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Basic Radio Propagation Predictions

F O R M A Y 1 9 4 9

Three Months in Advance

Issued February 1949

CRPL Series D



Number 54

The Central Radio Propagation Laboratory

The propagation of radio waves over long distances depends on their reflection from the ionosphere, the electrically conducting layers in the earth's upper atmosphere. The characteristics of these layers are continuously changing. For regular and reliable communication, it is therefore necessary to collect and analyze ionospheric data from stations all over the world in order that predictions of usable frequencies between any two places at any hour can be made. During the war, the United States Joint Communications Board set up the Interservice Radio Propagation Laboratory at the National Bureau of Standards to centralize ionospheric work and predictions for the Armed Forces of the United States.

On May 1, 1946, this activity returned to peacetime status as the Central Radio Propagation Laboratory of the National Bureau of Standards. Designed to act as a permanent centralizing agency for propagation predictions and studies, analogous in the field of radio to the reports of the Weather Bureau in the field of meteorology, the Central Radio Propagation Laboratory was established in cooperation with the many Government agencies vitally concerned with communication and radio propagation problems. These agencies are represented on an Executive Council which guides the work of the Laboratory; included are the Department of the Army, Department of the Navy, Department of the Air Force, Civil Aeronautics Administration, Federal Communications Commission, Department of State, Coast Guard, Coast and Geodetic Survey, and the Weather Bureau. In addition, industry is represented by the Radio Technical Planning Board, while the Carnegie Institution of Washington serves in an advisory capacity and the Research and Development Board has designated an observer.

The Central Radio Propagation Laboratory receives and analyzes data from approximately 60 stations located throughout the world, including 13 domestic and 8 overseas stations which are operated either directly or under contract by the National Bureau of Standards. Ionospheric data and predictions are disseminated to the armed forces, commercial users, scientists, and laboratories. The basic ionospheric research of the Laboratory includes theoretical and experimental studies of maximum usable frequencies, ionospheric absorption, long-time variations of radio propagation characteristics, the effects of the sun on radio propagation, and the relation between radio disturbance and geomagnetic variation. In the microwave field, the Laboratory is investigating the relation between radio propagation and weather phenomena, as well as methods by which predictions can be made and radio communications improved in this portion of the radio-frequency spectrum. Another phase of the Laboratory's work is the development and maintenance of standards and methods of measurement of many basic electrical quantities throughout the entire frequency spectrum.

Basic Radio Propagation Predictions

The CRPL Series D, Basic Radio Propagation Predictions, is issued monthly as an aid in the determination of the best sky-wave frequencies over any path at any time of day for average conditions for the month of prediction, 3 months in advance. Charts of extraordinary-wave critical frequency for the *F*2 layer, of maximum usable frequency for a transmission distance of 4,000 km, and of percentage of time occurrence for transmission by sporadic *E* in excess of 15 Mc, for a distance of 2,000 km, are included.

Beginning with the July 1946 issue (CRPL-D23) the CRPL-D series, "Basic Radio Propagation Predictions," is available on a purchase basis from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., on the following terms:

Single copy	10 cents
(CRPL-D23 through D36, 15 cents per copy)	
Annual subscription (12 issues)	\$1. 00
(To foreign countries not extending franking privileges, \$1. 25)	

The rules of the Superintendent of Documents require that remittances be made in advance, either by coupons sold in sets of 20 for \$1 and good until used, or by check or money order payable to the Superintendent of Documents. Currency, if used, is at sender's risk. Postage stamps, foreign money, and defaced or smooth coins are not acceptable. Postage is not required in the United States, to United States possessions, and to countries extending franking privileges. Remittances from foreign countries should be by international money order payable to the Superintendent of Documents or by draft on a United States bank.

Address subscriptions, remittances, and all inquiries relating thereto, to the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

The printing of this publication has been approved by the Director of the Bureau of the Budget, June 13, 1946.



BASIC RADIO PROPAGATION PREDICTIONS

For May 1949

Three Months in Advance

Introduction

Beginning with the September 1947 issue, the CRPL-D series, "Basic Radio Propagation Predictions," issued by the National Bureau of Standards, contains contour charts of F_2 -zero-MUF and F_2 -4000-MUF for each of the three zones, W, I, and E, into which the world is divided for the purpose of taking into consideration the variation of the characteristics of the F_2 layer with longitude (figs. 1 to 6); the world-wide contour chart of E -2000-MUF (fig. 7); the contour chart of median fEs (fig. 8); and the chart showing percentage of time occurrence for Es -2000-MUF in excess of 15 Mc (fig. 9).

Methods for using these charts are given in Circular 465 of the National Bureau of Standards, entitled "Instructions for the Use of Basic Radio Propagation Predictions," and available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., price 25 cents (foreign, 35 cents). Requests for this manual from members of the Army, Navy, or Air Force should be sent to the proper service address as follows. *For the Army and Air Force:* Office of the Chief Signal Officer, Department of the Army, Washington 25, D. C., Attention: SIGOL-2. *For the Navy:* Chief of Naval Operations, Department of the Navy, Washington 25, D. C. (CNC-20-Q).

Following figure 9 of each issue, sets of auxiliary figures (nos. 1, 2, 11, 12, NBS Circular 465) or forms CRPL-AF and AH are given in rotation, two in each issue of CRPL Series D. They are necessary or useful for the preparation of tables and graphs of MUF and FOT (OWF), as explained in NBS Circular 465.

The charts in this issue were constructed from data through November 1948, together with a predicted smoothed 12-month running-average Zürich sunspot number of 108, centered on May 1949.

Attention is invited to the blank form at the end of this publication, for use in reporting the accuracy of the predictions of MUF and FOT (OWF) as given in this report. Communications should be addressed to Central Radio Propagation Laboratory, National Bureau of Standards, Washington 25, D. C.

Information concerning the theory of radio wave propagation, measurement technics, structure of the ionosphere, ionospheric variations, prediction methods, absorption, field intensity, radio noise, lowest required radiated power and lowest useful high frequency is given in Circular 462 of the National Bureau of Standards, "Ionospheric Radio Propagation." This Circular is available from the Superintendent of Documents, price \$1.00 (foreign, \$1.25).

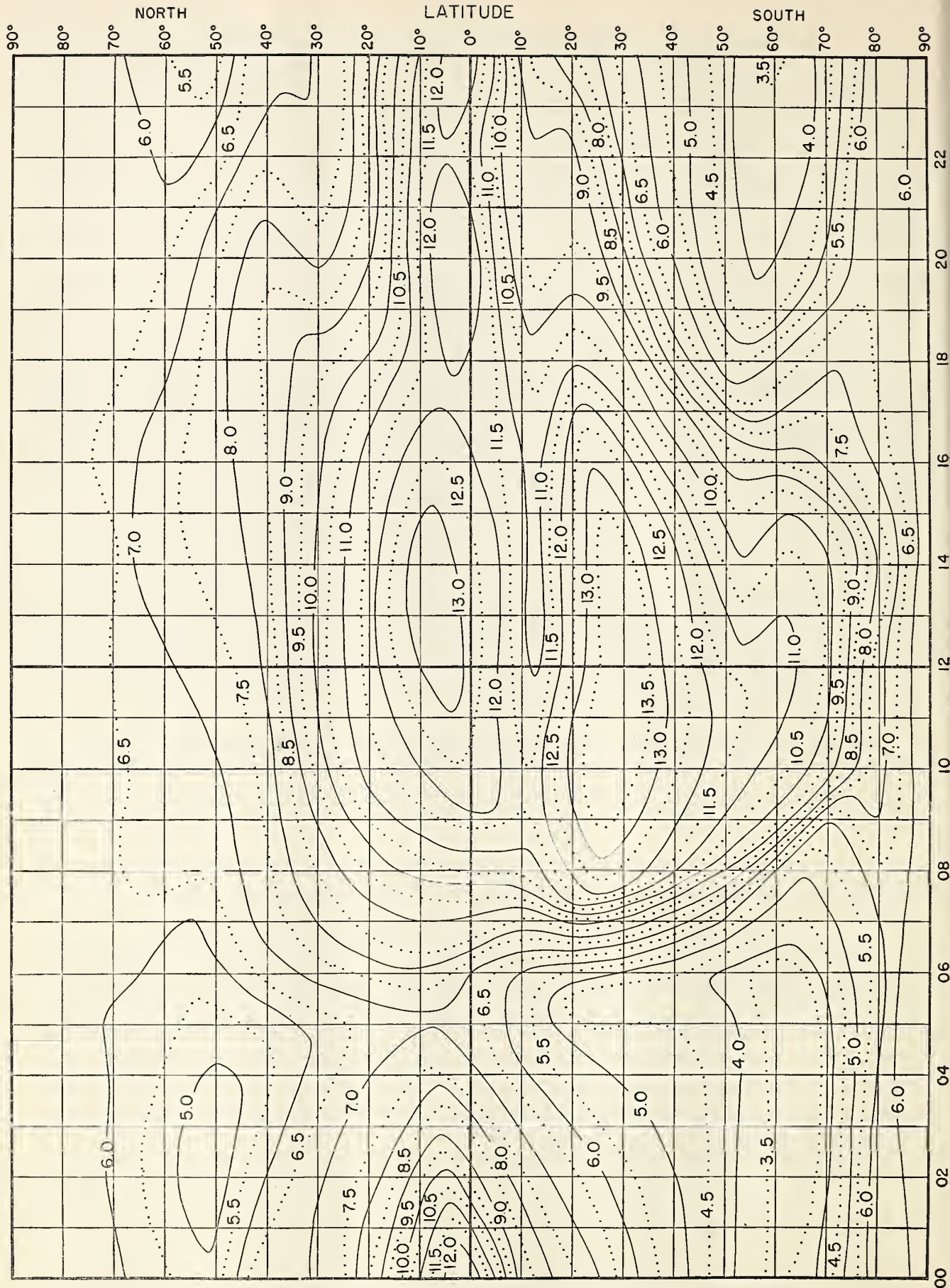


Fig. 1. F_2 ZERO-MUF, IN Mc, W ZONE, PREDICTED FOR MAY 1949.

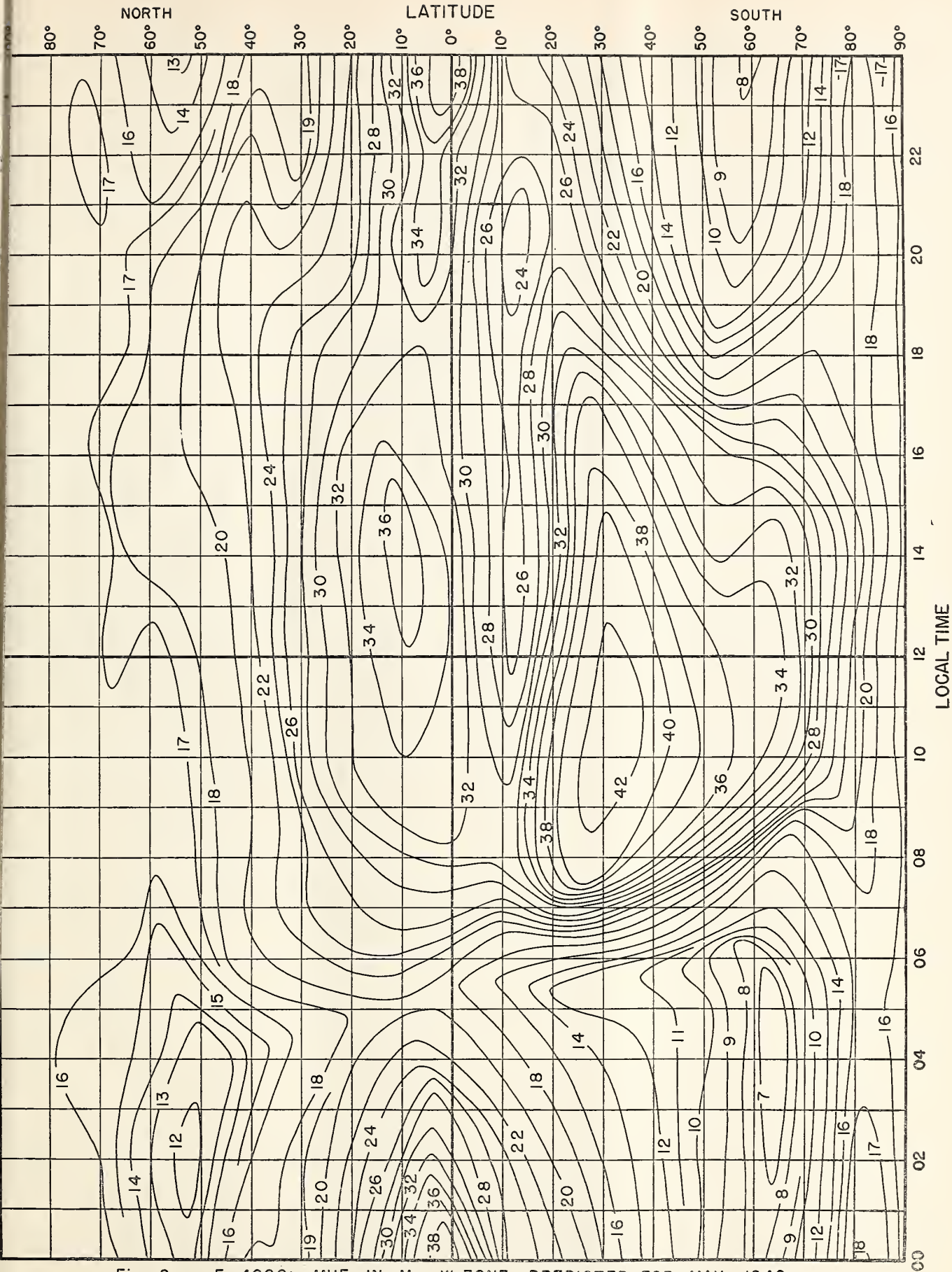


Fig. 2. F₂ 4000-MUF, IN Mc, W ZONE, PREDICTED FOR MAY 1949.

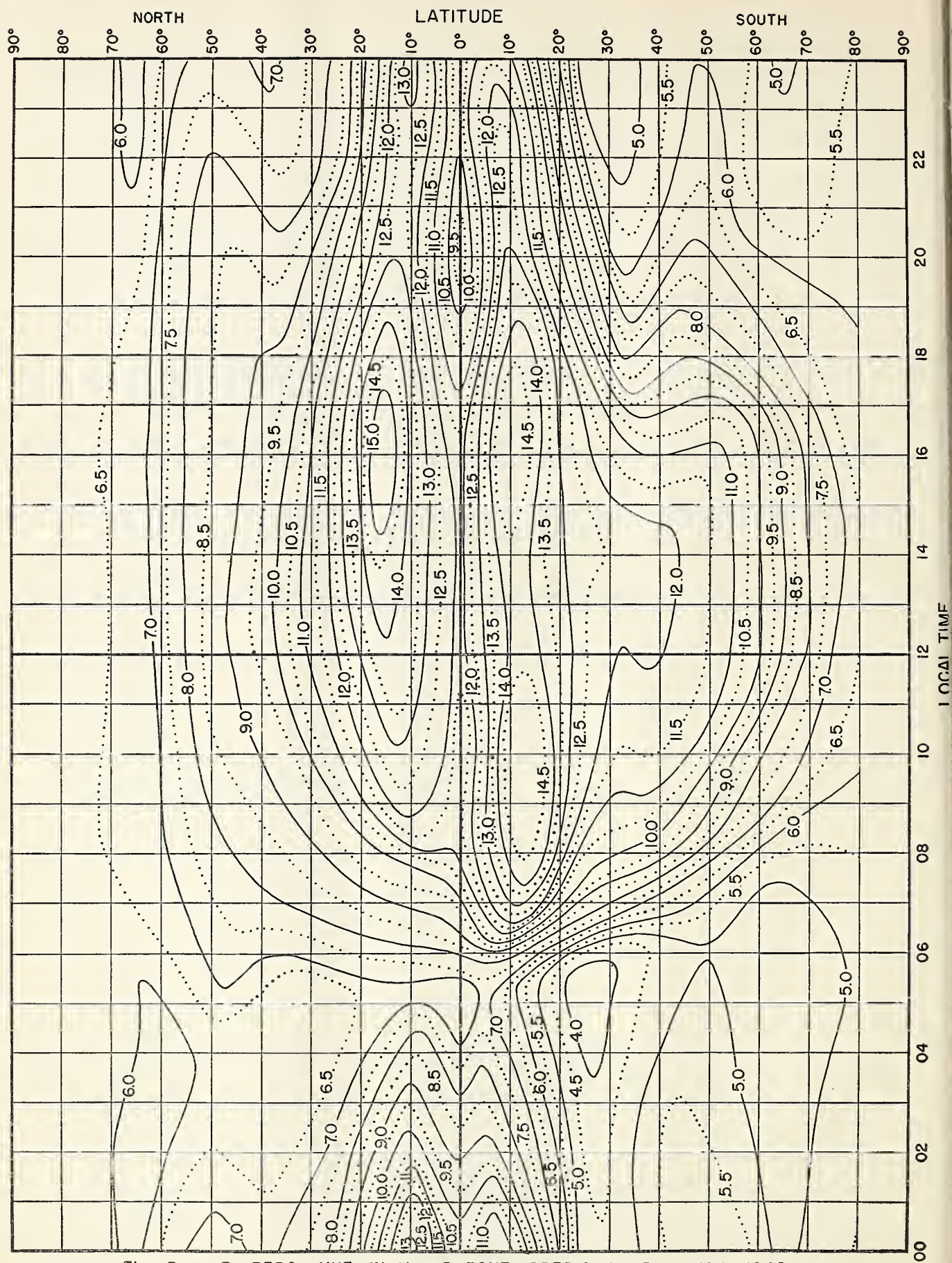


Fig. 3. F_2 ZERO-MUF, IN Mc, I ZONE, PREDICTED FOR MAY 1949.

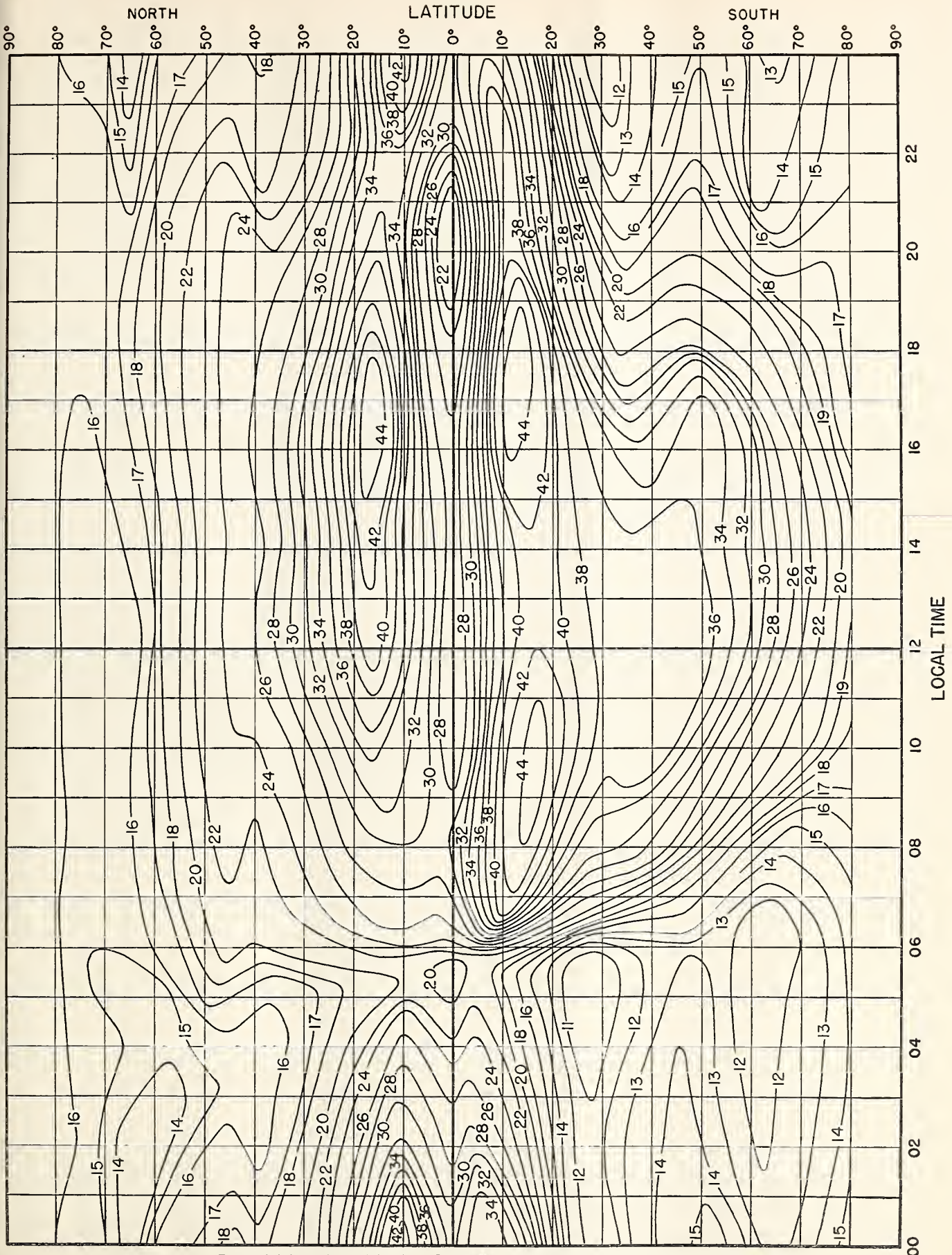


Fig. 4. F_2 4000-MUF, IN Mc, I ZONE, PREDICTED FOR MAY 1949.

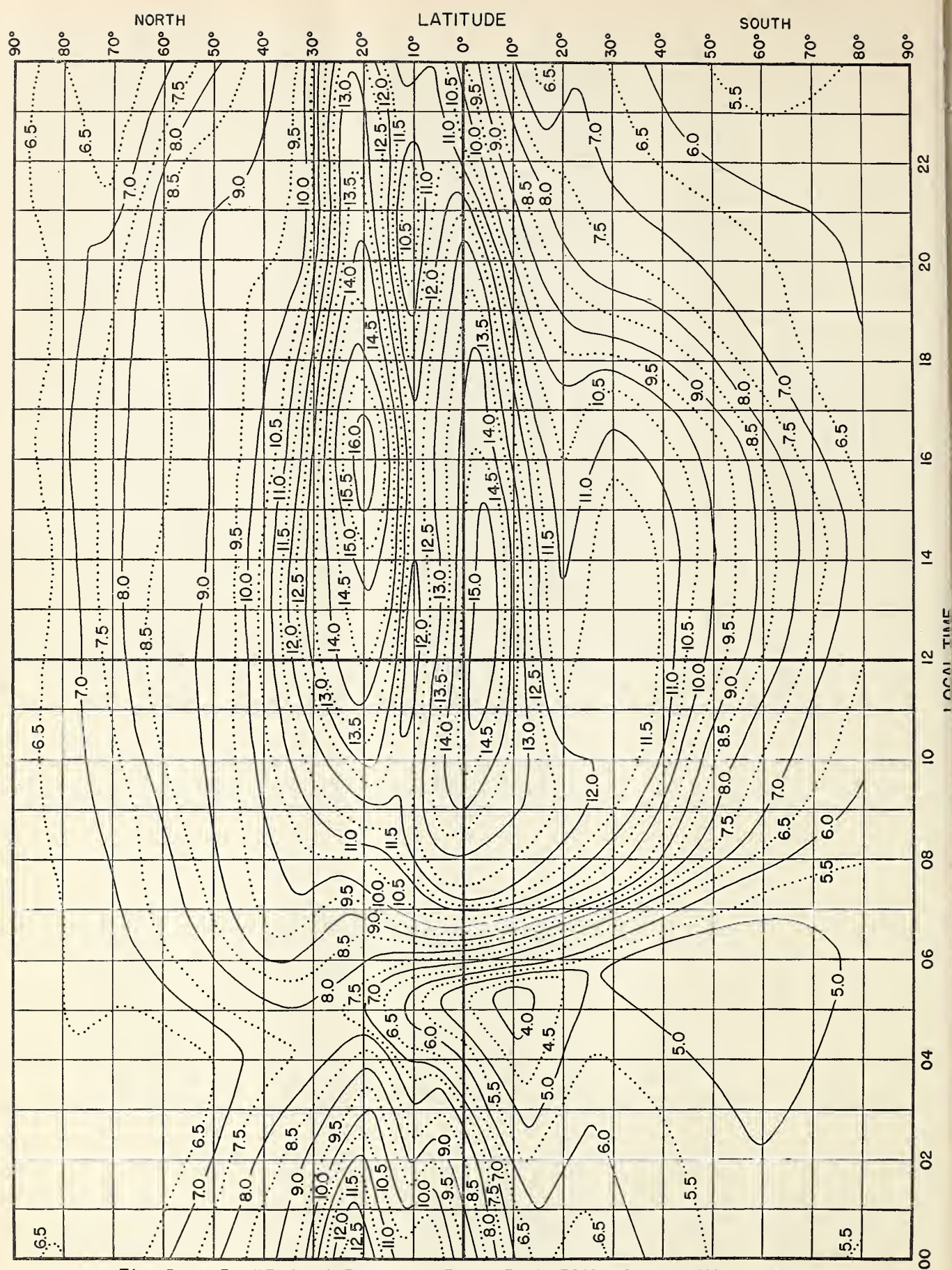


Fig. 5. F₂ ZERO-MUF, IN Mc, E ZONE, PREDICTED FOR MAY 1949.

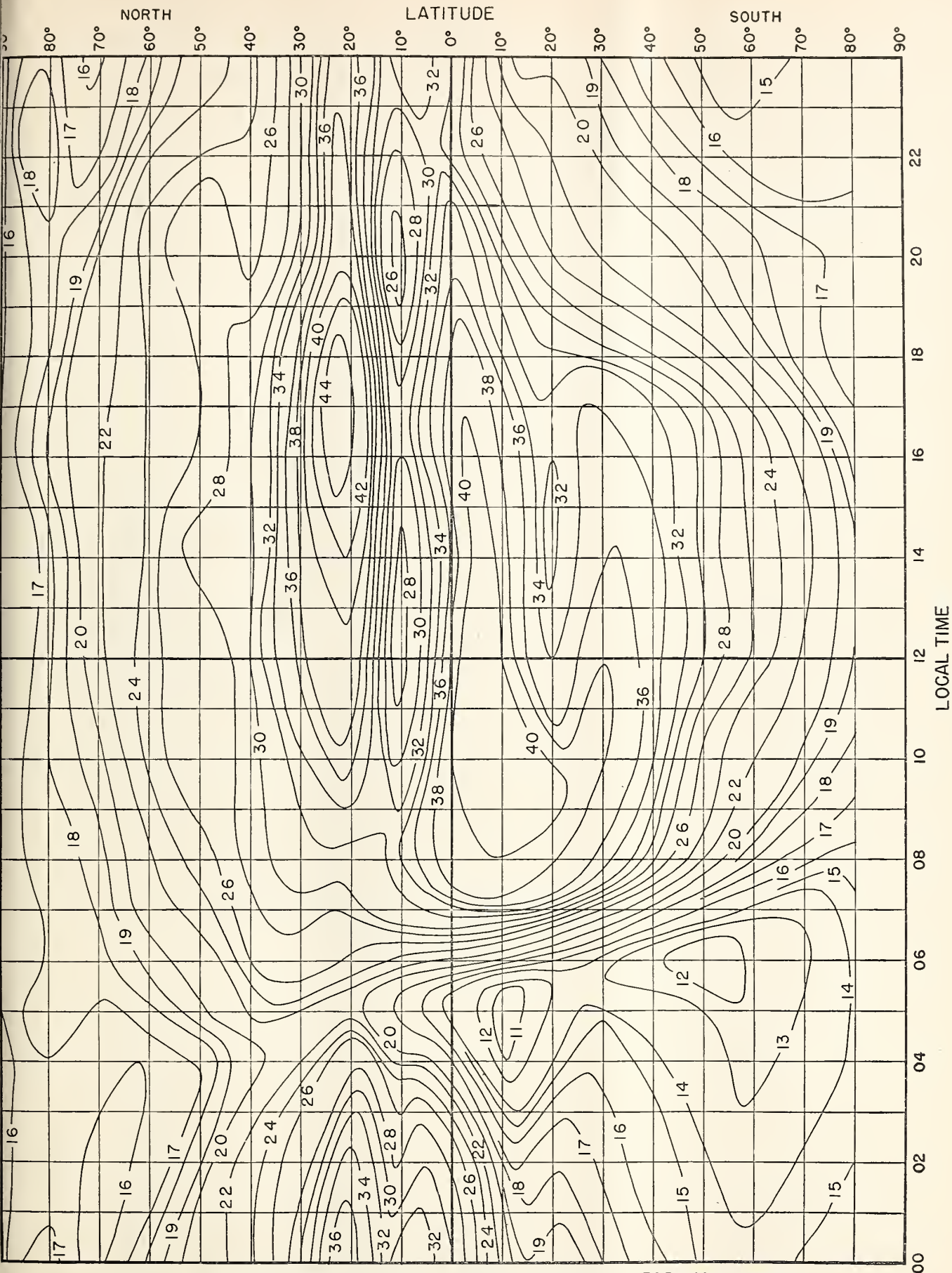


Fig. 6. F_2 4000-MUF, IN Mc, E ZONE, PREDICTED FOR MAY 1949.

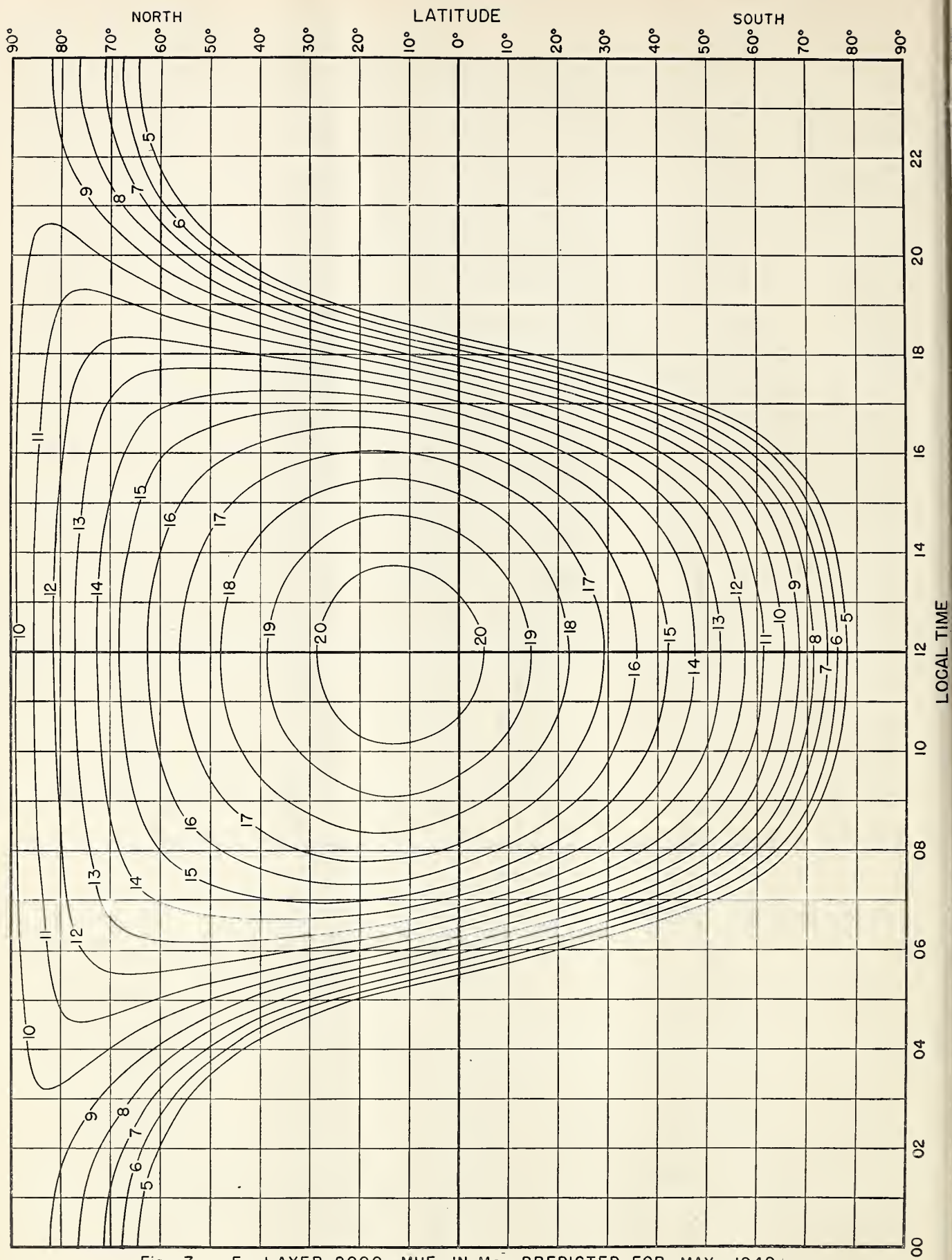


Fig. 7. E-LAYER 2000-MUF, IN Mc, PREDICTED FOR MAY 1949.

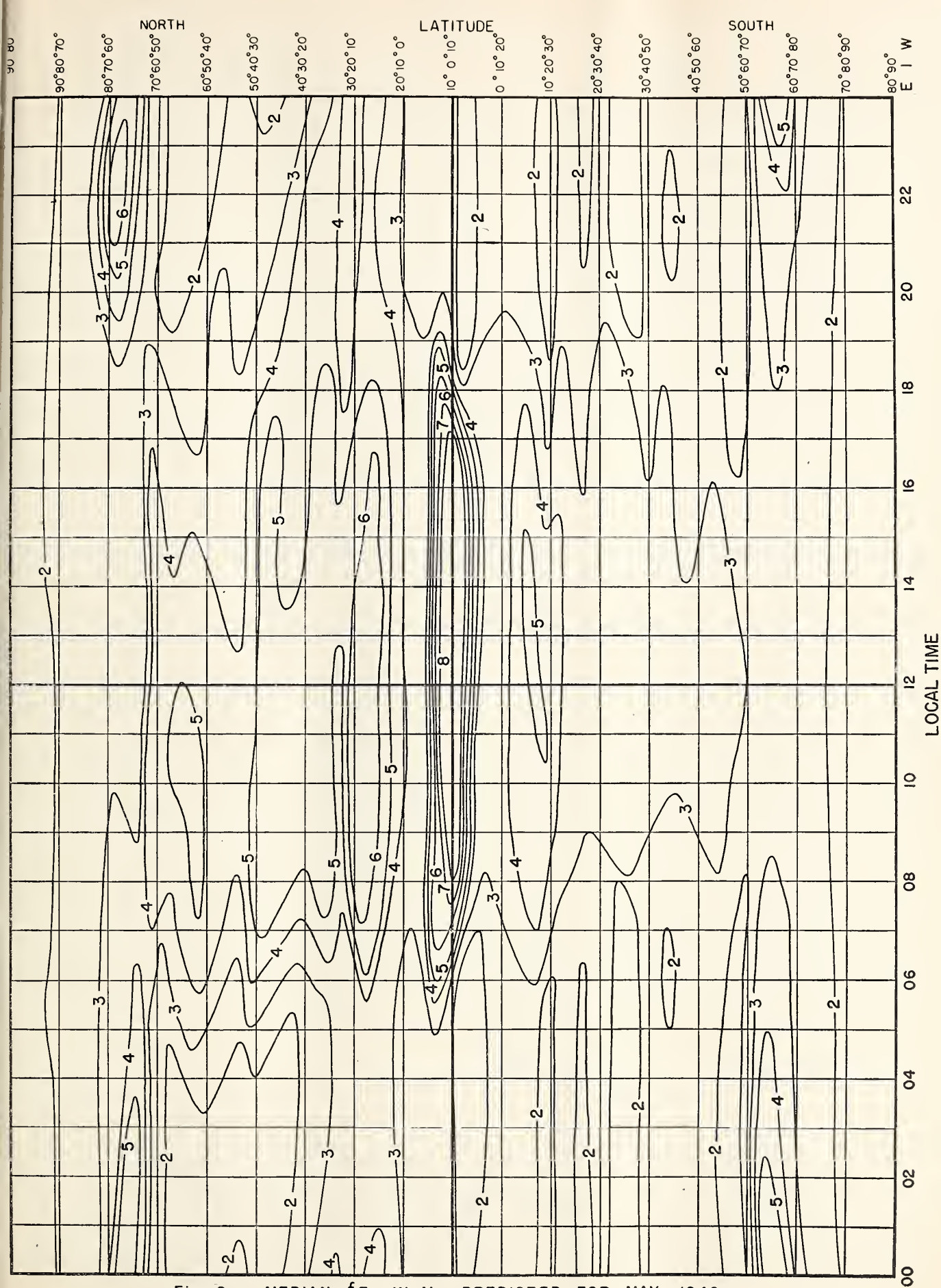


Fig. 8. MEDIAN fE_s , IN Mc, PREDICTED FOR MAY 1949.

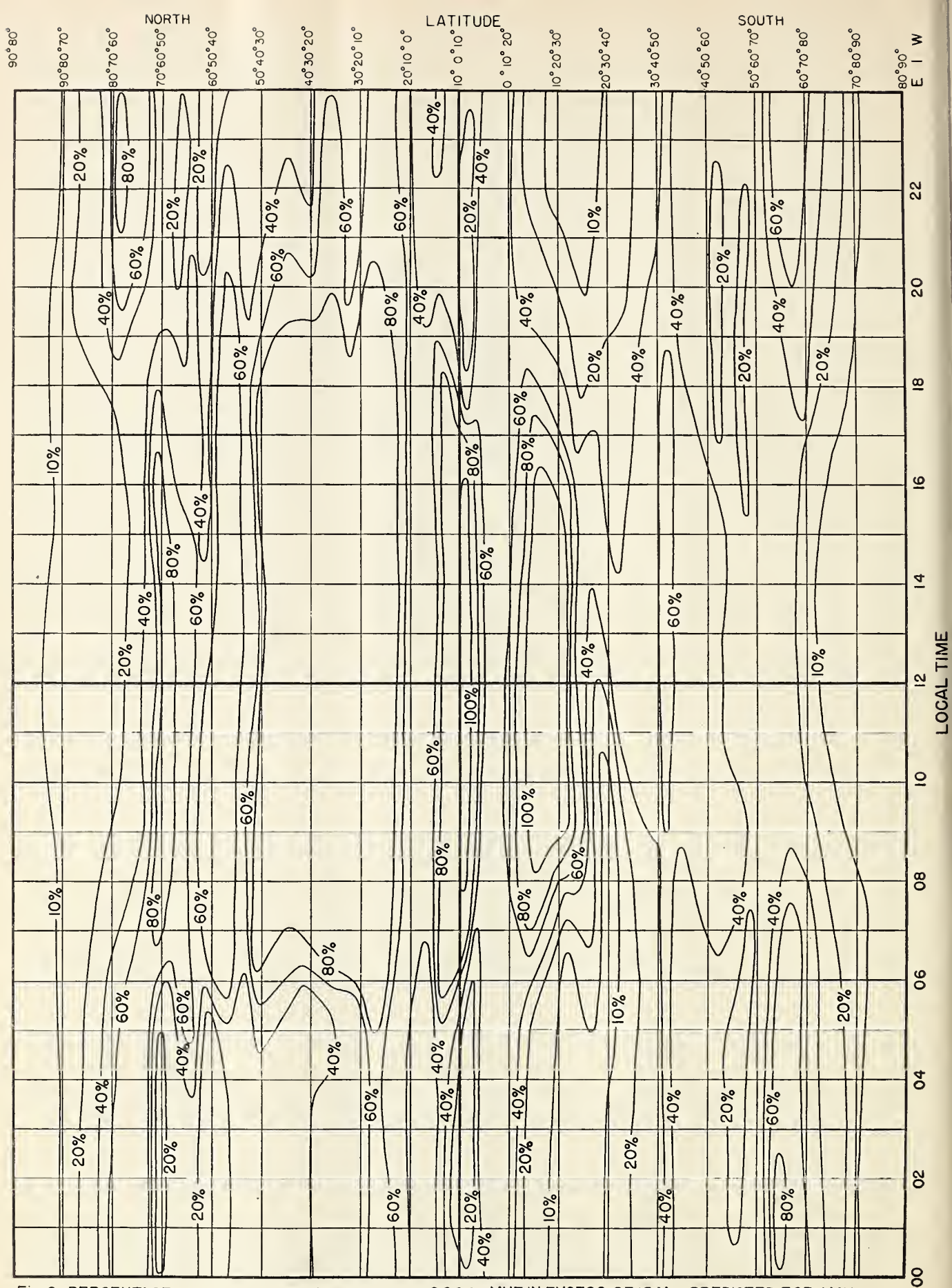


Fig. 9. PERCENTAGE OF TIME OCCURRENCE FOR E_s 2000-MUF IN EXCESS OF 15 Mc, PREDICTED FOR MAY 1949

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.

DISTANCE IN KM

FOR VALUES OF MUF GREATER THAN 35 Mc, MULTIPLY ALL MUF AND FOT SCALES BY 2.

ZERO MUF

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13
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MUF FOT

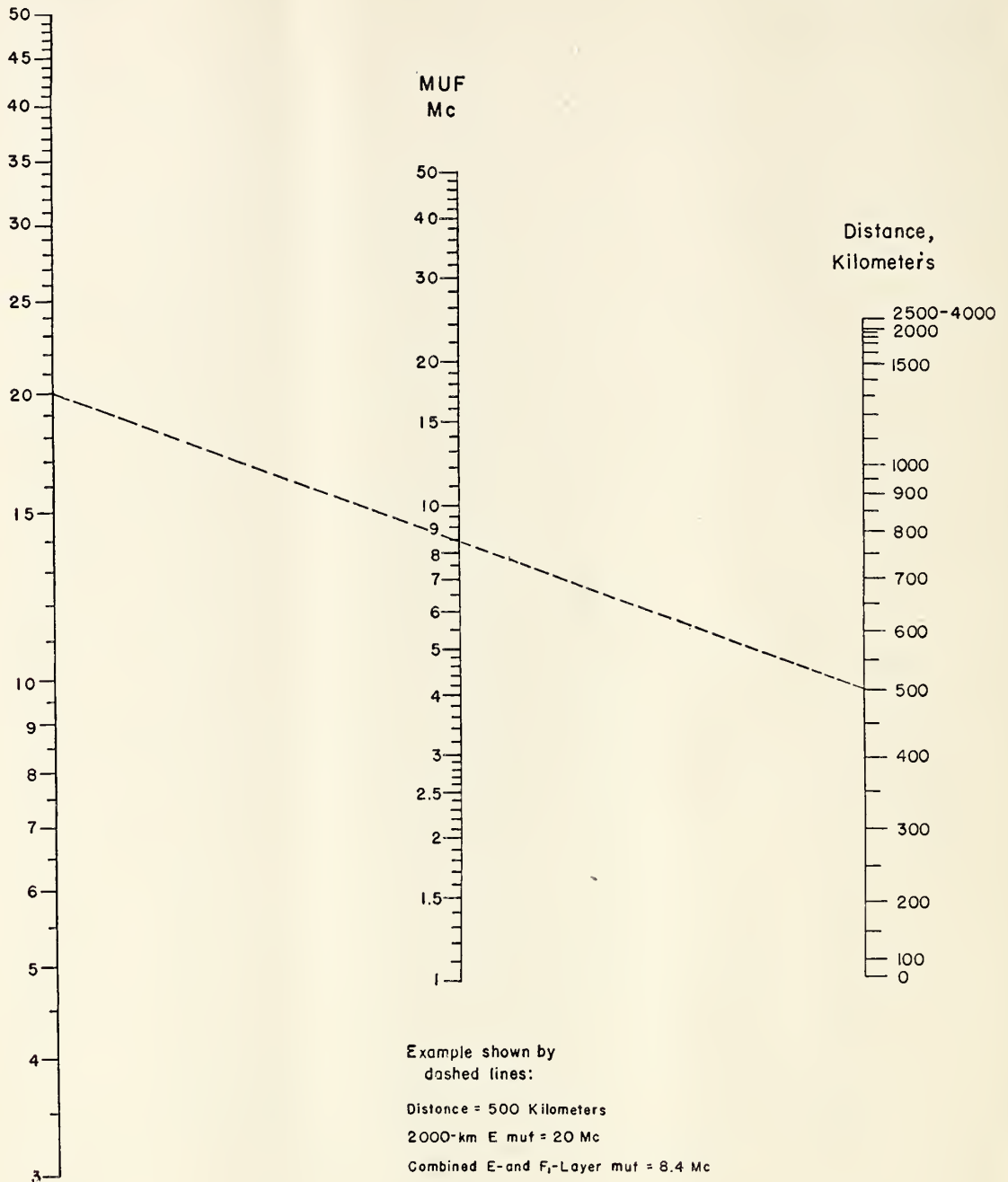
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4000 MUF

NOMOGRAM FOR TRANSFORMING F₂-ZERO-MUF AND F₂-4000-MUF TO EQUIVALENT MAXIMUM USABLE FREQUENCIES AT INTERMEDIATE TRANSMISSION DISTANCES; CONVERSION SCALE FOR OBTAINING OPTIMUM TRAFFIC FREQUENCY (FOT).

E-Layer 2000-muf

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 ml.



NOMOGRAM FOR TRANSFORMING E-LAYER 2000-MUF TO EQUIVALENT MAXIMUM USABLE FREQUENCIES AND OPTIMUM TRAFFIC FREQUENCIES DUE TO COMBINED EFFECT OF E LAYER AND F₁ LAYER AT OTHER TRANSMISSION DISTANCES.

CRPL and IRPL Reports

Daily:

Radio disturbance warnings, every half hour from broadcast station WWV of the National Bureau of Standards. Telephoned and telegraphed reports of ionospheric, solar, geomagnetic, and radio propagation data.

Weekly:

CRPL-J. Radio Propagation Forecast (of days most likely to be disturbed during following month).

Semimonthly:

CRPL-Ja. Semimonthly Frequency Revision Factors for CRPL Basic Radio Propagation Prediction Reports.

Monthly:

CRPL-D. Basic Radio Propagation Predictions—Three months in advance. (Dept. of the Army, TB 11-499, monthly supplements to TM 11-499; Dept. of the Navy, DNC-13-1 (), monthly supplements to DNC-13-1.)

CRPL-F. Ionospheric Data.

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*IRPL-A. Recommended Frequency Bands for Ships and Aircraft in the Atlantic and Pacific.

*IRPL-H. Frequency Guide for Operating Personnel.

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CRPL-1-2, 3-1. High Frequency Radio Propagation Charts for Sunspot Minimum and Sunspot Maximum.

CRPL-1-2, 3-1, A. Supplement to Report CRPL-1-2, 3-1.

CRPL-1-3. Some Methods for General Prediction of Sudden Ionospheric Disturbances.

CRPL-1-4. Observations of the Solar Corona at Climax, 1944-46.

CRPL-1-5. Comparison of Predictions of Radio Noise with Observed Noise Levels.

CRPL-1-6. The Variability of Sky-Wave Field Intensities at Medium and High Frequencies.

CRPL-7-1. Preliminary Instructions for Obtaining and Reducing Manual Ionospheric Records.

NBS Circular 462. Ionospheric Radio Propagation.

NBS Circular 465. Instructions for the Use of Basic Radio Propagation Predictions.

Reports issued in past:

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IRPL-G1 through G12. Correlation of D. F. Errors With Ionospheric Conditions.

IRPL-R. Nonscheduled reports:

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R5. Criteria for Ionospheric Storminess.

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R7. Second Report on Experimental Studies of Ionospheric Propagation as Applied to the Loran System.

R9. An Automatic Instantaneous Indicator of Skip Distance and MUF.

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R11. A Nomographic Method for Both Prediction and Observation Correlation of Ionosphere Characteristics.

R12. Short Time Variations in Ionospheric Characteristics.

R14. A Graphical Method for Calculating Ground Reflection Coefficients.

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R16. Predicted F_2 -layer Frequencies Throughout the Solar Cycle, for Summer, Winter, and Equinox Season.

R17. Japanese Ionospheric Data—1943.

R18. Comparison of Geomagnetic Records and North Atlantic Radio Propagation Quality Figures—October 1943 Through May 1945.

R19. Nomographic Predictions of F_2 -layer Frequencies Throughout the Solar Cycle, for June.

R20. Nomographic Predictions of F_2 -layer Frequencies Throughout the Solar Cycle, for September.

R21. Notes on the Preparation of Skip-Distance and MUF Charts for Use by Direction-Finder Stations. (For distances out to 4000 km.)

R22. Nomographic Predictions of F_2 -layer Frequencies Throughout the Solar Cycle, for December.

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R24. Relations Between Band Width, Pulse Shape and Usefulness of Pulses in the Loran System.

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R28. Nomographic Predictions of F_2 -layer Frequencies Throughout the Solar Cycle, for January.

R30. Disturbance Rating in Values of IRPL Quality-Figure Scale from A. T. & T. Co. Transmission Disturbance Reports to Replace T. D. Figures as Reported.

R31. North Atlantic Radio Propagation Disturbances, October 1943 Through October 1945.

R32. Nomographic Predictions of F_2 -layer Frequencies Throughout the Solar Cycle, for February.

R33. Ionospheric Data on File at IRPL.

R34. The Interpretation of Recorded Values of fEs .

R35. Comparison of Percentage of Total Time of Second-Multiple Es Reflections and That of fEs in Excess of 3 Mc.

IRPL-T. Reports on tropospheric propagation:

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T2. Radar coverage and weather. (Superseded by JANP 102.)

CRPL-T3. Tropospheric Propagation and Radio-Meteorology. (Reissue of Columbia Wave Propagation Group WPG-5.)

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