IRPL-D11

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BASIC RADIO PROPAGATION PREDICTIONS
FOR OCTOBER 1945
THREE MONTHS IN ADVANCE

ISSUED

JULY 1945

PREPARED BY INTERSERVICE RADIO PROPAGATION LABORATORY
National Bureau of Standards
Washington 25, D. C.

INTERSERVICE RADIO PROPAGATION LABORATORY
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The monthly reports of the IRPL–D series are now distributed to the Army as the TB 11–499 series, by the Adjutant General; to the Navy as the DNC–13–1 series, by the Registered Publications Section, Division of Naval Communications; and to others by the IRPL.

This IRPL–D series is a monthly supplement to the IRPL Radio Propagation Handbook, Part 1, issued by the Army as TM 11–499 and by the Navy as DNC–13–1, and is required in order to make practical application of the basic Handbook.

Comments are invited from users of this report as to the accuracy of predictions when applied to the solution of specific radio propagation problems. Such comments or queries concerning radio propagation should be addressed as follows:

For the Army:
Headquarters, Army Service Forces,
Office of the Chief Signal Officer,
Washington 25, D. C.
Attention: SPSOL.

For the Navy:
Chief of Naval Operations,
Navy Department,
Washington 25, D. C.
(DNC–20–F).

For Others:
Interservice Radio Propagation Laboratory,
National Bureau of Standards,
Washington 25, D. C.

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I. TERMINOLOGY

The following symbols are used, as recommended by the International Radio Propagation Conference held in Washington, D. C., 17 April to 5 May 1944.

$f^\circ F2$=ordinary-wave critical frequency for the $F2$ layer. The term night F layer will no longer be used. The term $F2$ layer is now used for the night F as well as the daytime $F2$ layer.

$f^x F2$=extraordinary-wave critical frequency for the $F2$ layer.

Es=sporadic, or abnormal E.

fEs=highest frequency of Es reflections.

muf or MUF=maximum usable frequency.

owf or OWF=optimum working frequency.

4000-muf chart=contour chart of muf for 4000-kilometer paths.

2000-muf chart=contour chart of muf for 2000-kilometer paths.

Zero-muf chart=contour chart of vertical-incidence critical frequency, extraordinary wave.

K=absorption index (ratio of actual absorption to absorption at the subsolar point).

NOTE.—The designation FF_2 has been replaced by F_2.

II. WORLD-WIDE PREDICTION CHARTS AND THEIR USES

The charts, figures 5 to 11, present world-wide predictions of monthly average maximum usable frequencies for October 1945. Conditions may be markedly different on disturbed days, especially in or near the auroral zones, shown on the map of figure 1. The method of prediction is discussed in the IRPL Radio Propagation Handbook, Part 1, War Dept. TM 11–499, Navy Dept. DNC–13–1, p. 52, 53.

Although ionosphere characteristics are roughly similar for locations of equal latitude, there is also a considerable variation with longitude, especially in the case of the $F2$ layer. This "longitude effect" seems to be related to geomagnetic latitude. Attention was first called to this effect in the report "Radio Propagation Conditions" issued 10 Sept. 1943; it was brought into general operational use in the next issue (14 Oct. 1943).

The longitude effect in the $F2$ layer is taken care of by providing world charts for three zones, in each of which the ionosphere characteristics are independent of longitude, for practical purposes. These zones are indicated on the world map, figure 1.

Two $F2$ charts are provided for each zone, one of which, the "zero-muf chart," shows the vertical-incidence muf, or the critical frequency for the extraordinary wave, and the other, the "4000-muf chart," shows the muf for a transmission distance of 4000 km. Do not confuse the zero-muf charts with the $f^\circ F2$ charts appearing in the previous IRPL reports "Radio Propagation Conditions." (Values of $F2$-zero-muf exceed those of $f^\circ F2$ for the same location and local time by an amount approximately equal to half the gyrofrequency for the location. See IRPL Radio Propagation Handbook, Part 1 (War Dept. TM 11–499 and Navy Dept. DNC–13–1), p. 18, 19, 28, and fig. 9).

The longitude variation is operationally negligible in the case of the normal E layer and therefore only one E-layer chart is provided.

The variation of fEs with geomagnetic latitude seems to be well marked and important. Consequently, the fEs charts are constructed on the basis of geomagnetic latitude. Since there are, as yet, insufficient correlated data, the fEs charts are much less precise than the other charts. Instructions for use of these charts appear in section IV, 3.

III. DETERMINATION OF GREAT-CIRCLE DISTANCES, BEARINGS, LOCATION OF TRANSMISSION CONTROL POINTS, SOLAR ZENITH ANGLES

1. The first step in any radio propagation calculation is the determination of the transmission path, which is the great-circle distance between transmitting and receiving stations. Use the world map, figure 1, and the great-circle chart, figure 2, for this purpose, as follows:

a. Place a piece of transparent paper over the map, figure 1, and draw upon it a convenient reference latitude line, the locations of the transmitting and receiving stations, and the meridian whose local times are to be used as the times for calculation.

b. Place this transparency over the chart, figure 2, and, keeping the reference line at the proper latitude, slide the transparency horizontally until the terminal points marked on it either fall on the same great-circle curve, or fall the same proportional distance between adjacent great-circle curves. Draw in the path.

c. Locate the midpoint of the path, for paths under 4000 km, or the "control points," 2000 km from either end of the path, for paths greater than 4000 km, and use for this purpose the small circles of figure 2.

d. Place the transparency over the predicted chart at the proper latitude and local time, and read the values of muf off the chart, as direted in section IV.

2. Great-circle distances, bearings, location of midpoints, or other "control points" 2000 km in from the ends of the transmission path, as well as solar zenith angles, may be readily obtained from the nomogram, figure 4.

Referring to the auxiliary diagram, figure 3, let Z and S be the locations of transmitting and receiving stations, where Z is the west, and S the east end of the path. Consider north latitudes+ and south latitudes−, and take the absolute value of any sums or differences of angles (without regard to sign). Use the nomogram, figure 4, as follows:

a. To obtain the great-circle distances ZS:

(1) Draw slant line from (lat. of $Z-$lat. of S) measured up from bottom of left scale, to (lat. of $Z+$lat. of S), measured down from top of right scale.

(2) From the longitude difference between S and Z, on bottom scale, measured from left to right, draw vertical line to the slant line obtained in (1). (Use either the longitude difference or 360°−the longitude difference, whichever is the smaller.)

(3) From the intersection, draw a horizontal line to the left scale. This gives ZS in degrees.

(4) Convert the distance ZS to kilometers, statute miles, or nautical miles, by using the scale at the bottom of figure 4.

b. To obtain the bearing angle PZS:

(1) Subtract the distance ZS (in degrees) from 90° to get h.

(2) Draw slant line from (lat $Z-h$), measured up from bottom on left scale, to (lat. $Z+h$), measured down from top on right scale.

(3) From 90°−lat. S) on left, measured up from bottom on left scale, draw horizontal line until it intersects previous slant line.

(4) From the intersection, draw a vertical line to the bottom scale, which gives the bearing angle PZS, in degrees.

c. To obtain the bearing angle PSZ:

(1) Repeat steps (1), (2), (3) and (4) in b, interchanging Z and S in all computations. The result obtained is the interior angle PSZ, in degrees.

(2) The bearing angle PSZ is 360° minus the result obtained in (1) (since bearings are customarily given clockwise from due north).

d. To obtain latitude of Q (mid, or other, point of path):

(1) Obtain ZQ in degrees. If Q is the midpoint of the path, ZQ will be equal to one-half ZS. If Q is one of the 2000-km "control points," ZQ will be approximately 18°, or $ZS-18°$.

(2) Subtract ZQ from 90° to get h'.

(3) Draw slant line from (lat. $Z-h'$), measured up from bottom of left scale, to (lat. $Z+h'$), measured down from top on right scale.

(4) From bearing angle PZS, measured to right on bottom scale, draw vertical line to the above slant line.

(5) From this intersection, draw horizontal line to left scale.

(6) Subtract the reading given from 90° to give latitude of Q in degrees.

e. To obtain longitude difference, t′, between Z and Q:

(1) Draw straight line (lat. $Z-$lat. Q), measured up from the bottom on left-hand scale, to (lat. $Z+$lat. Q), measured down from the top on right-hand scale.

(2) From the left side, at ZQ, in degrees, draw a horizontal line to the above slant line.

(3) From the intersection, drop a vertical line to bottom scale to get t' in degrees.

f. To obtain solar zenith angle, ψ, at a given place:

(1) Let the declination of the sun be d, and let Z be the place under consideration.

(2) Draw straight line from (lat. $Z-d$), measured up from bottom on left scale, to (lat. $Z+d$), measured down on right scale.

(3) From [(12−local time of Z, in hours)×15] degrees, on bottom scale, measured from left to right, draw a vertical line to the slant line above.

(4) From this intersection, draw a horizontal line to the left scale. This gives ψ, in degrees.

IV. CALCULATION OF MAXIMUM USABLE FREQUENCIES AND OPTIMUM WORKING FREQUENCIES

1. PROCEDURE FOR DETERMINATION OF MUF OR OWF FOR TRANSMISSION DISTANCES UNDER 4000 KW

Radio propagation over distances up to 4000 km is usually determined by ionospheric conditions at the midpoint of the great-circle path between transmitting and receiving station.

Use the following procedure for obtaining the muf and owf for distances less than 4000 km:

a. Locate the midpoint of the transmission path. (Methods for doing this are given in the preceding section of this report.)

b. Read the values of $F2$-zero-muf, $F2$-4000-muf, and E-layer 2000-muf for the midpoint of the path at the local time for this midpoint. Be sure to choose the $F2$ charts for the geographical zone in which the midpoint lies. (For a path just 4000 km long the $F2$-zero muf need not be read; omit step c below, in this case, since the F2-4000-muf is the $F2$-layer path muf.)

c. Place a straightedge between the values of $F2$-zero-muf and $F2$-4000-muf at the left- and right-hand sides, respectively, of the grid nomogram, figure 13, and read the value of the muf for the actual path length at the intersection point of the straightedge with the appropriate vertical distance line. (Note that the 4000-muf scale on the grid nomogram is only for frequencies up to 35 Mc. To use the nomogram for higher values of *F*2-4000-muf multiply *both* the zero-muf and the 4000-muf scales by two, and use as instructed above.)

d. The *F*2-layer optimum working frequency (owf) is 85 percent of the muf, to allow a margin of safety for day-to-day variations; to determine the owf, use the auxiliary scale at the right of the grid nomogram of figure 13. (For values of muf greater than 35 Mc, multiply the muf and owf scales by two.)

e. Place a straightedge between the value of the *E*-layer 2000-muf located on the left-hand scale of the nomogram, figure 14, and the value of the path length on the right-hand scale, and read the combined *E*- and *F*1-layer muf or owf for that path length, off the central scale. (The characteristics of the *E* layer and of the *F*1 layer are sufficiently related that, for most practical purposes, they may be combined in this manner.)

f. Compare the values of muf or owf obtained by operations c to e. The higher of the two values thus determined is the muf or owf for the path.

2. PROCEDURE FOR DETERMINATION OF MUF OR OWF FOR TRANSMISSION DISTANCES GREATER THAN 4000 KM

The complexities of long-distance radio propagation are such that the simple multihop *E* or *F*2 layer calculations do not give accurate results. The following procedure will give results which are operationally satisfactory; the theory involved is outside the scope of this report.

a. Locate the two "control points" 2000 km from the ends of the great-circle distance between transmitting and receiving stations. For very long paths both the "short route" (minor arc of the great-circle path) and the "long route" (major arc) need to be considered.

b. Read the value of the *F*2-4000-muf, at the local time for each point, at these points, being sure to choose the appropriate zone for each point.

c. Calculate the *F*2-4000-owf for each point (85 percent of the muf) by means of the auxiliary muf-owf scale of figure 13. (For values of muf greater than 35 Mc, multiply the muf and owf scales by two.)

d. Compare these two muf or owf values. The lower of the two is the muf or owf for the transmission path under consideration.

e. When one of the control points lies in a region where the *E*-2000-muf is greater than the *F*2-4000-muf, read the *E*-2000-muf at an *E*-layer control point 1000 km from the end of the path, instead of the *F*2-4000-muf, as in step b. Use the *E*-2000-muf in step d. instead of the *F*2-4000-muf or owf.

3. PROCEDURE FOR DETERMINATION OF *Es* TRANSMISSION

(Note Change in Charts and Procedure)

Sporadic-*E* (*Es*) propagation plays an important part in transmission over paths in some parts of the world and at certain times. It may often allow regular transmission at times when regular *F*2-layer propagation would not. *Es* data are not yet sufficient to permit accurate calculations of such propagation, but the *fEs* charts of figures 12 and 15 are given as a guide to *Es* occurrence.

Since the *fEs* charts are constructed from considerations of geomagnetic latitude, three latitude scales are provided at the right of the charts of figures 12 and 15, one for each of the three zones of figure 1 (*W*, *I*, and *E*).

Until improvements are made the following procedure should be used to find the prevalence of *Es* propagation over a transmission path.

a. For paths over 4000 km long:

(1) Place the great-circle path transparency prepared in section III, 1. over the median *fEs* chart, figure 12, using the latitude scale for the zone containing the control point.

(2) Scale *fEs* at each *E*-layer control point (1000 km from either end of the path), multiply by 5 and subtract 4 Mc. The result is the *Es*-owf.

(3) Plot as the owf for each control point the highest of the three values; the *F*2-4000-owf, the *E*-2000-owf, and the *Es*-owf.

b. For paths less than 4000 km long, scale the *fEs* at the midpoint of the path, using the latitude scale for the appropriate zone, multiply by 5 and subtract 4 Mc, and use the resultant frequency as outlined above for the *E*-layer 2000-muf in the nomogram of figure 14. The result is the *Es*-owf.

V. ABSORPTION, DISTANCE RANGE, AND LOWEST USEFUL HIGH FREQUENCY

The determination of absorption, distance range, and lowest useful high frequency is discussed at length in IRPL Radio Propagation Handbook, Part 1, p. 69–97 (War Dept. TM 11–499, Navy Dept. DNC–13–1), and formulas, graphs, and nomograms for calculation are given there. For convenience in estimating absorption (exclusive of auroral absorption) over a path, the absorption index (or K) chart, figure 16, is presented. By superposing on this chart the transparency with the great-circle path, prepared as in section III, 1, the relation of the path to the sun's zenith angle is readily seen (the sunrise-sunset line corresponds to an absorption index approximately=0.14).

The absorption is erratic and considerably greater in and near the auroral zones, shown on the map of figure 1; paths passing through or near these zones are subject at times to severe disturbances.

VI. SAMPLE MUF AND OWF CALCULATIONS

1. FOR SHORT PATHS

Required: The muf and owf for transmission between Washington, D. C. (39.0° N, 77.5° W) and Miami, Fla. (25.7° N, 80.5° W) for average conditions during the month of October 1945.

Solution:

Let the local time used for this problem be GCT (Z time or that of 0° longitude).

The midpoint of the path is at approximately 32.5° N, 79.0° W, and the transmission path length is approximately 1500 km.

The values of E- and $F2$-layer muf and owf, and also Es-owf for alternate hours, GCT, as determined by using the procedure given in section IV, are given in table 1. The final values are presented graphically in figure 17. In obtaining the combined muf for all layers, the Es-owf is used because of the great variability of the muf.

Figure 17 shows that skip will occur, on the average, during the night hours, if a frequency as high as 8.0 Mc is used. A frequency as high as 6.5 Mc will not skip, on the average, at any time of day, but its use is not advisable because of (a) the day-to-day variability, causing some probability of skip during the night hours, and (b) ionospheric absorption during the daytime, which is more pronounced at low frequencies.

A satisfactory frequency plan to insure continuous transmission at all times, over a path like this, involves the use of two frequencies, one for night and one for day. Figure 17 shows that a night frequency of 5.6 Mc, to be used from 2315 to 1230 GCT, and a day frequency of 11.0 Mc, to be used from 1230 to 2315 GCT, would be satisfactory. The periods of usefulness of these frequencies are shown by the heavy dashed line on figure 17.

Periods of time during which transmission is controlled by either the E layer or the $F2$ layer may be easily recognized by noting the relative proximity of the muf and owf curves of figure 17. Coincidence of the curves indicates control by sporadic-E reflections.

2. FOR LONG PATHS

Required: The muf and owf for transmission between Nagasaki, Japan (33° N, 130° E), and San Francisco, Calif. (37.5° N, 122.4° W), for average conditions during the month of October 1945.

Solution:

Let the local time for this problem be GCT (Z time or that of 0° longitude).

The path length is approximately 9100 km, and the two $F2$-layer control points A and B, respectively, are at approximately 46° N, 146° W, and 43° N, 149° E. These are respectively in the I zone and E zone as shown on the map, figure 1. The two E-layer and Es-control points, A' and B', respectively, are located at approximately 44° N, 133° W, and 38° N, 138° E. The bearing of San Francisco from Nagasaki is approximately 52°, and of Nagasaki from San Francisco, approximately 305°, both determined by means of the nomogram of figure 4.

The values of muf and owf over this transmission path, as determined by using the procedure of section IV, are given in table 2 for alternate hours, GCT. The final values are shown graphically in figure 18.

Figure 18 shows that skip will occur, on the average, during the night hours if a frequency as high as 10.0 Mc is used, although higher frequencies may be used during a limited portion of the day.

A good practical arrangement to insure continuous transmission at all times is to select three frequencies, in a manner similar to that suggested in the preceding problem. A frequency of 7.5 Mc may be used from 0530 to 2015 GCT, a frequency of 18.5 Mc may be used from 2120 to 0320 GCT, and a transition frequency of 11.5 Mc may be used from 0320 to 0530, and from 2015 to 2120 GCT.

Relative proximity of the muf owf curves of figure 18 indicates that neither Es nor regular E layer controls transmission at any time.

By inspection of the absorption chart, figure 16, and the noise map (fig. 119 of the IRPL Radio Propagation Handbook, Part 1, War Dept. TM 11–499, Navy Dept. DNC–13–1), it may be seen that considerations of the lowest useful high frequency over this path may be considerable importance in selecting frequencies for use. Consequently, in cases of transmission failure on the frequencies here recommended, particularly in the case of the transition frequency, changing the frequency to a value slightly under the muf for the path may be advisable.

TABLE 1.—*Solution of short-path transmission problem*

[Washington, D. C., to Miami, Fla., October 1945]

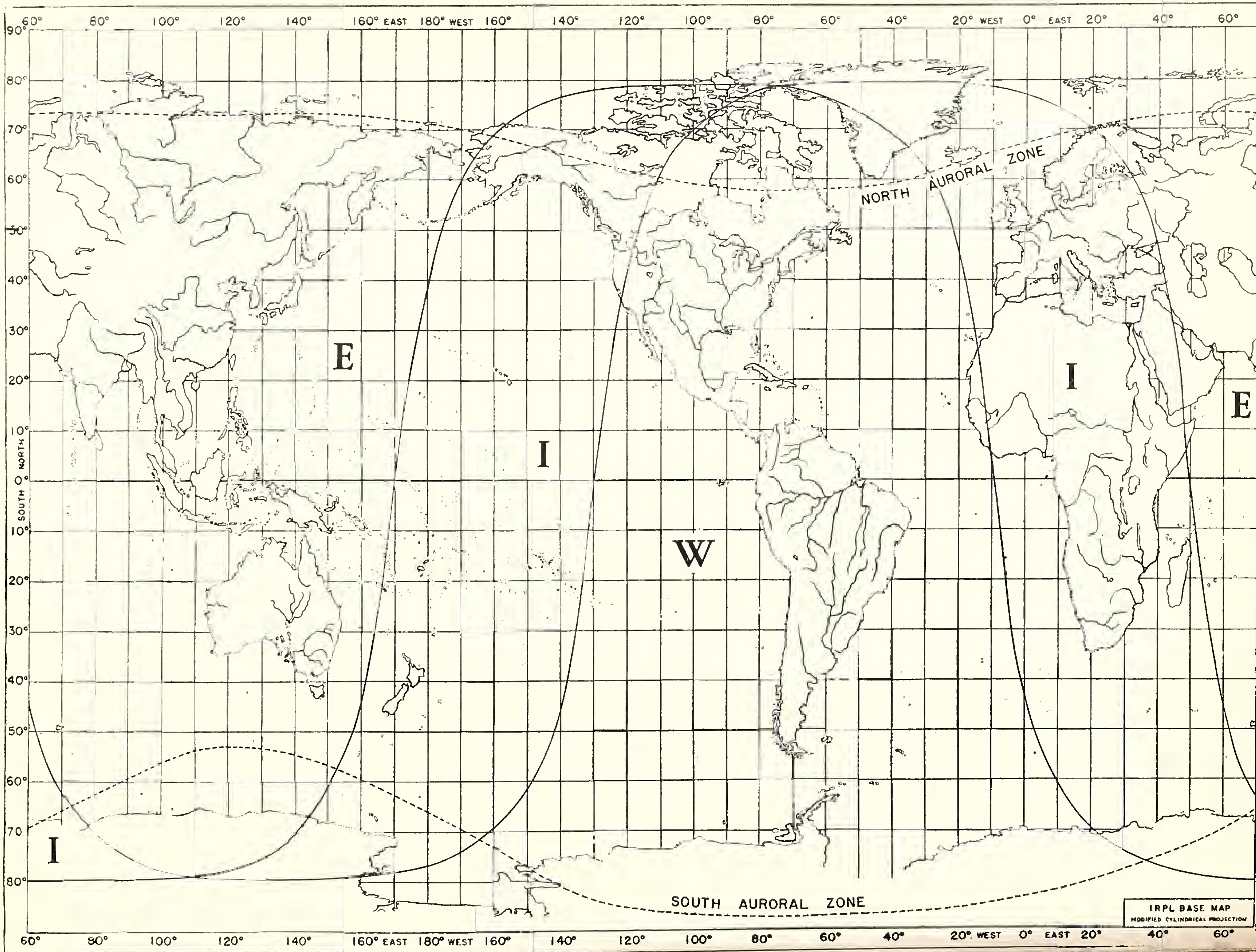
Time, GCT	*E*-layer-2000-muf	Combined *E*-and *F*1-layer-1500-muf	Combined *E*-and *F*1-layer-1500-owf	Median *fEs*	*Es*-2000-owf	*Es*-1500-owf	*F*2-layer-zero muf, *W* zone	*F*2-ayer-4000-muf, *W* zone	*F*2-layer-1500-muf	*F*2-layer-1500-owf	Combined muf, all layers	Combined owf, all layers
	Mc	*Mc*	*Mc*	*Mc*	*Mc*	*Mc*	*Mc*	*Mc*	*Mc*	*Mc*	*Mc*	*Mc*
00	-----	----	-----	2. 1	6. 5	6. 0	5. 8	17. 3	10. 3	8. 8	10. 3	8. 8
02	-----	----	-----	2. 1	6. 5	6. 0	4. 3	11. 1	7. 0	5. 9	7. 0	6. 0
04	-----	----	-----	2. 1	6. 5	6. 0	4. 1	10. 9	6. 8	5. 7	6. 8	6. 0
06	-----	----	-----	2. 2	7. 0	6. 4	4. 1	11. 0	6. 9	5. 8	6. 9	6. 4
08	-----	----	-----	-----	----	-----	4. 2	12. 0	7. 3	6. 2	7. 3	6. 2
10	-----	----	-----	-----	----	-----	3. 9	11. 2	6. 7	5. 7	6. 7	5. 7
12	8. 9	8. 2	8. 0	2. 2	7. 0	6. 4	6. 0	19. 0	11. 1	9. 3	11. 1	9. 3
14	14. 0	12. 8	12. 3	3. 1	11. 5	10. 5	7. 4	24. 0	14. 0	11. 9	14. 0	12. 3
16	15. 8	14. 5	14. 1	3. 2	12. 0	11. 0	8. 5	27. 0	15. 9	13. 5	15. 9	14. 1
18	16. 0	14. 6	14. 2	3. 1	11. 5	10. 5	9. 4	29. 8	17. 6	14. 9	17. 6	14. 9
20	14. 7	13. 4	13. 0	3. 1	11. 5	10. 5	9. 0	29. 2	17. 0	14. 4	17. 0	14. 4
22	10. 5	9. 7	9. 3	2. 3	7. 5	6. 9	7. 9	25. 5	14. 9	12. 7	14. 9	12. 7

TABLE 2.—*Solution of long-path transmission problem*

[Nagasaki, Japan, to San Francisco, Calif., October 1945]

Time, GCT	*E*-layer-2000-muf, control point *A′*	*E*-layer-2000-owf, control point *A′*	Median *fEs*, control point *A′*	*Es*-owf, control point *A′*	*F*2-4000-muf, *I*-zone, control point *A*	*F*2-4000-owf, *I*-zone control point *A*	Combined muf, control points *A* and *A′*	Combined owf, control points *A* and *A′*	*E*-layer-2000-muf, control point *B′*	*E*-layer-2000-owf, control point *B′*
	Mc	*Mc*	*Mc*	*Mc*	*Mc*	*Mc*	*Mc*	*Mc*	*Mc*	*Mc*
00	13.0	12.5	3.5	13.5	25.0	21.2	25.0	21.2	14.1	13.8
02	7.9	7.6	2.4	8.0	23.9	20.3	23.9	20.3	15.4	15.0
04	----	----	2.2	7.0	19.9	16.9	19.9	16.9	15.3	14.8
06	----	----	2.2	7.0	11.6	9.8	11.6	9.8	13.3	12.8
08	----	----	2.2	7.0	10.2	8.7	10.2	8.7	8.0	7.7
10	----	----	2.3	7.5	10.0	8.5	10.0	8.5	----	----
12	----	----	----	----	9.9	8.3	9.9	8.3	----	----
14	----	----	----	----	8.8	7.5	8.8	7.5	----	----
16	9.9	9.5	2.5	8.5	14.0	11.9	14.0	11.9	----	----
18	13.7	13.2	3.5	13.5	23.4	19.9	23.4	19.9	----	----
20	14.9	14.4	3.8	15.0	25.3	21.5	25.3	21.5	----	----
22	14.9	14.4	3.2	12.0	25.2	21.4	25.2	21.4	10.5	10.2

Time, GCT	Median *feS*, control point *B′*	*Es*-owf, control point B′	*F*2-4000-muf, *E*-zone, control point *B*	*F*2-4000-owf, *E*-zone control point *B′*	Combined muf, control points *B* and *B′*	Combined owf, control points *B* and *B′*	Muf for transmission path	Owf for transmission path
	Mc	*Mc*	*Mc*	*Mc*	*Mc*	*Mc*	*Mc*	*Mc*
00	----	----	28.1	23.9	28.1	23.9	25.0	21.2
02	2.5	8.5	28.2	23.9	28.2	23.9	23.9	20.3
04	2.8	10.0	26.8	22.7	26.8	22.7	19.9	16.9
06	2.8	10.0	25.5	21.7	25.5	21.7	11.6	9.8
08	2.7	9.5	19.3	16.4	19.3	16.4	10.2	8.7
10	2.0	6.0	13.5	10.6	13.5	10.6	10.0	8.5
12	----	----	10.4	8.9	10.4	8.9	9.9	8.3
14	----	----	9.7	8.2	9.7	8.2	8.8	7.5
16	----	----	9.6	8.1	9.6	8.1	9.6	8.1
18	----	----	9.4	7.9	9.4	7.9	9.4	7.9
20	----	----	12.0	10.1	12.0	10.1	12.0	10.1
22	----	----	24.4	20.7	24.4	20.7	24.4	20.7



NORTH AURORAL ZONE
SOUTH AURORAL ZONE
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IRPL BASE MAP
MODIFIED CYLINDRICAL PROJECTION

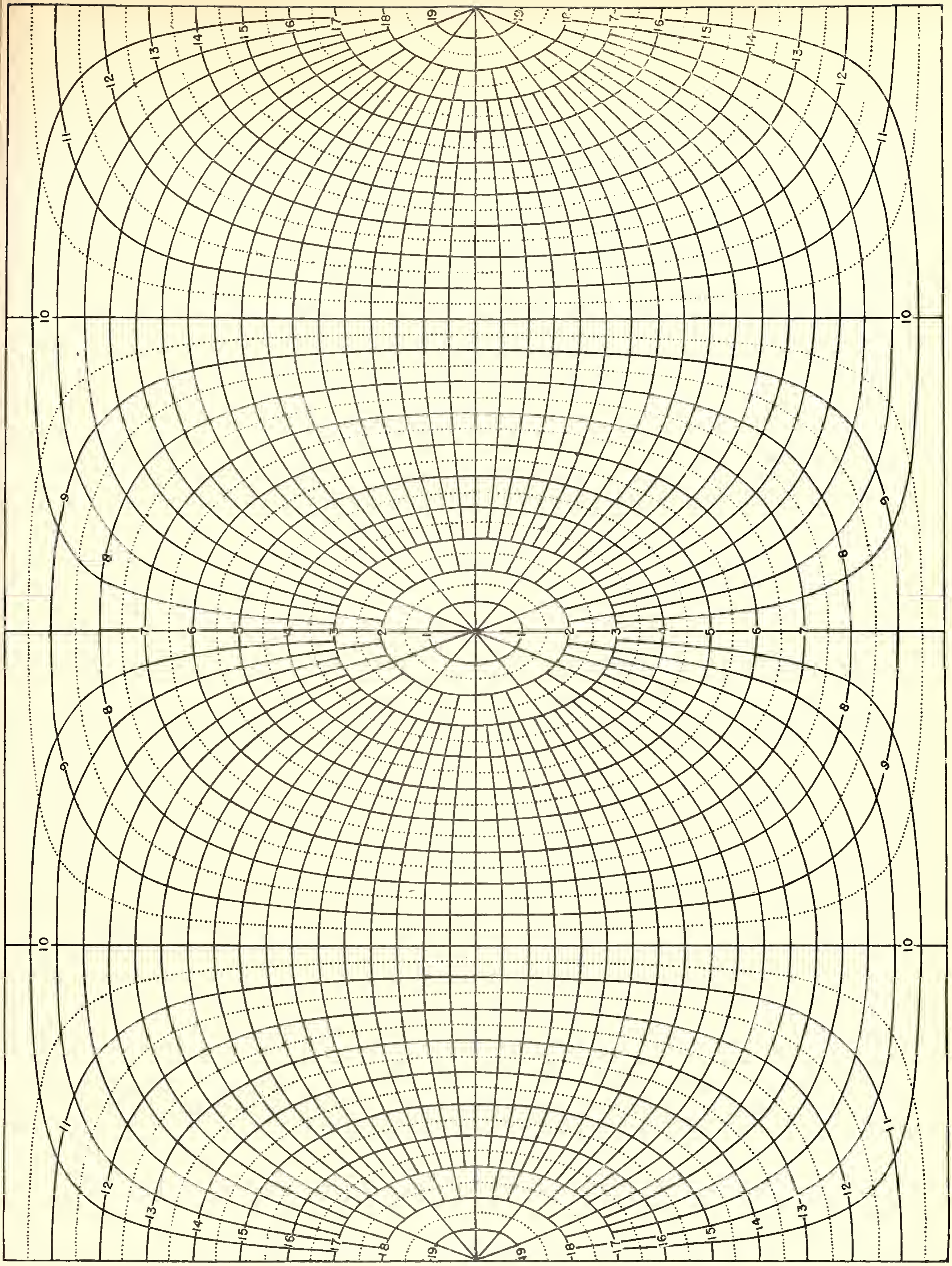

FIG. 2. GREAT CIRCLE CHART, CENTERED ON EQUATOR, WITH SMALL CIRCLES INDICATING DISTANCES IN KILOMETERS.

650802—45——2

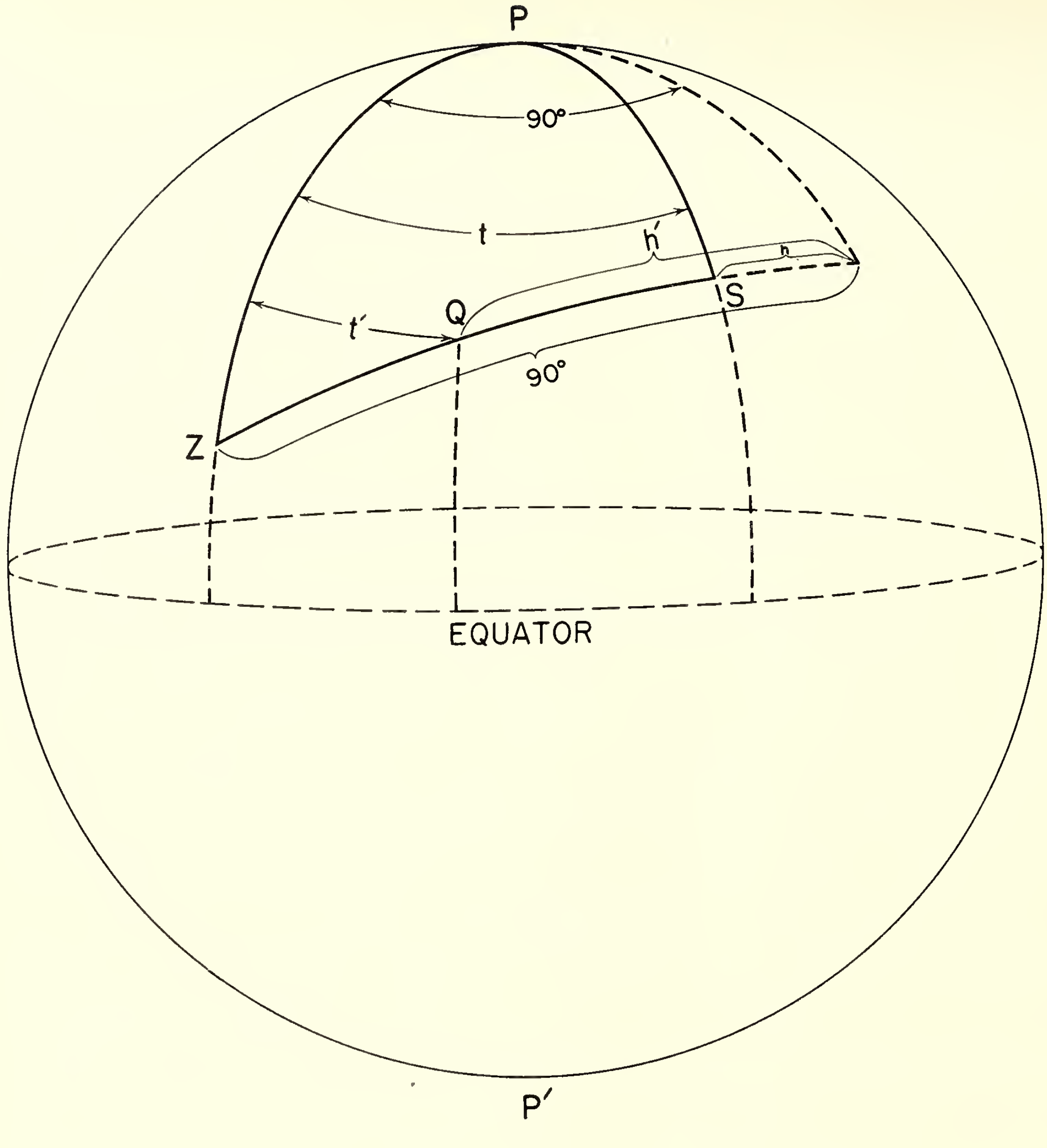

Fig. 3. DIAGRAM OF TRANSMISSION PATH AUXILIARY TO EXPLANATION OF USE OF DISTANCE — BEARING NOMOGRAM, FIG. 4.

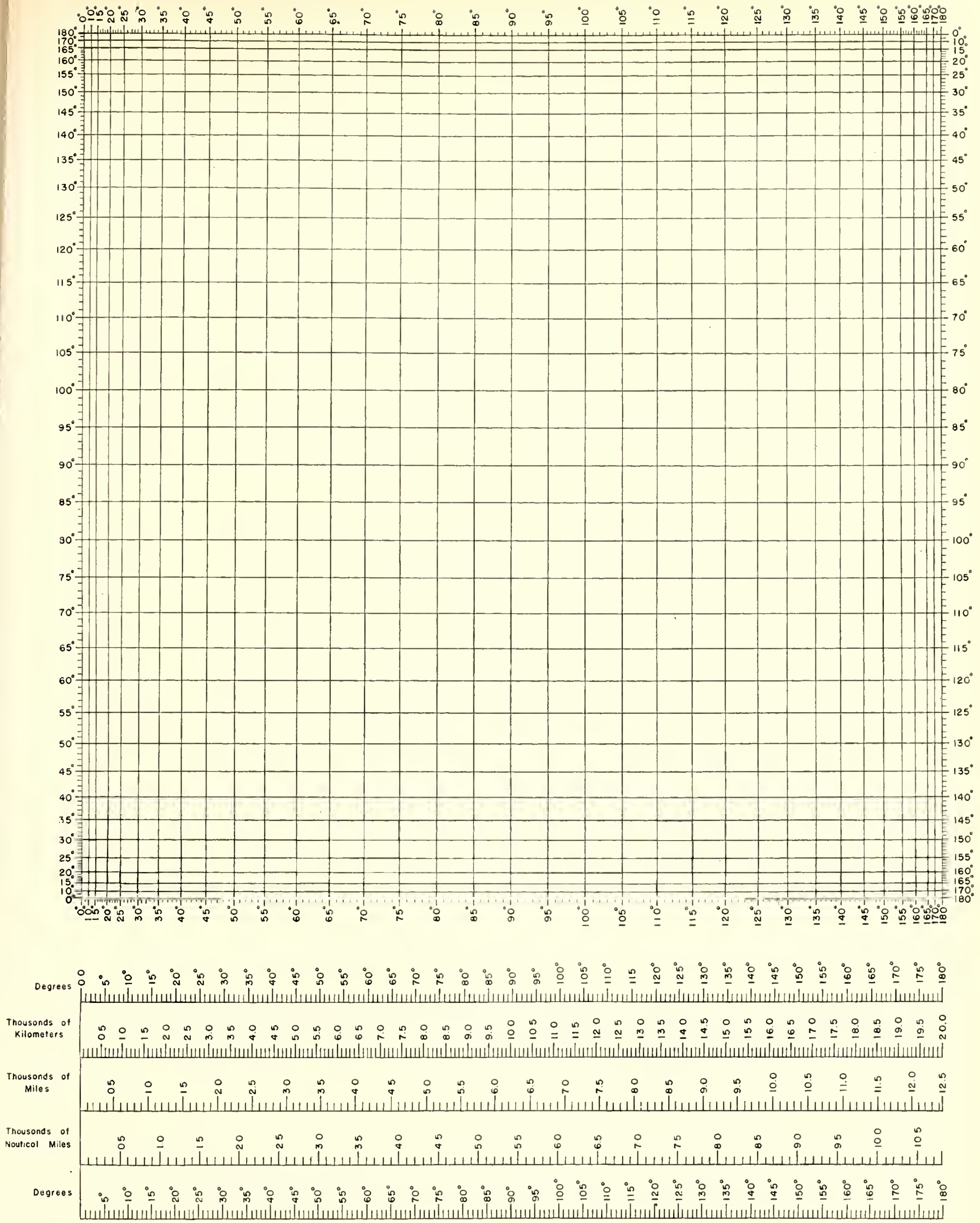

Fig. 4. NOMOGRAM (AFTER D'OCAGNE) FOR OBTAINING GREAT-CIRCLE DISTANCES, BEARINGS, LATITUDE AND LONGITUDE OF TRANSMISSION CONTROL POINTS, SOLAR ZENITH ANGLES.
CONVERSION SCALE FOR VARIOUS DISTANCE UNITS.

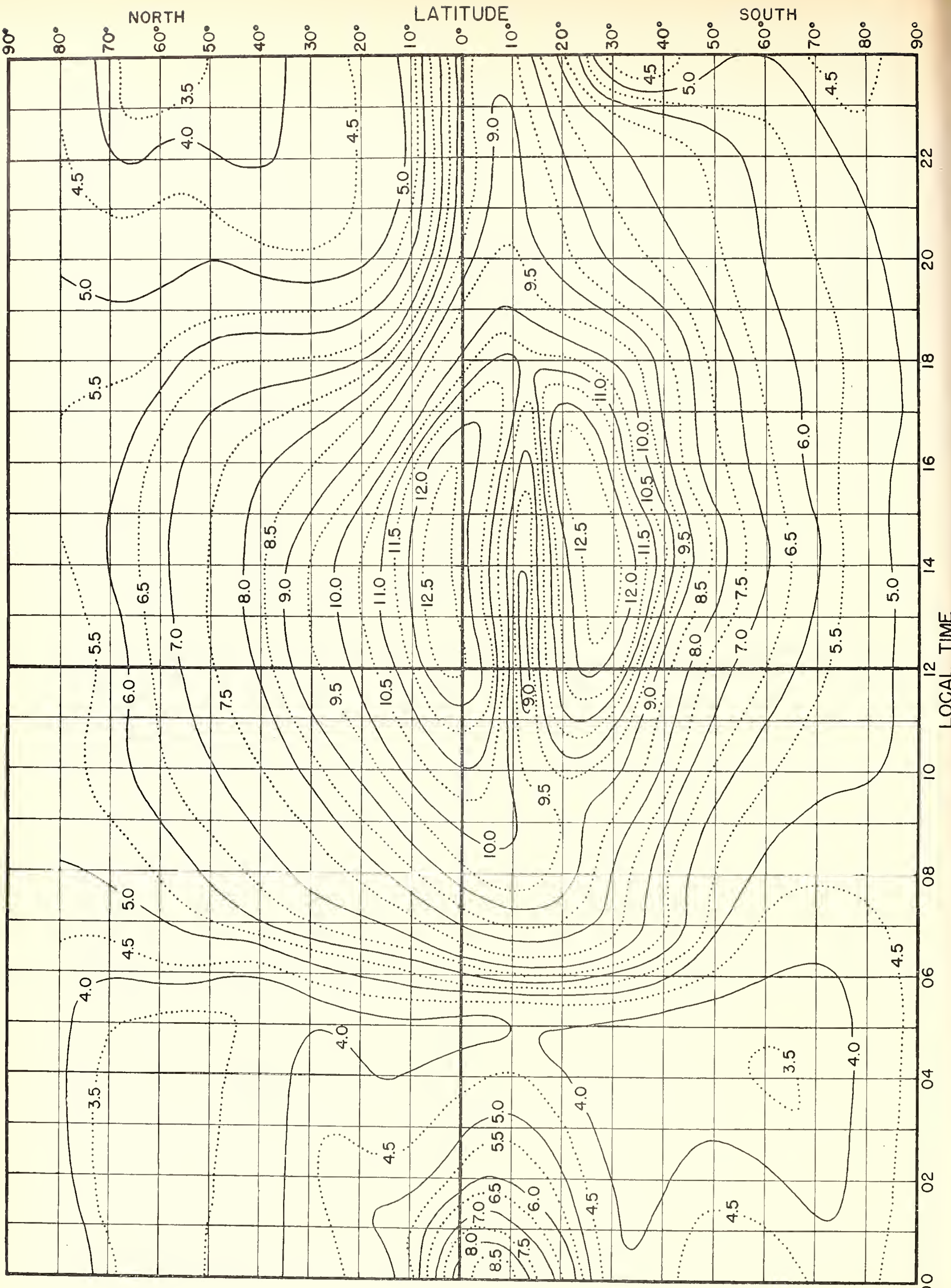

Fig. 5. F_2 ZERO—MUF, IN Mc, W ZONE, PREDICTED FOR OCTOBER, 1945.

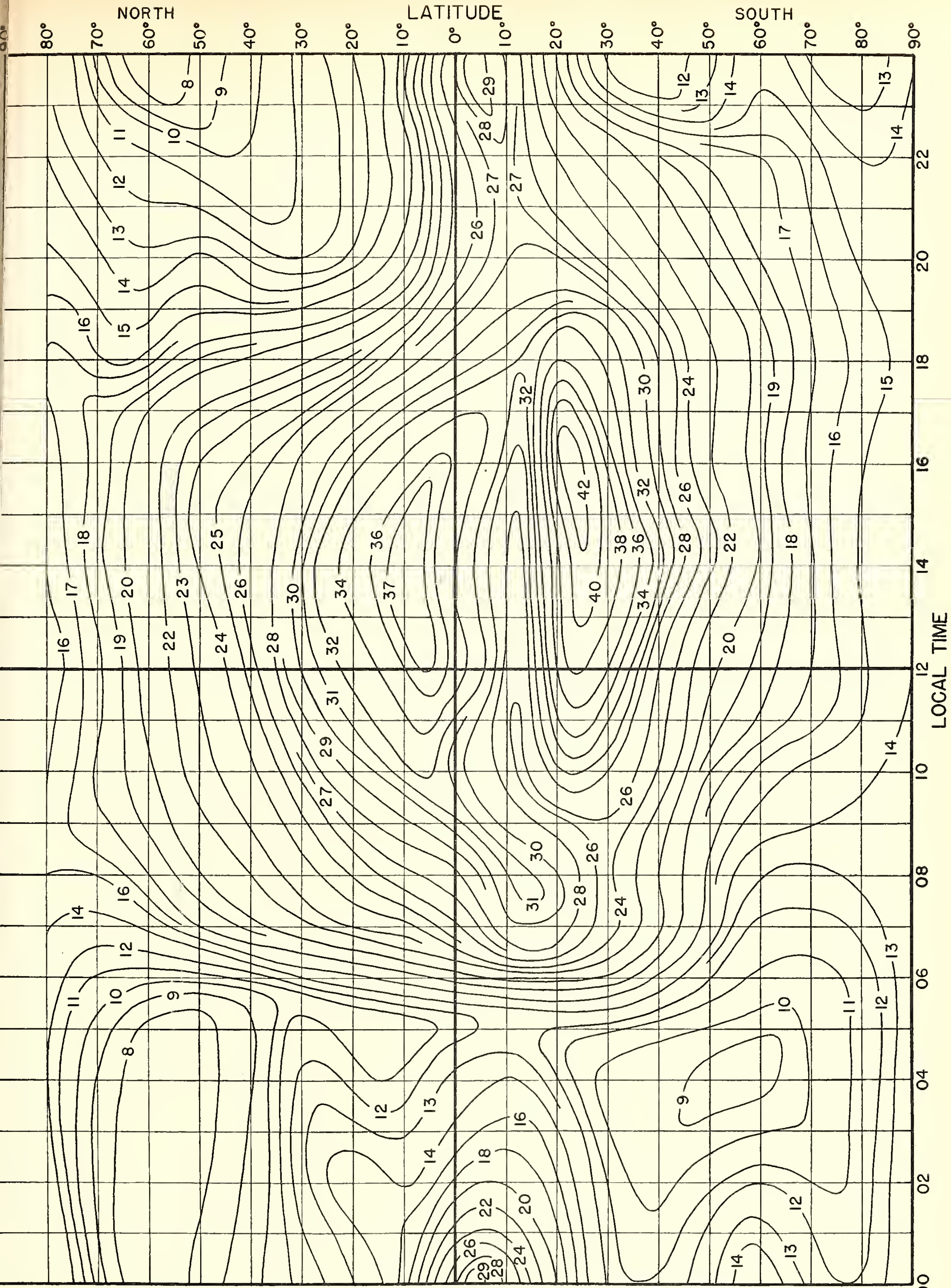

Fig. 6. F_2 4000-MUF, IN Mc, W ZONE, PREDICTED FOR OCTOBER, 1945.

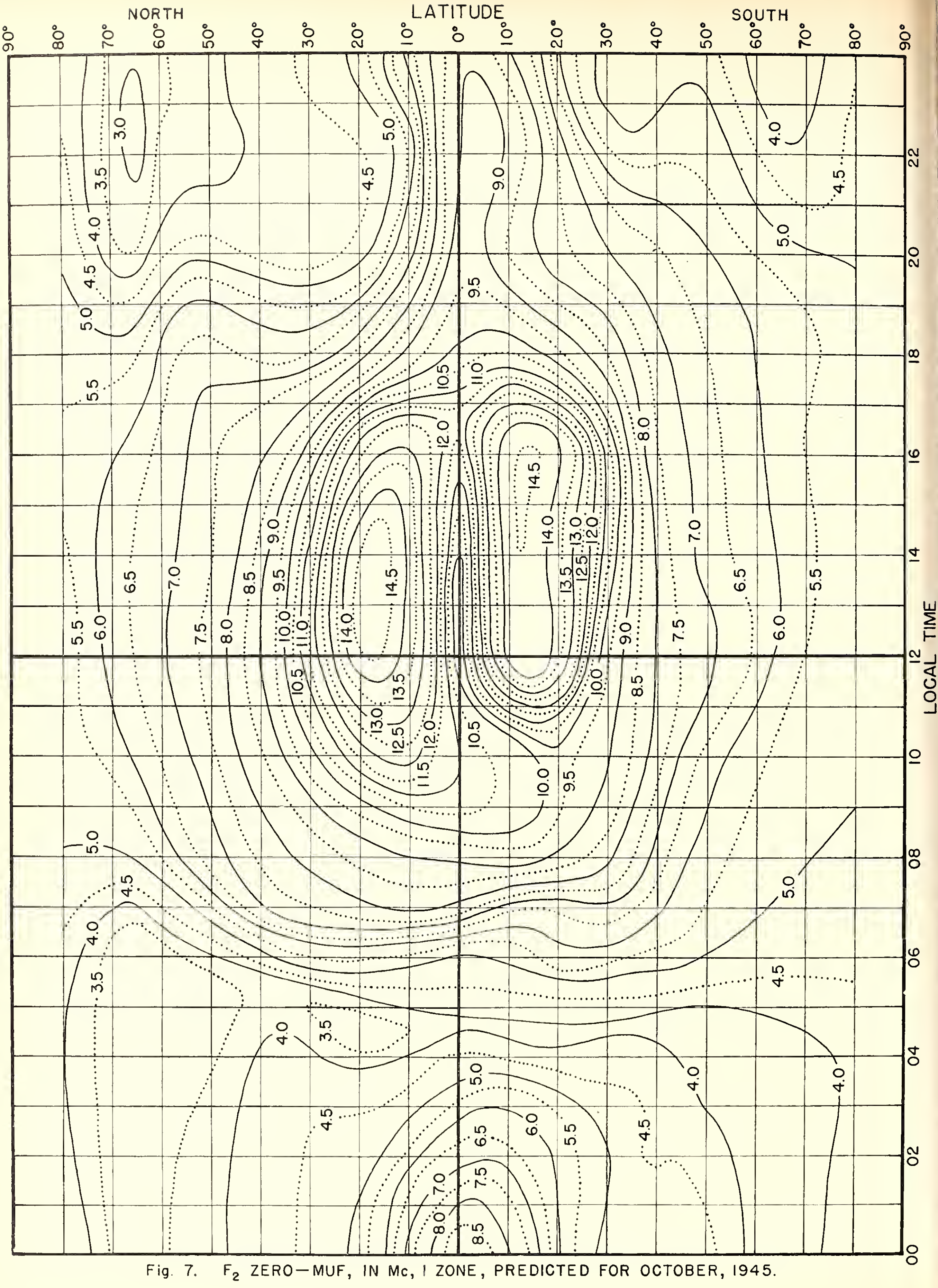

Fig. 7. F_2 ZERO—MUF, IN Mc, I ZONE, PREDICTED FOR OCTOBER, 1945.

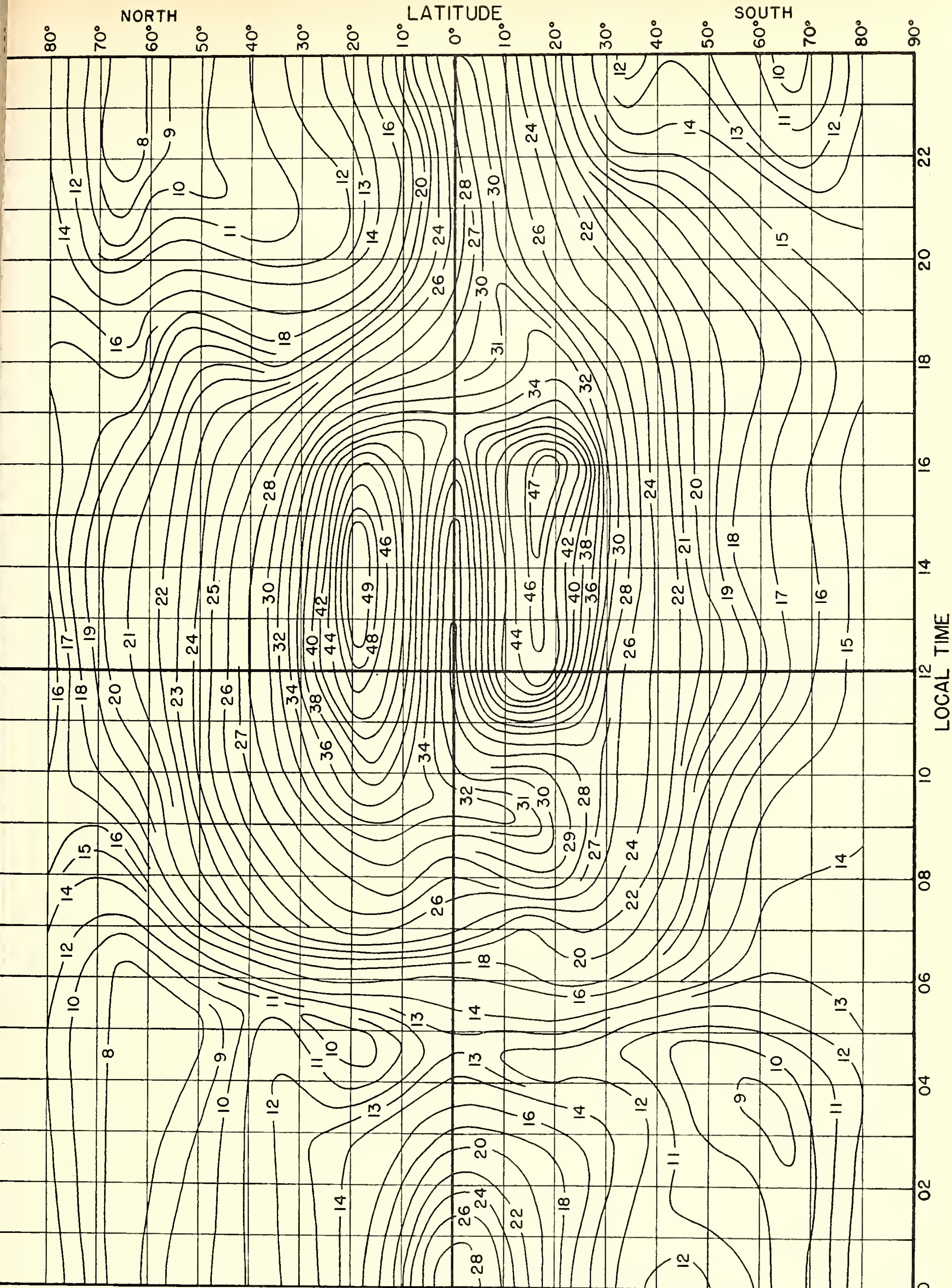

Fig. 8. F_2 4000—MUF, IN Mc, I ZONE, PREDICTED FOR OCTOBER, 1945.

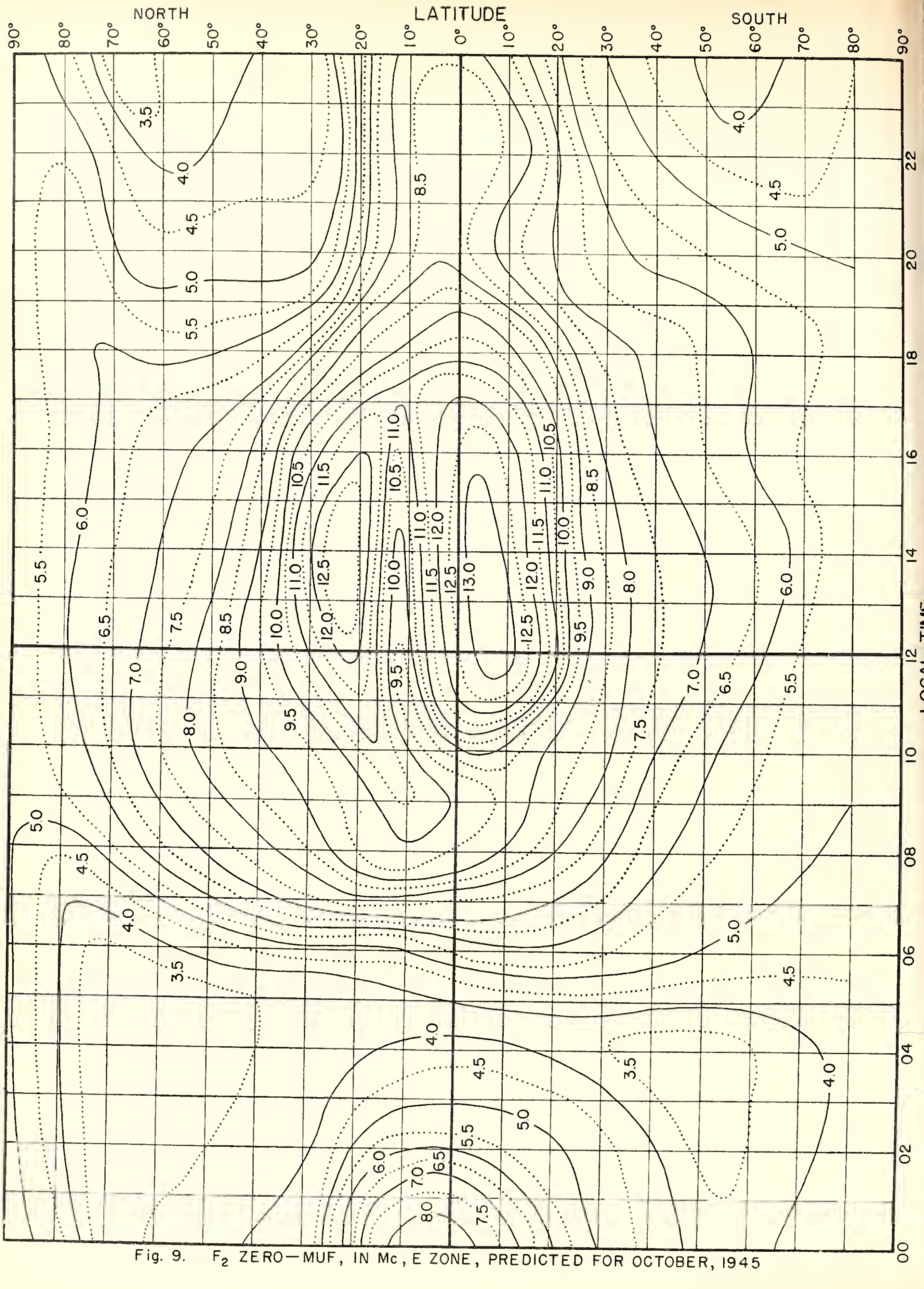

Fig. 9. F_2 ZERO—MUF, IN Mc, E ZONE, PREDICTED FOR OCTOBER, 1945

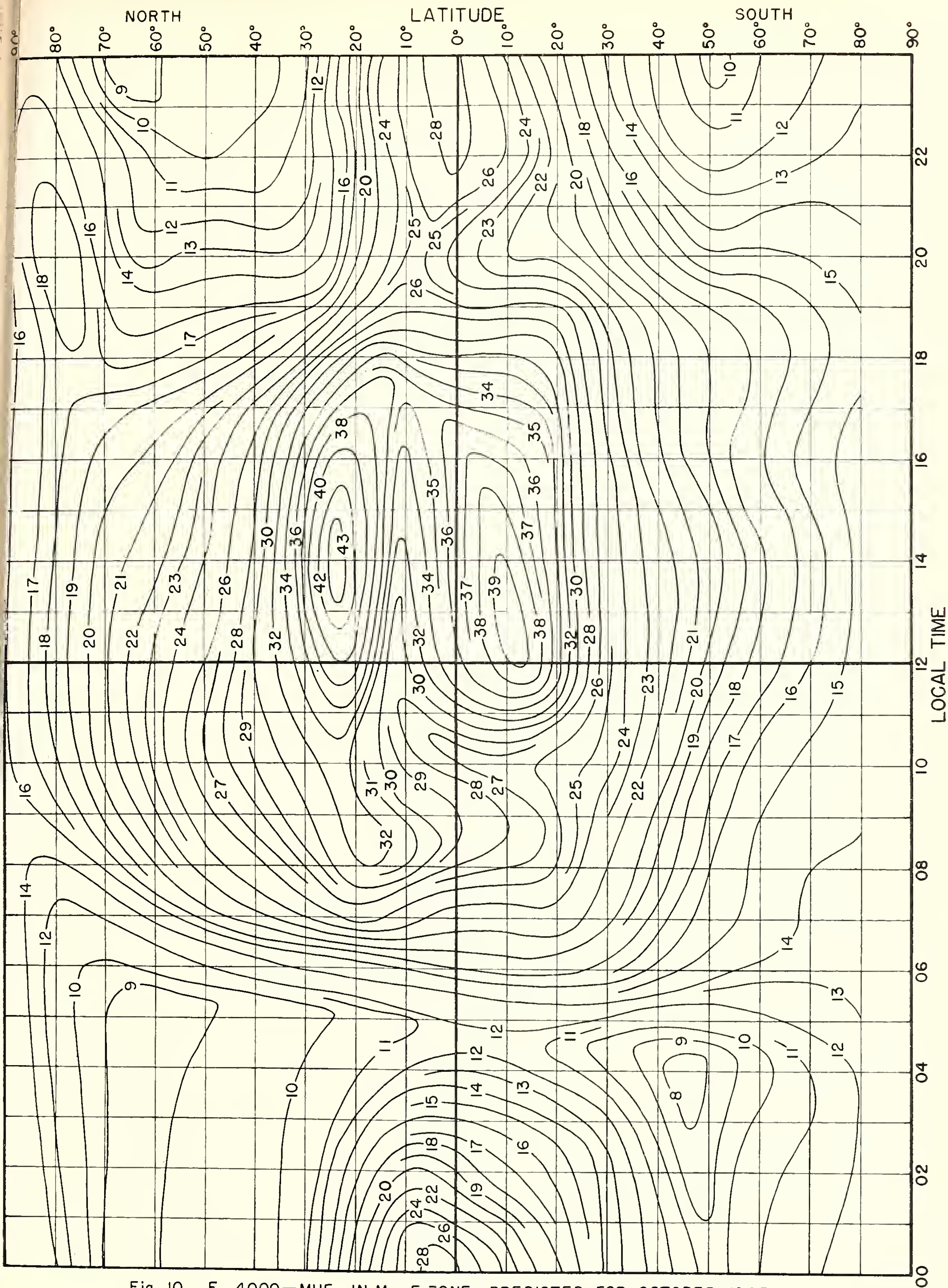

Fig. 10. F_2 4000—MUF, IN Mc, E ZONE, PREDICTED FOR OCTOBER, 1945.

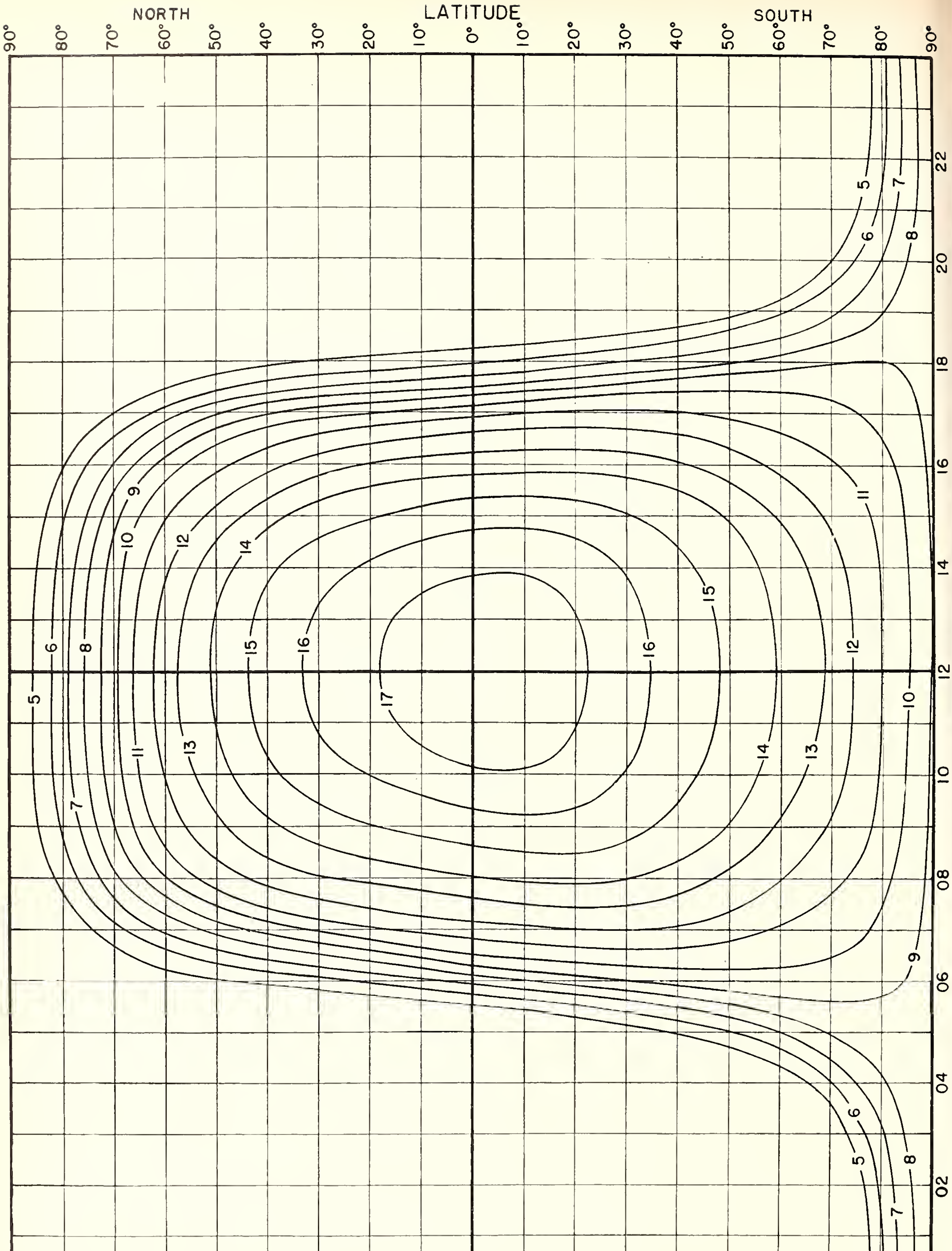

Fig. 11. E-LAYER 2000-MUF, IN Mc, PREDICTED FOR OCTOBER, 1945.

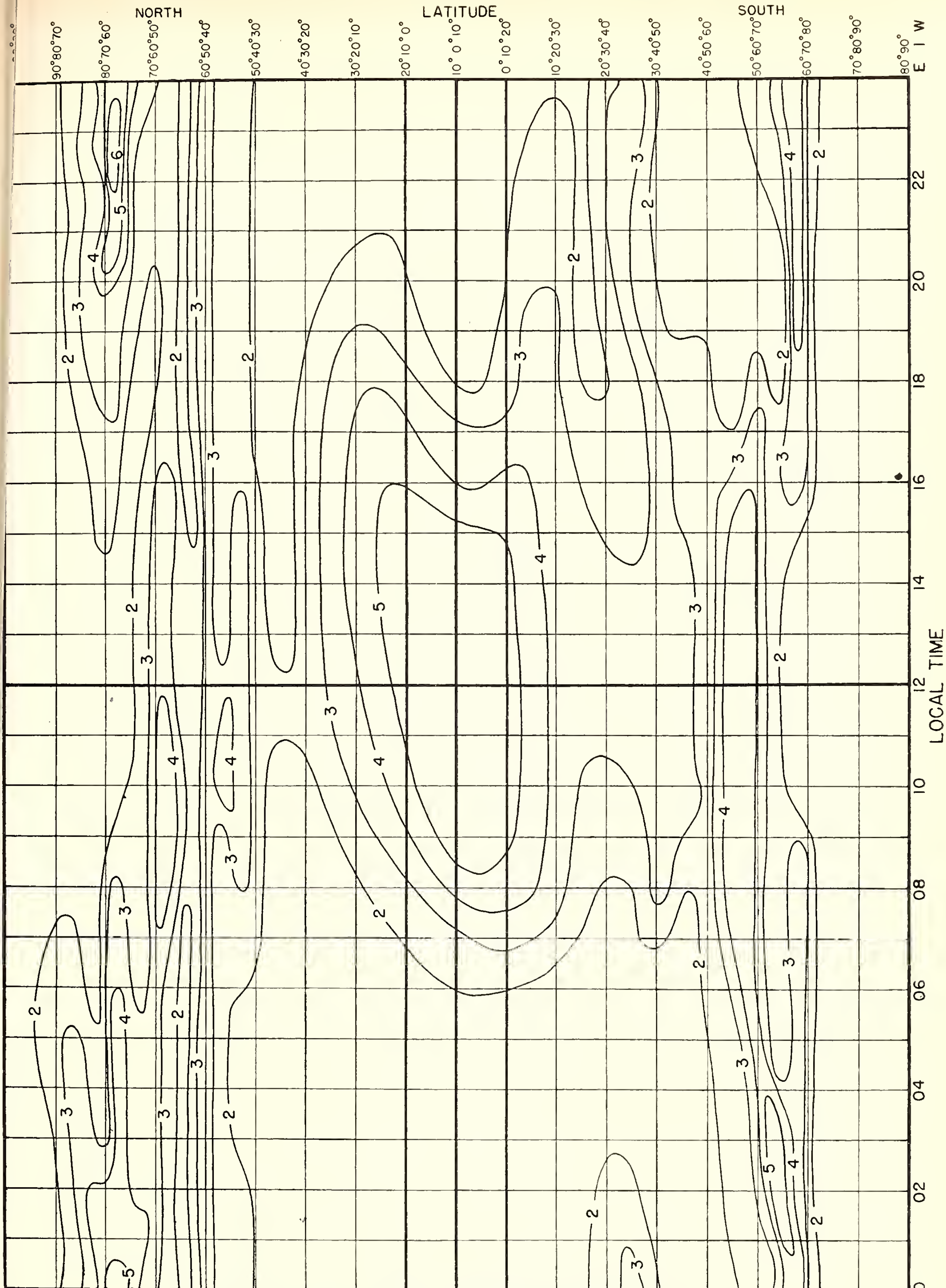

Fig. 12. MEDIAN fE_s, IN Mc, PREDICTED FOR OCTOBER, 1945.

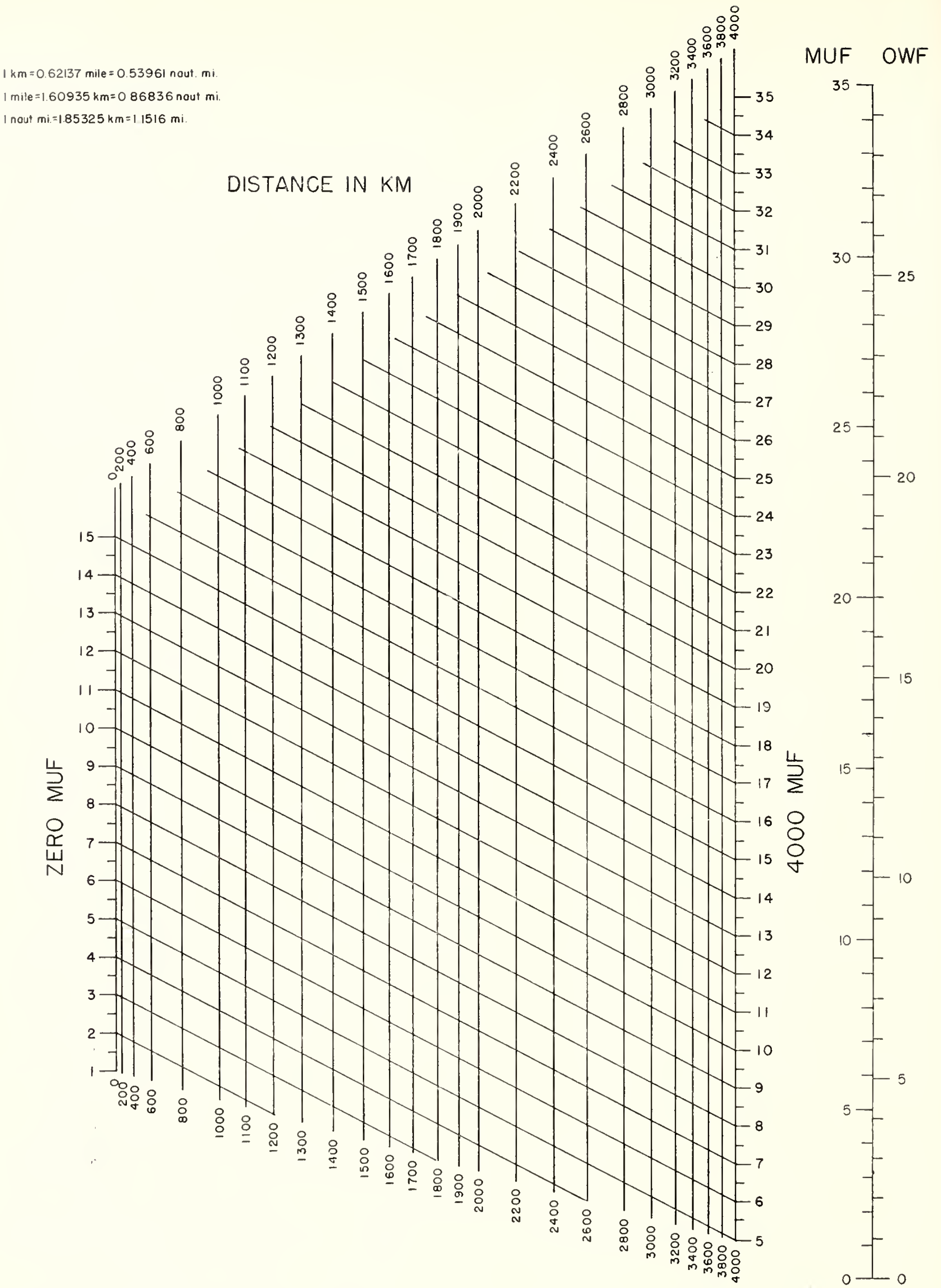

FIG. 13. NOMOGRAM FOR TRANSFORMING F_2–ZERO–MUF AND F_2–4000–MUF TO EQUIVALENT MAXIMUM USABLE FREQUENCIES AT INTERMEDIATE TRANSMISSION DISTANCES; CONVERSION SCALE FOR OBTAINING OPTIMUM WORKING FREQUENCIES.

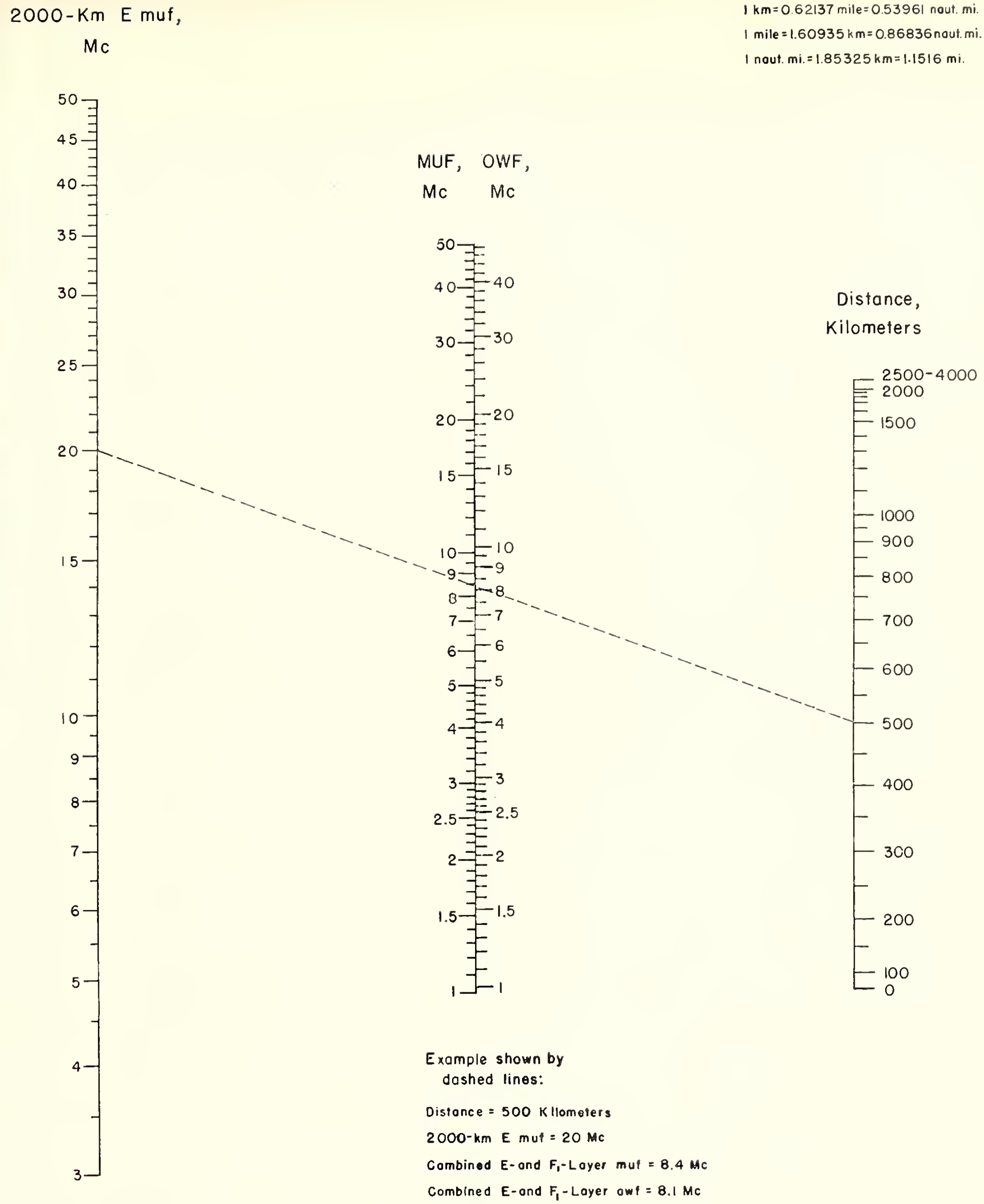

FIG. 14. NOMOGRAM FOR TRANSFORMING E—LAYER 2000—MUF TO EQUIVALENT MAXIMUM USABLE FREQUENCIES AND OPTIMUM WORKING FREQUENCIES DUE TO COMBINED EFFECT OF E LAYER AND F_1 LAYER AT OTHER TRANSMISSION DISTANCES.

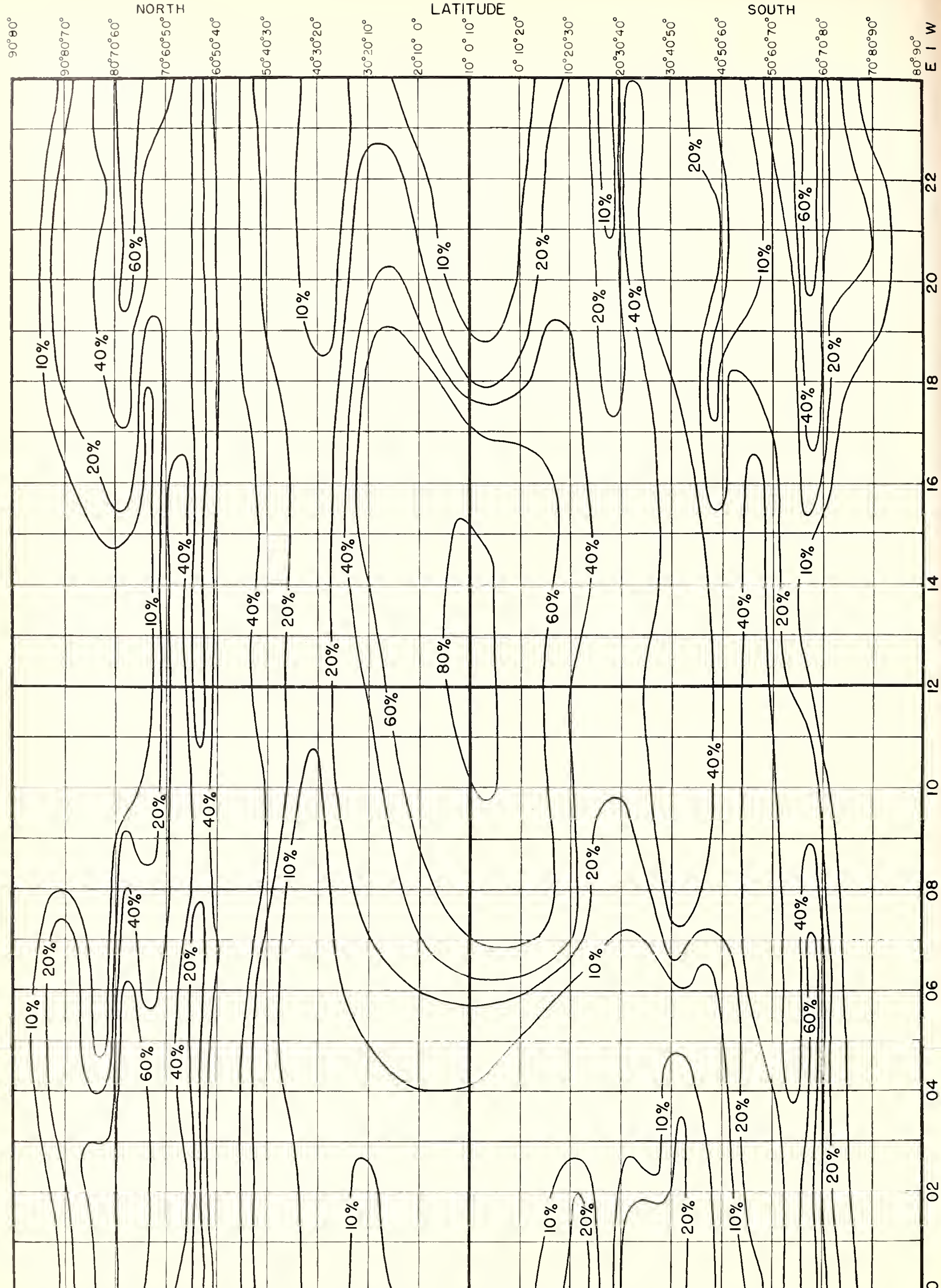

Fig. 15. PERCENTAGE OF TIME OCCURRENCE FOR E_s IN EXCESS OF 15 Mc, PREDICTED FOR OCTOBER, 1945.

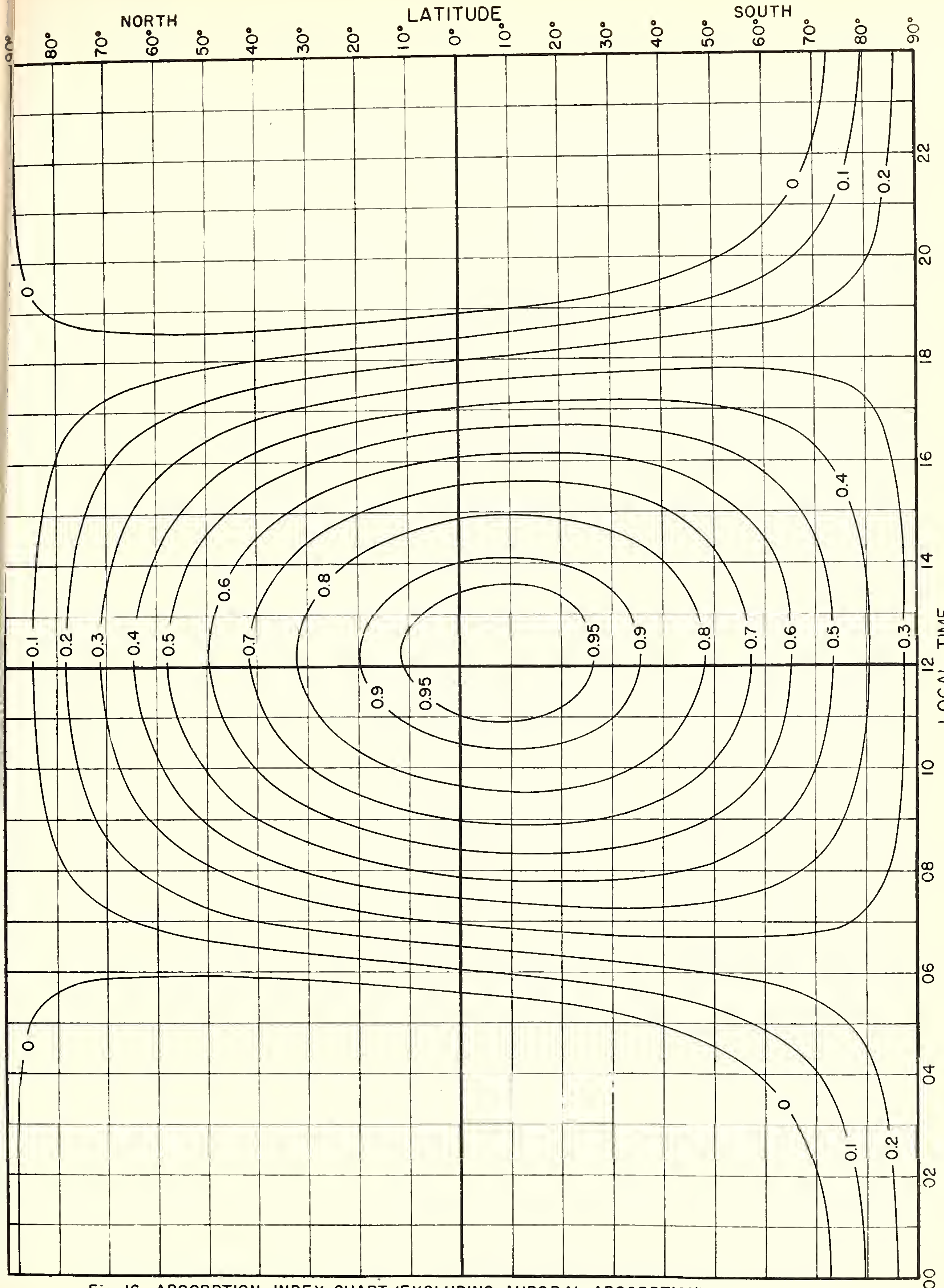

Fig. 16. ABSORPTION INDEX CHART (EXCLUDING AURORAL ABSORPTION) FOR OCTOBER.

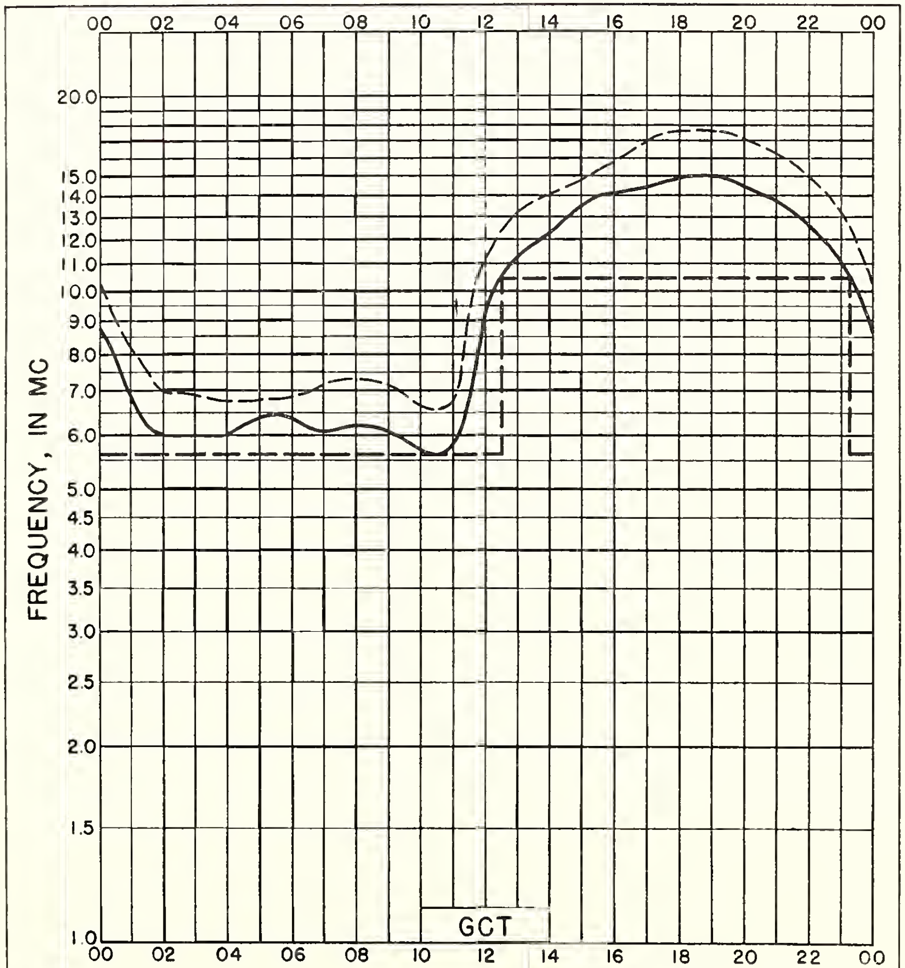

Fig. 17. SAMPLE SOLUTION OF TRANSMISSION PROBLEM FOR SHORT PATH, OCTOBER, 1945.

TRANSMISSION PATH: WASHINGTON, D.C. (39.0° N, 77.5° W) TO MIAMI, FLORIDA (25.7° N, 80.5° W)

--- MUF ——— OWF ---- SUGGESTED FREQUENCY USAGE

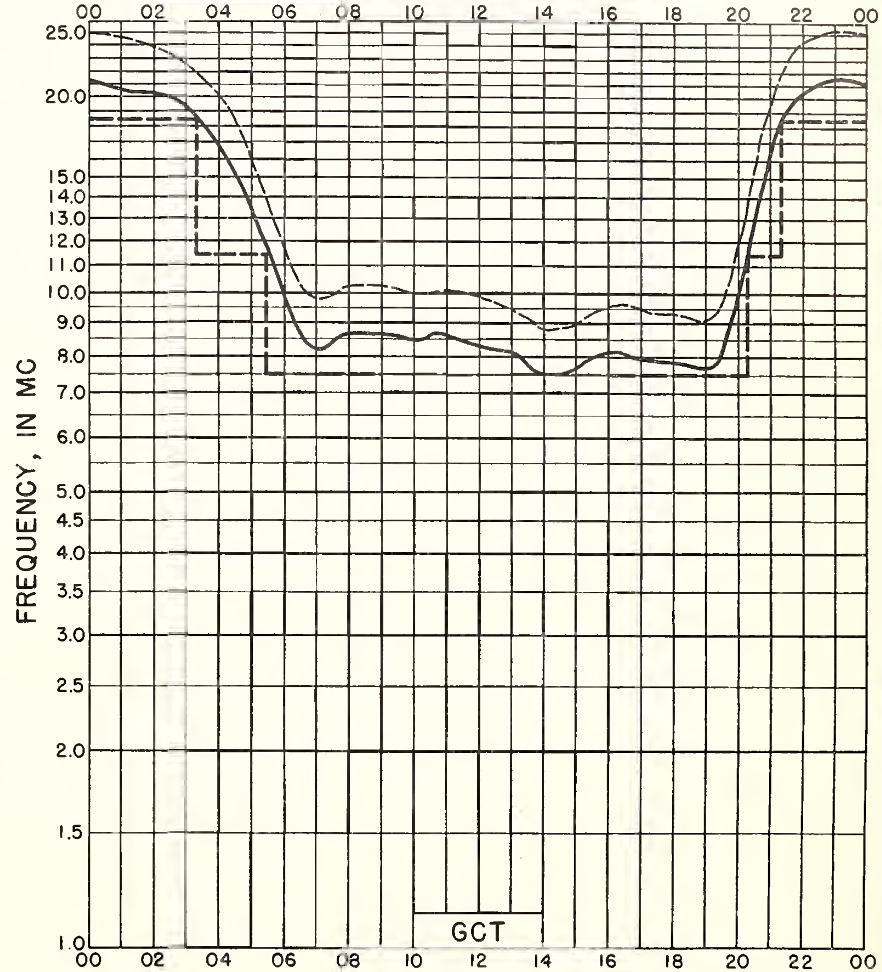

Fig. 18. SAMPLE SOLUTION OF TRANSMISSION PROBLEM FOR LONG PATH, OCTOBER, 1945.

TRANSMISSION PATH: NAGASAKI, JAPAN (33° N, 130° E) TO SAN FRANCISCO, CALIF. (37.5° N, 122.4° W)

--- MUF ——— OWF ---- SUGGESTED FREQUENCY USAGE

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