IRPL-D2

RESTRICTED

BASIC RADIO PROPAGATION PREDICTIONS FOR JANUARY, 1945 THREE MONTHS IN ADVANCE

ISSUED

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PREPARED BY INTERSERVICE RADIO PROPAGATION LABORATORY
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INTERSERVICE RADIO PROPAGATION LABORATORY
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This monthly report is the successor to "Radio Propagation Conditions", prepared by the Interservice Radio Propagation Laboratory, which was previously distributed to requesting Army personnel by the Chief Signal Officer, and to Navy personnel by the Director of Naval Communications under the short title DNC-13-1 ( ).

The monthly reports of this series are now distributed to the Army as the TB 11-499 series by the Adjutant General, and to the Navy as the DNC-13-1 series, by the Registered Publications Section, Division of Naval Communications.

This series is the basic supplement to the IRPL Radio Propagation Handbook 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.

CONTENTS

I. Terminology . . . . Page 3
II. World-wide prediction charts and their uses . . . . Page 3
World map showing zones covered by predicted charts, and auroral zones. . . . . Fig. 1
F2-zero-muf, in Mc, W zone, predicted for January 1945 . . . Fig. 5
F2-4000-muf, in Mc, W zone, predicted for January 1945 . . . Fig. 6
F2-zero-muf, in Mc, I zone, predicted for January 1945 . . . Fig. 7
F2-4000-muf, in Mc, I zone, predicted for January 1945 . . . Fig. 8
F2-zero-muf, in Mc, E zone, predicted for January 1945 . . . Fig. 9
F2-4000-muf, in Mc, E zone, predicted for January 1945 . . . Fig.10
E-layer 2000-muf, in Mc, predicted for January 1945 . . . . . Fig.11
Median Es, in Mc, predicted for January 1945. . . . . Fig.12
Percentage of time occurrence for Es in excess of 15 Mc, predicted for January 1945 . . . . Fig.15
III. Determination of great-circle distances, bearings, location of transmission control points, solar zenith angles . . . Page 4
Great-circle chart, centered on equator, with small circles indicating distances in kilometers . . . . Fig. 2
Diagram of transmission path auxiliary to explanation of use of distance-bearing nomogram, Fig. 4 . . . . Fig. 3
Nomogram for obtaining great-circle distances, bearings, latitude and longitude of transmission control points, solar zenith angles. Conversion scale for various distance units . . . . Fig. 4
IV. Calculation of maximum usable frequencies and optimum working frequencies . . . . Page 6
Nomograms for transforming F2-zero-muf and F2-4000-muf to equivalent maximum usable frequencies at intermediate transmission distances; conversion scale for obtaining optimum working frequencies Fig.13
Nomogram for transforming E-layer 2000-muf to equivalent maximum usable frequencies and optimum working frequencies due to combined effect of E layer and F1 layer at other transmission distances Fig.14
V. Absorption, distance range, and lowest useful high frequency . Page 8
Absorption index chart (excluding auroral absorption) for January Fig.16
VI. Sample muf and owf calculations . . . . Page 8
For short path (under 4000 km) . page 8, Table 1, page 11, & Fig.17
For long path (over 4000 km). . . page 9, Table 2, page 11, & Fig.18

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^oF2 - 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 layer as well as the daytime F2 layer.
f^xF2 - 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 F2.

II. WORLD-WIDE PREDICTION CHARTS AND THEIR USES

The charts, Fig. 5 through Fig.11, present world-wide predictions of monthly average maximum usable frequencies for December, 1944. Conditions may be markedly different on disturbed days, especially in or near the auroral zones, shown on the map of Fig. 1. The method of prediction is discussed in the IRPL Radio Propagation Handbook, Part 1, War Dept. TM11-499, Navy Dept. DNC-13-1, pp. 52, 53.

Ionospheric characteristics are roughly similar for locations of equal latitude, but 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 ionospheric characteristics are independent of longitude, for practical purposes. These zones are indicated on the world map, Fig. 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^oF2 charts appearing in the previous IRPL reports "Radio Propagation Conditions." (Values of F2 zero-muf exceed those of f^oF2 for the same location and local time by an amount approximately equal to half the gyro-frequency for the location. See IRPL Radio Propagation Handbook, Part 1, (War Dept. TM 11-499 and Navy Dept. DNC-13-1) pp. 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 Es with geomagnetic latitude seems to be well-marked and important, but there are, as yet, insufficient correlated data to permit an estimate of this variation; the Es charts furnished here are therefore of a far lower degree of precision than the other charts.

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, Fig. 1, and the great-circle chart, Fig. 2 , for this purpose, as follows:

a. Place a piece of transparent paper over the map, Fig. 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, Fig. 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, using for this purpose the small circles of Fig. 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 directed 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, Fig. 4.

Referring to the auxiliary diagram, Fig. 3, let Z and S be the locations of transmitting and receiving stations; then, by using the nomogram, Fig. 4

a. <u>To obtain the great-circle distance ZS:</u>

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

(2) From (Long. of S - Long. of Z) on bottom scale, measured from left to right, draw vertical line to the slant line obtained in (1).

(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 Fig. 4.

b. <u>To obtain the bearing angle PZS:</u>

(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. <u>To obtain the bearing angle PSZ:</u>

(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. <u>To obtain latitude of Q (mid, or other, point of path):</u>

(1) Obtain ZQ in degrees. If Q is the midpoint of the path, ZQ will be equal to ZS/2. 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. <u>To obtain longitude difference, t', between Z and Q</u>:

(1) Draw straight line (Lat. Z - Lat. Q), measured up from bottom on left-hand scale, to (Lat. Z + Lat. Q), measured down from 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. <u>To obtain solar zenith angle, ψ, at a given place</u>:

(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) x 15]°, 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. <u>Procedure for determination of muf or owf for transmission distances under 4000 km.</u>

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 stations.

For a path 4000 km in length, read the predicted monthly average F2 muf directly off the 4000-muf charts furnished, at the latitude and local time of the midpoint of the path. For a path 2000 km in length read the predicted monthly average E-layer muf directly off the E-layer 2000-muf chart. Use the following procedure for other distances:

a. Locate the midpoint of the transmission path. (Methods for doing this are given in the following 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.

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, Fig. 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.

d. The optimum working frequency (owf) is 85% 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 Fig. 13.

e. Place a straightedge between the value of the E-layer 2000-muf located on the left-hand scale of the nomogram, Fig. 14, and the value of the path length on the right-hand scale, and read the combined E- and F1-layer muf or owf for that path length, off the central scale. (The characteristics of the E layer and of the F1 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 F2 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 F2-4000-muf, at the local time for each point, at these points, being sure to choose the appropriate zone for each point.

c. Compare these two muf values. The lower of the two is the muf for the transmission path under consideration. Calculate the owf (85% of the muf) for the path, by means of the auxiliary muf-owf scale of Fig. 13.

d. When one of the control points lies in a region where the E-2000-muf is greater than the F2-4000-muf, read the E-2000-muf at an E-layer control point 1000 km from the end of the path, instead of the F2-4000-muf as in step b. Use the E-2000-muf in step c, instead of the F2-4000-muf.

3. Procedure for determination of Es transmission.

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 produce regular transmission at times when regular F2-layer propagation would not. Es data are not yet sufficient to permit accurate calculations of such propagation, but the charts of Figs. 12 and 15 are given as a guide to Es occurrence. Until such time as more definite information is available, the following procedure should be used, to find the prevalence of Es propagation over long paths.

a. For paths over 4000 km long:

(1) Place the great-circle path transparency, prepared in Sec. III, 1, over the median fEs chart, Fig. 12.

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

(3) Plot as the owf for each control point the higher of the two values, the F2-4000-owf and the Es-owf.

b. For use over paths of lengths up to 4000 km scale the Es at the midpoint of the path, multiply by 5 and subtract 4 Mc, and use the resultant frequency instead of the E-2000-muf in the nomogram of Fig. 14.

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, pp. 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, Fig. 16, is presented. By superposing the transparency with the great-circle path on it, prepared as in Sec. 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 = 0.14).

The absorption is erratic and considerably greater in and near the auroral zones, shown on the map of Fig. 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, Florida (25.7°N, 80.5°W) for average conditions during the month of January 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 as well as Es-owf over this transmission path, as determined by using the procedure given in Section IV, for alternate hours, GCT, are given in Table 1. The final values are presented graphically in Fig. 17.

Fig. 17 shows that skip will occur, on the average, during the night hours if a frequency as high as 7.0 Mc is used. A frequency as high as 5.3 Mc will not skip, on the average, at any time of day, but it 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, on a circuit like this, consists of the use of two frequencies, one for night and one for day.

Fig. 17 shows that a night frequency of 4.5 Mc used between the hours of 2045 and 1415 GCT, and a day frequency of 10.5 Mc to be used from 1415 to 2045, would be satisfactory. The periods of usefulness of these frequencies are shown by the heavy dashed line on Fig. 17.

It may be seen from the chart, Fig. 12, that the values of fEs at the midpoint of the path are frequently only slightly under 2 Mc, and that therefore transmission is often possible by sporadic-E reflection on frequencies as high as 6 Mc. The abrupt increases in both muf and owf apparent in Fig. 17 at 0200 and 0900 GCT are cases where the transmission is definitely controlled by sporadic-E reflection. (No distinction is made here between Es-owf and Es-muf since the Es-owf is derived from the fEs by using the procedures given in Sec. IV 3(a)(2), which is based on only approximate relationships. Approximately, the logarithm to the base 10 of the ratio of percentages of time occurrences of vertical-incidence sporadic-E reflections above any two selected frequencies is proportional to the difference of the two frequencies, the constant of proportionality varying from about -0.3 for months near both summer and winter solstices to about -0.7 for months near equinoctial periods).

2. <u>For long paths:</u>

Required: The muf and owf for transmission between New York City (40.5°N, 74.0°W) and Moscow (56.0°N, 37.0°E), for average conditions during the month of January 1945.

Solution:
Let the local time used for this problem be GCT, or that of 0°.

The path length is approximately 7500 km and the two F2-layer control points are at approximately 54.0°N, 56.0°W and 64.0°N, 4.0°E. These are respectively in zone W and zone I as shown on the map, Fig. 1. The two E-layer and Es-control points are located at 47°N, 66°W and 61°N, 23°E. The bearing of Moscow from New York City, determined by means of the nomogram of Fig. 4, is approximately 35°.

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

Fig. 18 shows that skip will occur, on the average, during the night hours if a frequency as high as 7 Mc is used, although much 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 for the preceding problem.

In this case a frequency of 5.4 Mc may be used from 2245 to 0130 GCT; a frequency of 11.5 Mc may be used from 0130 to 0730, and again from 1000 to 2100, while a transition frequency of 8.0 Mc may be used from 0730 to 1000 and from 2100 to 2245.

Periods of time during which transmission is controlled by sporadic-E reflection may be readily noted on Fig. 18 by coincidence of the muf and owf curves. E-layer control of transmission may be recognized (at 0800) by the relatively small distance between muf and owf curves to that where transmission is controlled by the F2 layer.

Table 1

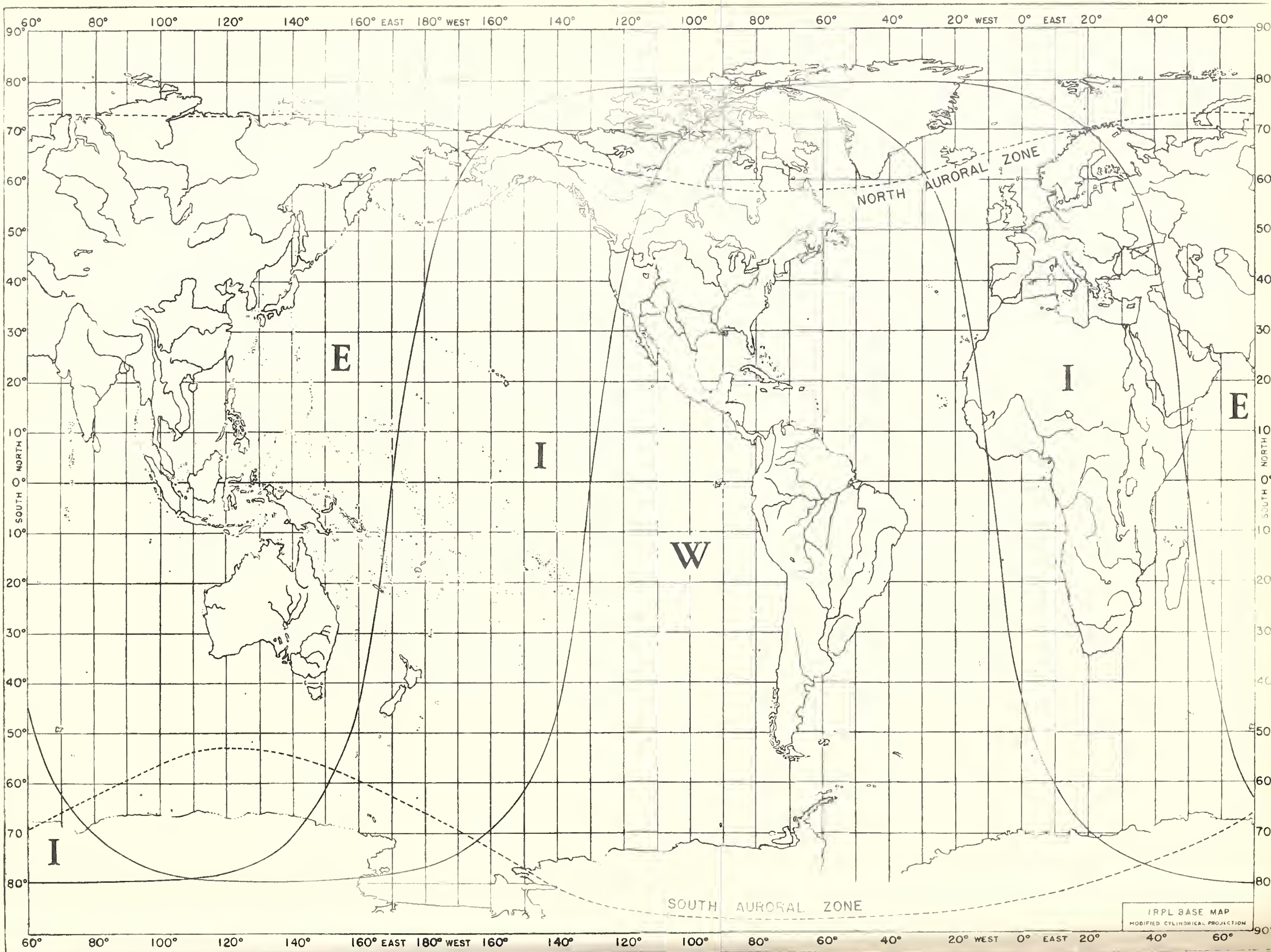
Solution of Short-Path Transmission Problem
Path: Washington, D.C. to Miami, Florida.

Time, GCT	E-layer-2000-muf, Mc	Combined E- and F1-layer-1500-muf, Mc	Combined E- and F1-layer-1500-owf, Mc	Median fEs, Mc	Es-owf, Mc	F2-layer-zero-muf, Mc, W-zone	F2-layer-4000-muf, Mc, W-zone	F2-layer-1500-muf, Mc	F2-layer-1500-owf, Mc	Combined muf, Mc, all layers	Combined owf, Mc, all layers
00				<2	<6	3.7	11.1	6.6	5.6	6.6	5.6
02				2.2	6.4	3.4	8.6	5.5	4.7	6.4	6.4
04				<2	<6	3.5	9.8	5.9	5.0	5.9	5.0
06				<2	<6	3.6	10.5	6.3	5.4	6.3	5.4
08				<2	<6	3.8	10.7	6.6	5.6	6.6	5.6
10				<2	<6	3.6	8.7	5.7	4.6	5.7	4.6
12	5.4	5.0	4.9	<2	<6	4.2	12.0	7.3	6.2	7.3	6.2
14	11.6	10.7	10.4	<2	<6	5.8	19.3	11.3	9.6	11.3	10.4
16	13.9	12.8	12.4	<2	<6	6.6	22.0	12.8	10.9	12.8	12.4
16	14.2	13.1	12.7	<2	<6	7.0	23.3	13.6	11.6	13.6	12.7
20	12.3	11.3	11.0	<2	<6	6.8	21.3	12.6	10.7	12.6	11.0
22	7.5	6.9	6.7	<2	<6	5.6	18.3	10.9	9.2	10.8	9.2

Table 2

Solution of Long-Path Transmission Problem
Path: New York City to Moscow.

Time, GCT	E-layer-2000-muf, Mc Control point A'	E-layer-2000-owf, Mc Control point A'	Median fEs, Mc Control point A'	Es-owf, Mc Control point A'	F2-4000-muf, Mc W-zone Control point A	F2-4000-owf, Mc W-zone Control point A	Combined muf, Mc, Control points A and A'	Combined owf, Mc, Control points A and A'	E-layer 2000-muf, Mc, Control point B'	E-layer 2000-owf, Mc Control point B'	Median fEs, Mc, Control point B'	Es-owf, Mc, Control point B'	F2-4000-muf, Mc, I-zone, Control point B	F2-4000-owf, Mc, I-zone, Control point B	Combined muf, Mc Control points B and B'	Combined owf, Mc Control points B and B'	Muf, Mc, for transmission path	Owf, Mc, for transmission path
00			<2	<6	6.4	5.4	6.4	5.4			5.8	25.0	5.8	4.9	25.0	25.0	6.4	5.4
02			3.3	12.5	5.0	4.2	12.5	12.5			4.9	20.5	5.6	4.8	20.5	20.5	12.5	12.5
04			3.4	13.0	4.6	3.9	13.0	13.0			4.8	20.0	5.6	4.8	20.0	20.0	13.0	13.0
06			3.6	14.0	4.9	4.2	14.0	14.0			4.2	17.0	5.7	4.8	17.0	17.0	14.0	14.0
08			3.5	13.5	5.3	4.5	13.5	13.5	8.2	8.0	2.3	7.5	7.0	5.9	8.2	8.0	8.2	8.0
10			3.5	13.5	5.7	4.8	13.5	13.5	9.8	9.5	< 2	<6	13.5	11.5	13.5	11.5	13.5	11.5
12	6.0	5.8	3.8	15.0	10.3	8.8	15.0	15.0	9.0	8.7	< 2	<6	15.9	13.5	15.9	13.5	15.0	13.5
14	11.2	10.9	4.3	17.5	16.2	13.8	17.5	17.5	5.7	5.5	2.0	6.0	16.0	13.6	16.0	13.6	16.0	13.6
16	12.4	12.0	4.3	17.5	19.3	16.4	19.3	17.5			3.1	11.5	11.7	9.9	11.7	11.5	11.7	11.5
18	11.8	11.4	3.7	14.5	18.7	15.9	18.7	15.9			3.8	15.0	6.4	5.4	15.0	15.0	15.0	15.0
20	9.0	8.7	2.5	8.5	15.8	13.4	15.8	13.4			4.9	20.5	4.8	4.1	20.5	20.5	15.8	13.4
22			<2	<6	11.0	9.3	11.0	11.0			6.2	27.0	5.5	4.7	27.0	27.0	11.0	11.0



NORTH AURORAL ZONE
SOUTH AURORAL ZONE
E
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IRPL BASE MAP
MODIFIED CYLINDRICAL PROJECTION
60° 80° 100° 120° 140° 160° EAST 180° WEST 160° 140° 120° 100° 80° 60° 40° 20° WEST 0° EAST 20° 40° 60°
90° 80° 70° 60° 50° 40° 30° 20° 10° NORTH 0° SOUTH 10° 20° 30° 40° 50° 60° 70 80° 90°

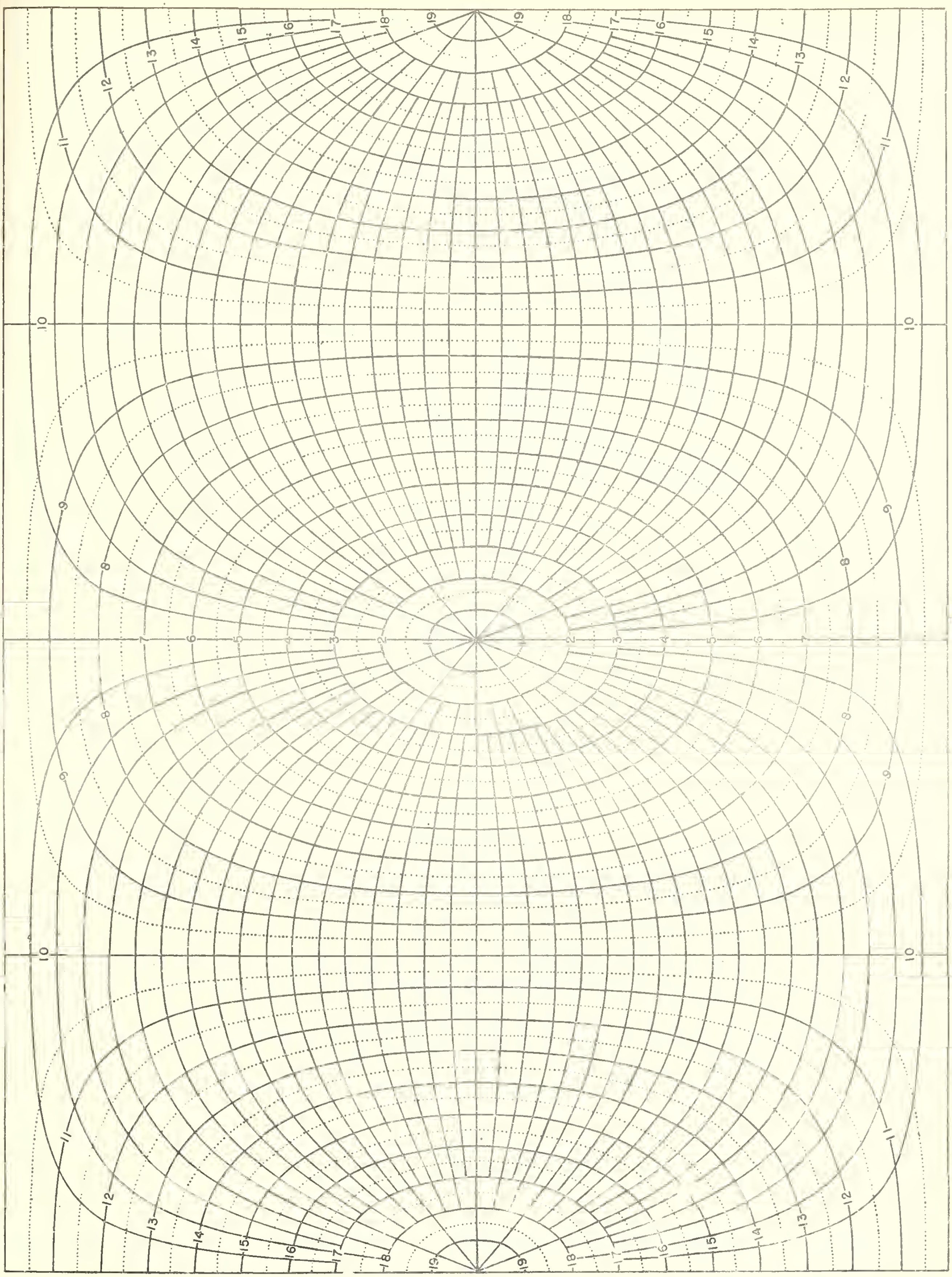

FIG. 2. GREAT CIRCLE CHART, CENTERED ON EQUATOR, WITH SMALL CIRCLES INDICATING DISTANCES IN KILOMETERS.

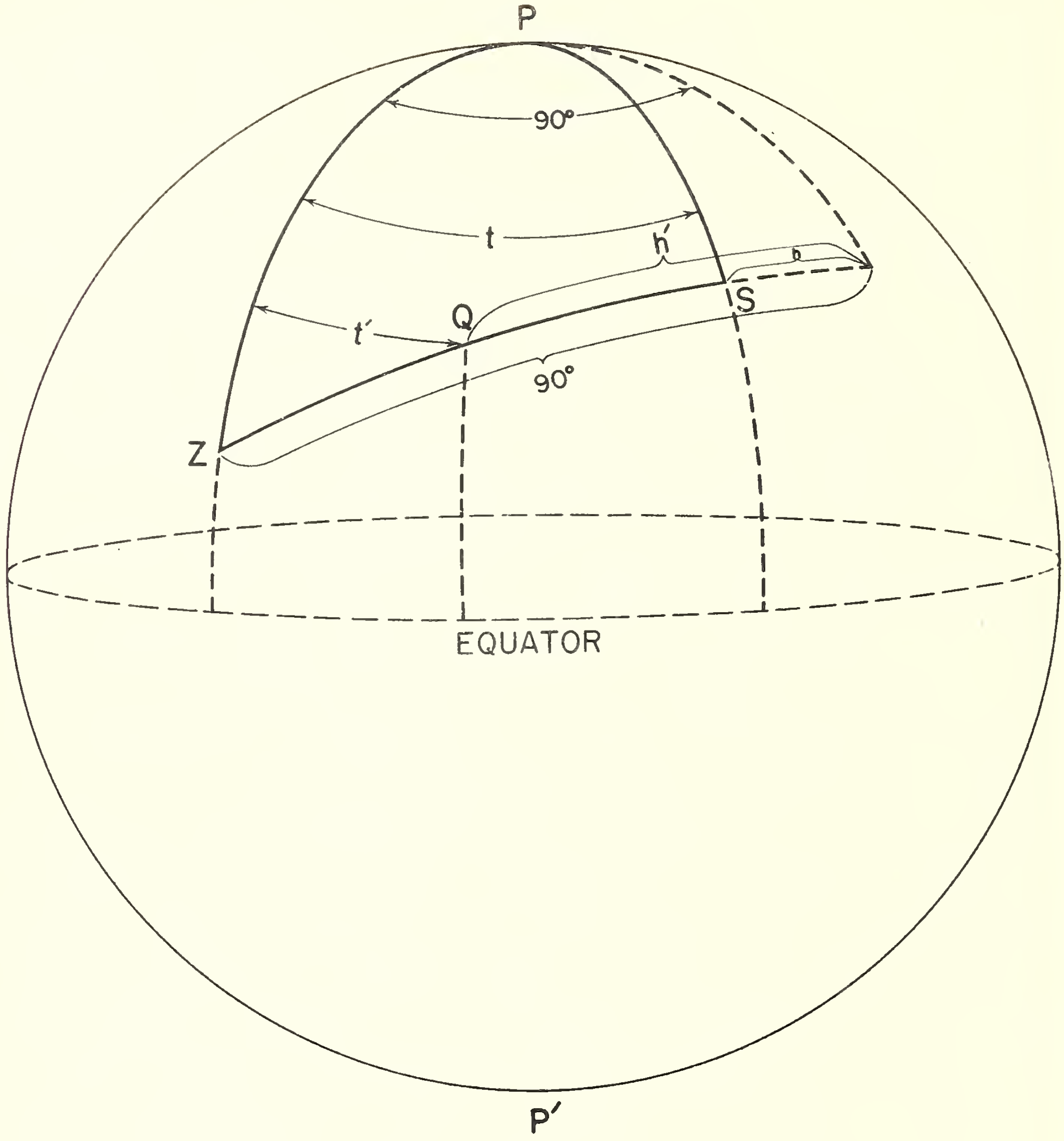

Fig. 3. DIAGRAM OF TRANSMISSION PATH AUXILIARY TO EXPLANATION OF USE OF DISTANCE – BEAR
NOMOGRAM, FIG. 4.

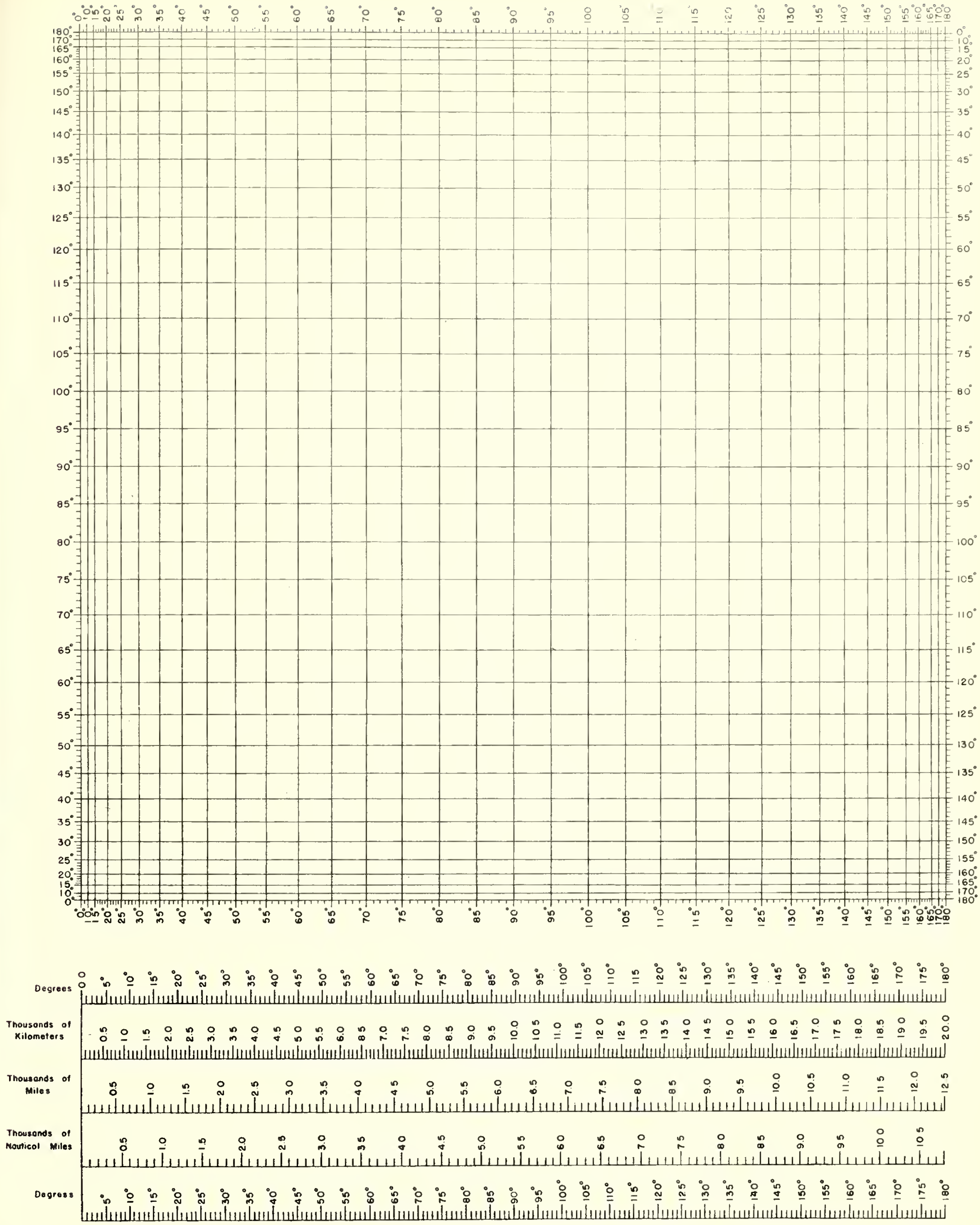

Fig. 4. NOMOGRAM (AFTER D'OCAGNE) FOR OBTAINING GREAT-CIRCLE DISTANCES, BEARINGS, LATITUDE AND LONGITUDE OF TRANSMISSION CONTROL POINTS, SOLAR ZENITH ANGLES.
CONVERSION SCALE FOR VARIOUS DISTANCE UNITS.

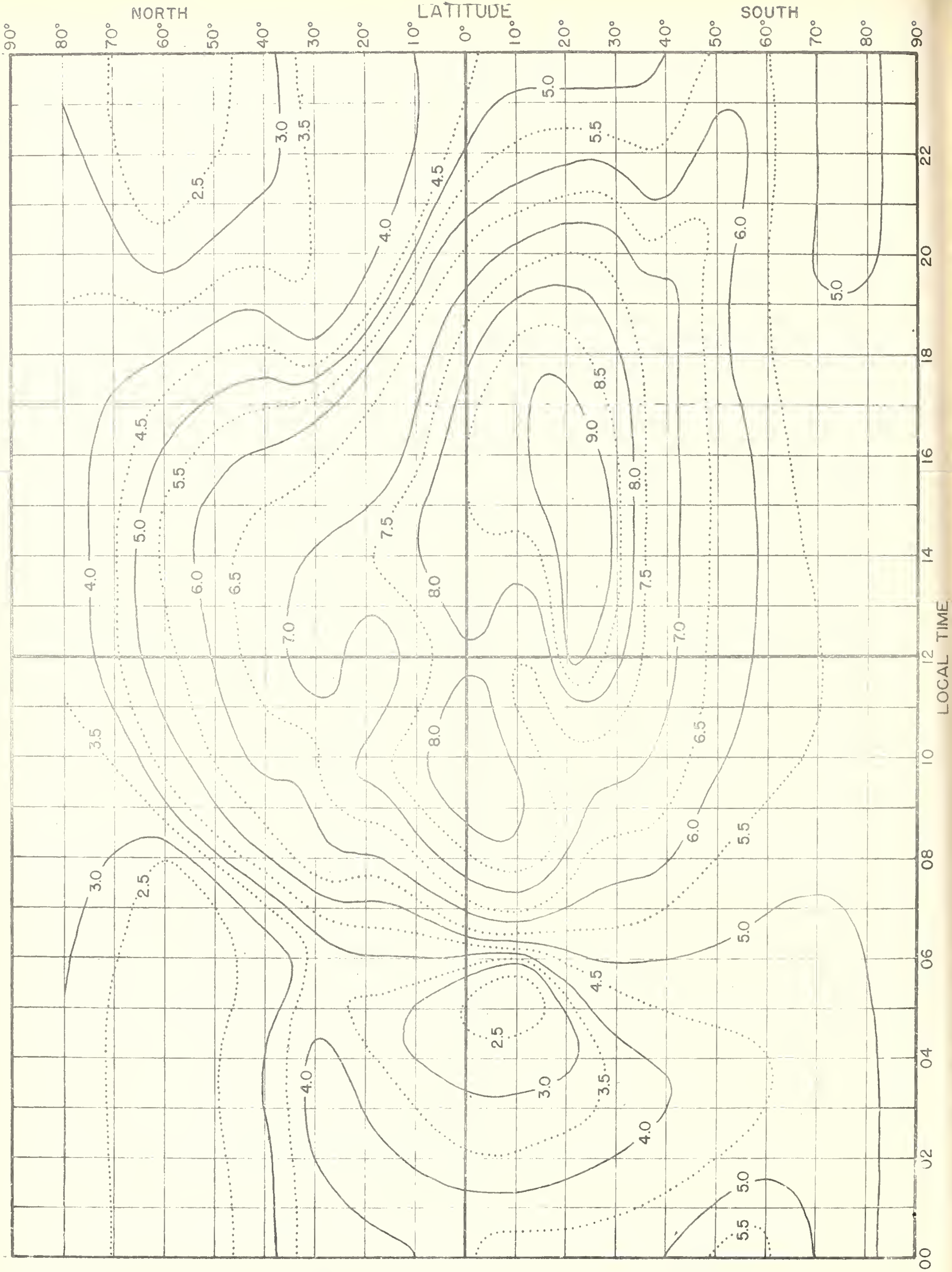

Fig. 5. F_2 ZERO-MUF, IN Mc, W ZONE, PREDICTED FOR JANUARY, 1945.

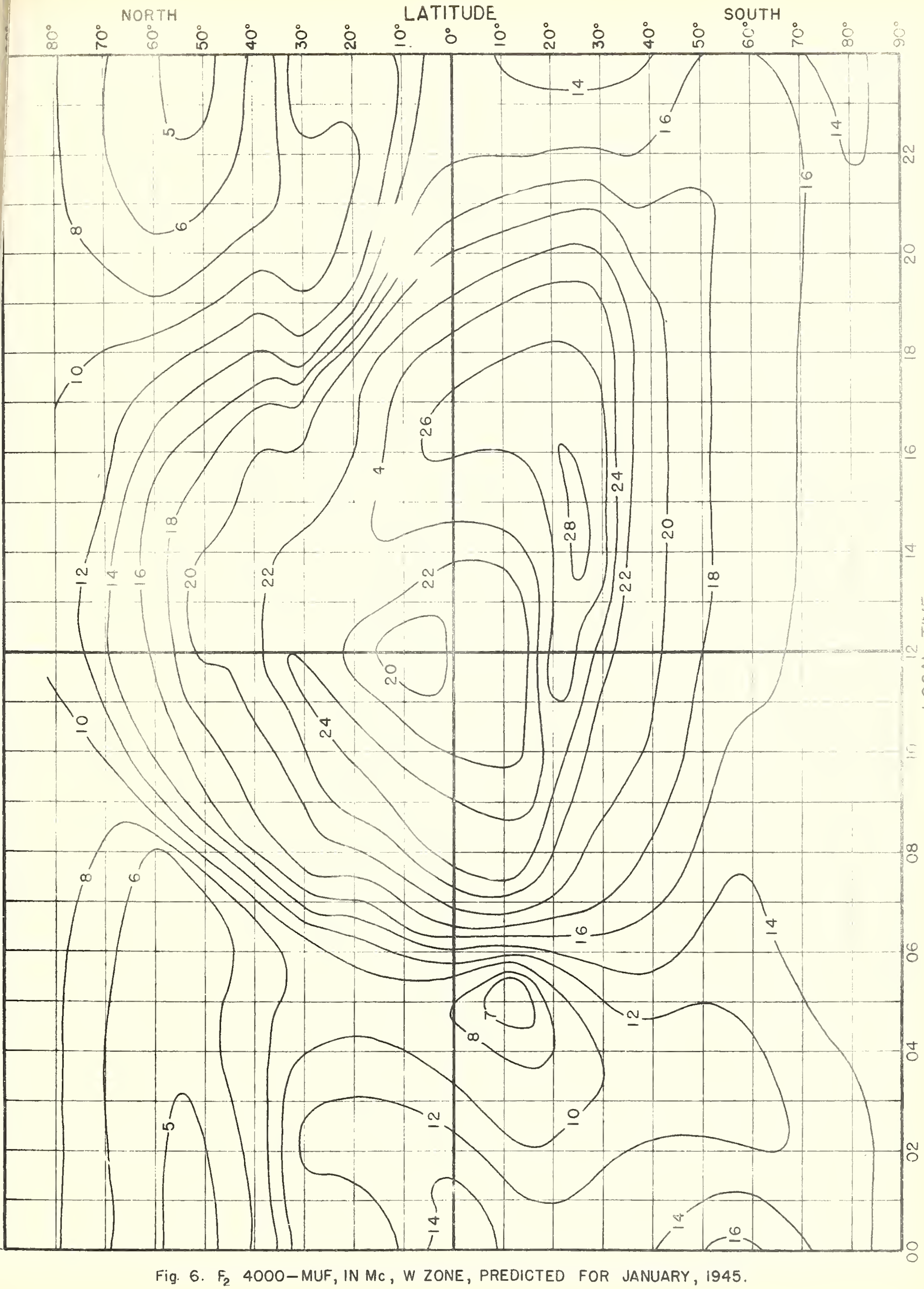

Fig. 6. F_2 4000—MUF, IN Mc, W ZONE, PREDICTED FOR JANUARY, 1945.

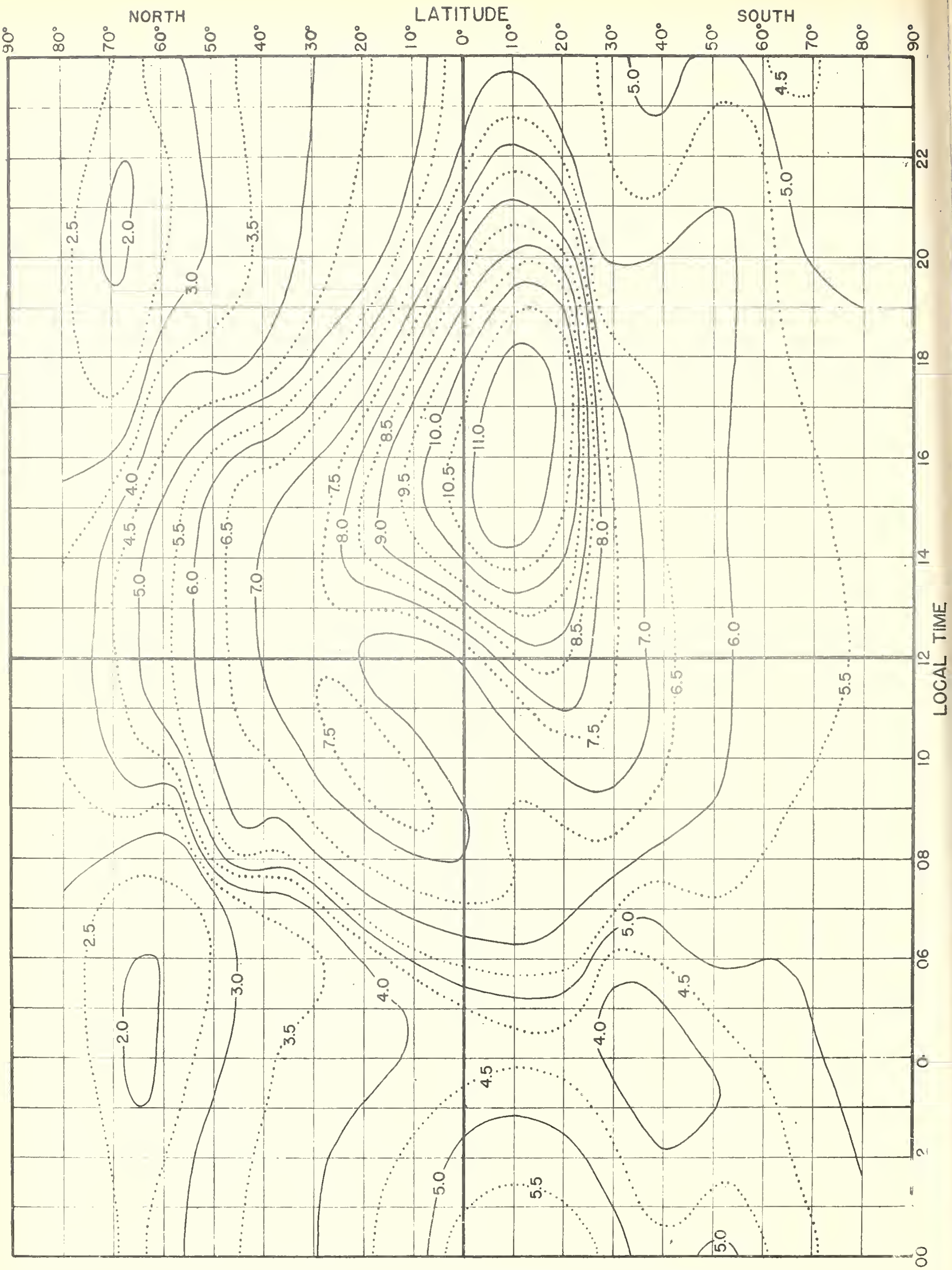

Fig. 7. F_2 ZERO—MUF, IN Mc, I ZONE, PREDICTED FOR JANUARY, 1945.

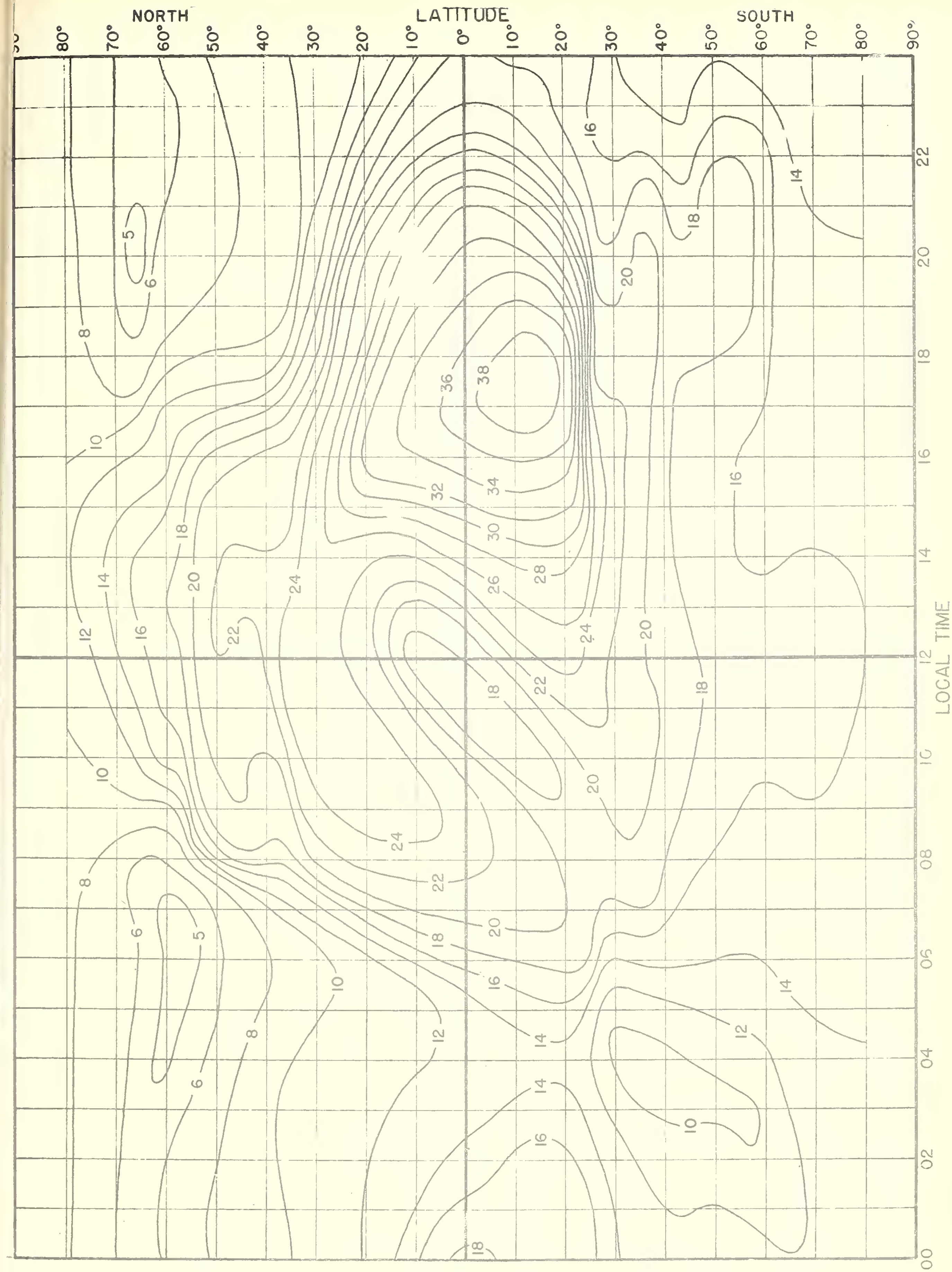

Fig. 8. F_2 4000—MUF, IN Mc, I ZONE, PREDICTED FOR JANUARY, 1945.

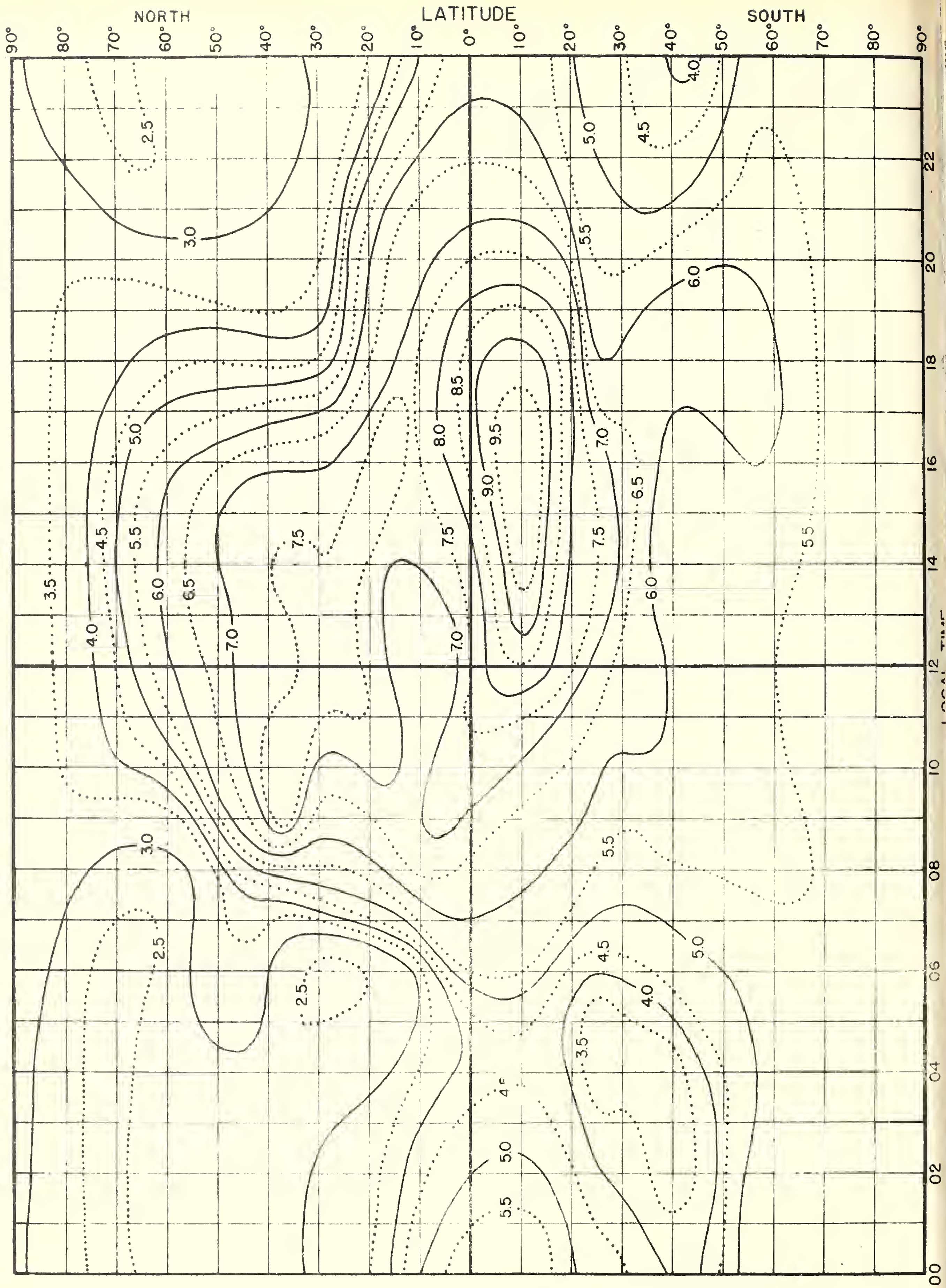

Fig. 9. F_2 ZERO-MUF, IN Mc, E ZONE, PREDICTED FOR JANUARY, 1945.

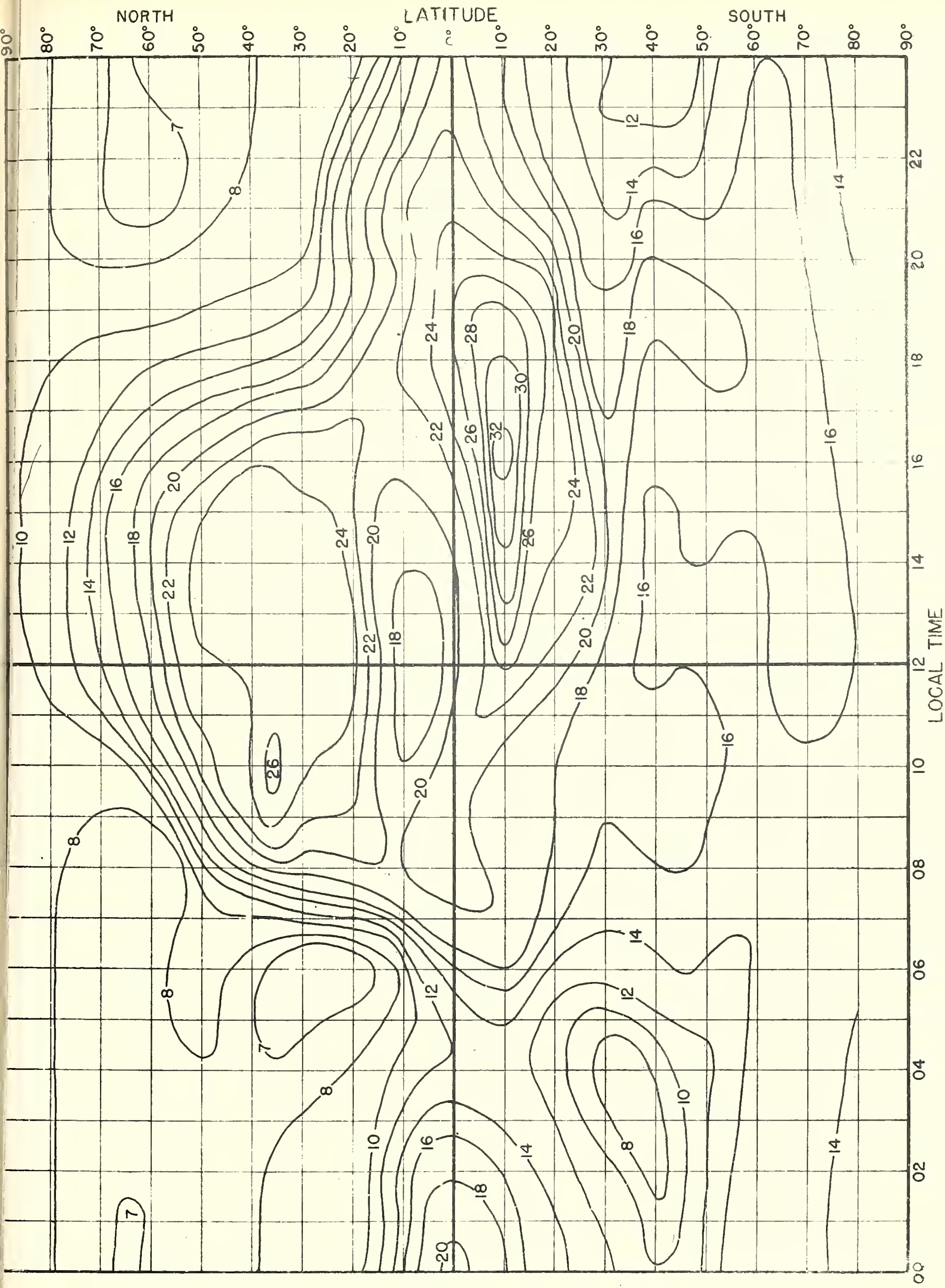

Fig. 10. F_2 4000—MUF, IN Mc, E ZONE, PREDICTED FOR JANUARY, 1945.

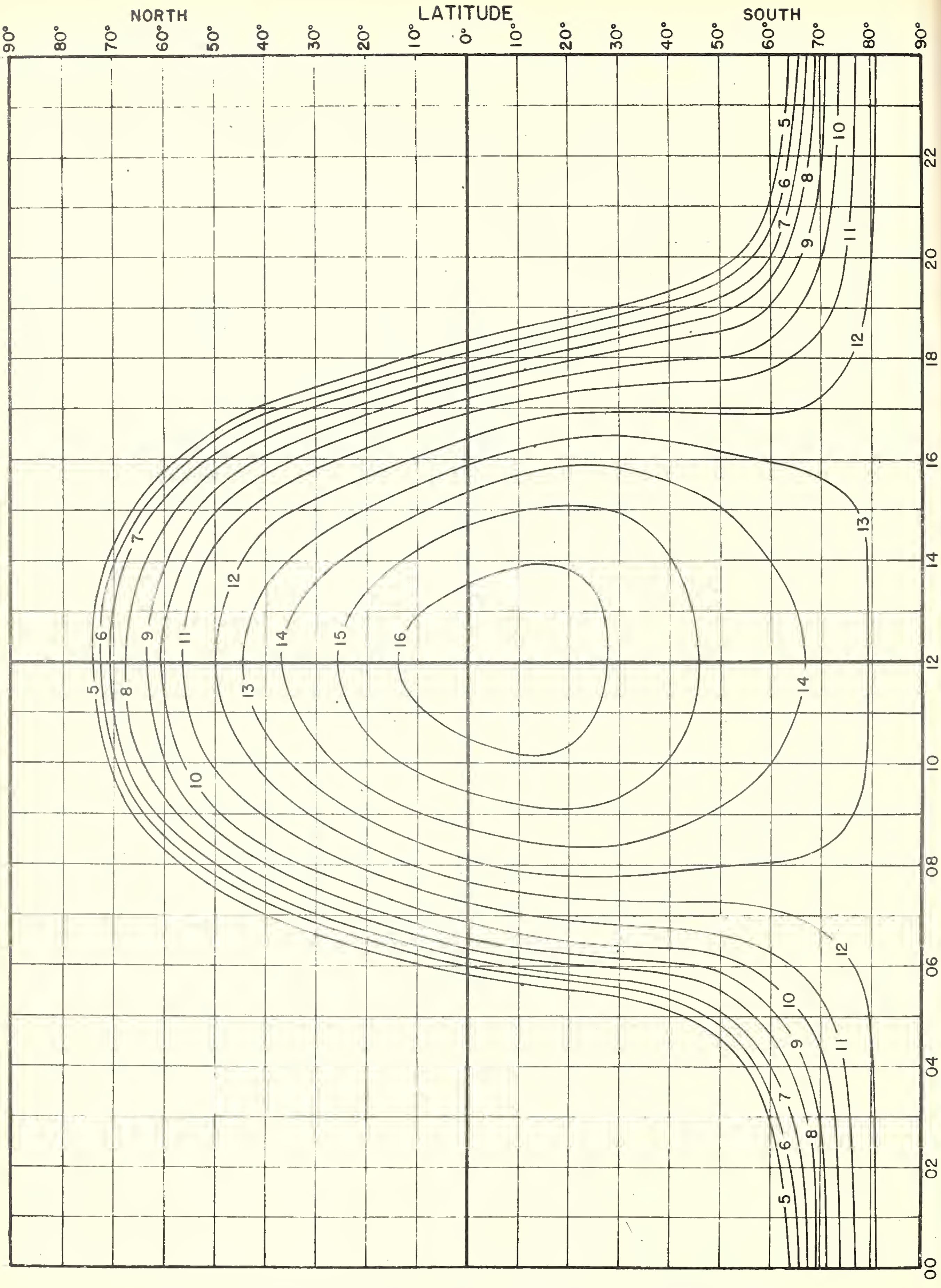

Fig.11. E-LAYER 2000-MUF, IN Mc, PREDICTED FOR JANUARY, 1945.

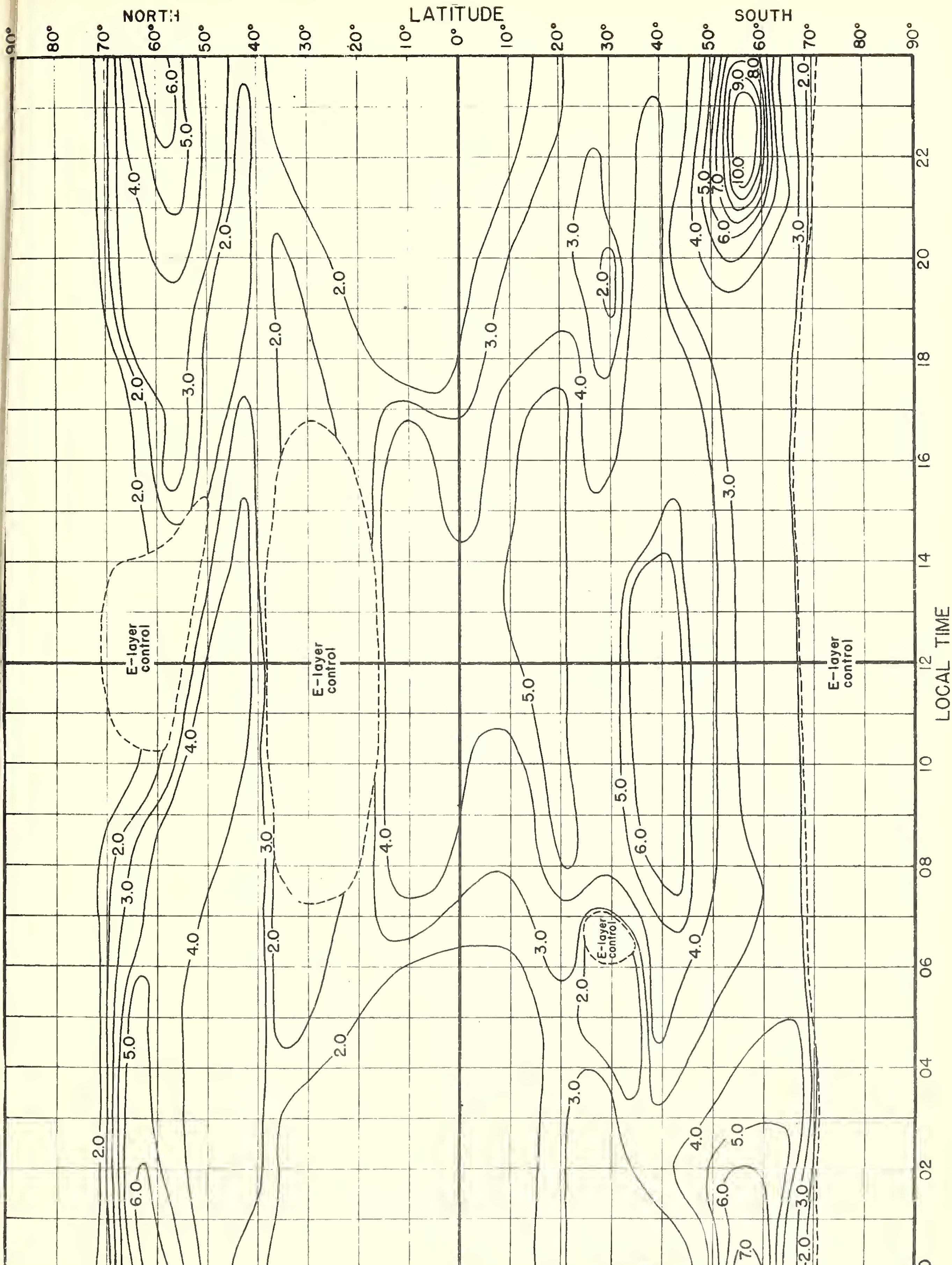

Fig. 12. MEDIAN fE_S, IN Mc, PREDICTED FOR JANUARY, 1945.

1 km = 0.62137 mile = 0.53961 naut. mi.
1 mile = 1.60935 km = 0.86836 naut. mi.
1 naut. mi. = 1.85325 km = 1.1516 mi

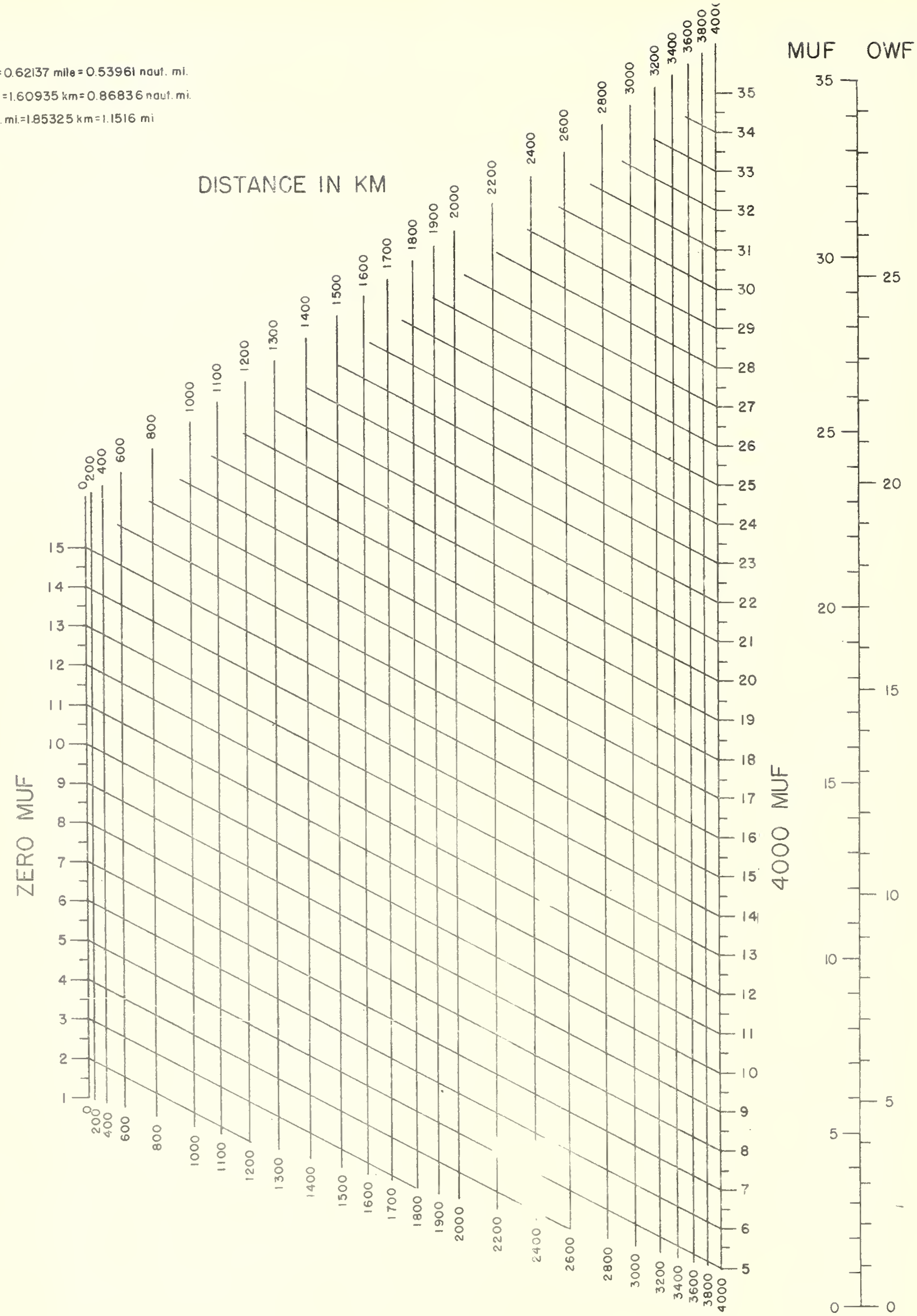

FIG. 13. NOMOGRAM FOR TRANSFORMING F_2 – ZERO – MUF AND F_2 – 4000 – MUF TO EQUIVALENT MAXIMUM USABLE FREQUENCIES AT INTERMEDIATE TRANSMISSION DISTANCES; CONVERSION SCALE FOR OBTAINING OPTIMUM WORKING FREQUENCIES.

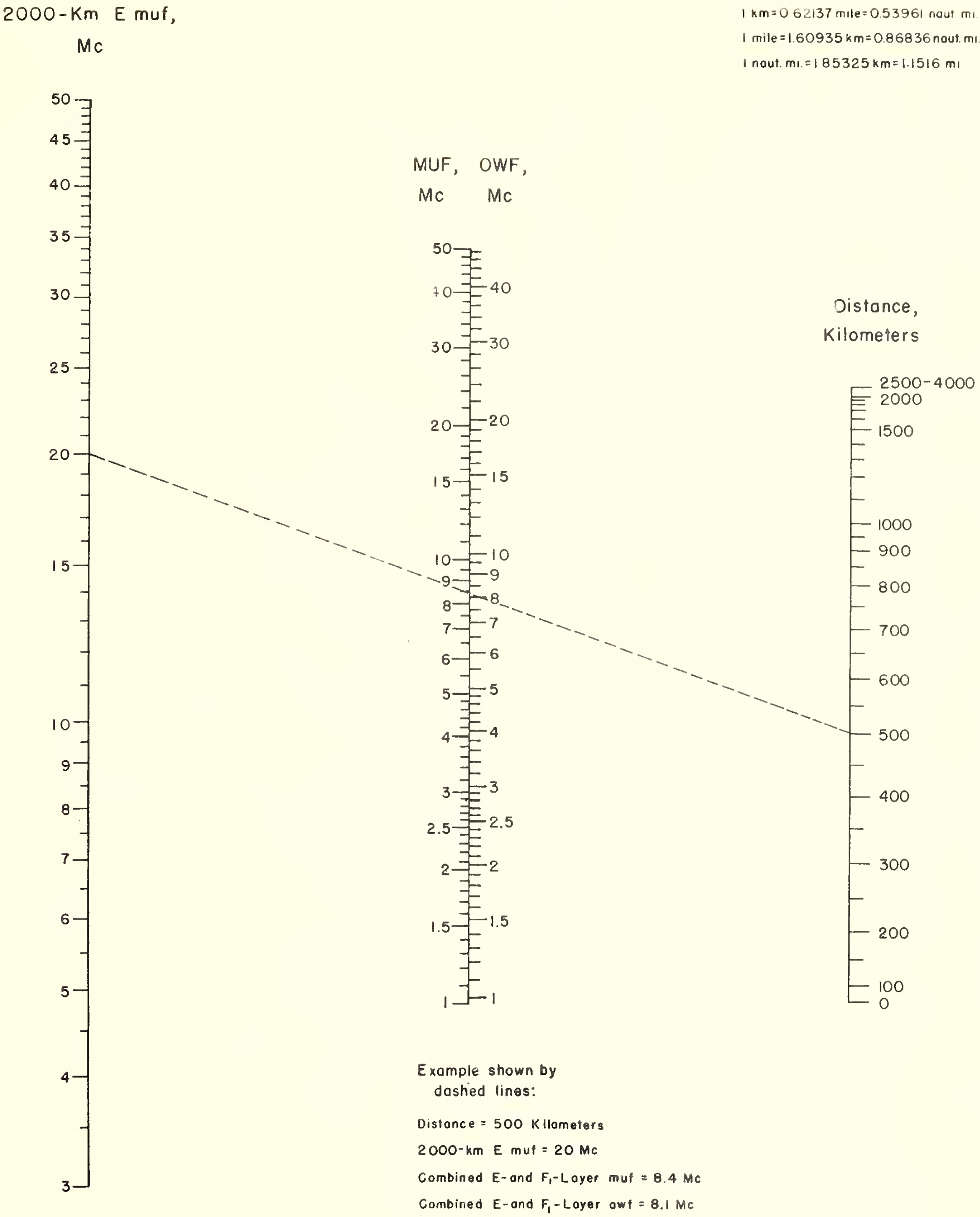

FIG. 14. NOMOGRAM FOR TRANSFORMING E—LAYER 2000—MUF TO EQUIVALENT MAXIMUM USABLE FREQUENCIES AND OPTIMUM WORKING FREQUENCIES DUE TO COMBINED EFFECT OF E LAYER AND F_1 LAYER AT OTHER TRANSMISSION DISTANCES.

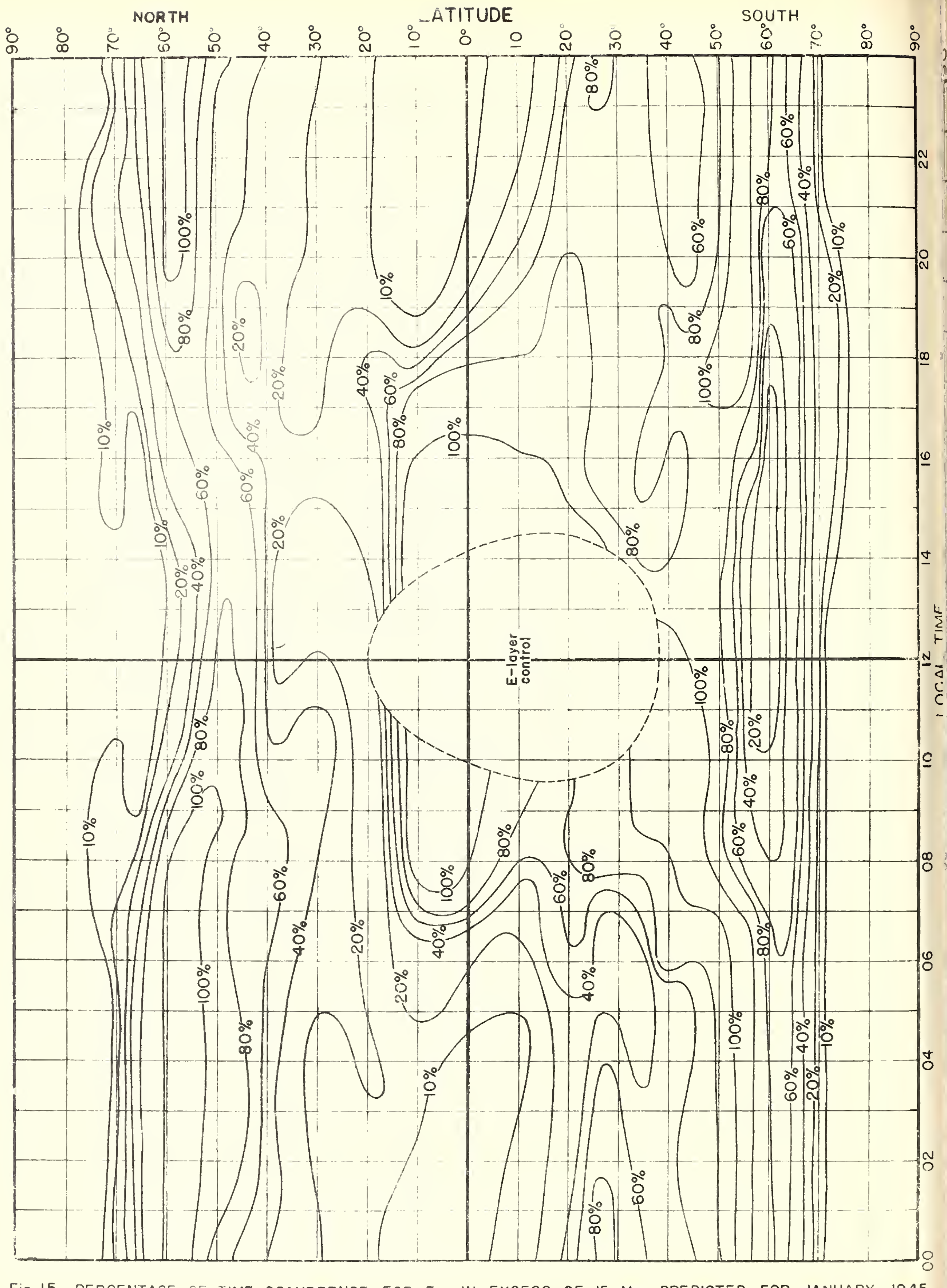

Fig. 15. PERCENTAGE OF TIME OCCURRENCE FOR E_s IN EXCESS OF 15 Mc, PREDICTED FOR JANUARY, 1945.

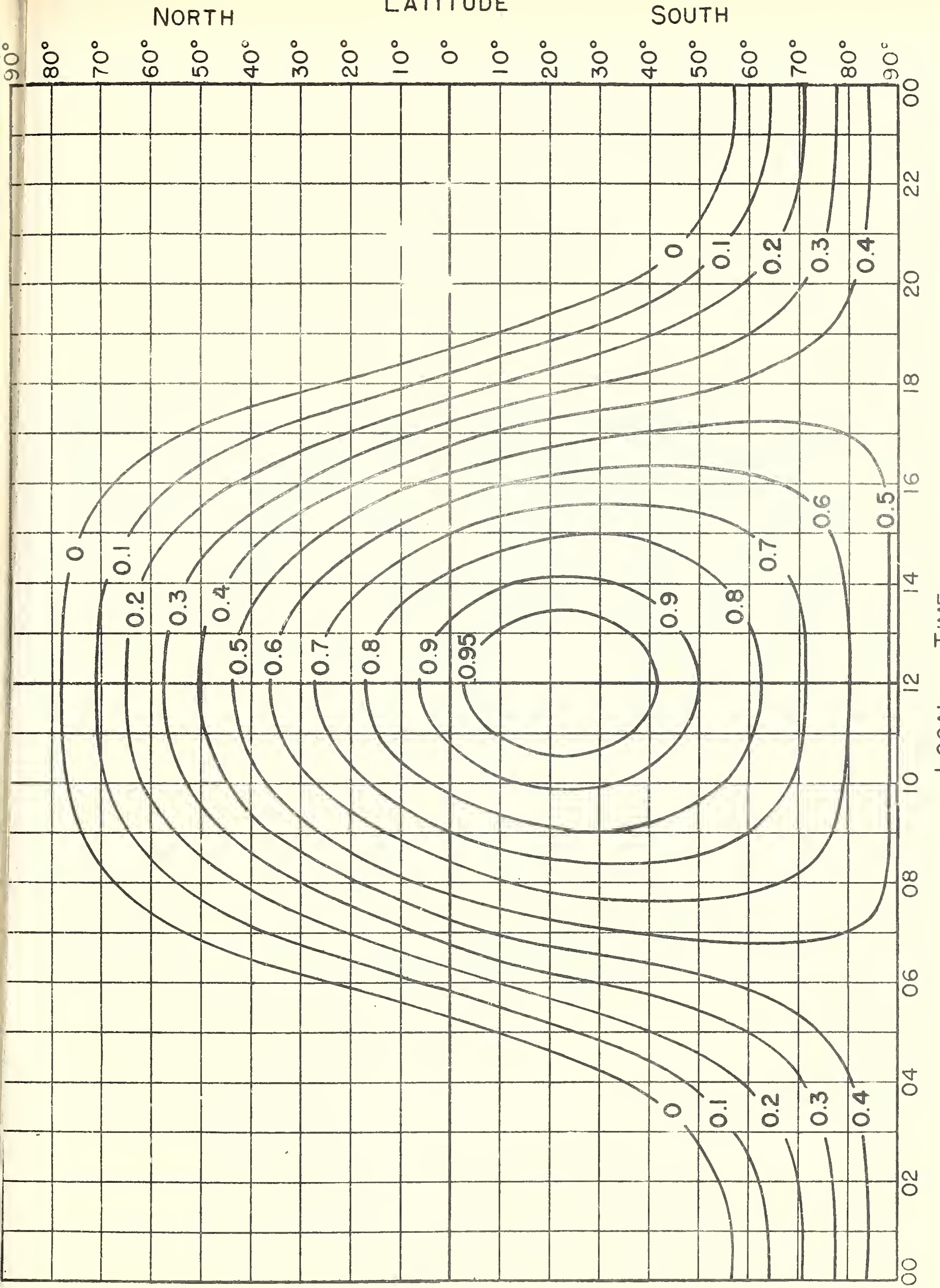

FIG. 16. ABSORPTION INDEX CHART (EXCLUDING AURORAL ABSORPTION) FOR JANUARY, 1944.

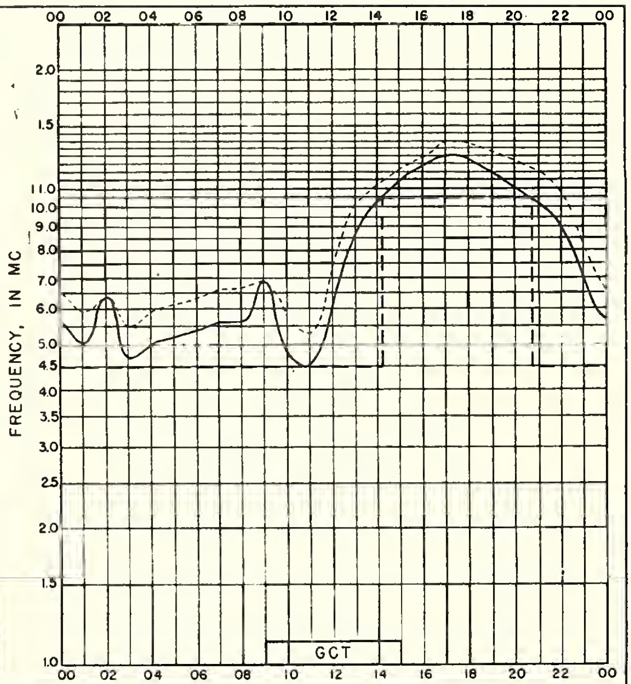

Fig. 17. SAMPLE SOLUTION OF TRANSMISSION PROBLEM FOR SHORT PATH, JANUARY, 1945.
TRANSMISSION PATH: WASHINGTON, D.C. (39.0° N, 77.5° W) TO MIAMI, FLORIDA (25.7° N, 80.5° W).

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

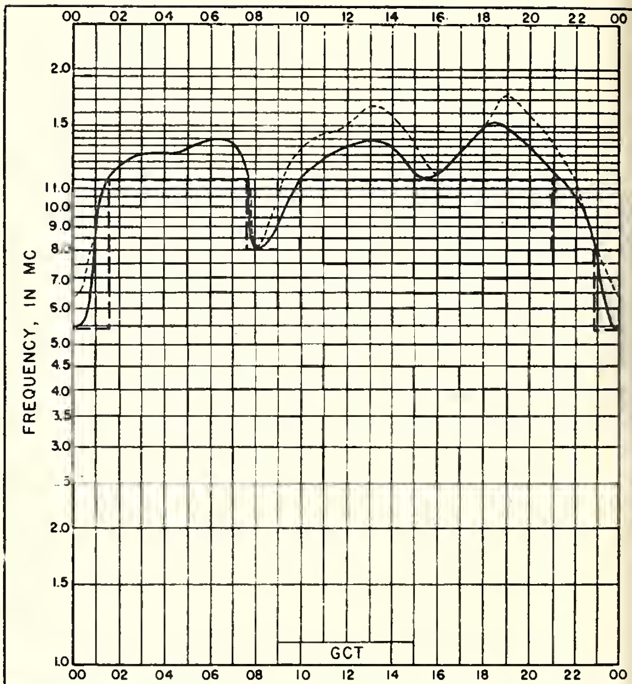

Fig. 18. SAMPLE SOLUTION OF TRANSMISSION PROBLEM FOR LONG PATH, JANUARY, 1945.
TRANSMISSION PATH: NEW YORK CITY, (40.5° N, 74.0° W) TO MOSCOW (56.0° N, 37.0° E)

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

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