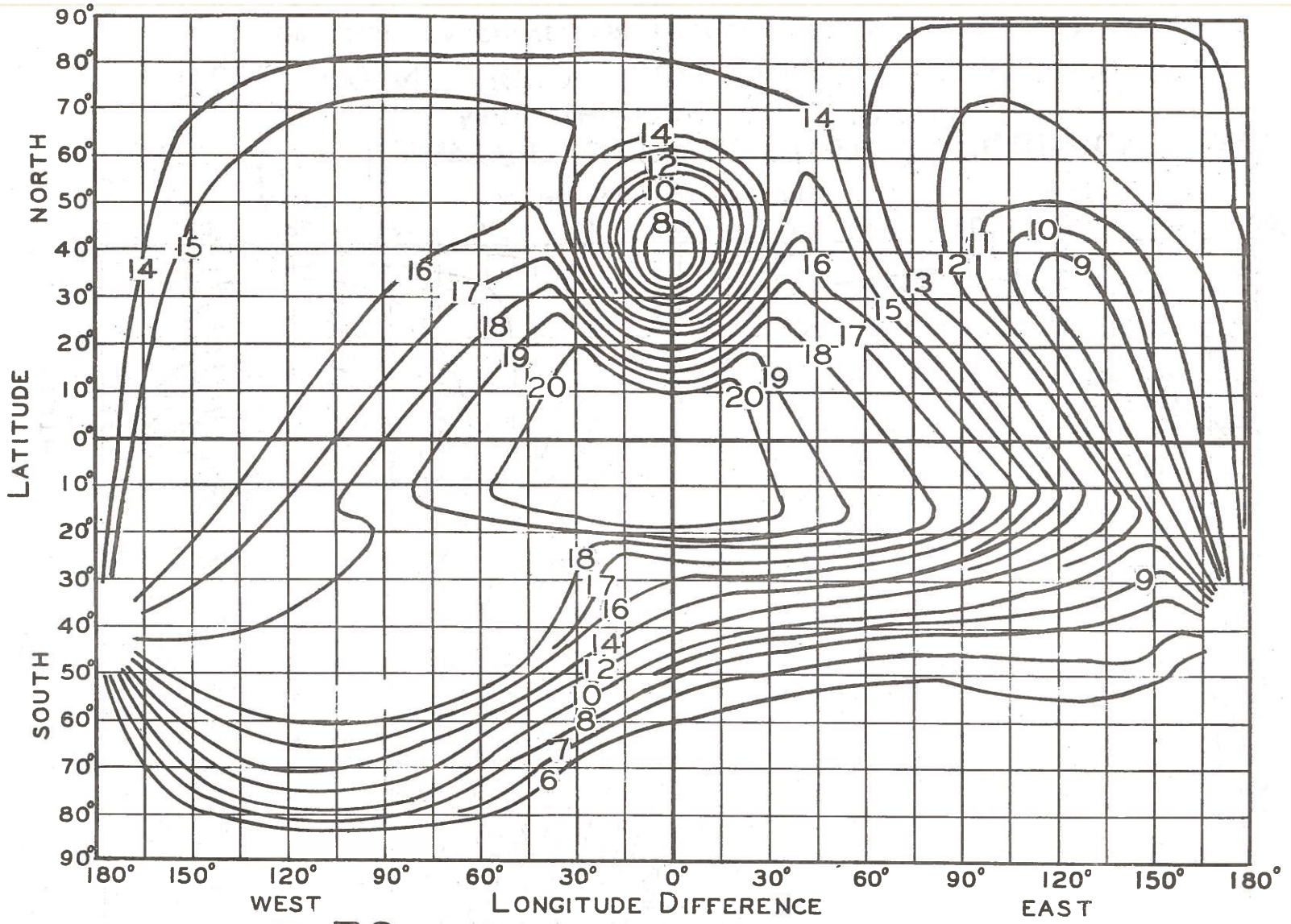


FIG. 32. MAXIMUM USABLE FREQUENCY.

MAY THROUGH AUG. 1942

LATITUDE 40° N. 2000 LOCAL TIME.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

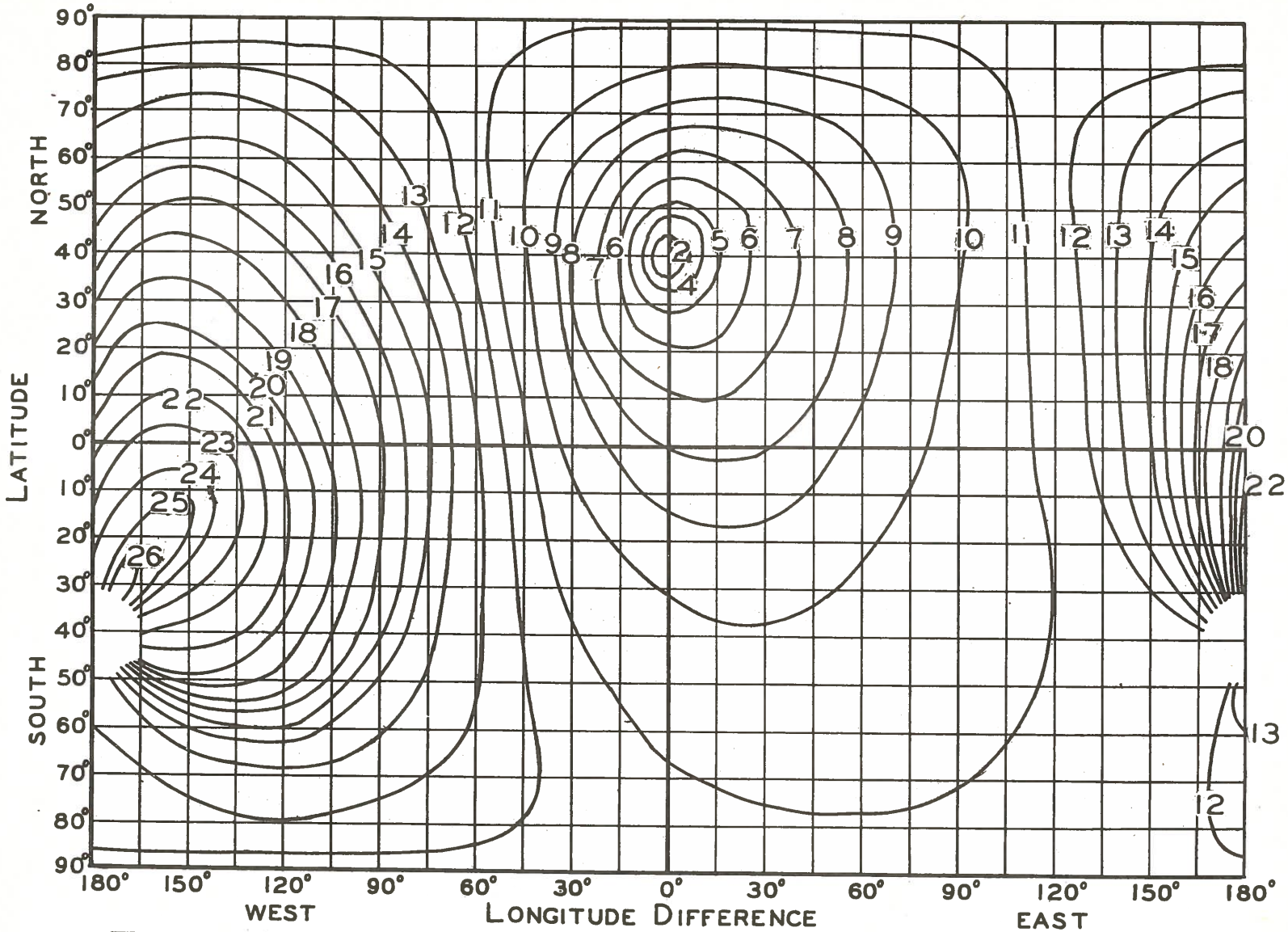


FIG. 33. LOWEST USEFUL HIGH FREQUENCY (1 KW).
MAY THROUGH AUG. 1942.
LATITUDE 40° N. 2000 LOCAL TIME. OVER OR NEAR LAND.
(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

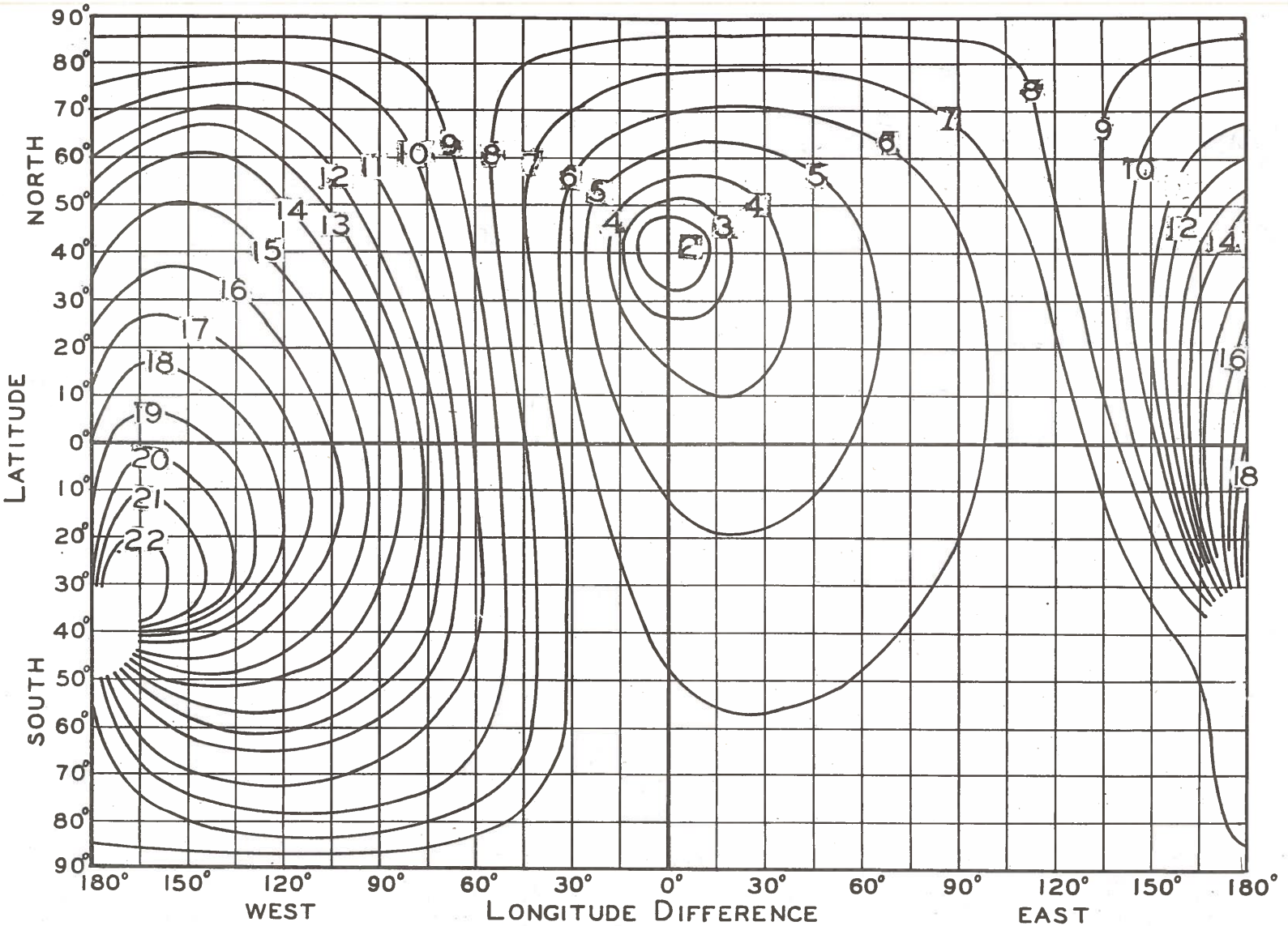


FIG. 34. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 40° N. 2000 LOCAL TIME. OVER OPEN OCEAN.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

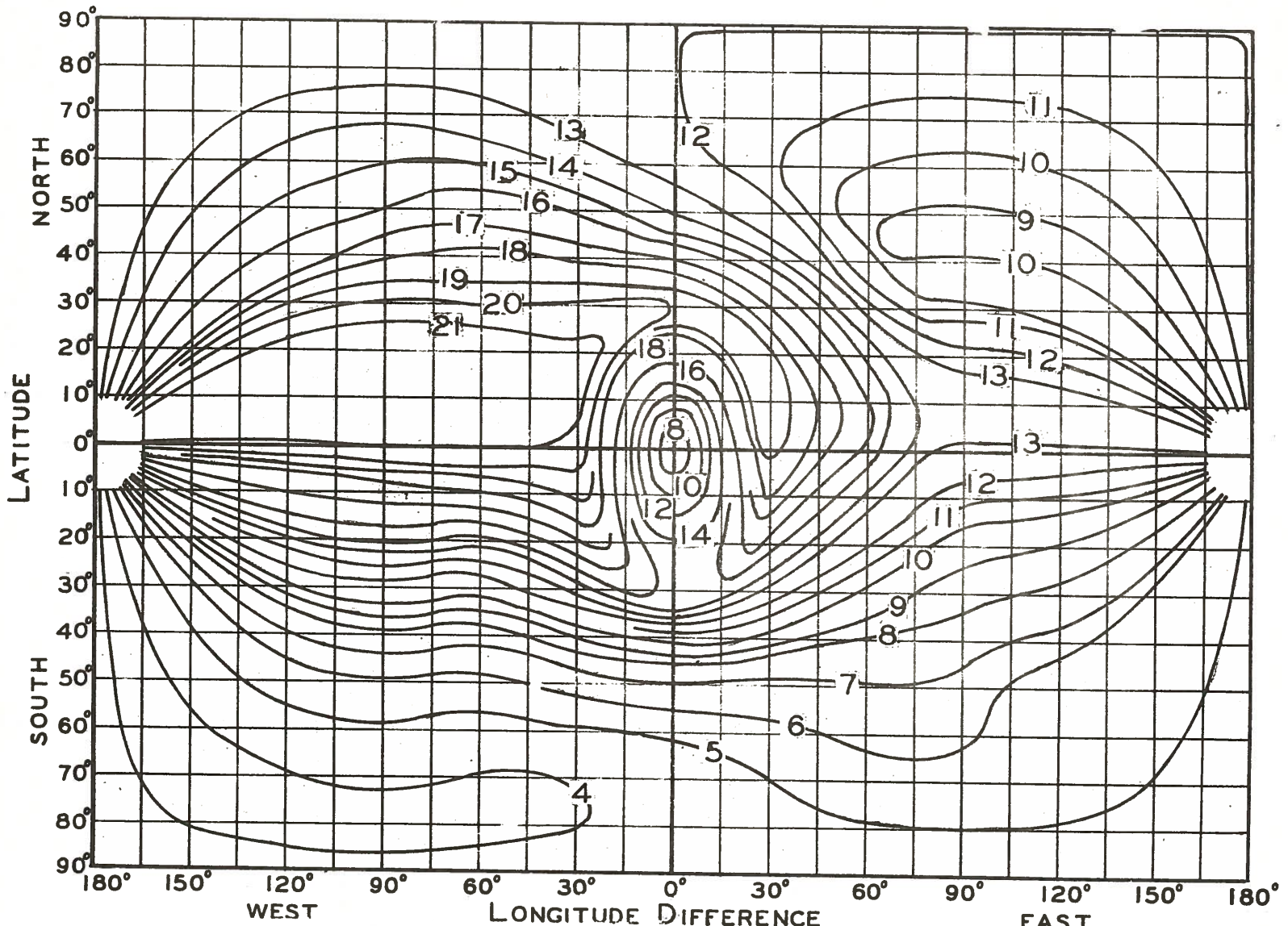


FIG. 35. MAXIMUM USABLE FREQUENCY.

MAY THROUGH AUG. 1942.

LATITUDE 0° 0000 LOCAL TIME.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

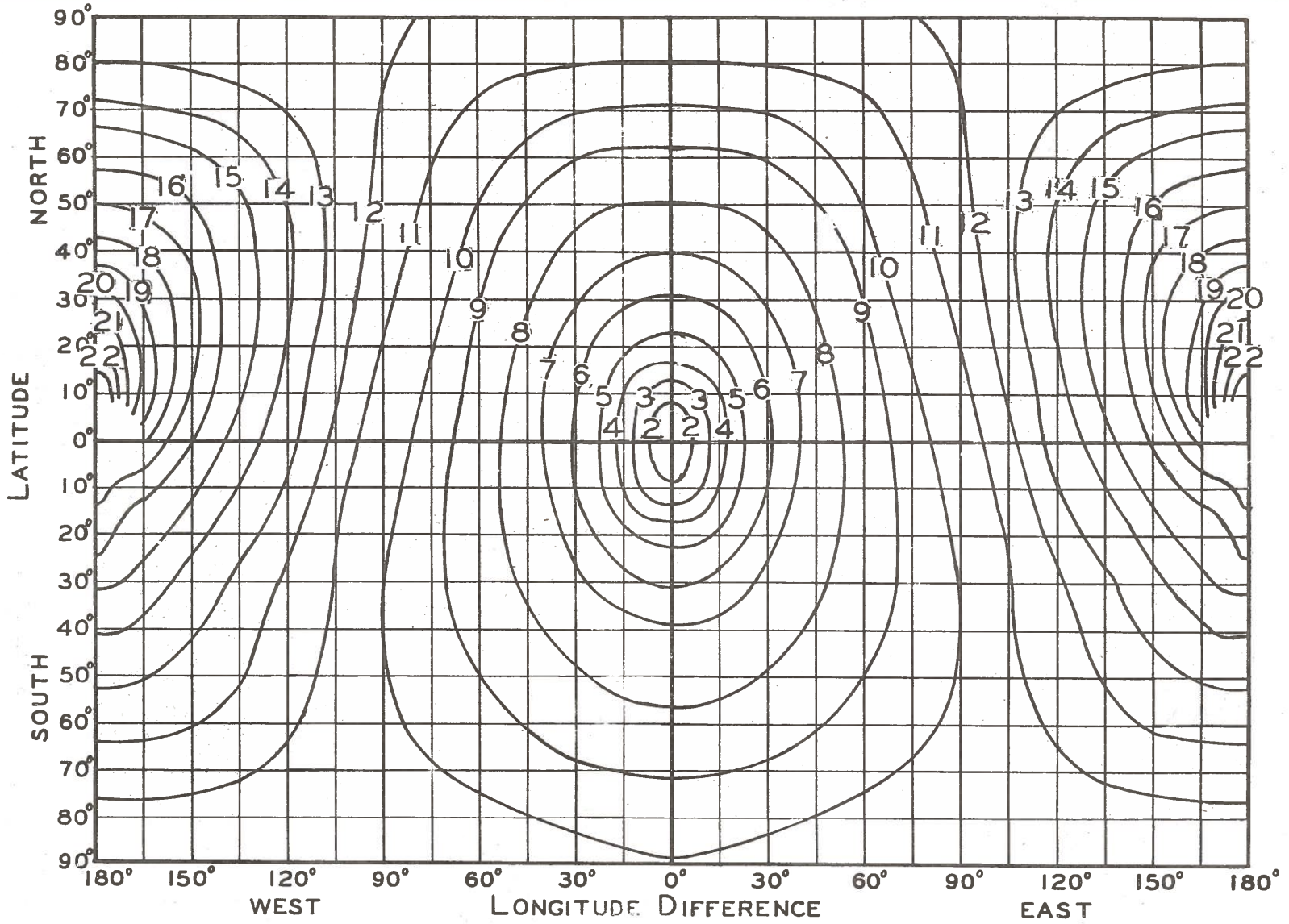


FIG. 36. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 0°. 0000 LOCAL TIME. OVER OR NEAR LAND.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

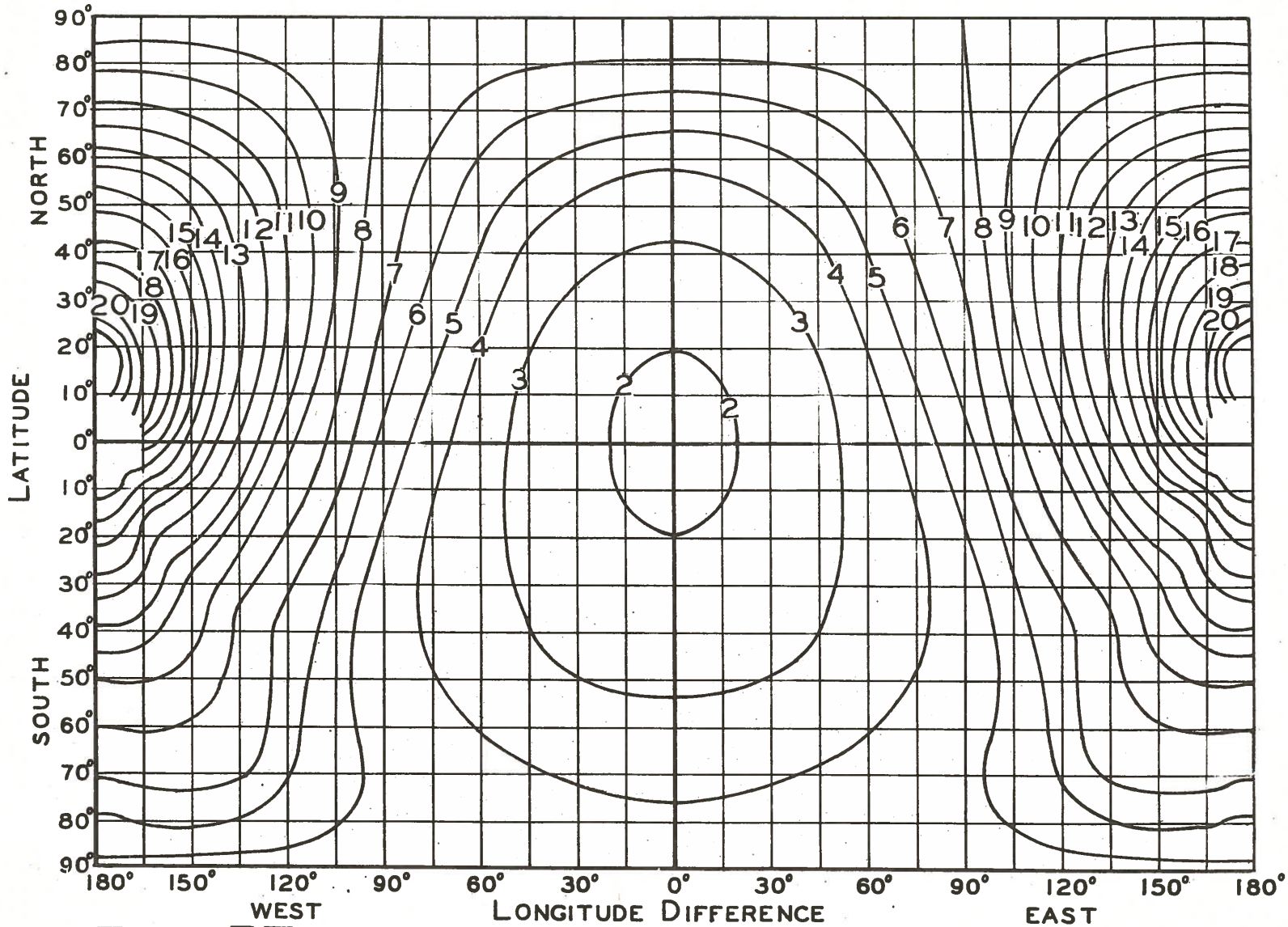


FIG. 37. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 0°. 0000 LOCAL TIME. OVER OPEN OCEAN.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

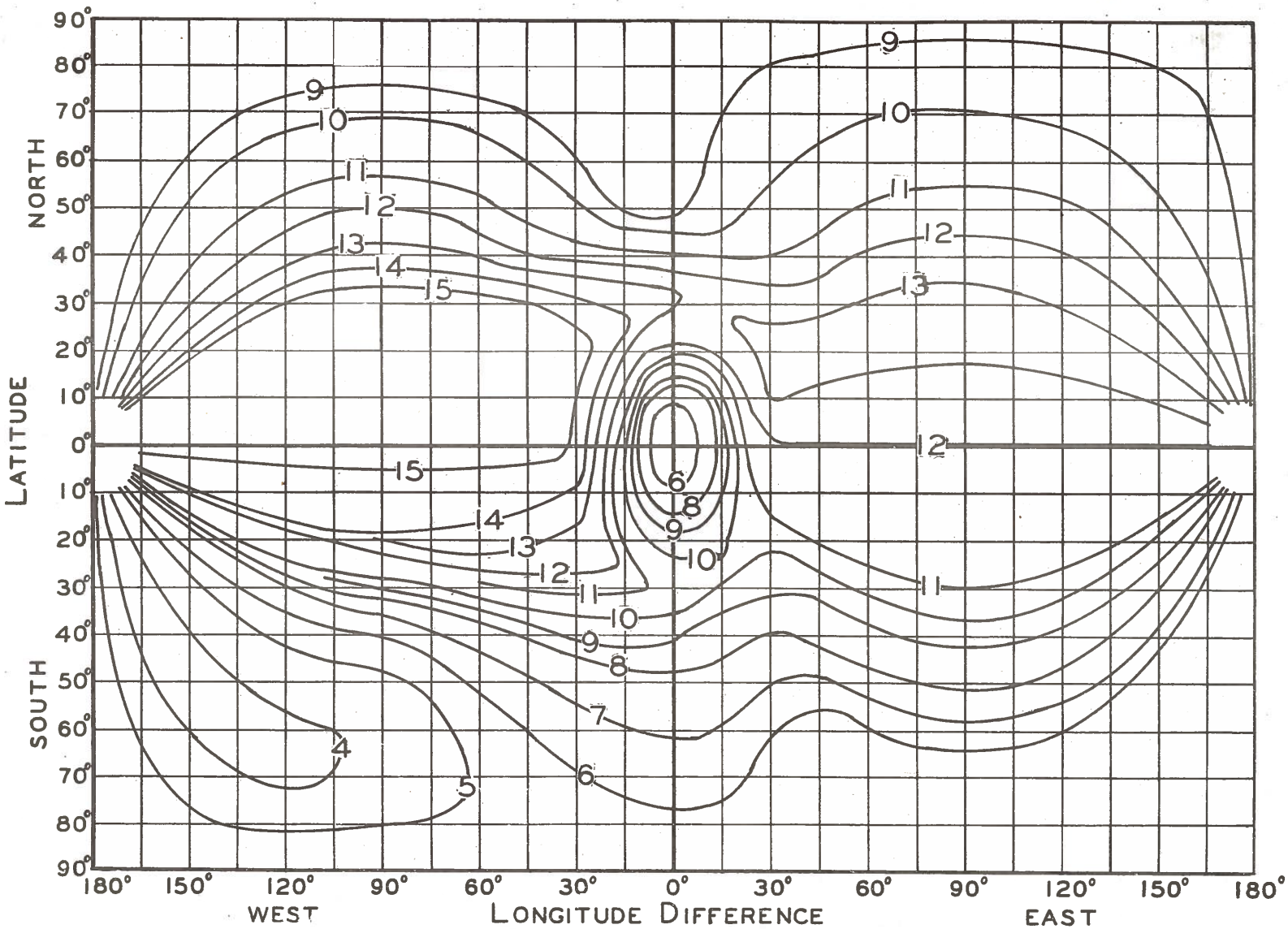


FIG. 38. MAXIMUM USABLE FREQUENCY.

MAY THROUGH AUG. 1942.

LATITUDE 0°. 0400 LOCAL TIME.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

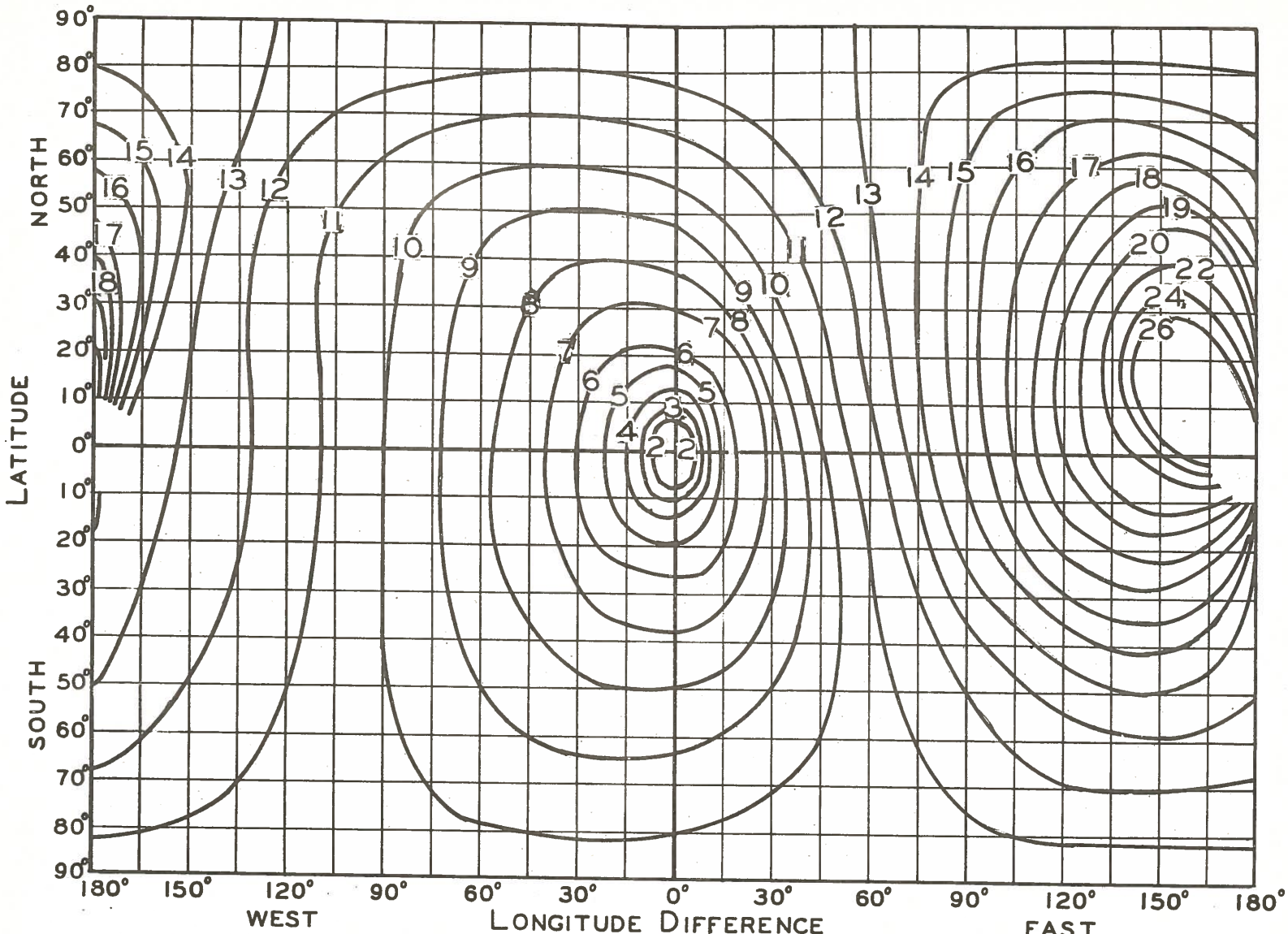


FIG. 39. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 0°. 0400 LOCAL TIME. OVER OR NEAR LAND.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

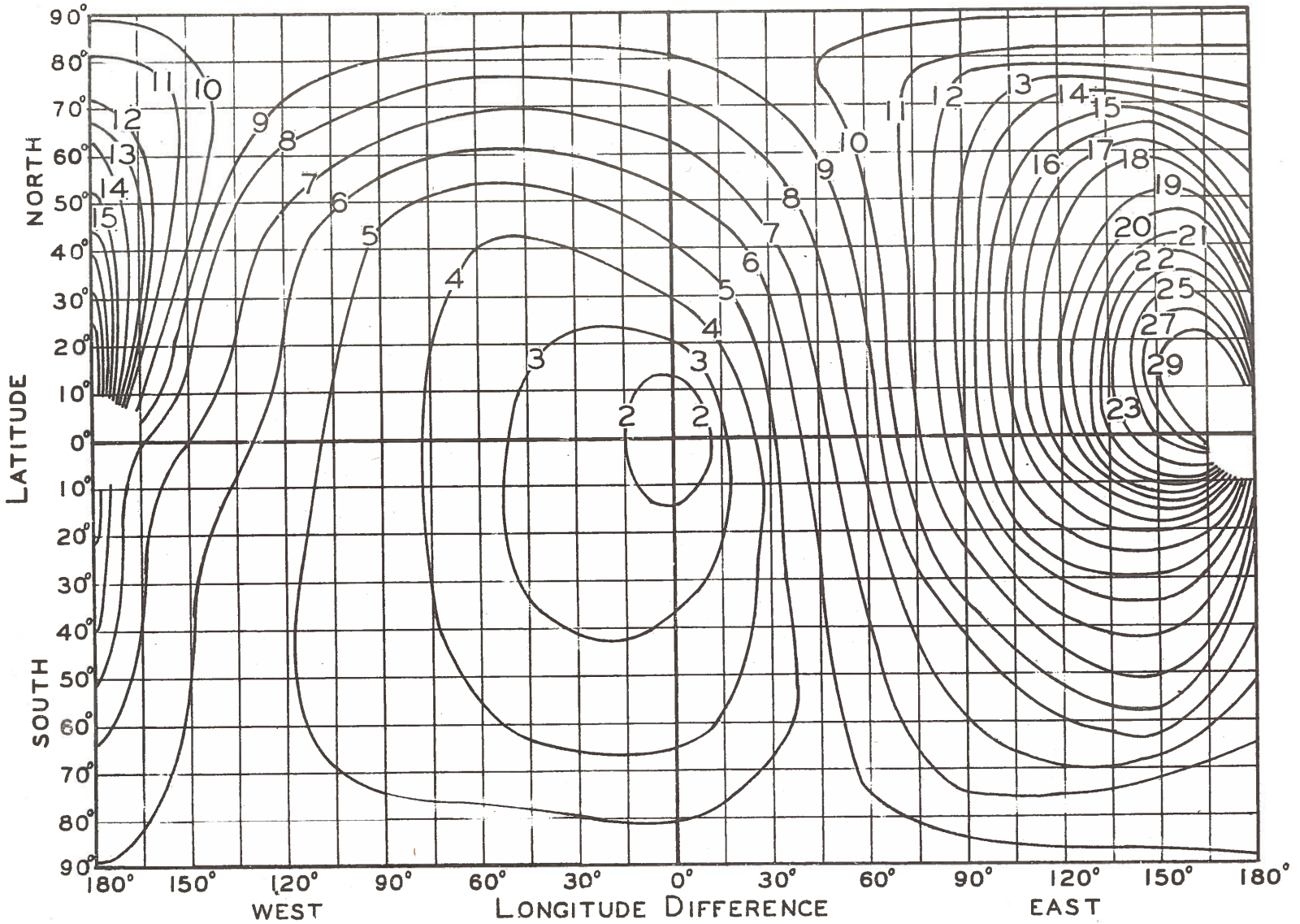


FIG. 40. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 0°. 0400 LOCAL TIME. OVER OPEN OCEAN.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

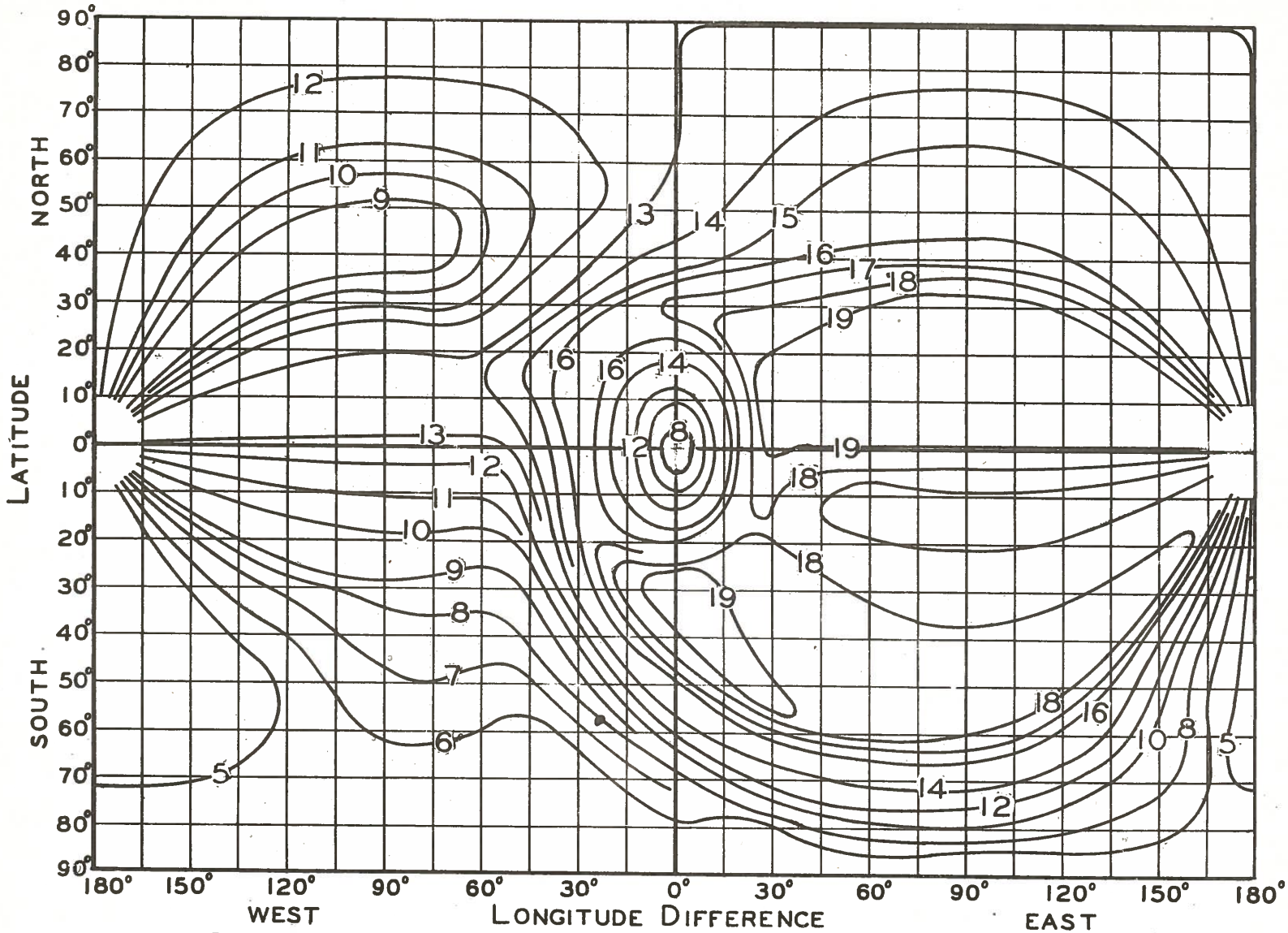


FIG. 41. MAXIMUM USABLE FREQUENCY.

MAY THROUGH AUG. 1942.

LATITUDE 0°. 0800 LOCAL TIME.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

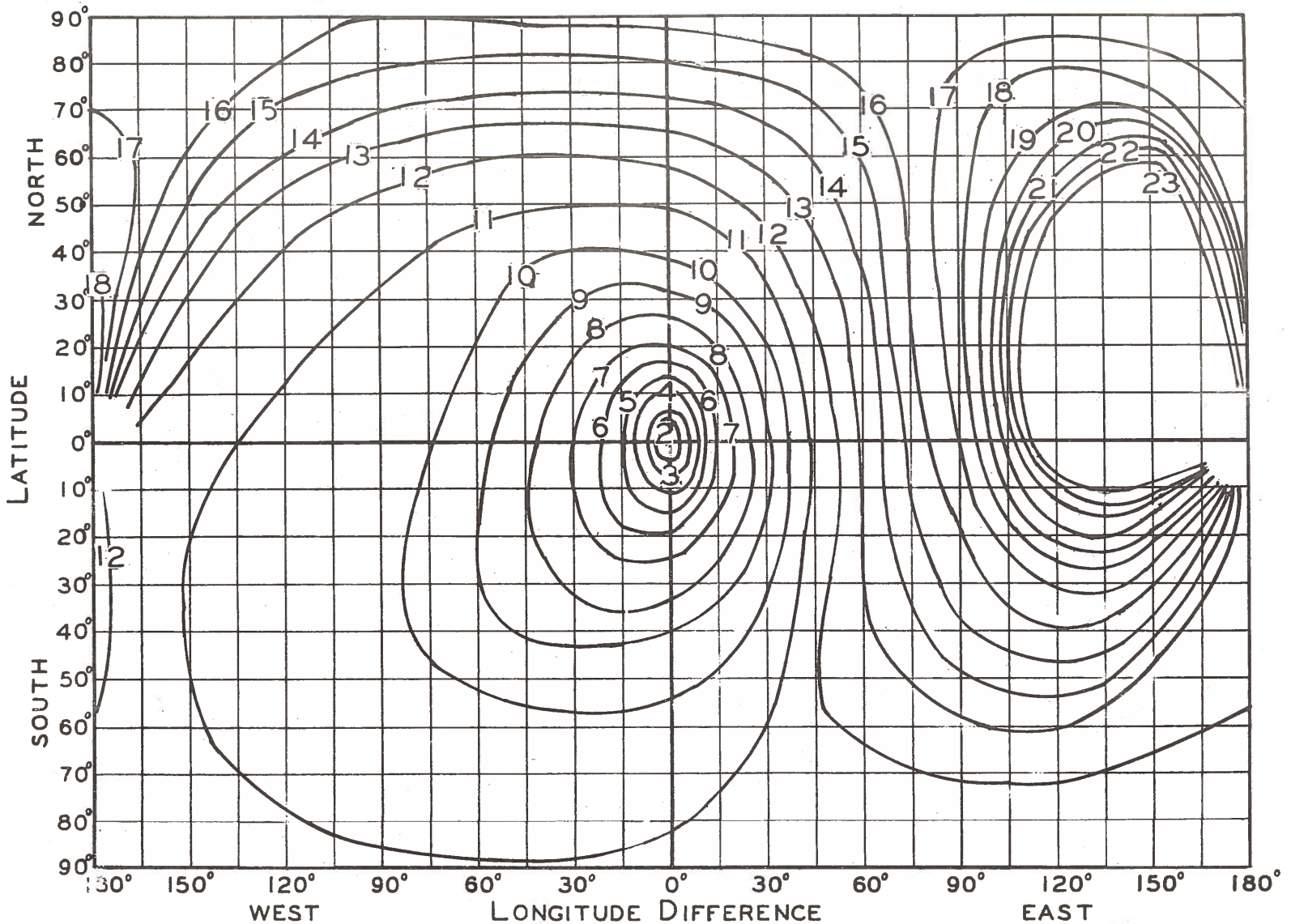


FIG. 42. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942

LATITUDE 0°. 0800 LOCAL TIME. OVER OR NEAR LAND.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

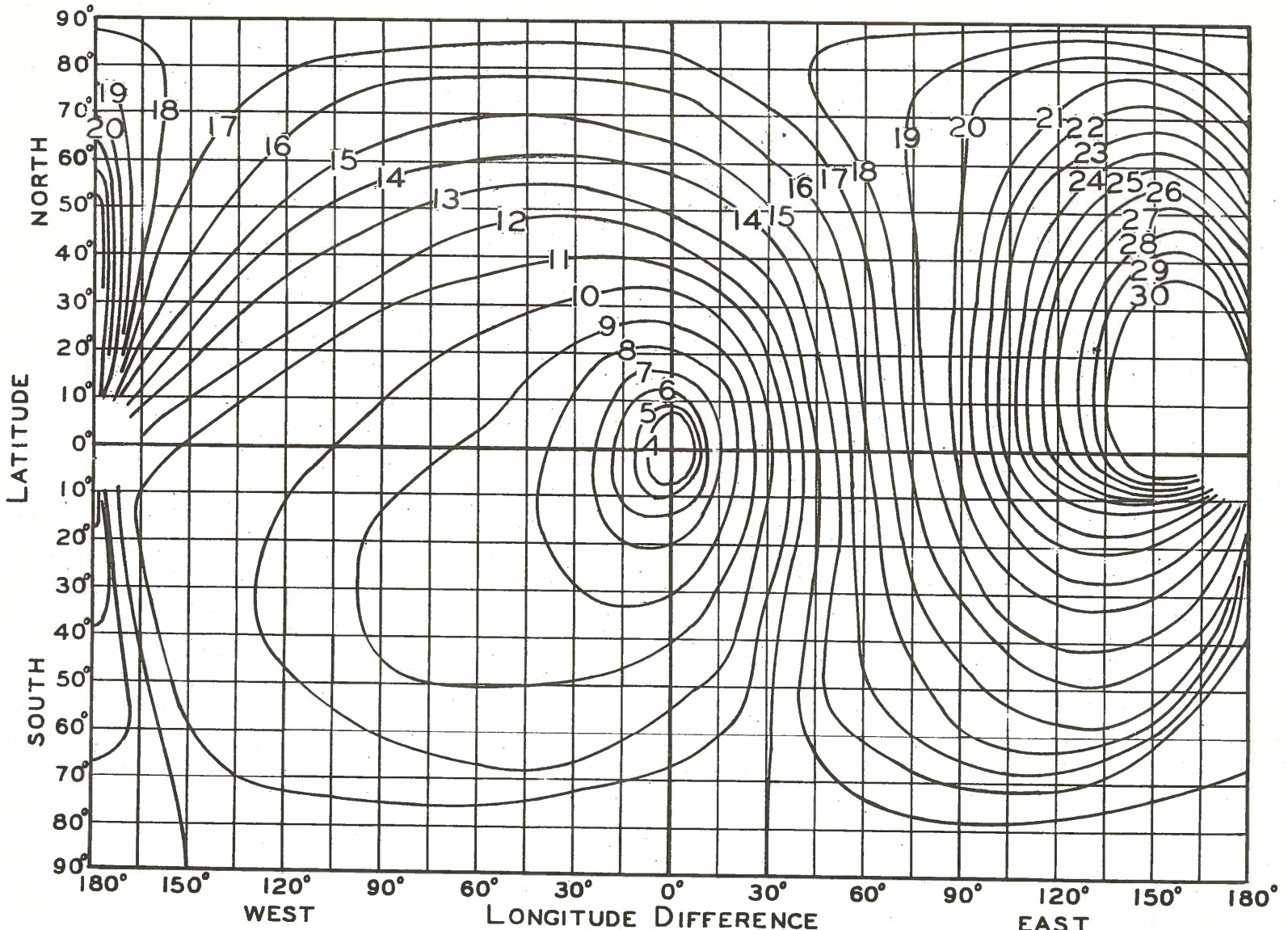


FIG. 43. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 0°. 0800 LOCAL TIME. OVER OPEN OCEAN.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

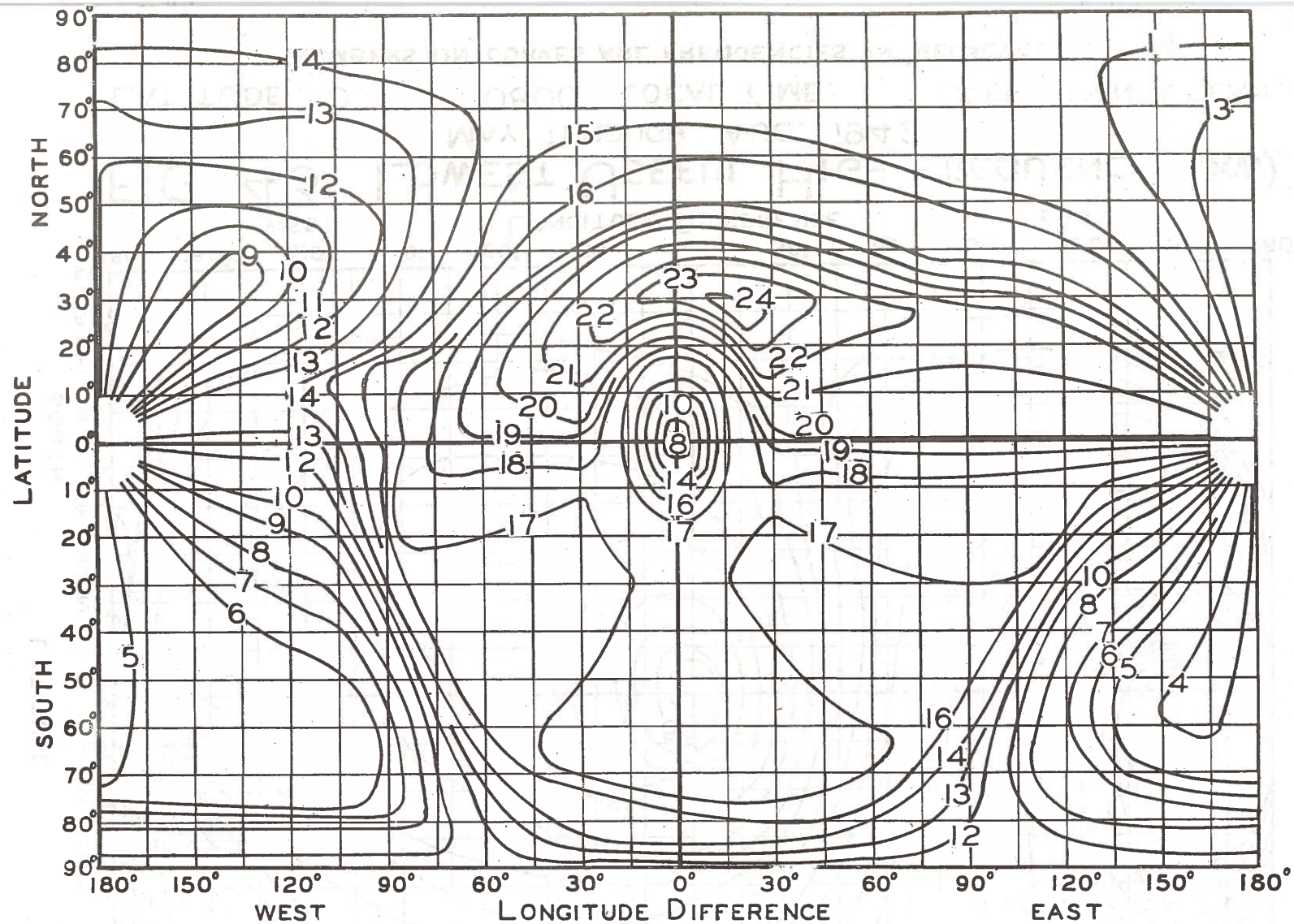


FIG. 44. MAXIMUM USABLE FREQUENCY.

MAY THROUGH AUG. 1942.

LATITUDE 0°. 1200 LOCAL TIME.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

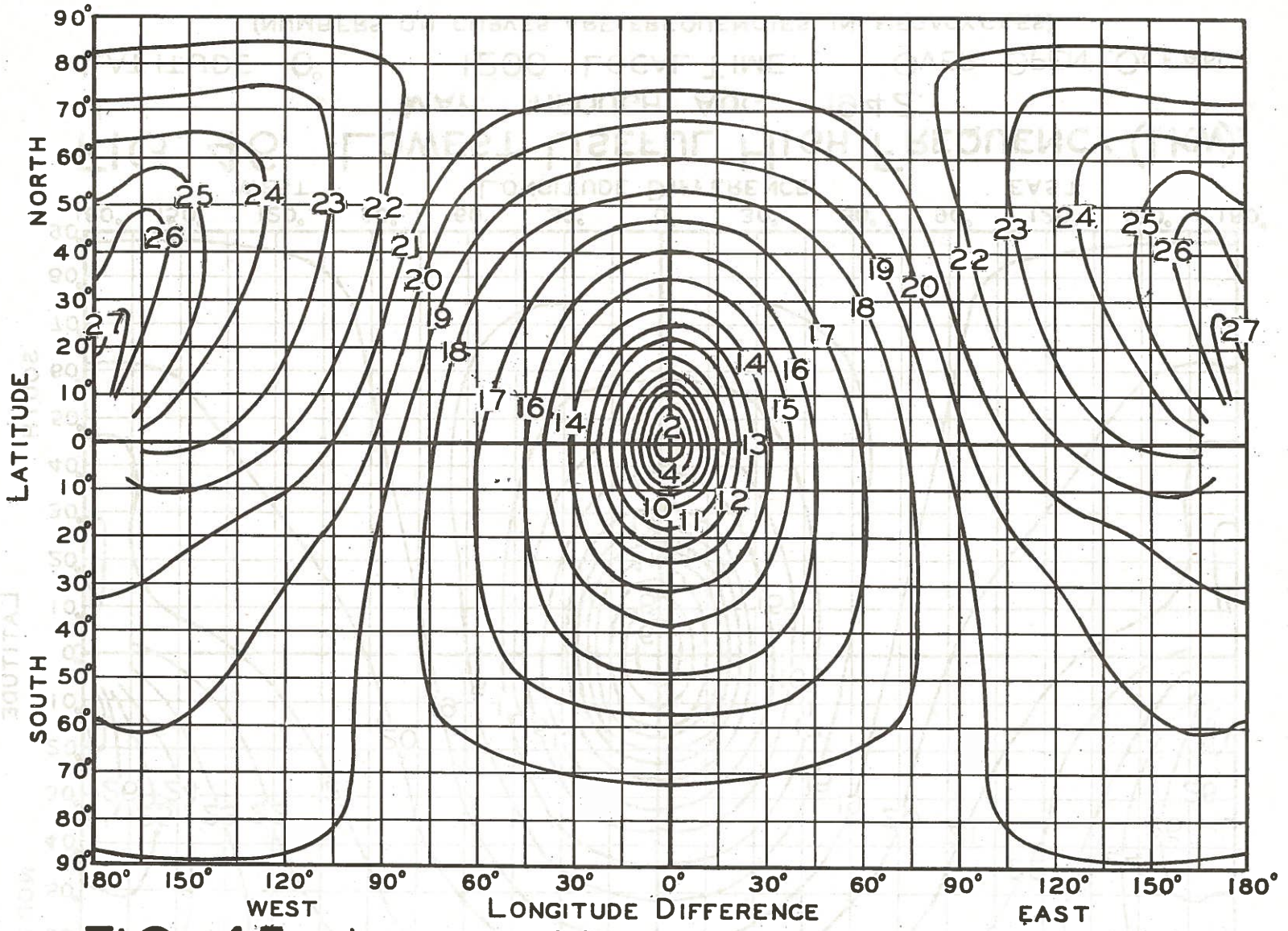


FIG. 45. LOWEST USEFUL HIGH FREQUENCY (1 KW)

MAY THROUGH AUG. 1942

LATITUDE 0°. 1200 LOCAL TIME. OVER OR NEAR LAND.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

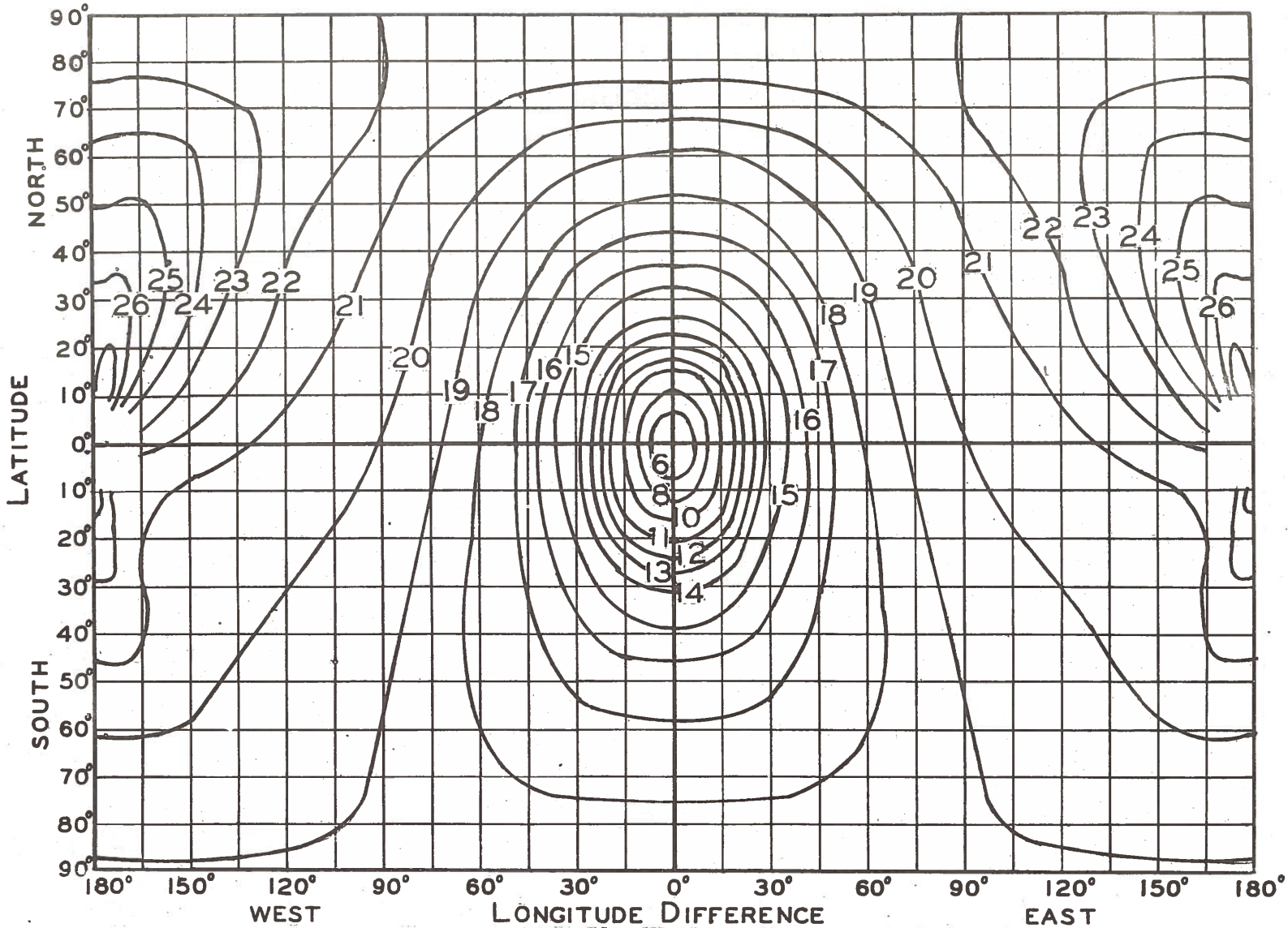


FIG. 46. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 0° 1200 LOCAL TIME. OVER OPEN OCEAN.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

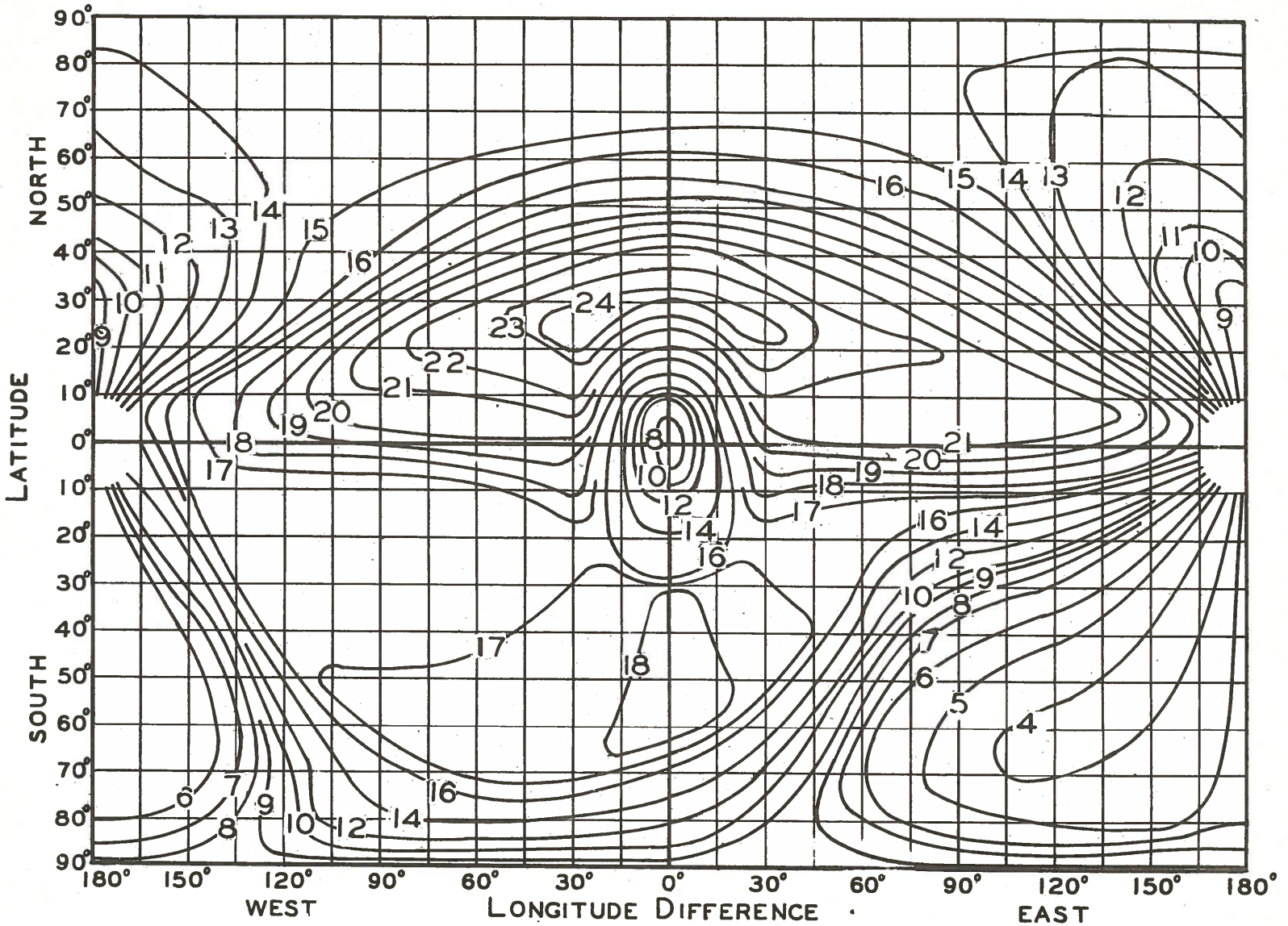


FIG. 47. MAXIMUM USABLE FREQUENCY.

MAY THROUGH AUG. 1942.

LATITUDE 0°. 1600 LOCAL TIME.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

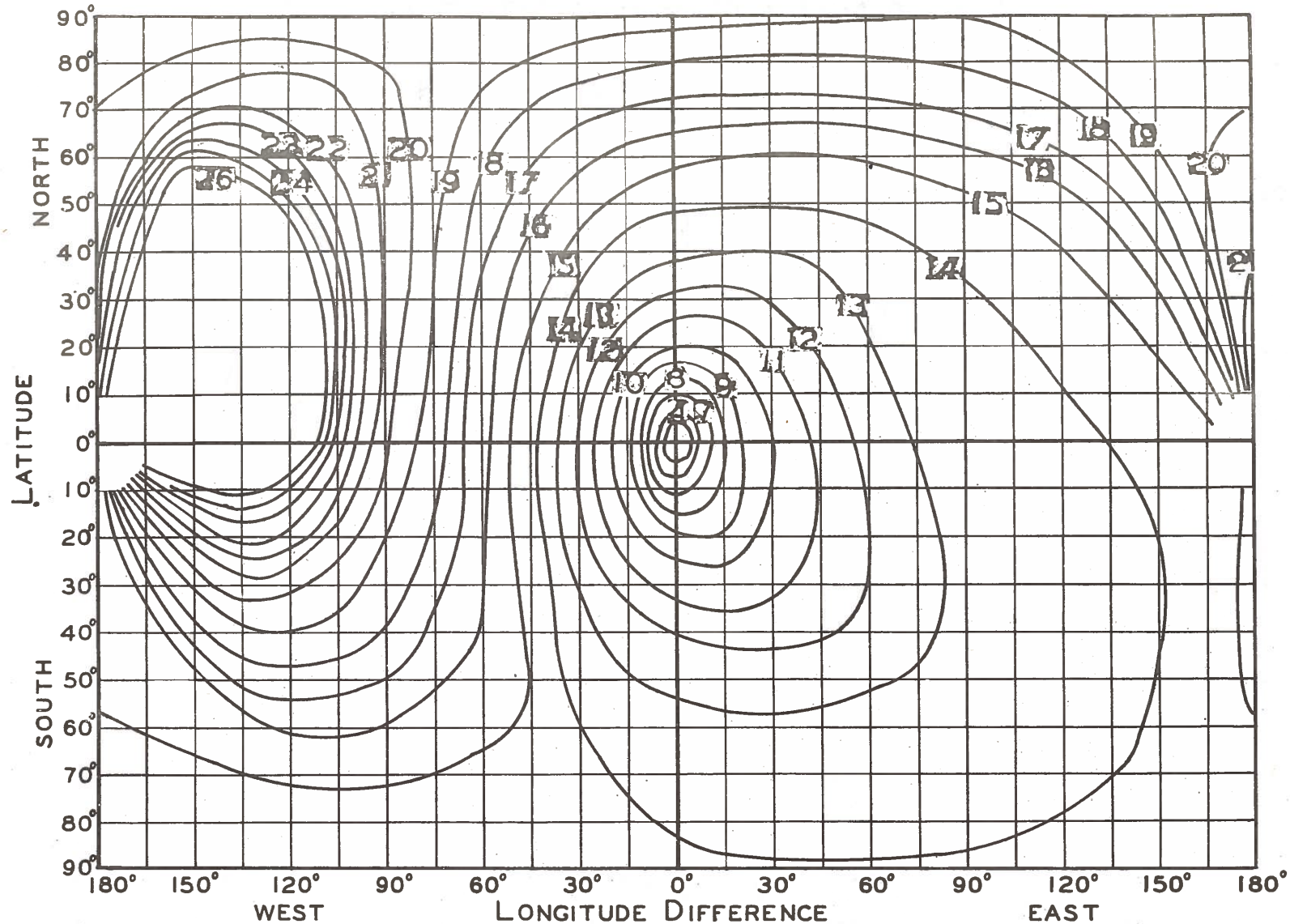


FIG. 48. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 0°. 1600 LOCAL TIME. OVER OR NEAR LAND.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

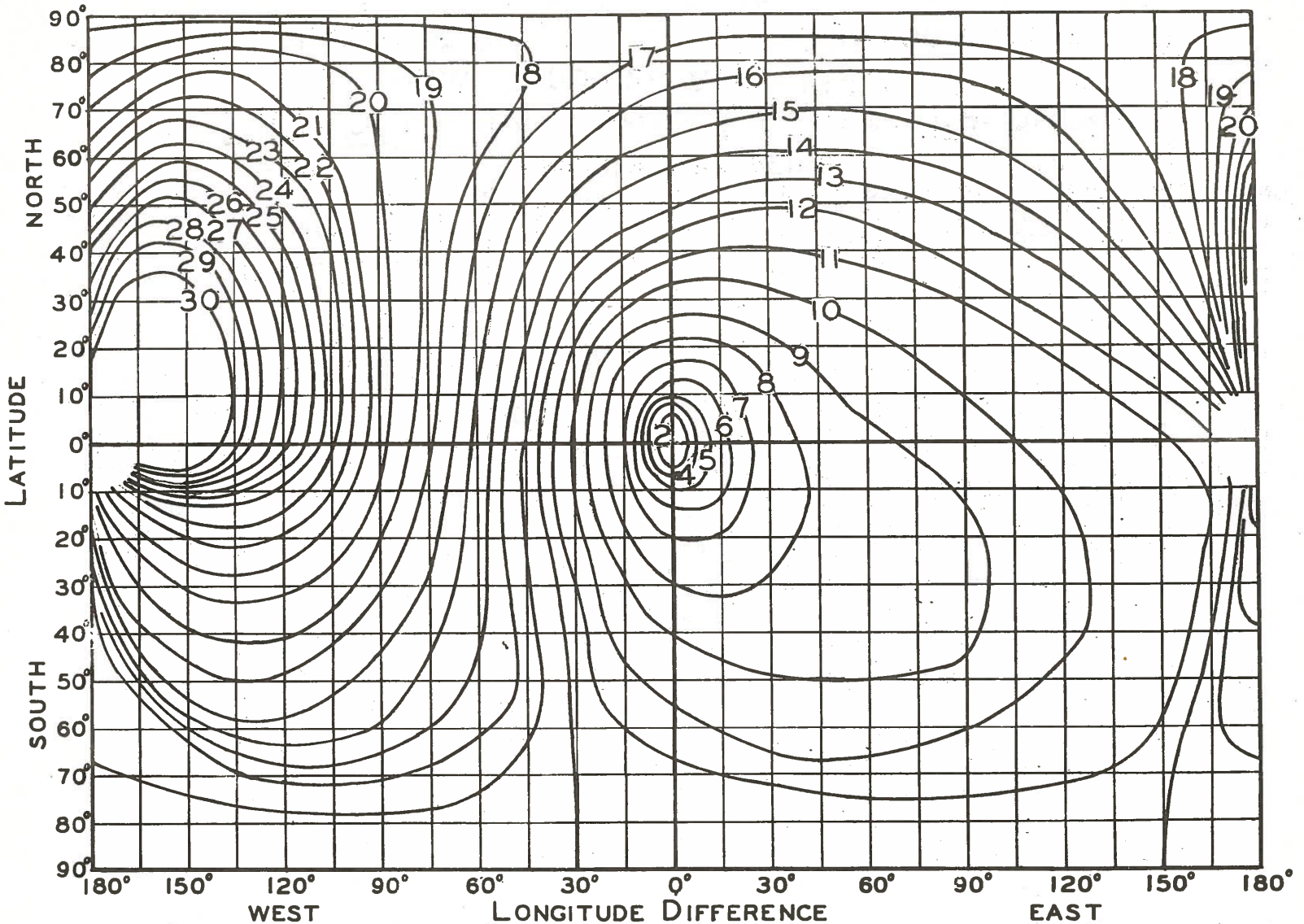


FIG. 49. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 0°. 1600 LOCAL TIME. OVER OPEN OCEAN.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

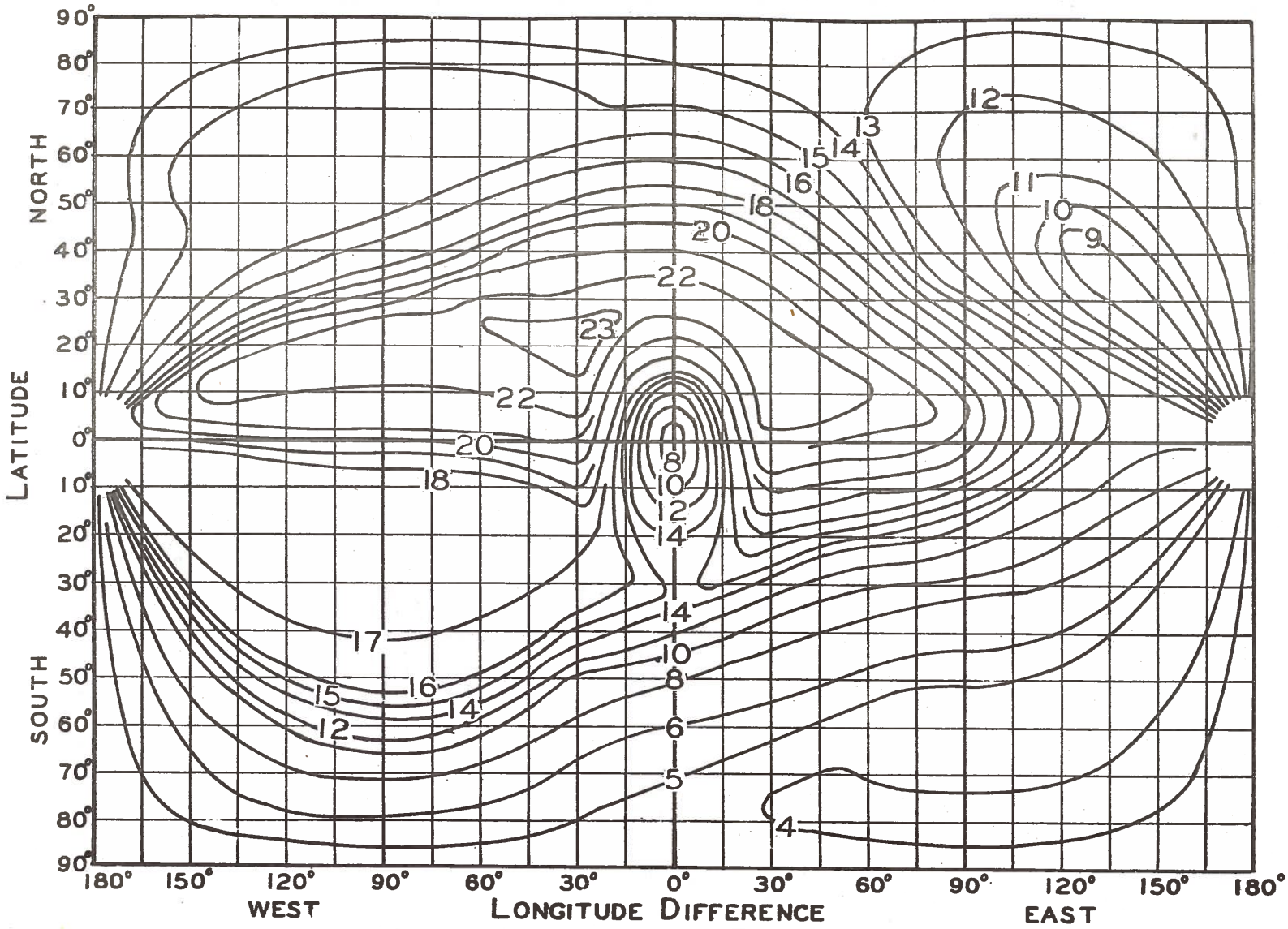


FIG. 50. MAXIMUM USABLE FREQUENCY.

MAY THROUGH AUG. 1942.

LATITUDE 0°. 2000 LOCAL TIME.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

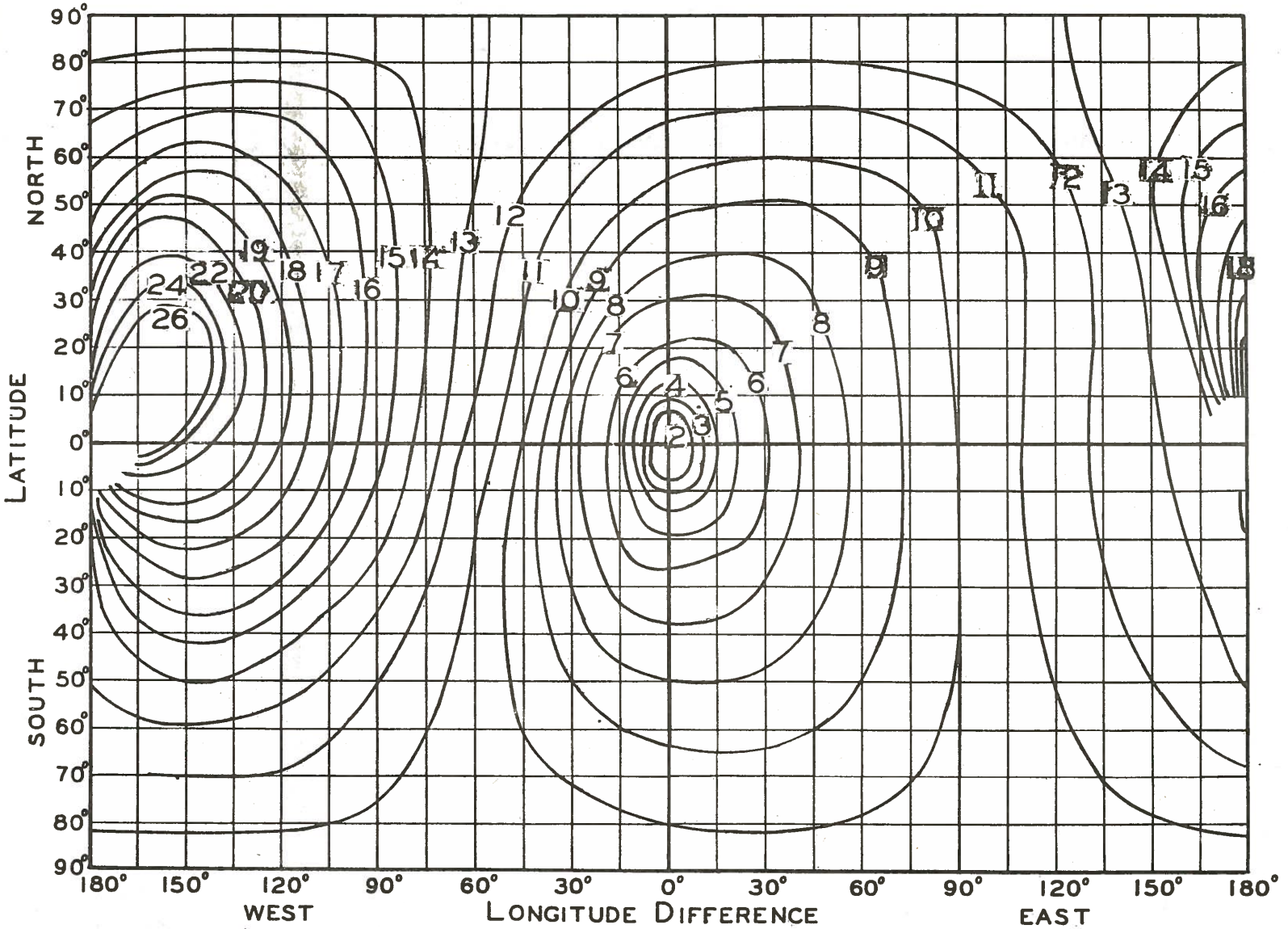


FIG. 51. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 0° 2000 LOCAL TIME. OVER OR NEAR LAND.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

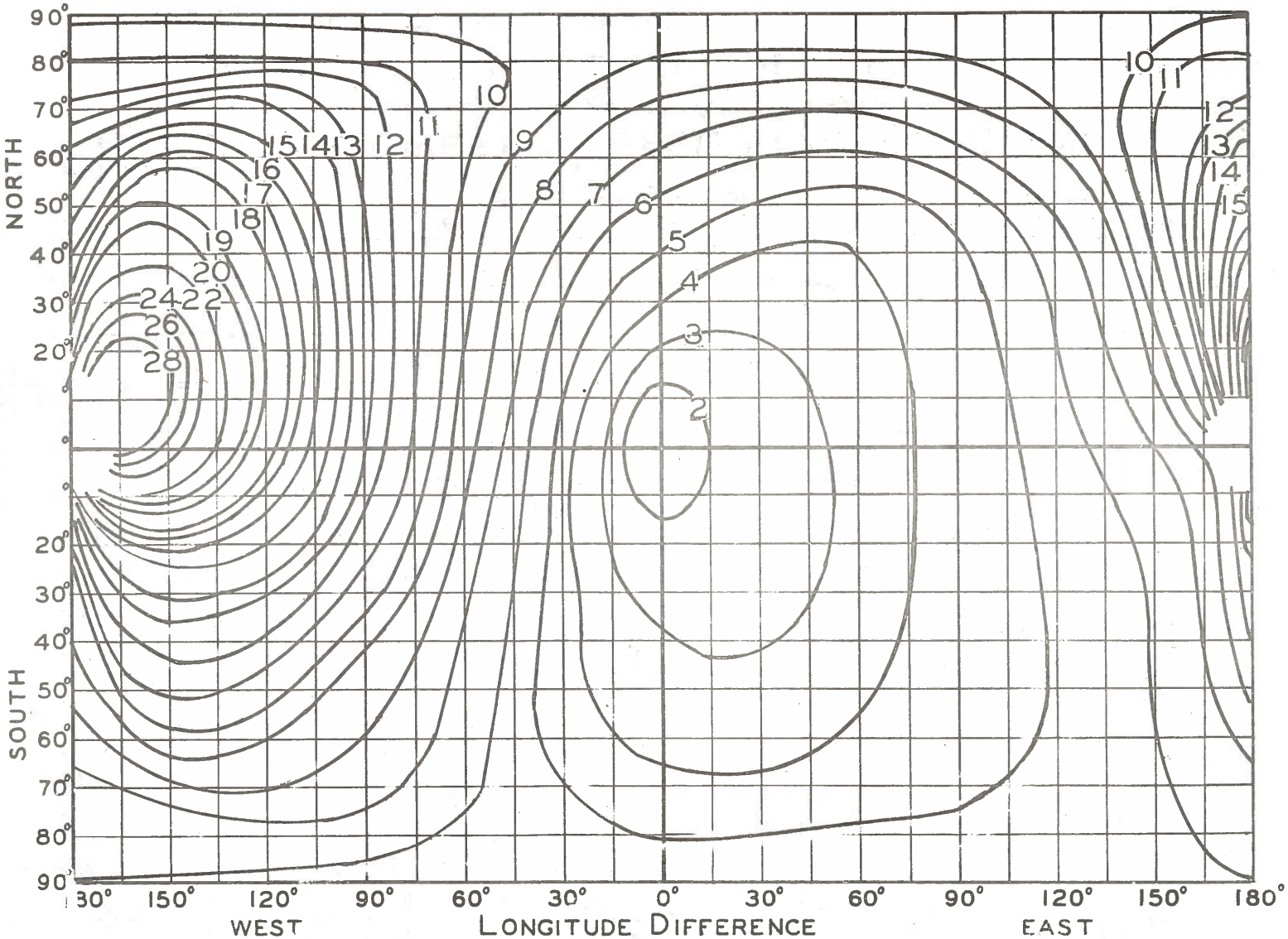


FIG. 52. LOWEST USEFUL HIGH FREQUENCY (1 KW).

MAY THROUGH AUG. 1942.

LATITUDE 0°. 2000 LOCAL TIME. OVER OPEN OCEAN.

(NUMBERS ON CURVES ARE FREQUENCIES IN MEGACYCLES)

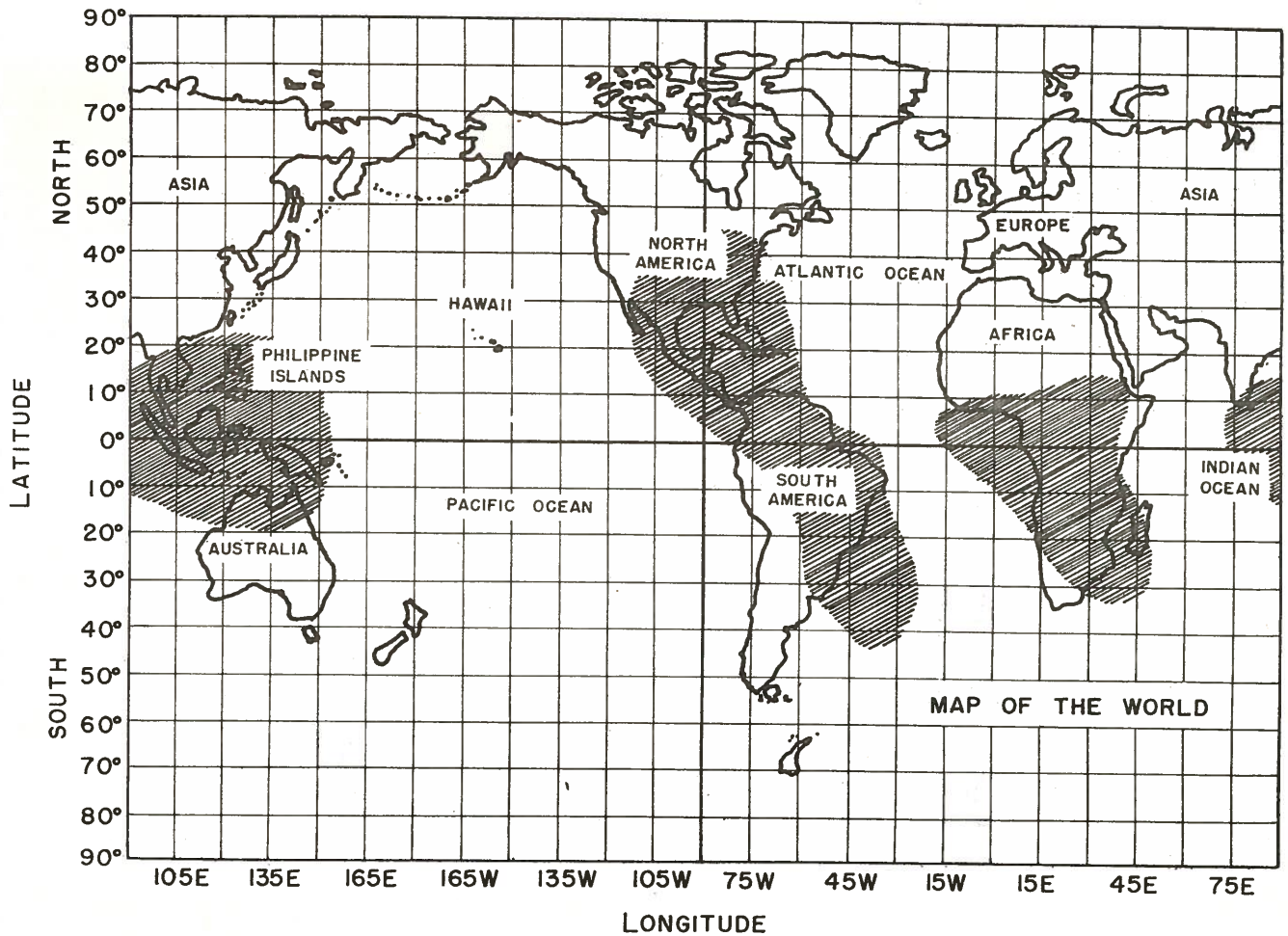


Fig. 53. Map of the world showing areas where atmospheric noise is severe. In cross-hatched section of map noise is severe in summer, and "over or near land" graphs are to be used. Elsewhere the "over open ocean" graphs are to be used.

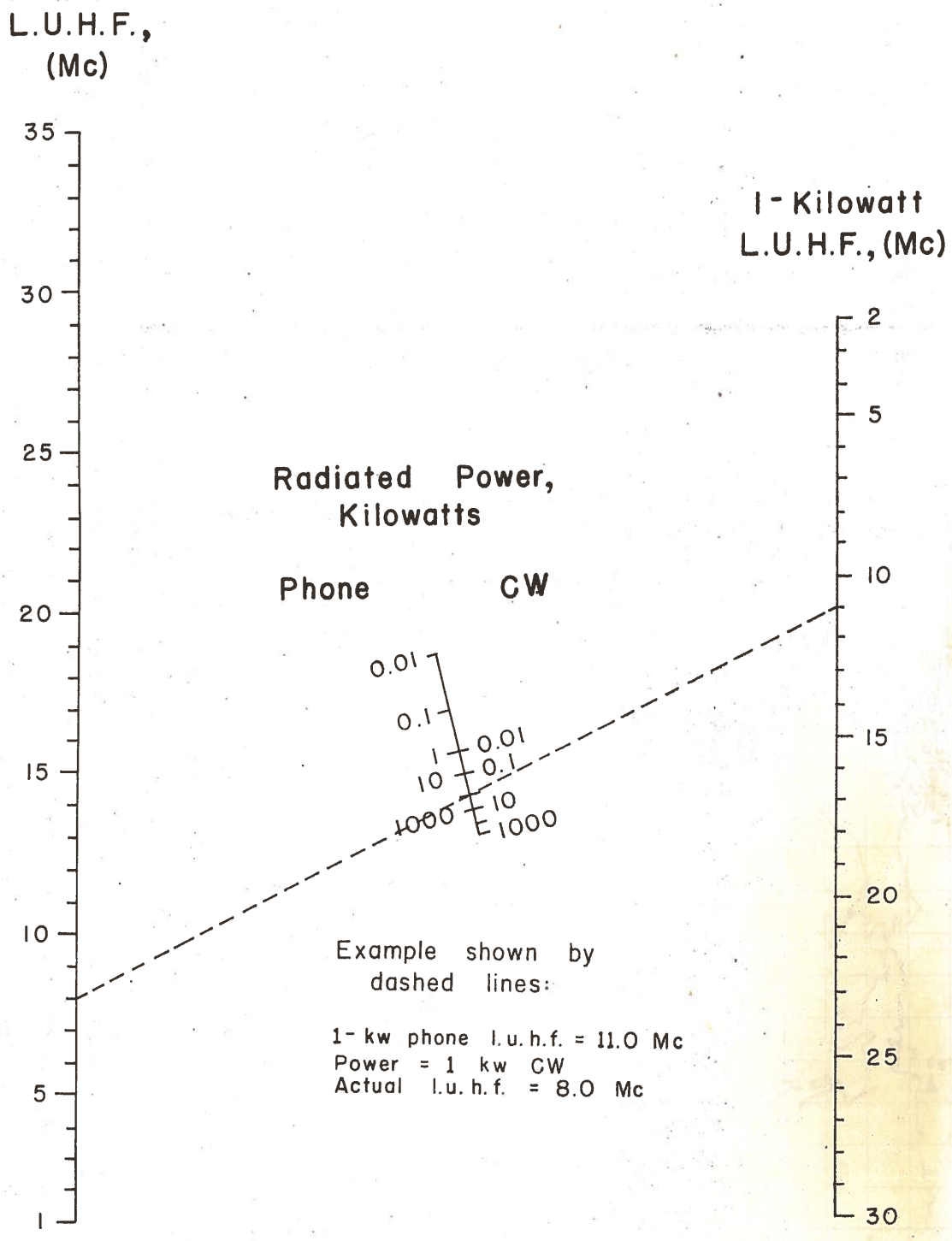


Fig. 54. Nomogram for determining lowest useful high frequency (l.u.h.f.) for any power, given its value for one kilowatt phone.

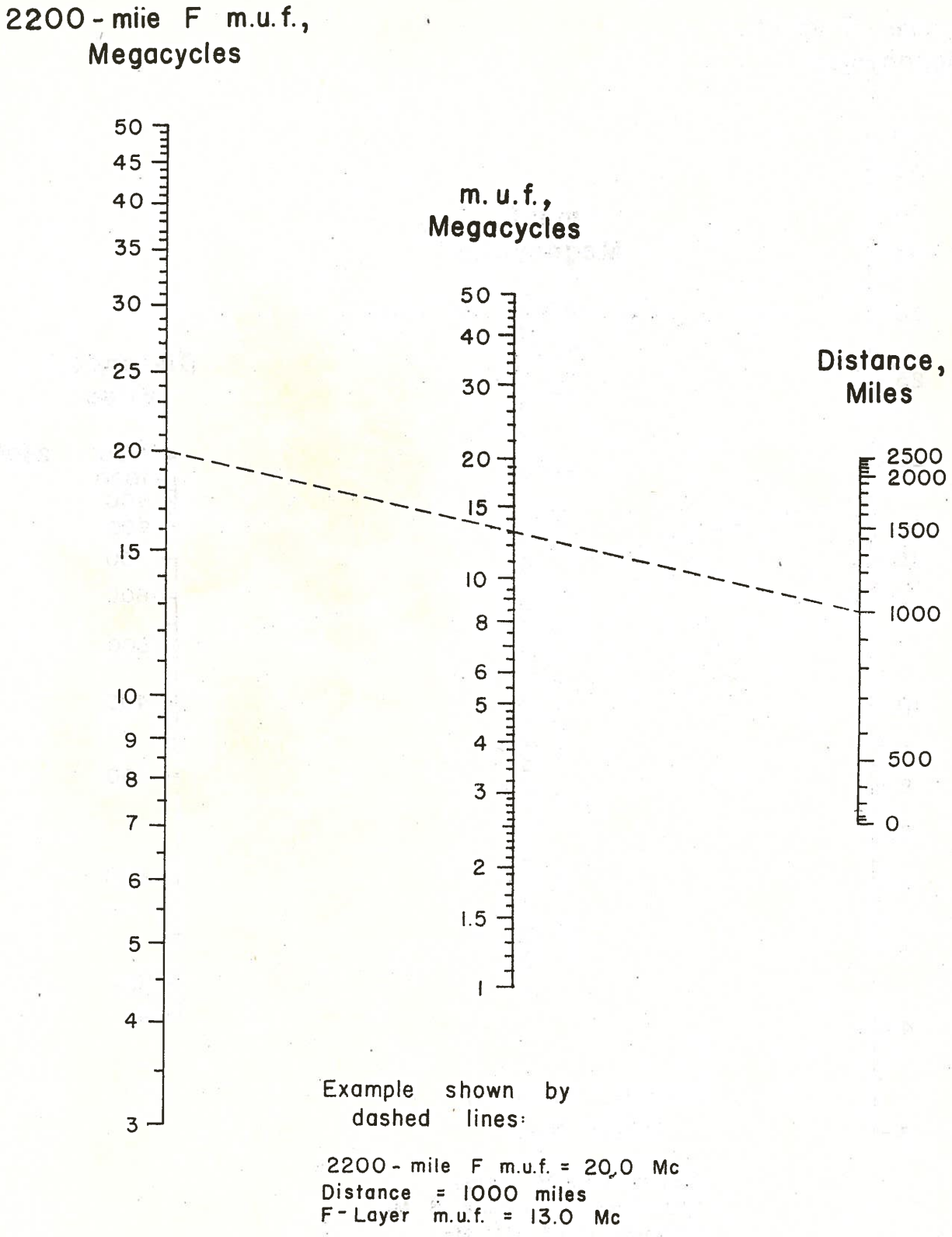


Fig. 55. Nomogram for determining maximum usable frequencies for F- or F_2-layer transmission over any distance up to 2500 miles.

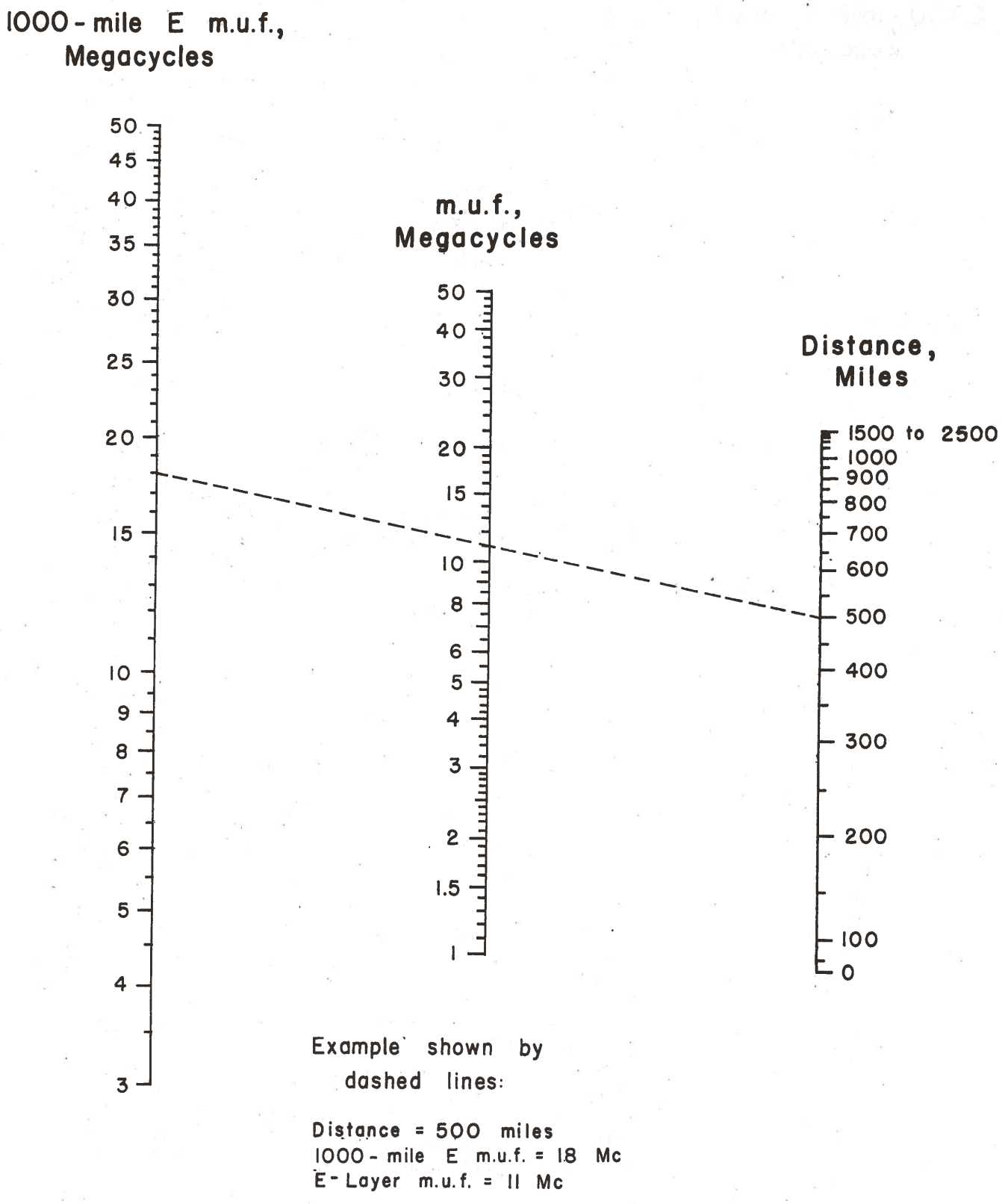


Fig. 56. Nomogram for determining maximum usable frequencies for E-layer transmission over any distance up to 2500 miles.

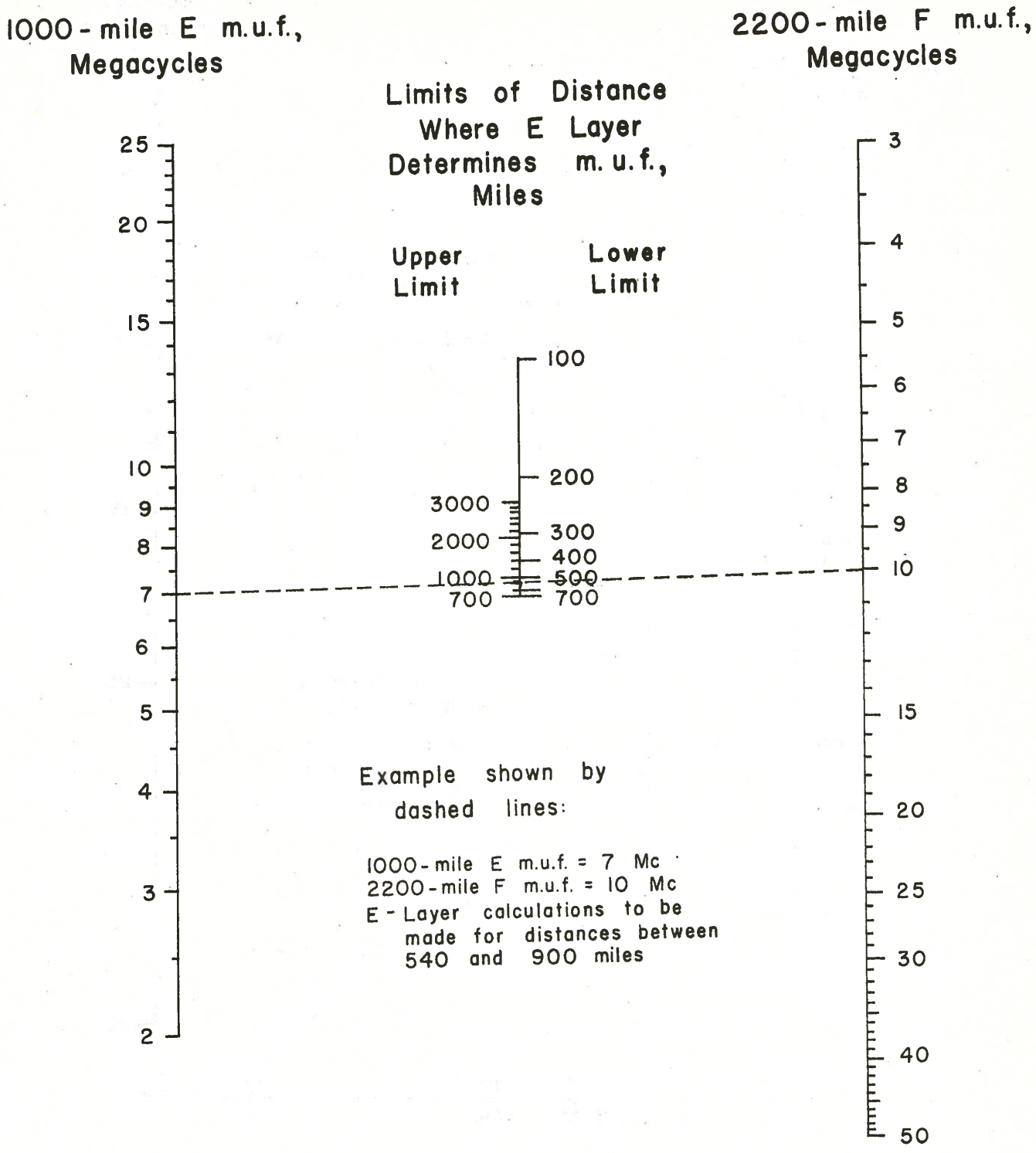


Fig. 57. Nomogram for determining range of distances for which E-layer m.u.f. calculations require consideration.

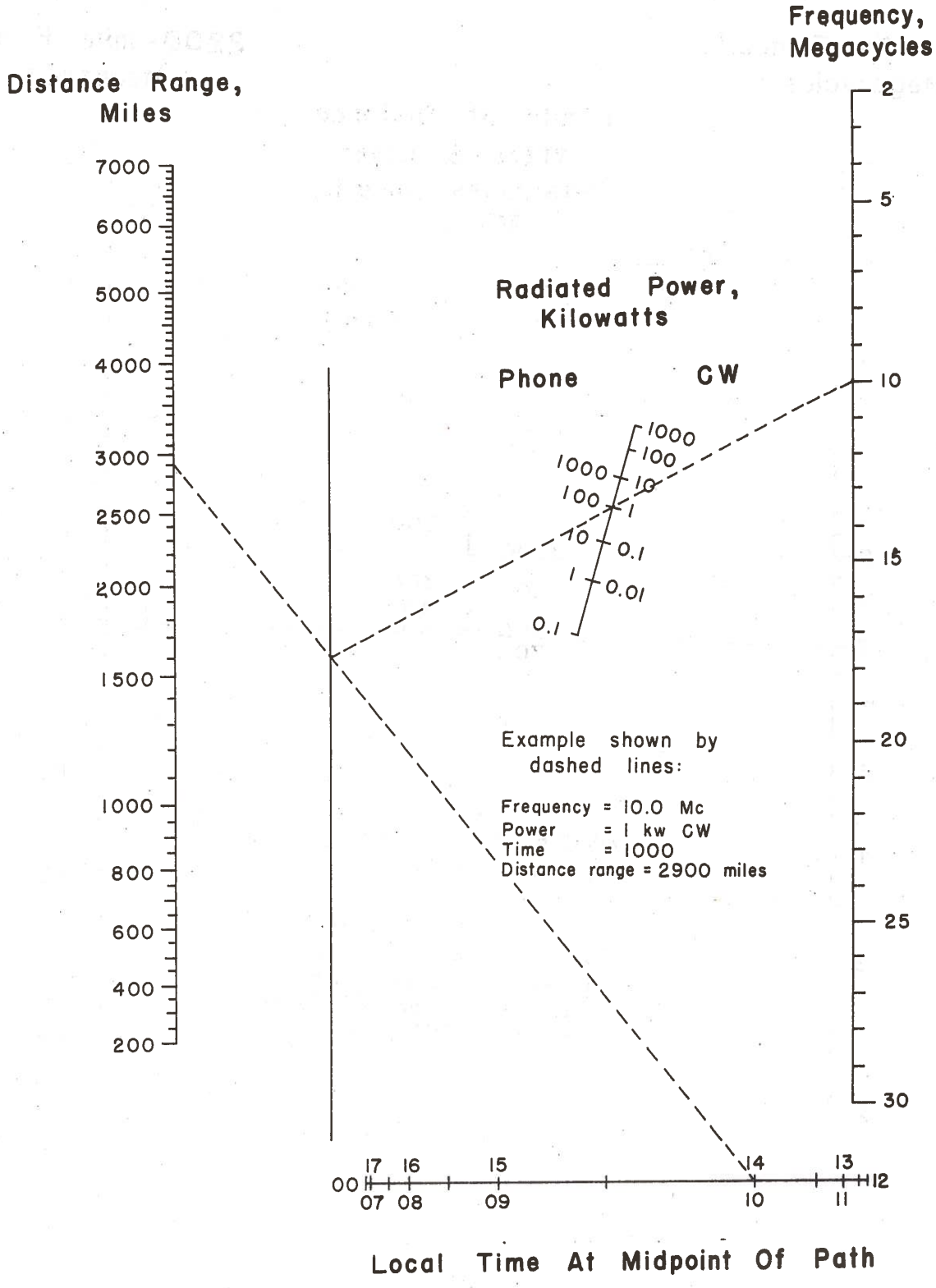


Fig. 58. Nomogram giving radio distance ranges for receiving locations between latitudes 50°S and 20°S. Average for quiet days, May through August, 1942, for transmission by way of the regular ionosphere layers.

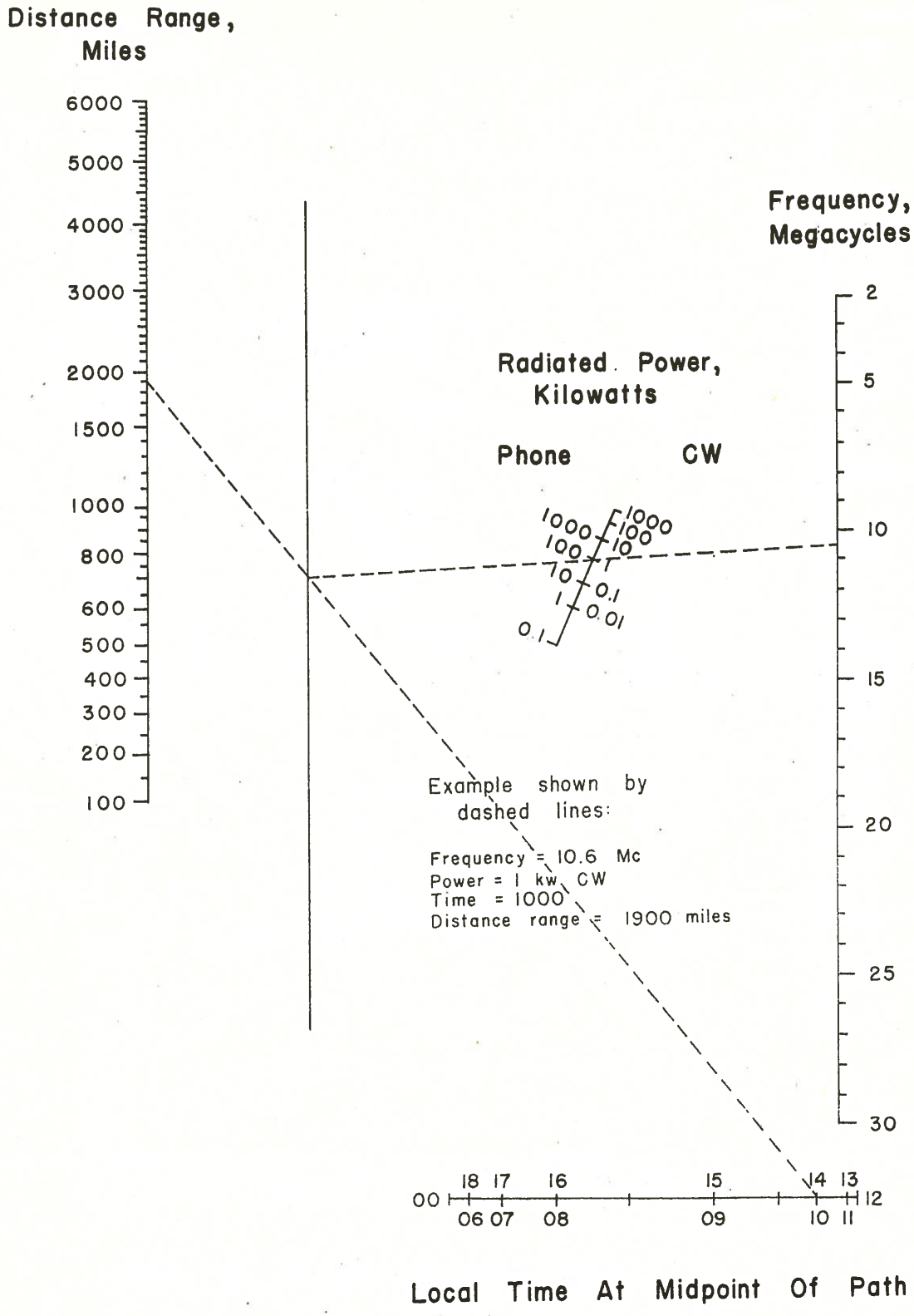


Fig. 59. Nomogram giving radio distance ranges for receiving locations between latitudes 20°S and 20°N. Average for quiet days, May through August, 1942, for transmission by way of the regular ionosphere layers, over or near land.

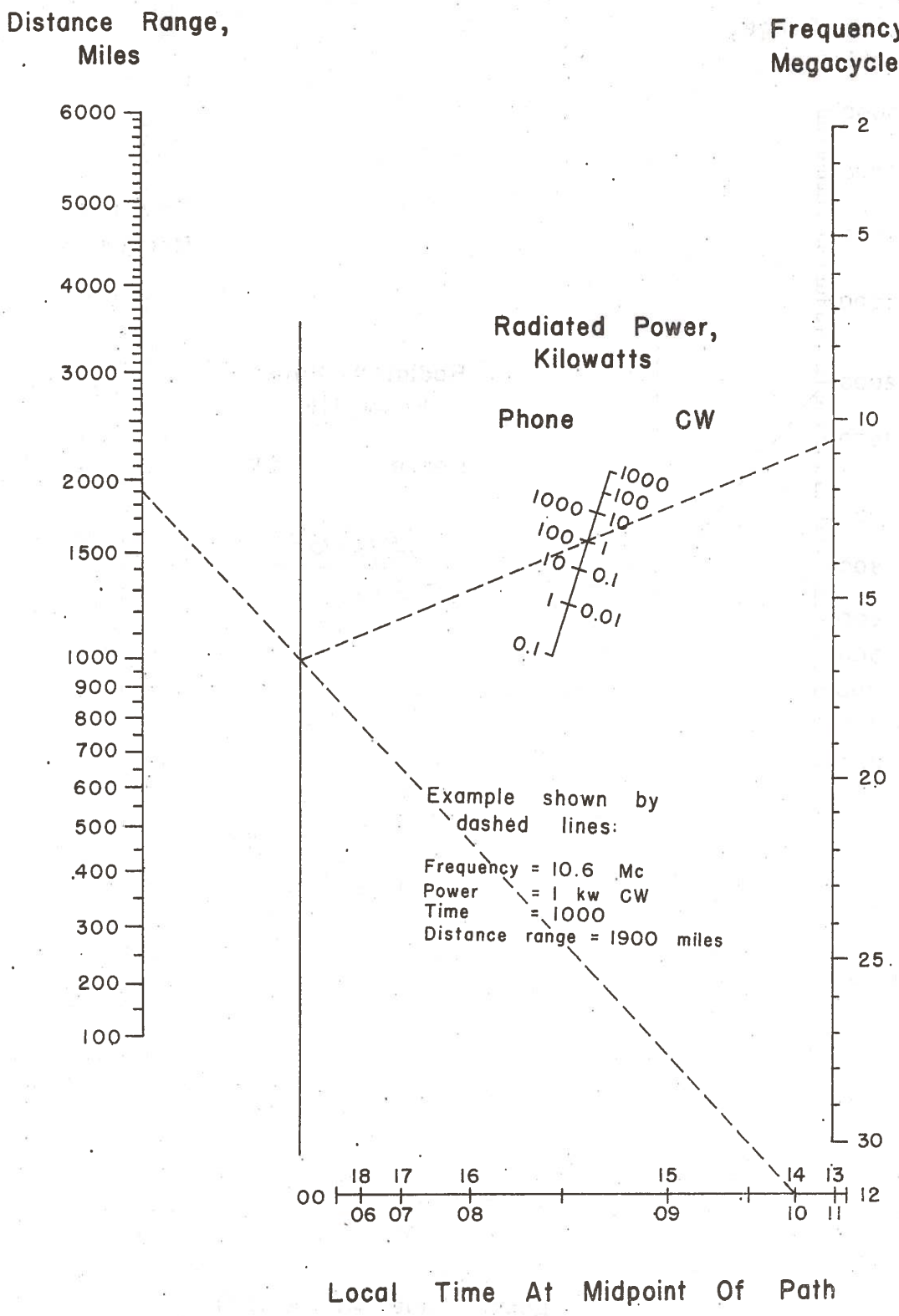


Fig. 60. Nomogram giving radio distance ranges for receiving locations between latitudes 20°S and 20°N. Average for quiet days, May through August, 1942, for transmission by way of the regular ionosphere layers, over open ocean.

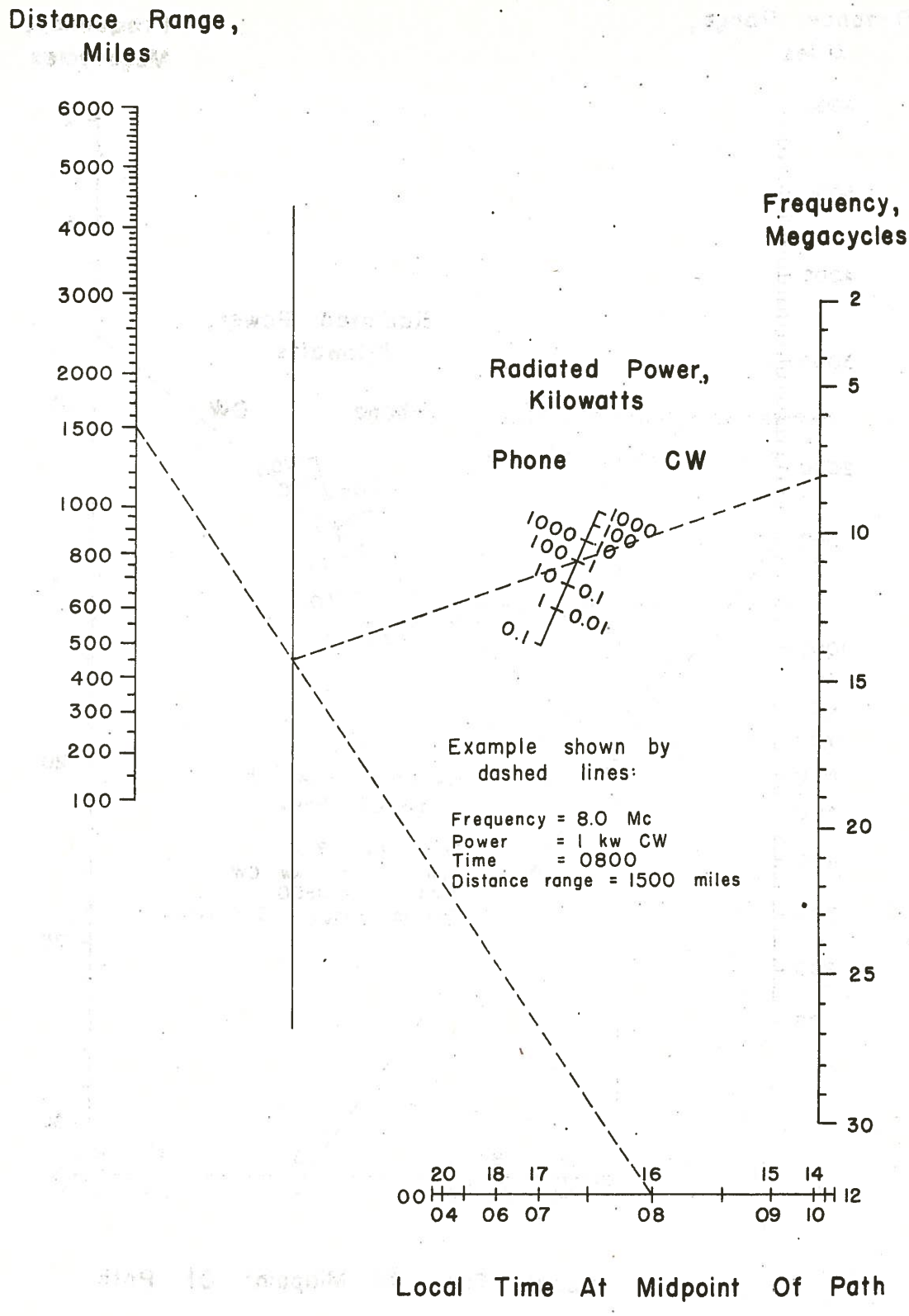


Fig. 61. Nomogram giving radio distance ranges for receiving locations between latitudes 20°N and 50°N. Average for quiet days, May through August, 1942, for transmission by way of the regular ionosphere layers, over or near land.

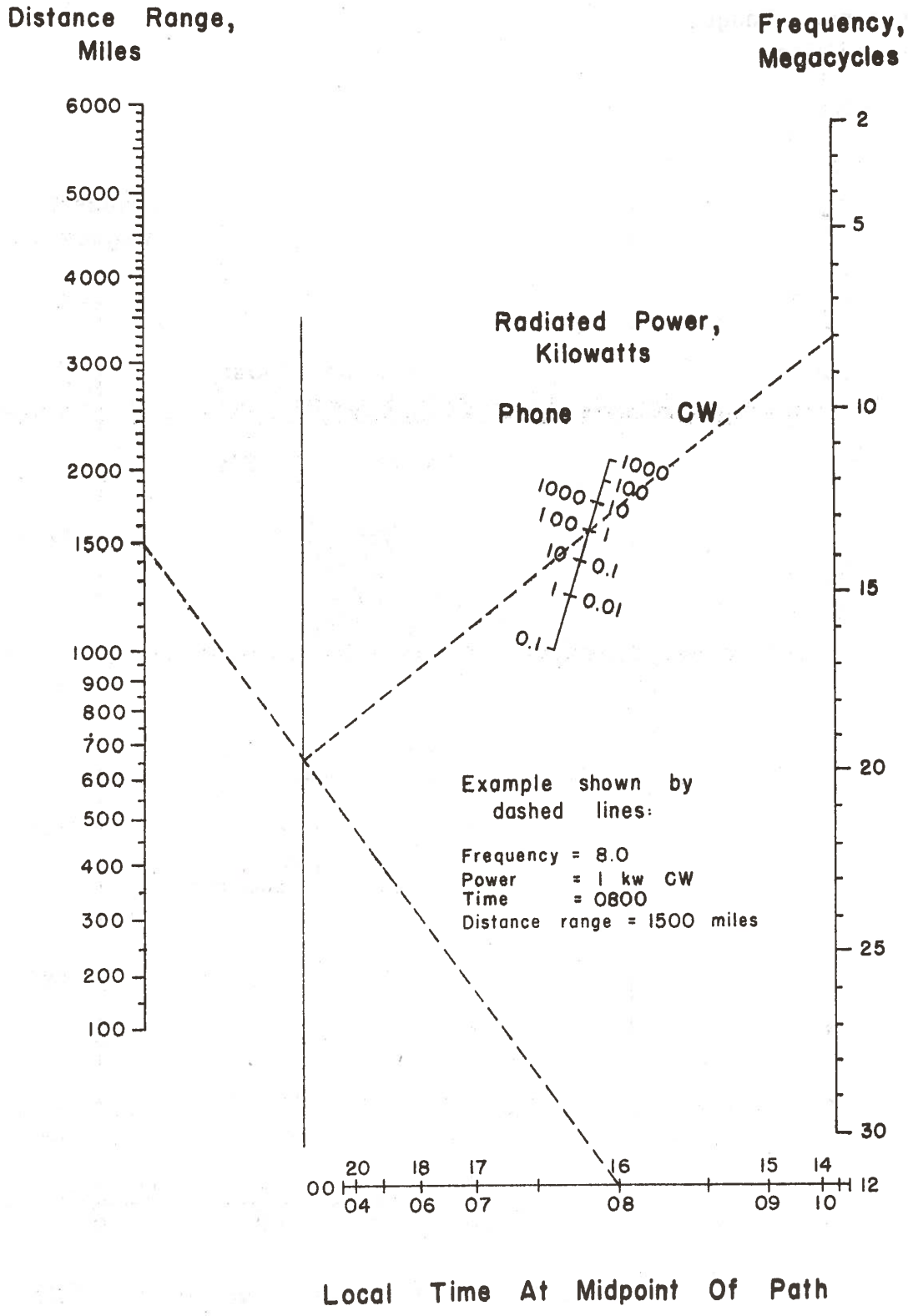
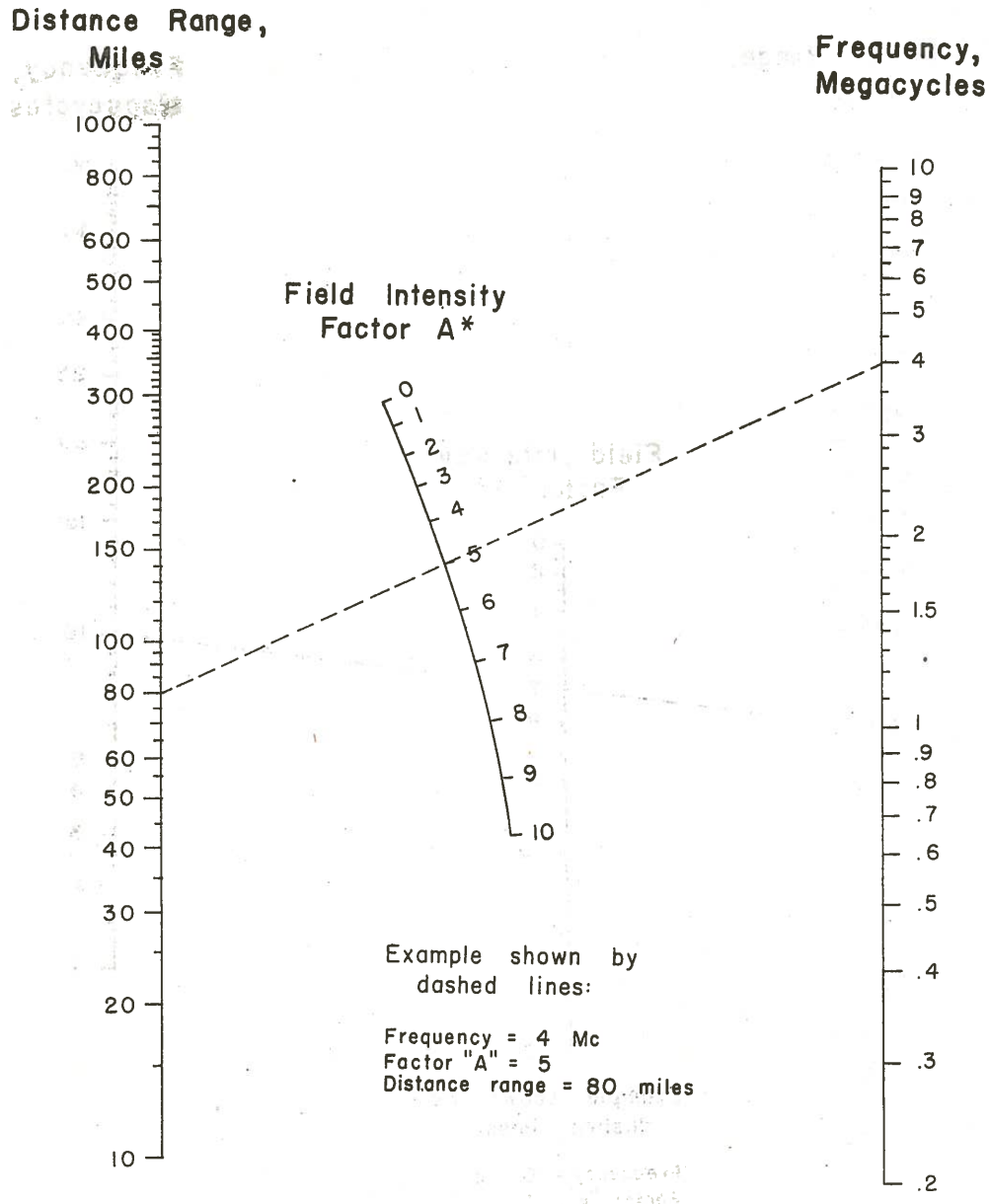


Fig. 62. Nomogram giving radio distance ranges for receiving locations between latitudes 20°N and 50°N. Average for quiet days, May through August, 1942, for transmission by way of the regular ionosphere layers, over open ocean.

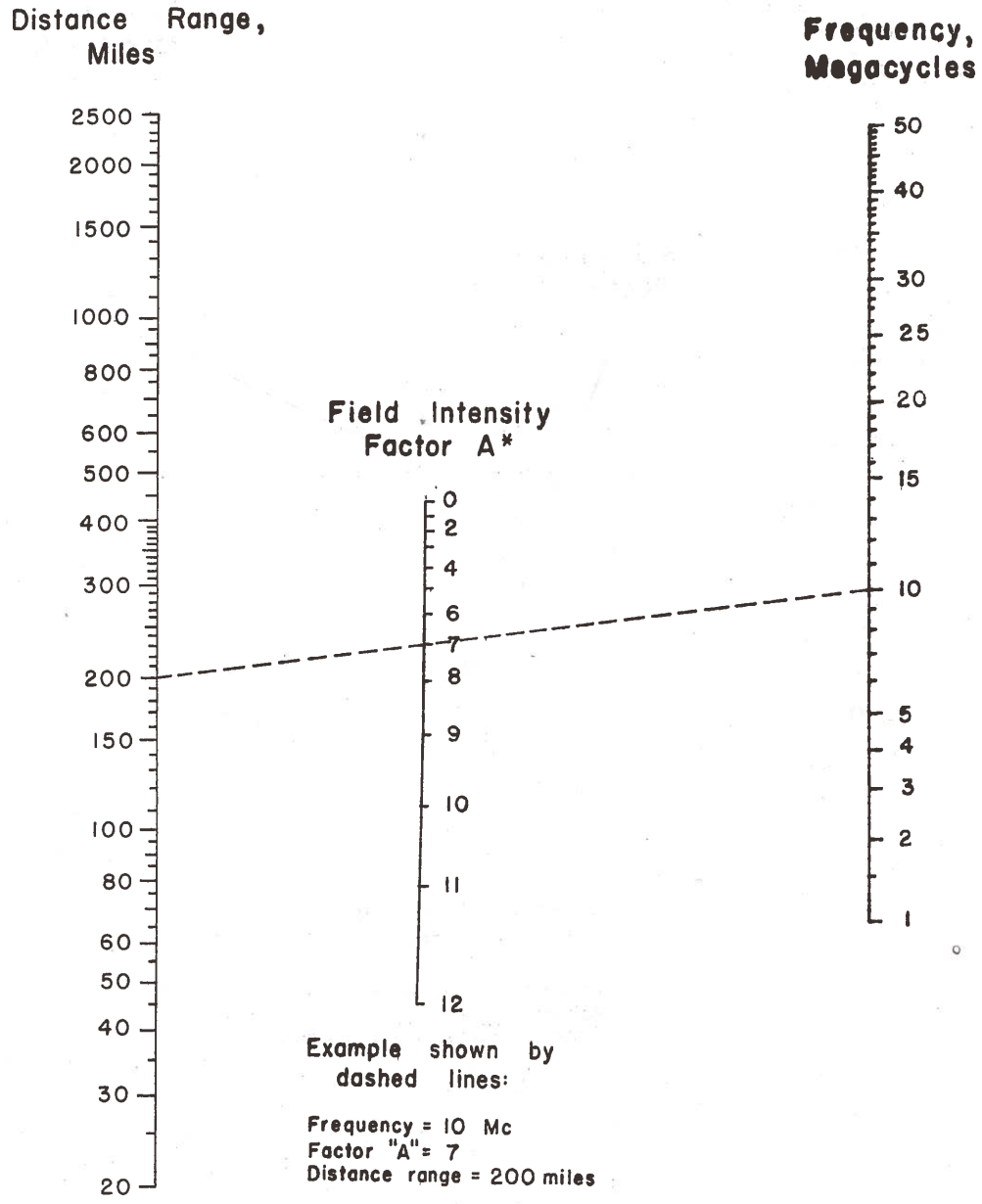
GROUND WAVE DISTANCE RANGES OVER LAND



*See Nomogram Fig. 65, or Table 6.

Fig. 63. Nomogram for determination of ground-wave distance ranges, for transmission over ground of average conductivity (5 10^{-14} e.m.u.) and dielectric constant (15). At times sky waves may exist and increase the distance ranges by a factor of 5 or more.

GROUND WAVE DISTANCE RANGES OVER OCEAN



* See Nomogram Fig. 65, or Table 6.

Fig. 64. Nomogram for determination of ground-wave distance ranges, for transmission over sea water (conductivity 5 10^{-11} e.m.u., dielectric constant 80).

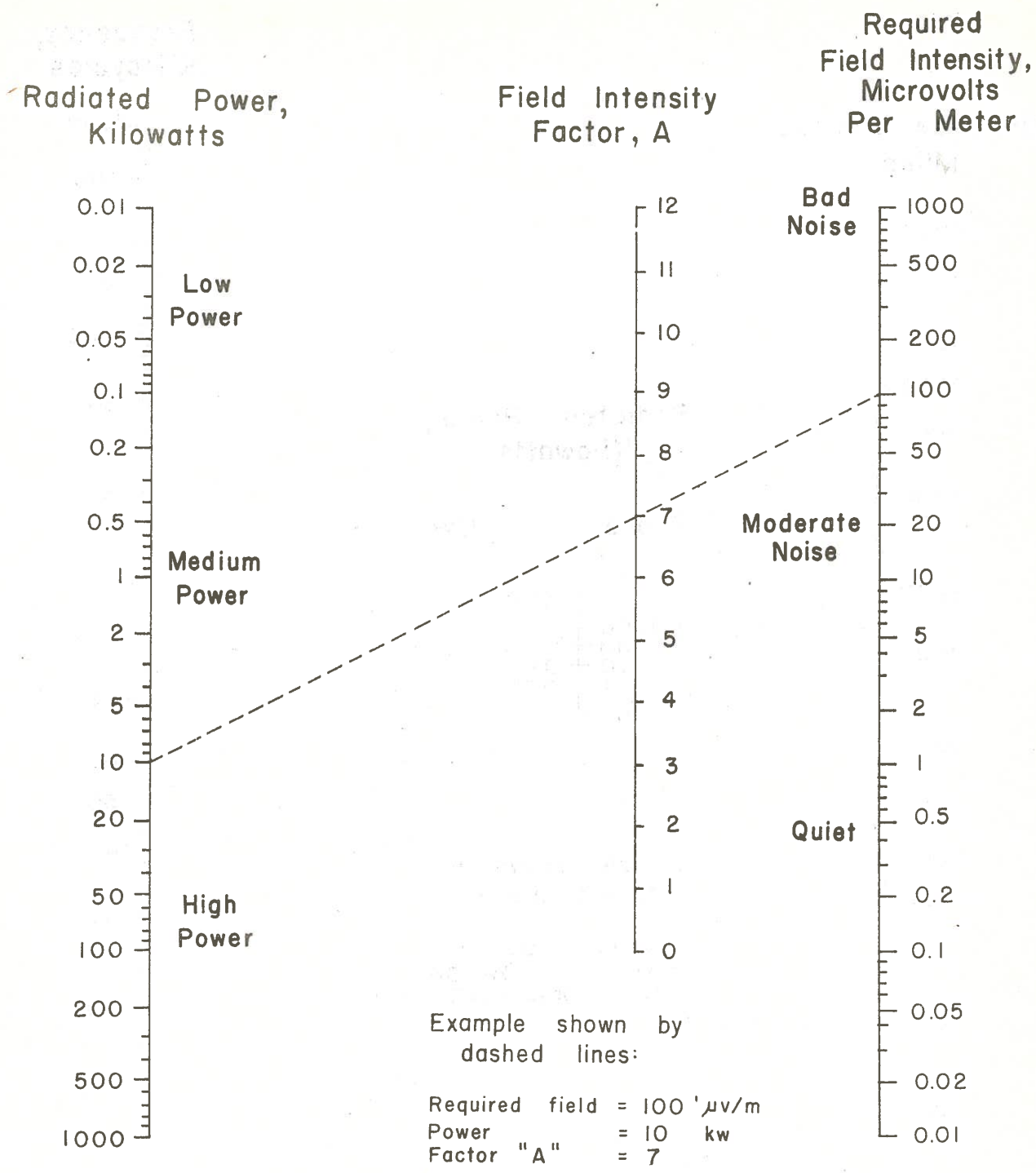


Fig. 65. Nomogram for determining field intensity factor "A", for use with nomograms of Figs. 63 and 64.

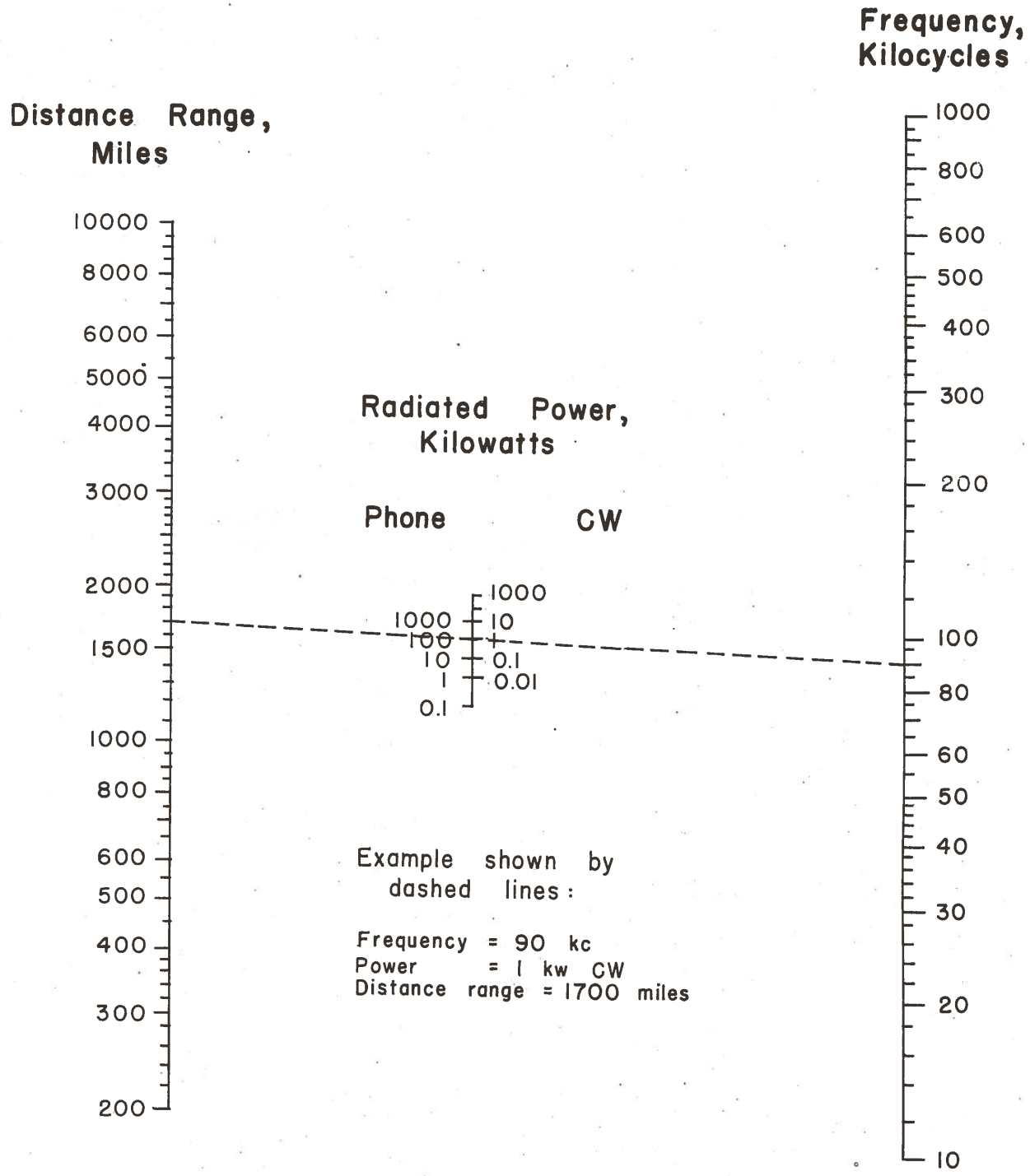


Fig. 66. Nomogram for determining low-frequency sky-wave distance ranges. Average for ionospherically quiet days, sunrise to sunset, May through August, 1942. For receiving location between 20°S and 50°N.

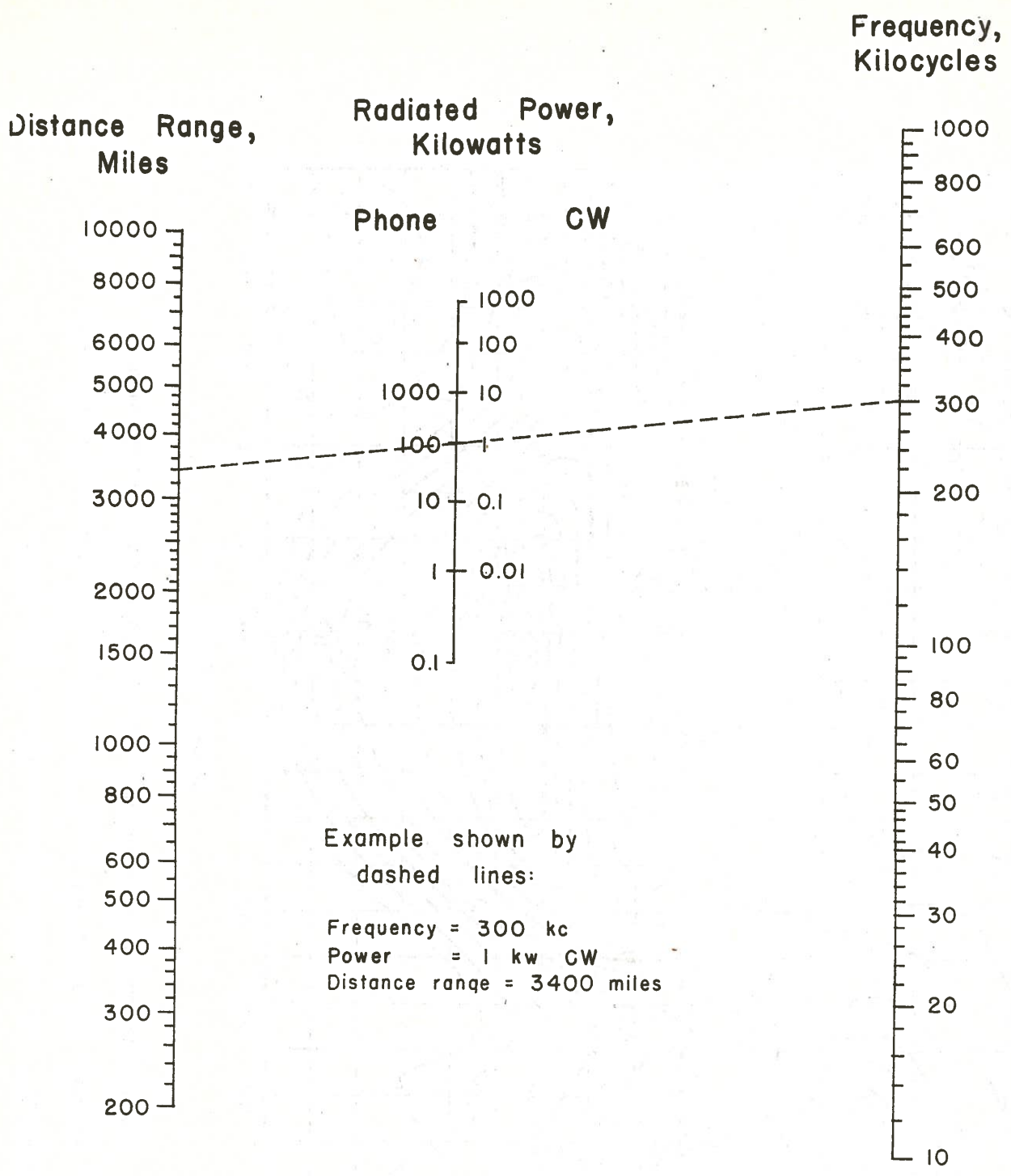


Fig. 67. Nomogram for determining low-frequency sky-wave distance ranges. Average for ionospherically quiet nights, sunset to sunrise, May through August, 1942. For receiving locations between 20°S and 50°N.

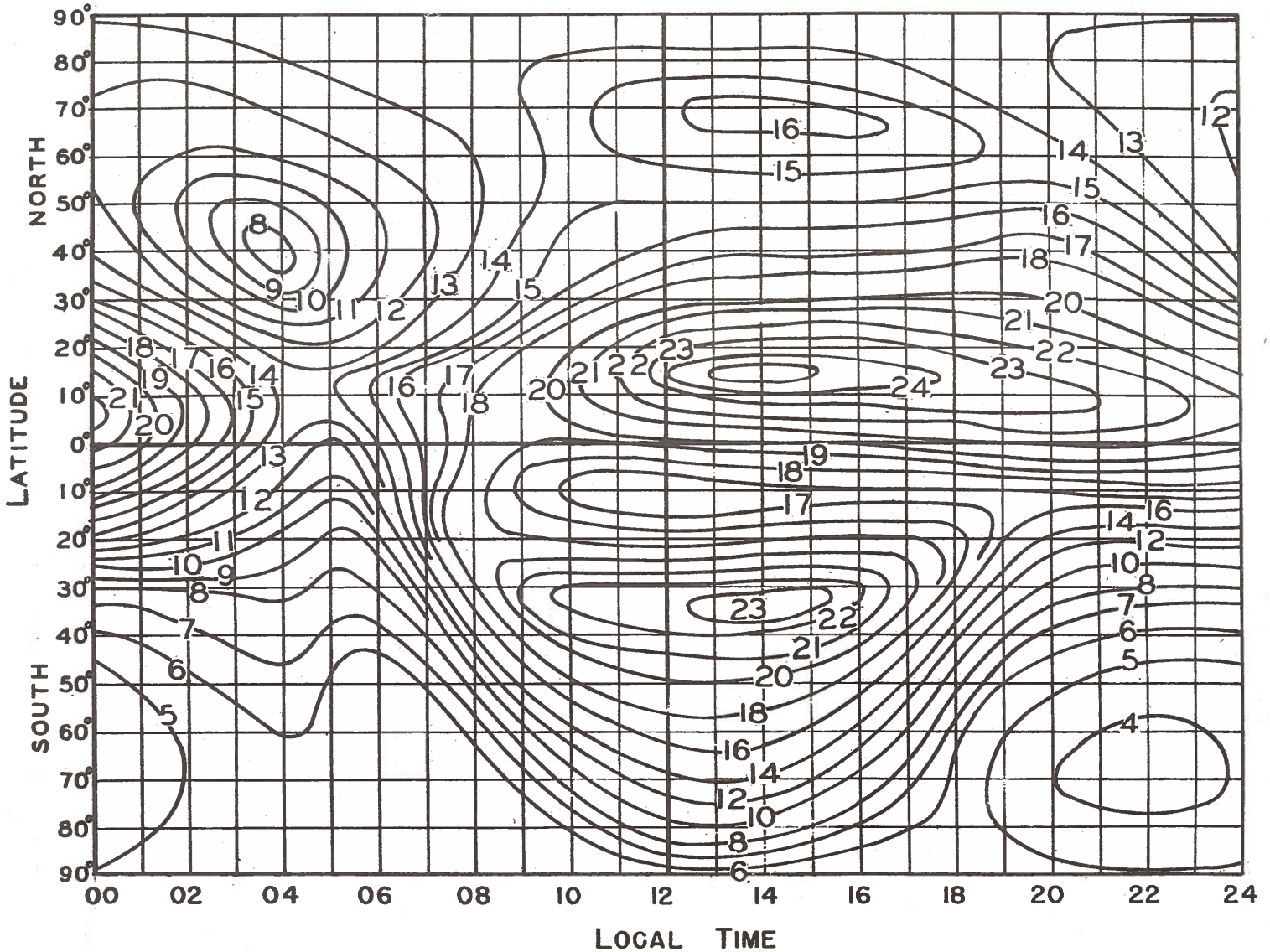


Fig. 68. F-layer frequencies, average for quiet days, May through August 1942. Numbers on curves are F- or F_2-layer maximum usable frequencies, in megacycles, for transmission distance of 2200 miles.

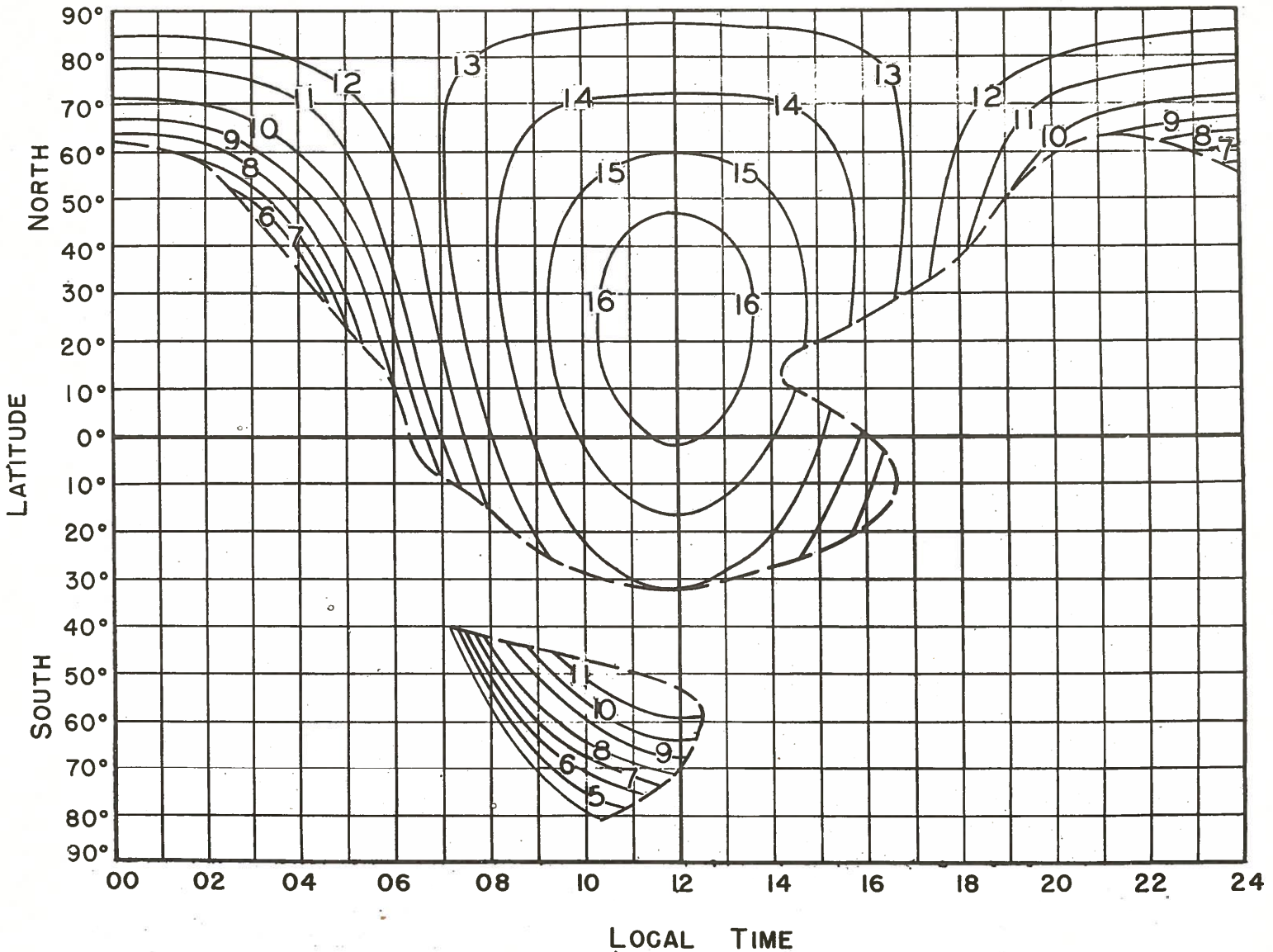


Fig. 69. E-layer frequencies, average for quiet days, May through August 1942. Numbers on curves are E-layer maximum usable frequencies, in megacycles, for transmission distance of 1000 miles.

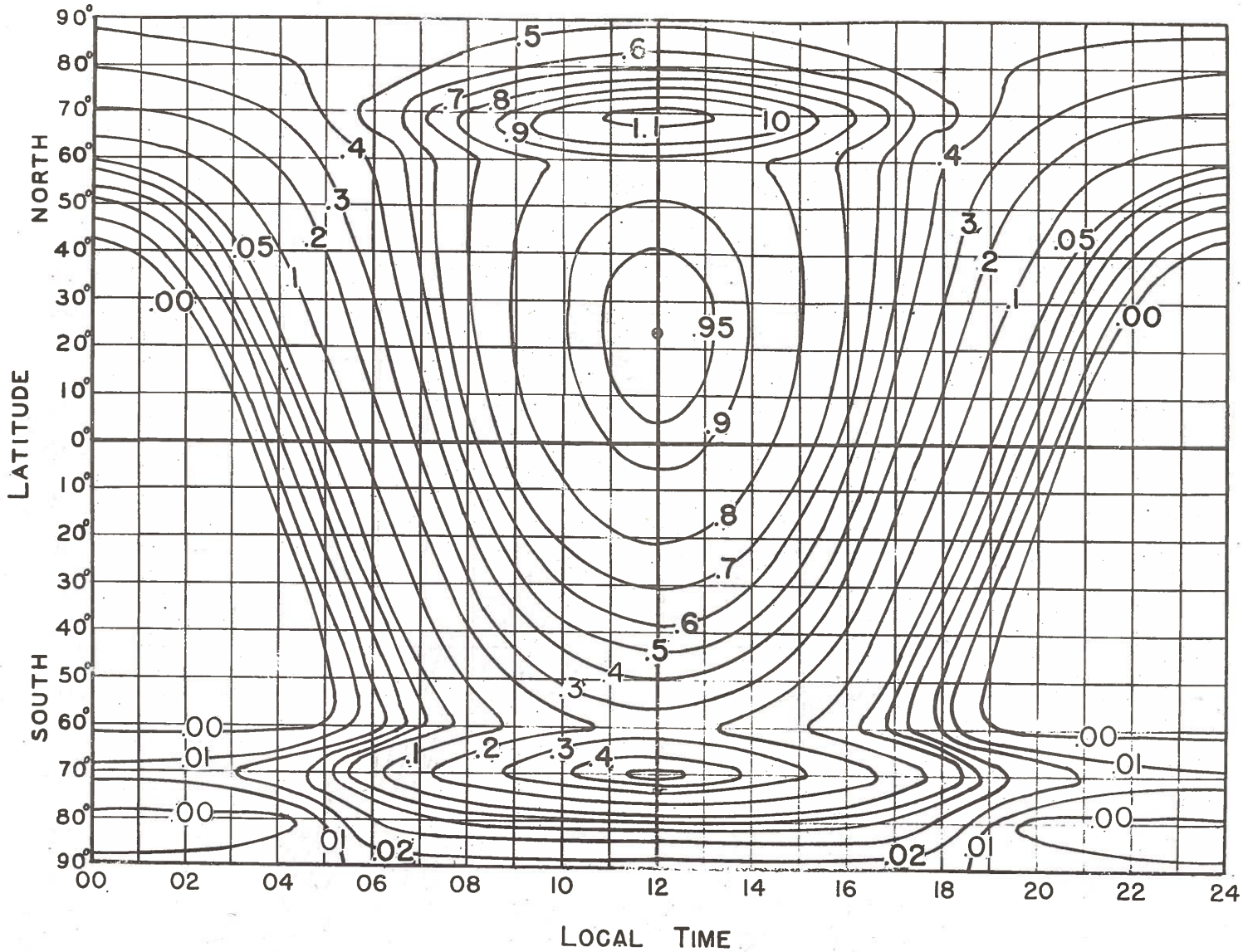


Fig. 70. Absorption index map of the world, May through August. S is the sub-solar point. Numbers on curves are values of absorption index, K (ratio of actual absorption to absorption at sub-solar point, for a given frequency and length of path).

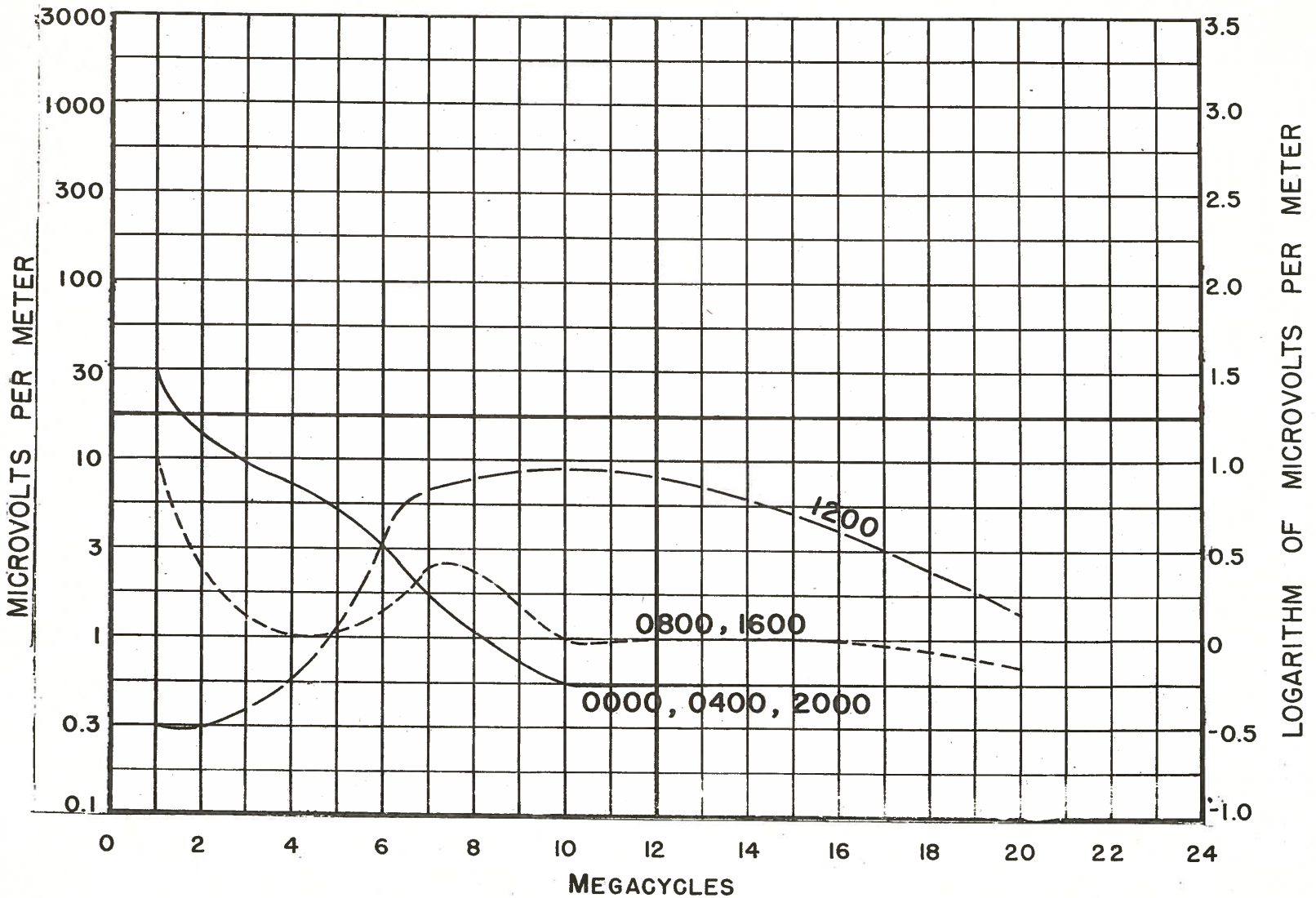


Fig. 71. Logarithms of required field intensities for phone reception, May through August, for receiving locations between 50°S and 20°S. For CW reception, field intensities required are 0.1 as great (decrease logarithm by 1). Numbers on curves are local times at receiving location.

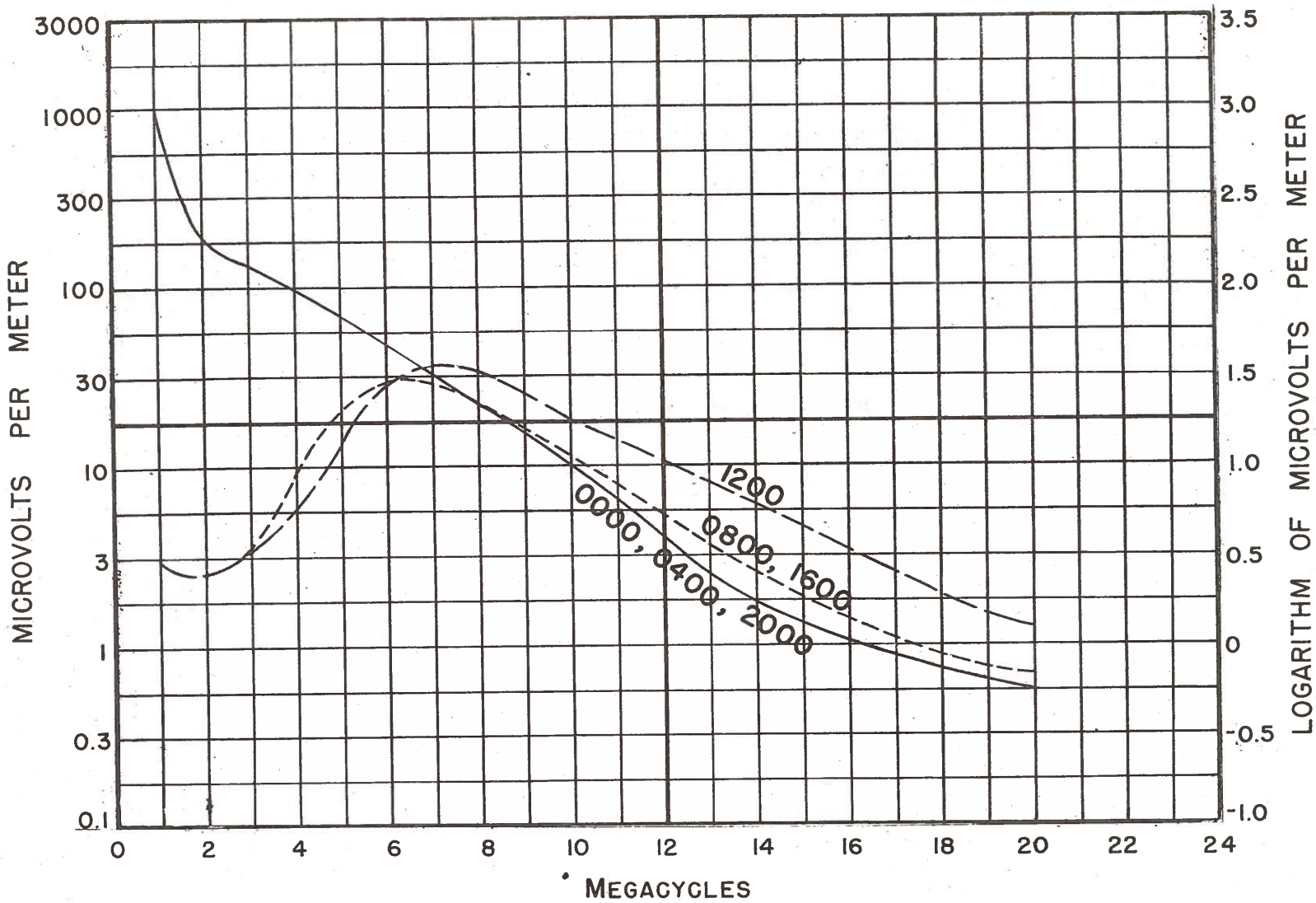


Fig. 72. Logarithms of required field intensities for phone reception, May through August, for receiving locations between 20°S and 50°N, in the cross-hatched areas shown on the map of Fig. 53. For CW reception, field intensities required are 0.1 as great (decrease logarithm by 1). Numbers on curves are local times at receiving location.

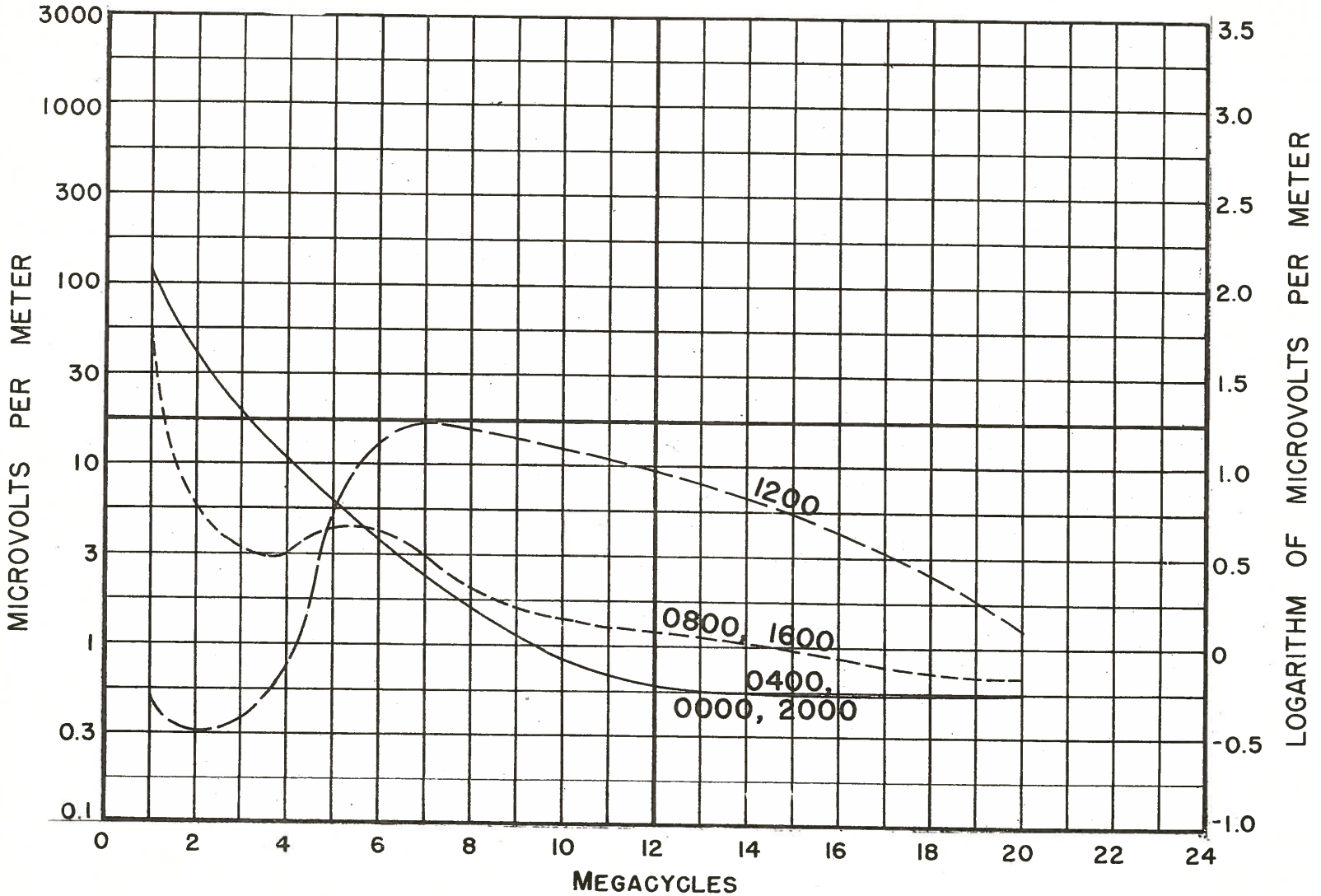


Fig. 73. Logarithms of required field intensities for phone reception, May through August, for receiving location between 20°S and 50°N, outside of the cross-hatched areas shown on the map of Fig. 53. For CW reception, field intensities required are 0.1 as great (decrease logarithm by 1). Numbers on curves are local times at receiving location.