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Basic Radio Propagation Predictions

FOR MAY 1960

Three Months in Advance

Issued February 1960

CRPL Series D Number 186

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 continually changing. For regular and reliable communication, it is therefore necessary to collect and analyze ionosphere 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 Interdepartmental Council on Radio Propagation and Standards which assists in furthering the work of the Laboratory; included are the Departments of State, Army, Navy, and Air Force, United States Information Agency, United States Coast Guard, Civil Aeronautics Administration, and Federal Communications Commission. Observers have been designated by the Air Navigation Development Board, Interdepartment Radio Advisory Committee, United States Coast and Geodetic Survey, and United States Weather Bureau. The Council works in cooperation with a Technical Advisory Committee appointed by the Institute of Radio Engineers at the request of the Director, National Bureau of Standards.

The Central Radio Propagation Laboratory receives and analyzes data from approximately 120 stations located throughout the world, including 8 domestic and 17 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 radiofrequency 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 $F2$ 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 January 1958 issue (CRPL-D161) 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	15 cents
Annual subscription (12 issues)	$1.50
(To foreign countries, $2.00)	

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. 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 24, 1958.

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U. S. DEPARTMENT OF COMMERCE
Frederick H. Mueller, Secretary
NATIONAL BUREAU OF STANDARDS
A. V. Astin, Director

FEBRUARY 1960
CRPL Series D
Number 186

BASIC RADIO PROPAGATION PREDICTIONS

FOR MAY 1960 THREE MONTHS IN ADVANCE

Introduction

The CRPL-D series, "Basic Radio Propagation Predictions," issued by the National Bureau of Standards, contains contour charts of monthly median $F2$-zero-MUF and $F2$-4000-MUF for each of four zones, W, I (Afro-European), E, I (Pacific), (figs. 1 to 8); a worldwide contour chart of monthly median E-2000-MUF (fig. 9); a contour chart of median fEs (fig. 10); and a chart showing percentage of time occurrence for Es-2000-MUF in excess of 15 Mc (fig. 11). Local time used for North Pole: 75°W; for South Pole: 105°E.

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 30 cents (to foreign countries, 40 cents). Procedures described in this manual should be modified to take into account the separate contour charts for the two I zones. Zone boundaries are the same as shown in figure 1 of Circular 465.

Requests for the manual of instructions and for the basic predictions from members of the Army, Navy, or Air Force should be sent to the proper service address as follows. For the Army: Office of the Chief Signal Officer, Department of the Army, Washington 25, D. C., Attention: SIGOL-2. For the Navy: The Director, Naval Communications. For the Air Force: Director of Communications-Electronics, Department of the Air Force, Washington 25, D. C., Attention: AFOAC–F/C.

Following figure 11 of each issue, sets of auxiliary figures (nos. 1, 2, 11, 12 of 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 1959, together with the smoothed 12-month running-average Zürich sunspot number 125, centered on May 1960. The mean provisional number for the year 1959 was 155.

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 $1.25 (to foreign countries, $1.65). Additional information about radio noise may be found in NBS Circular 557, "Worldwide and Radio Noise Levels Expected in the Frequency Band 10 Kilocycles to 100 Megacycles," also available from the Superintendent of Documents, price 30 cents (to foreign countries, 40 cents) and in C.C.I.R. Report No. 65, "Revision of Atmospheric Radio Noise Data," International Telecommunication Union, Geneva, 1957.

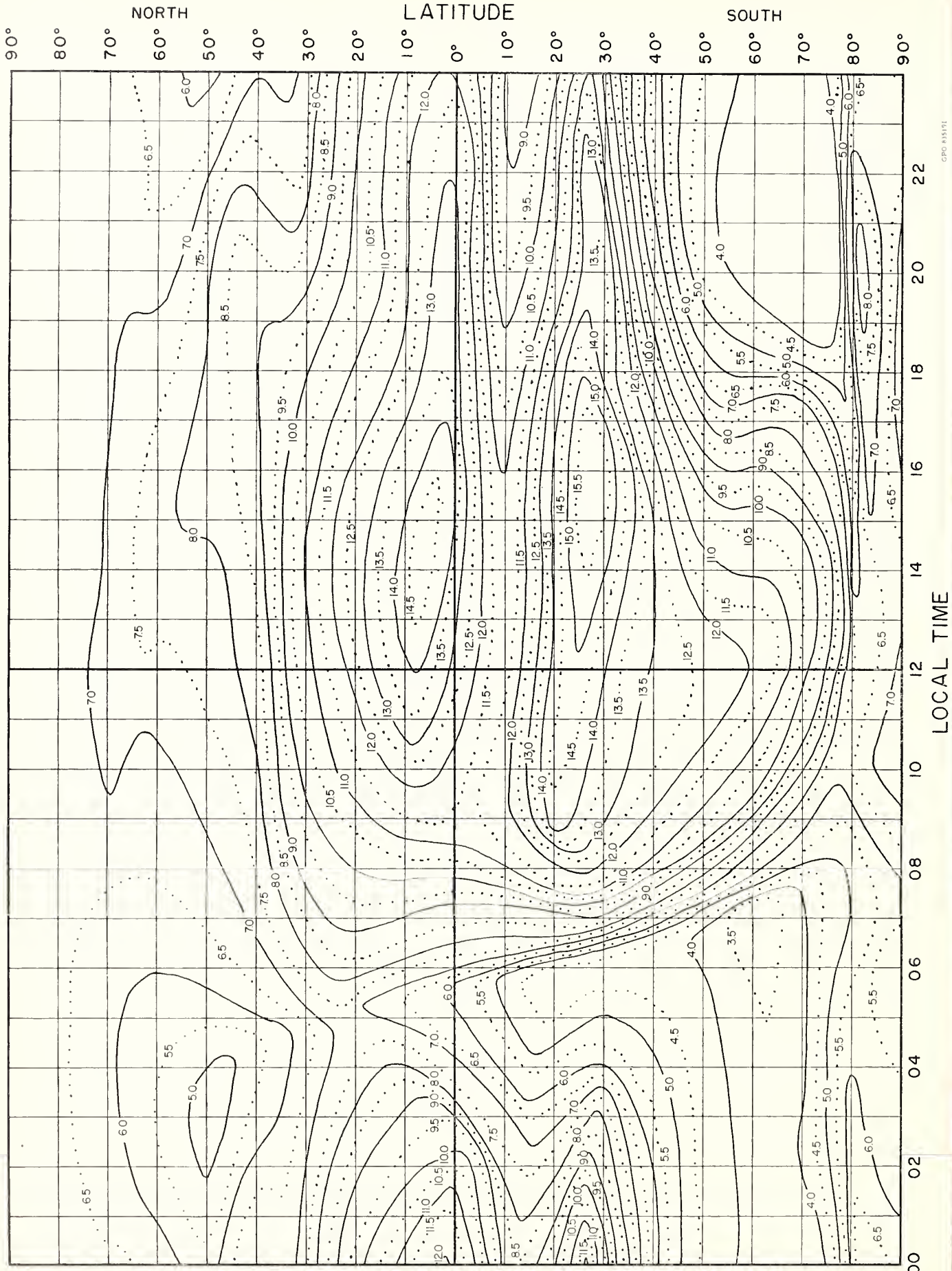


FIG 1 MEDIAN F2 - ZERO - MUF, IN Mc, W ZONE, PREDICTED FOR MAY 1960

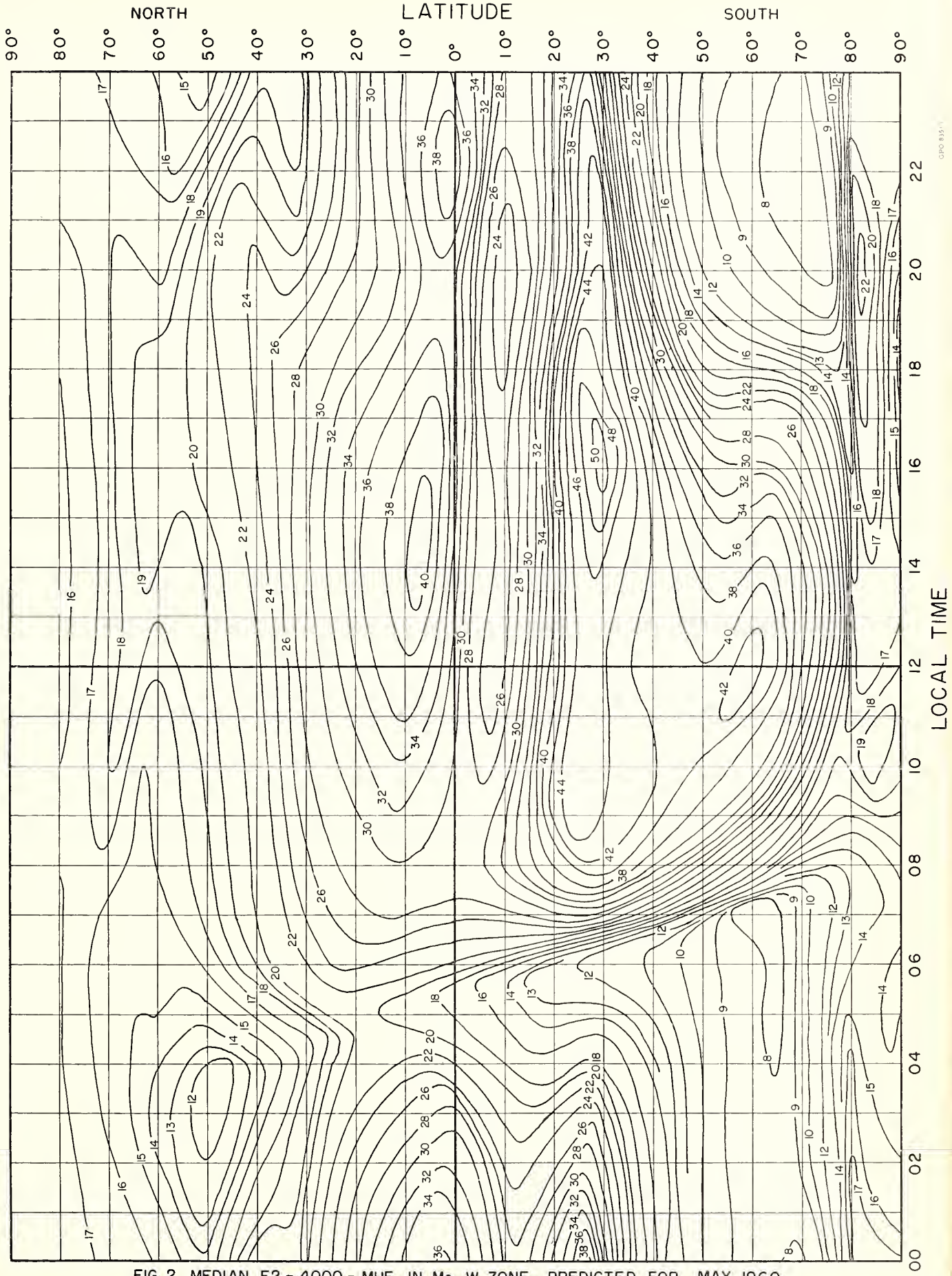


FIG 2 MEDIAN F2 - 4000 - MUF, IN Mc, W ZONE, PREDICTED FOR MAY 1960

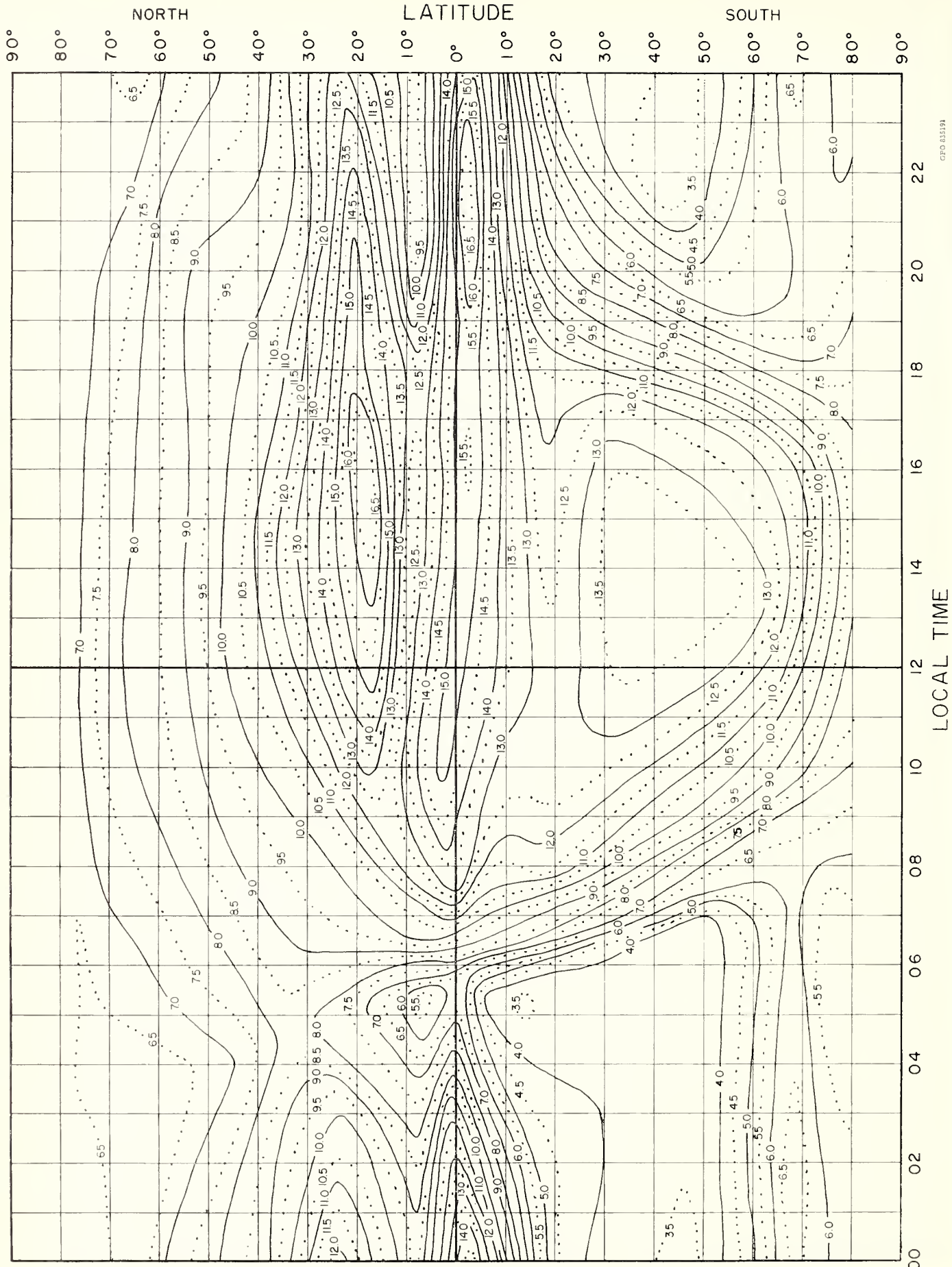


FIG. 3. MEDIAN F2 - ZERO - MUF, IN Mc, I ZONE (AFRO - EUROPEAN), PREDICTED FOR MAY 1960

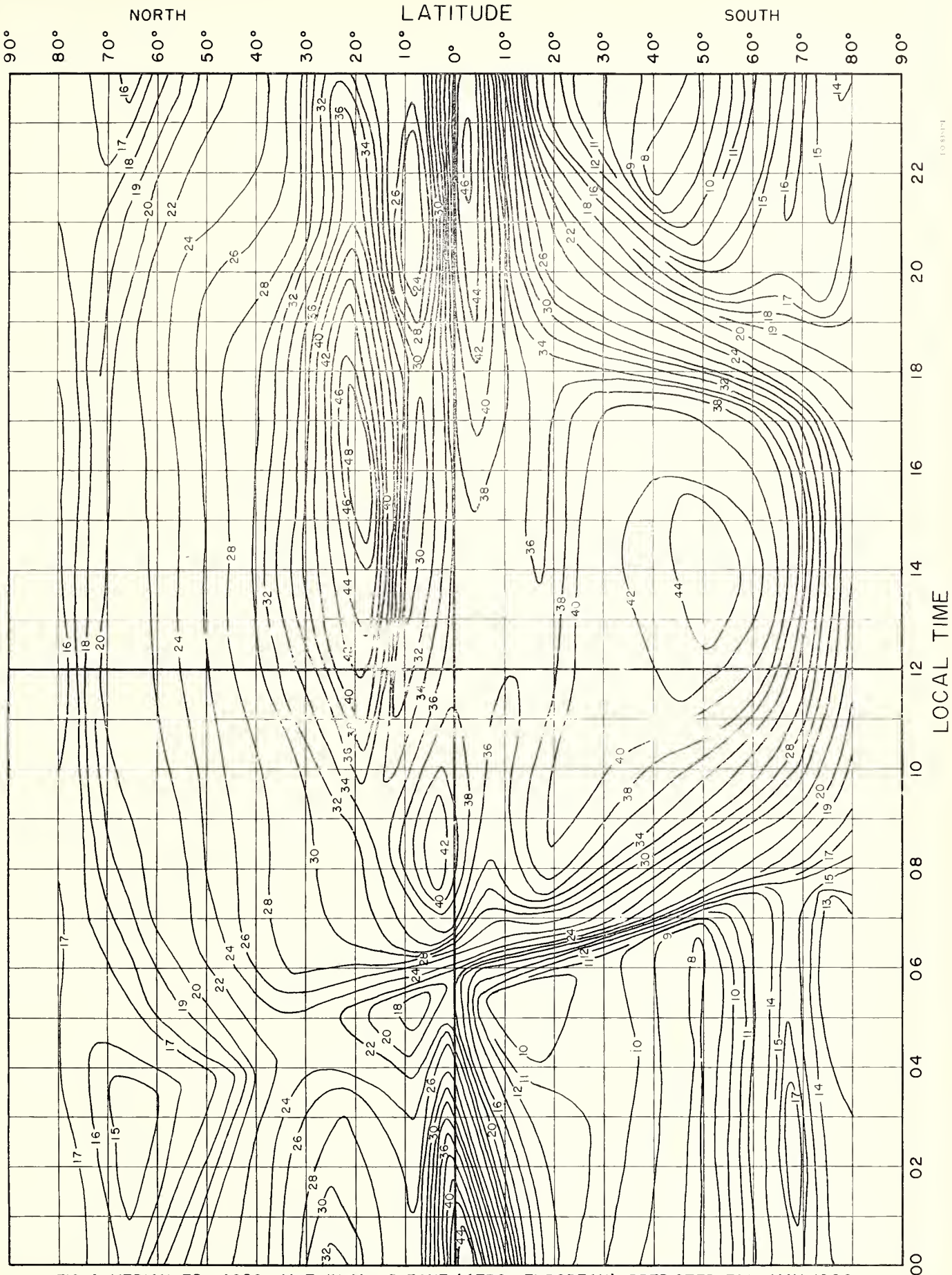


FIG. 4. MEDIAN F2 - 4000 - MUF, IN Mc, I ZONE (AFRO - EUROPEAN), PREDICTED FOR MAY 1960

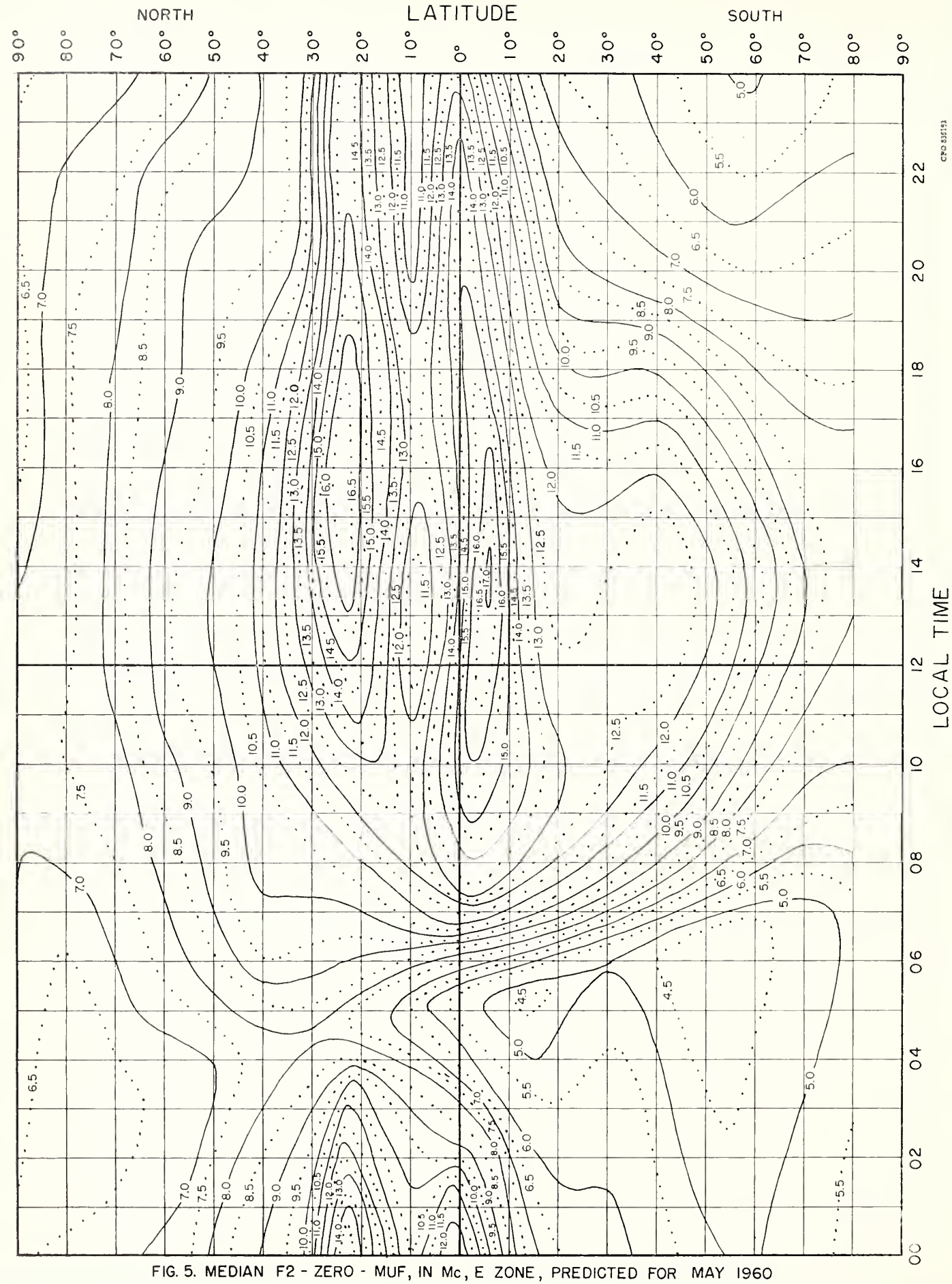


FIG. 5. MEDIAN F2 - ZERO - MUF, IN Mc, E ZONE, PREDICTED FOR MAY 1960

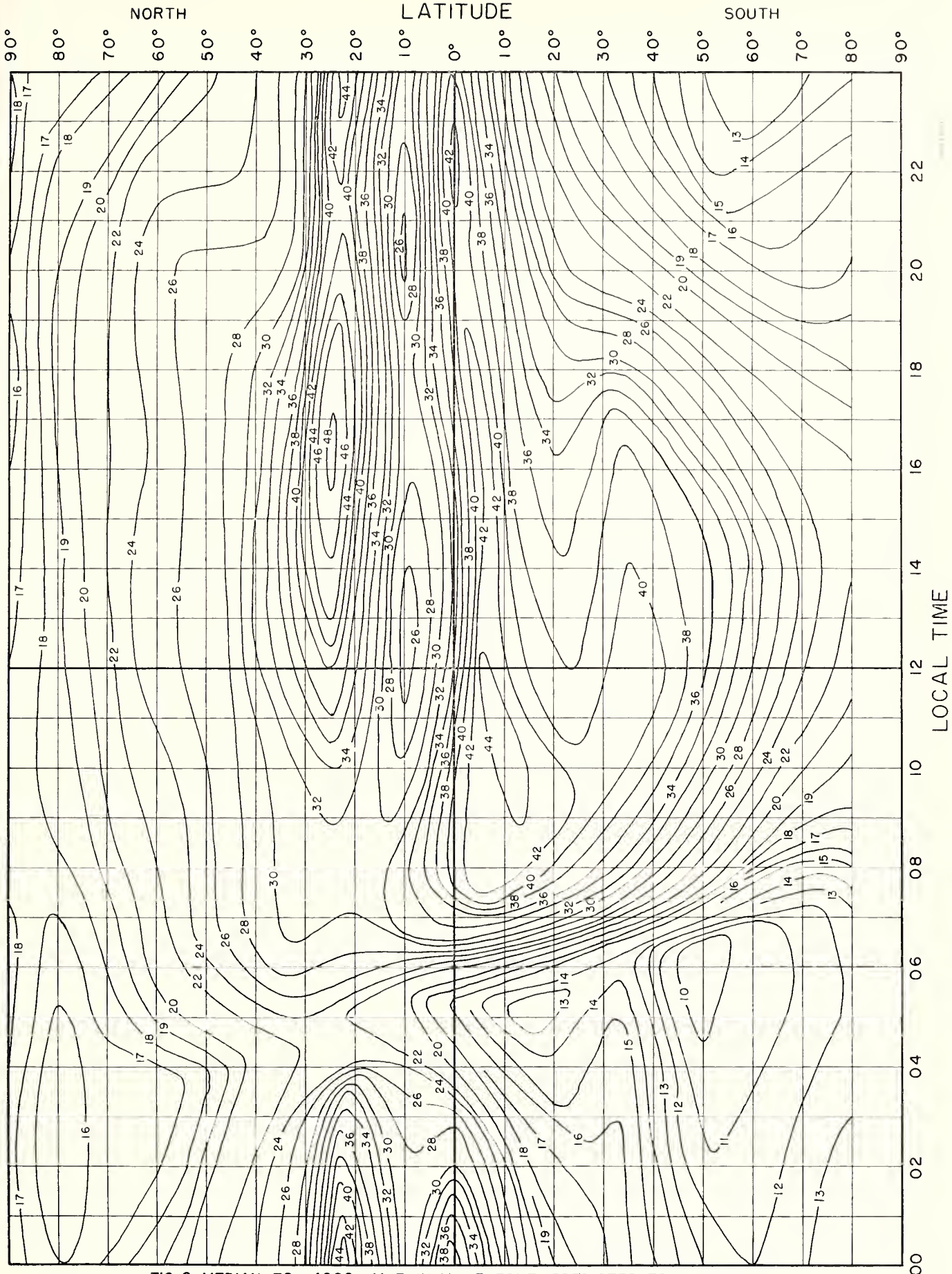


FIG. 6. MEDIAN F2 - 4000 - MUF, IN Mc, E ZONE, PREDICTED FOR MAY 1960

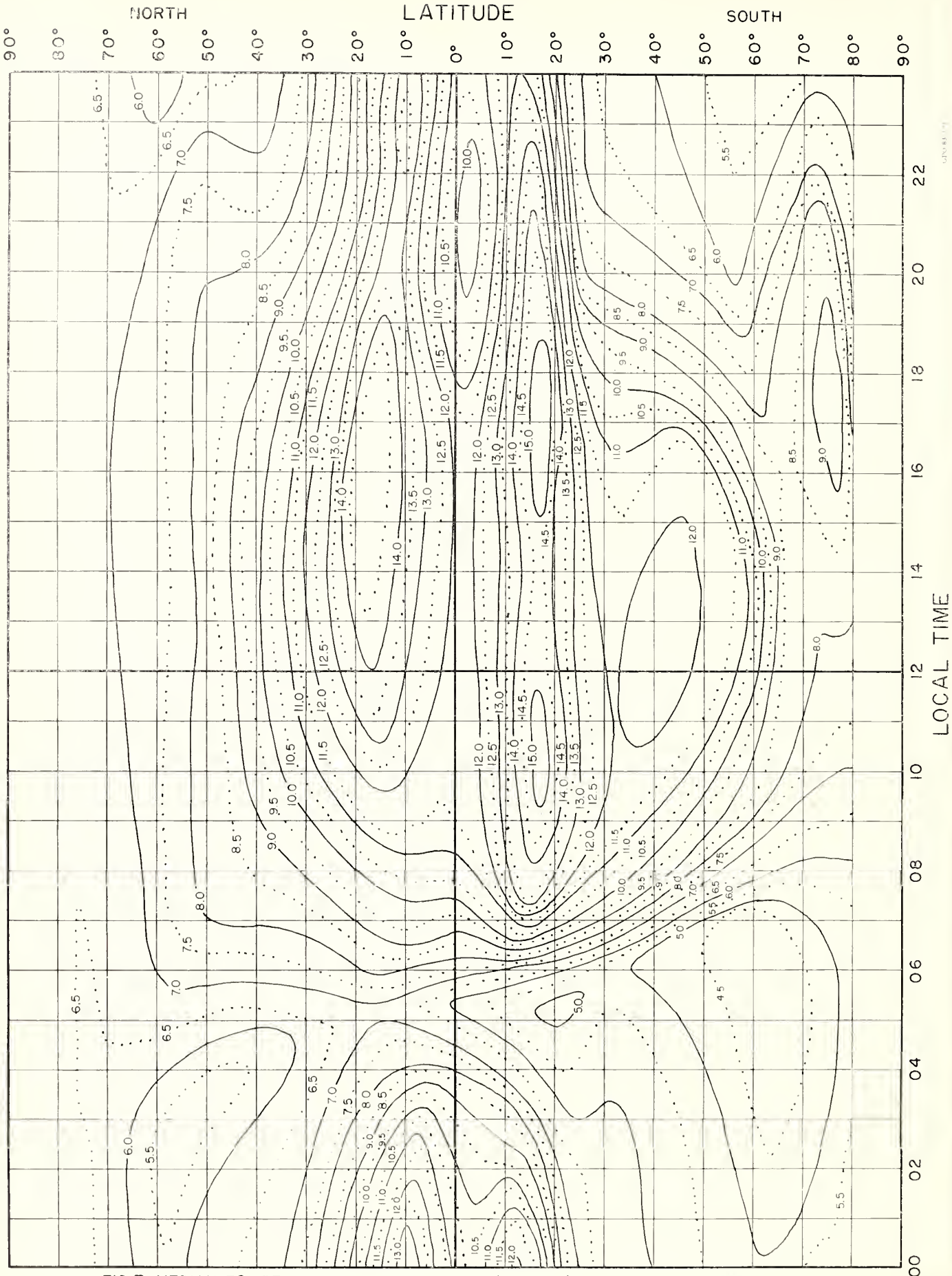


FIG. 7. MEDIAN F2 - ZERO - MUF, IN Mc, I ZONE (PACIFIC), PREDICTED FOR MAY 1960

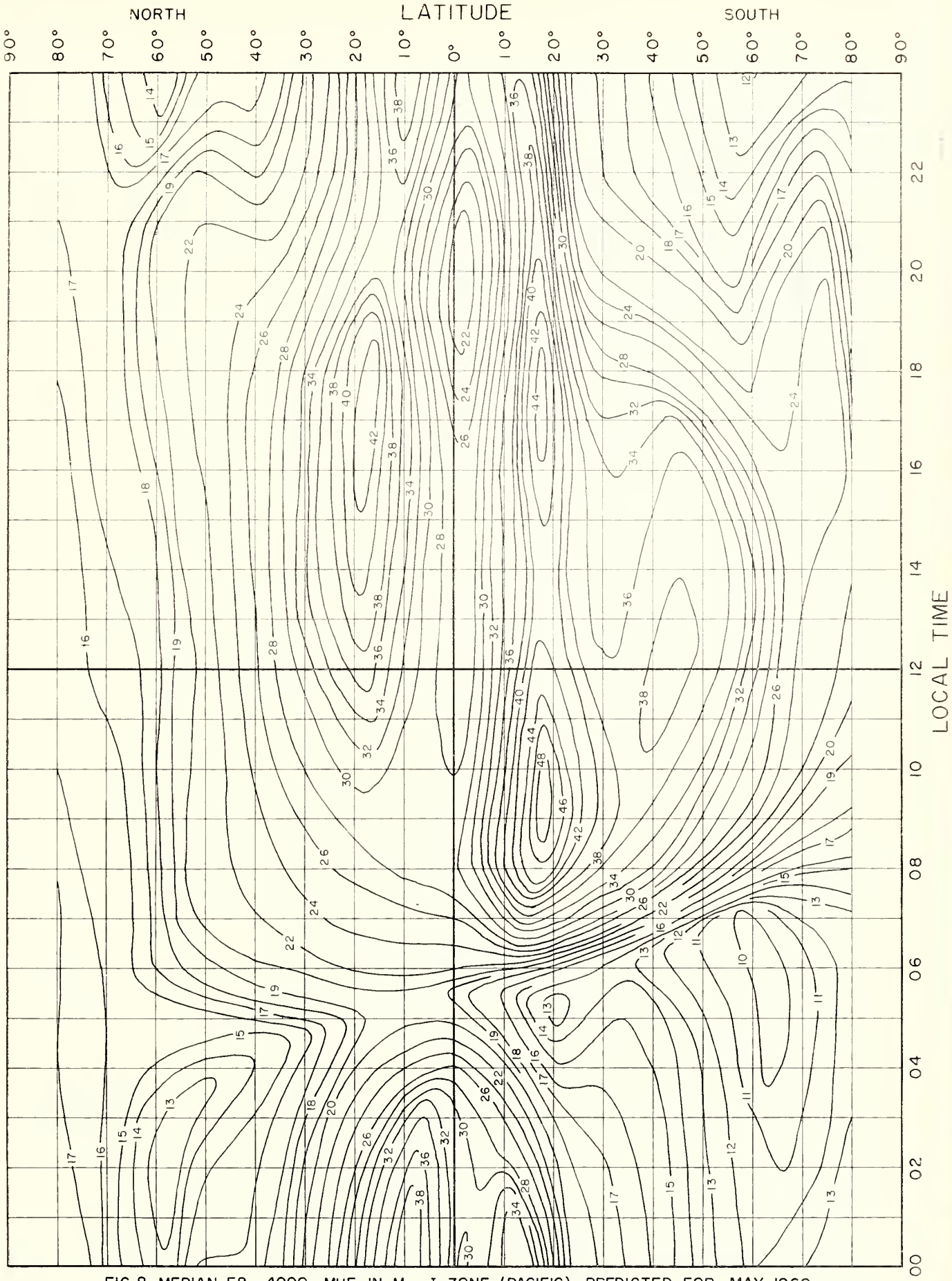


FIG 8. MEDIAN F2 - 4000 - MUF, IN Mc, I ZONE (PACIFIC), PREDICTED FOR MAY 1960

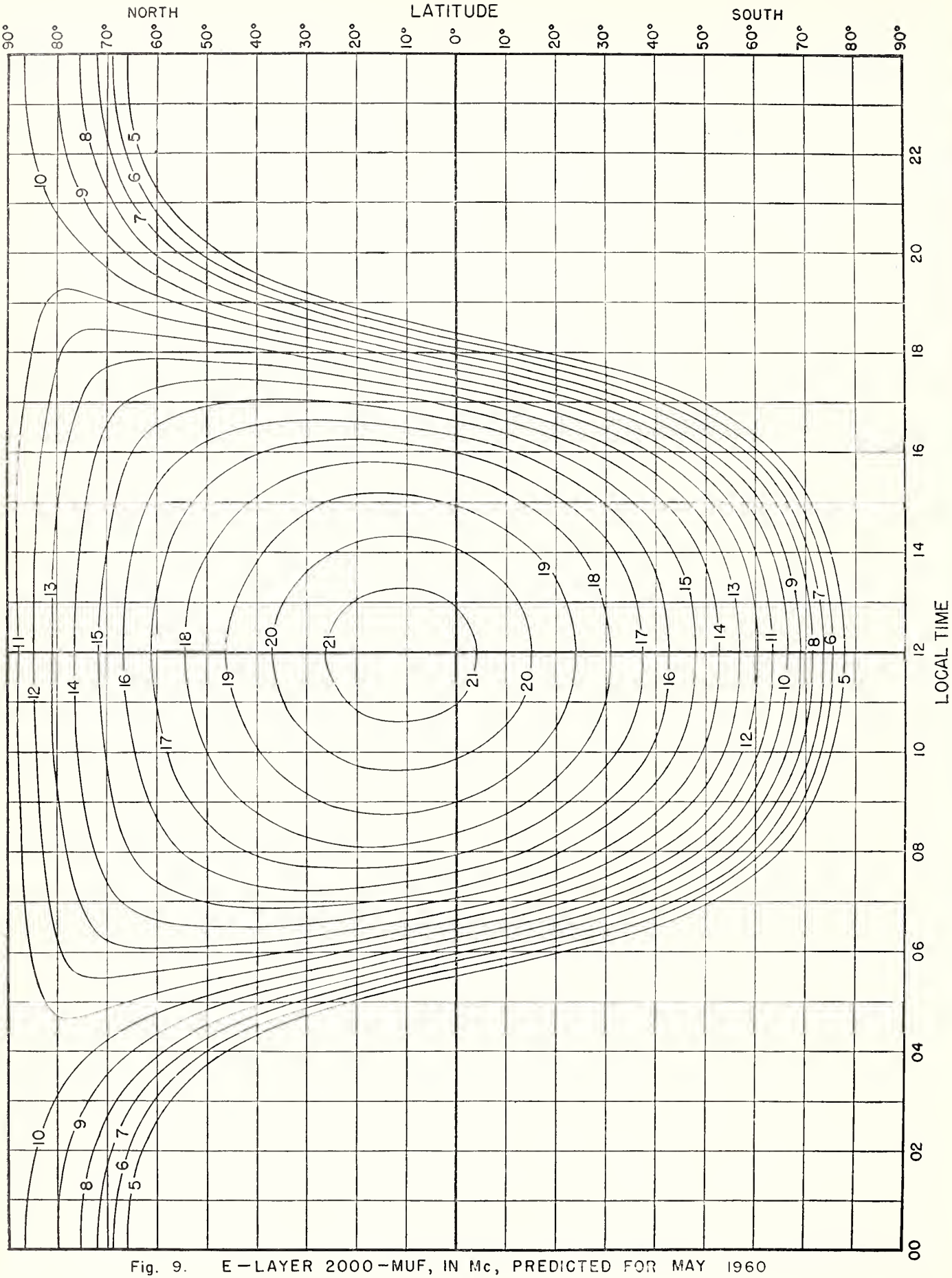
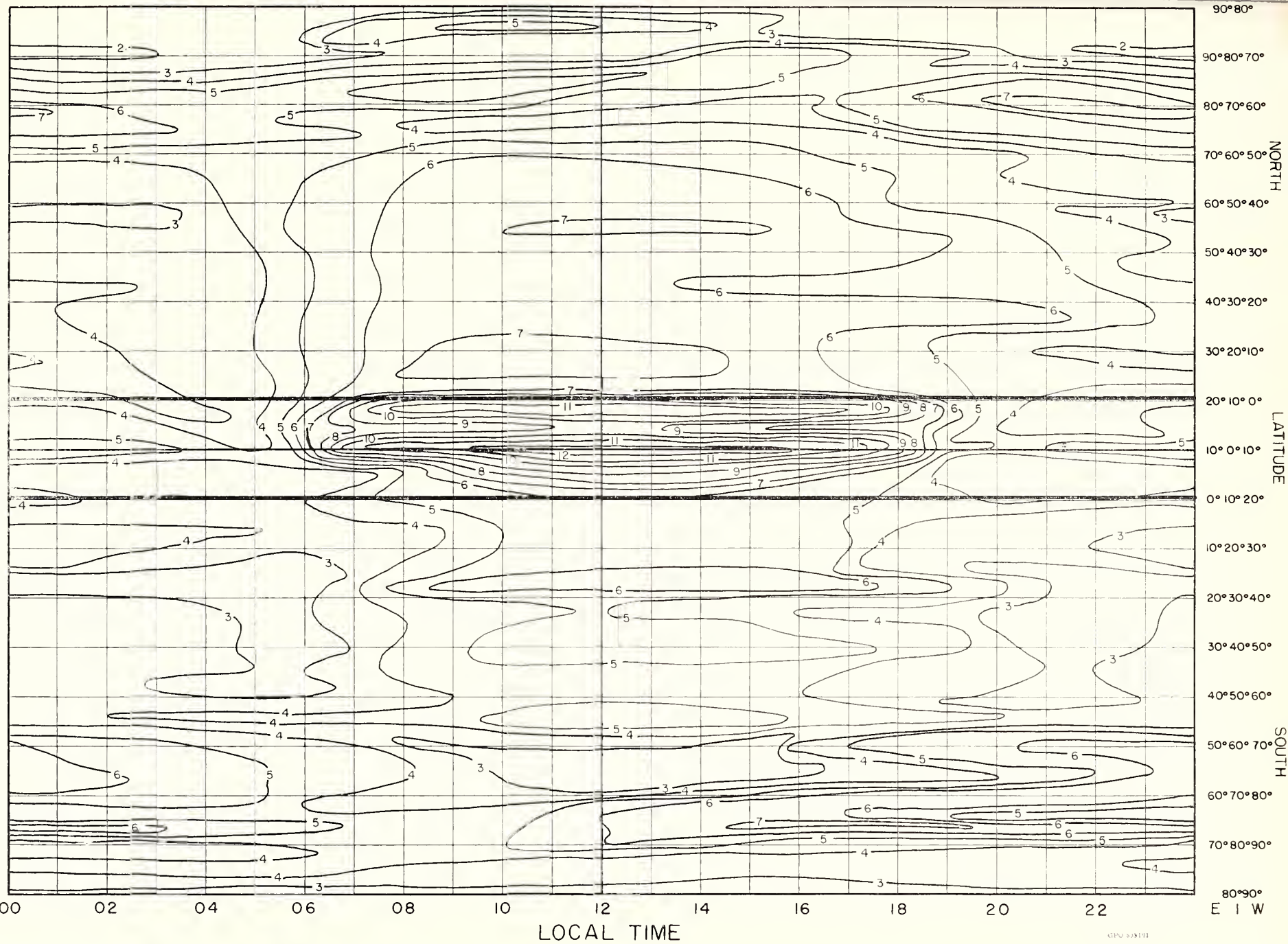


Fig. 9. E—LAYER 2000—MUF, IN Mc, PREDICTED FOR MAY 1960


FOF2 MEDIAN fEs, IN Mc, PREDICTED FOR MAY 1960
LOCAL TIME
00
02
04
06
08
10
12
14
16
18
20
22
E I W
LATITUDE
NORTH
SOUTH
90° 80°
90° 80° 70°
80° 70° 60°
70° 60° 50°
60° 50° 40°
50° 40° 30°
40° 30° 20°
30° 20° 10°
20° 10° 0°
10° 0° 10°
0° 10° 20°
10° 20° 30°
20° 30° 40°
30° 40° 50°
40° 50° 60°
50° 60° 70°
60° 70° 80°
70° 80° 90°
80° 90°

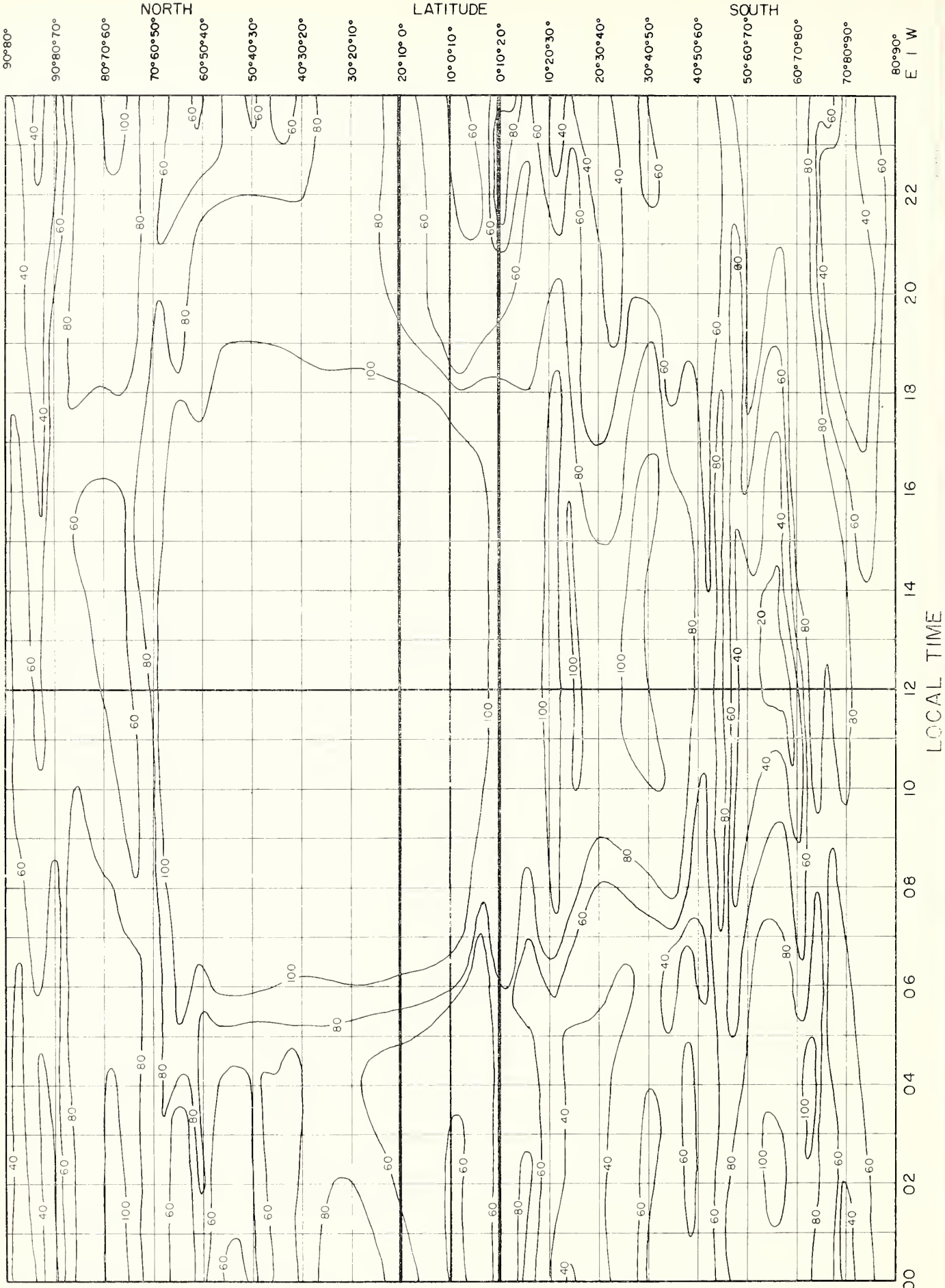
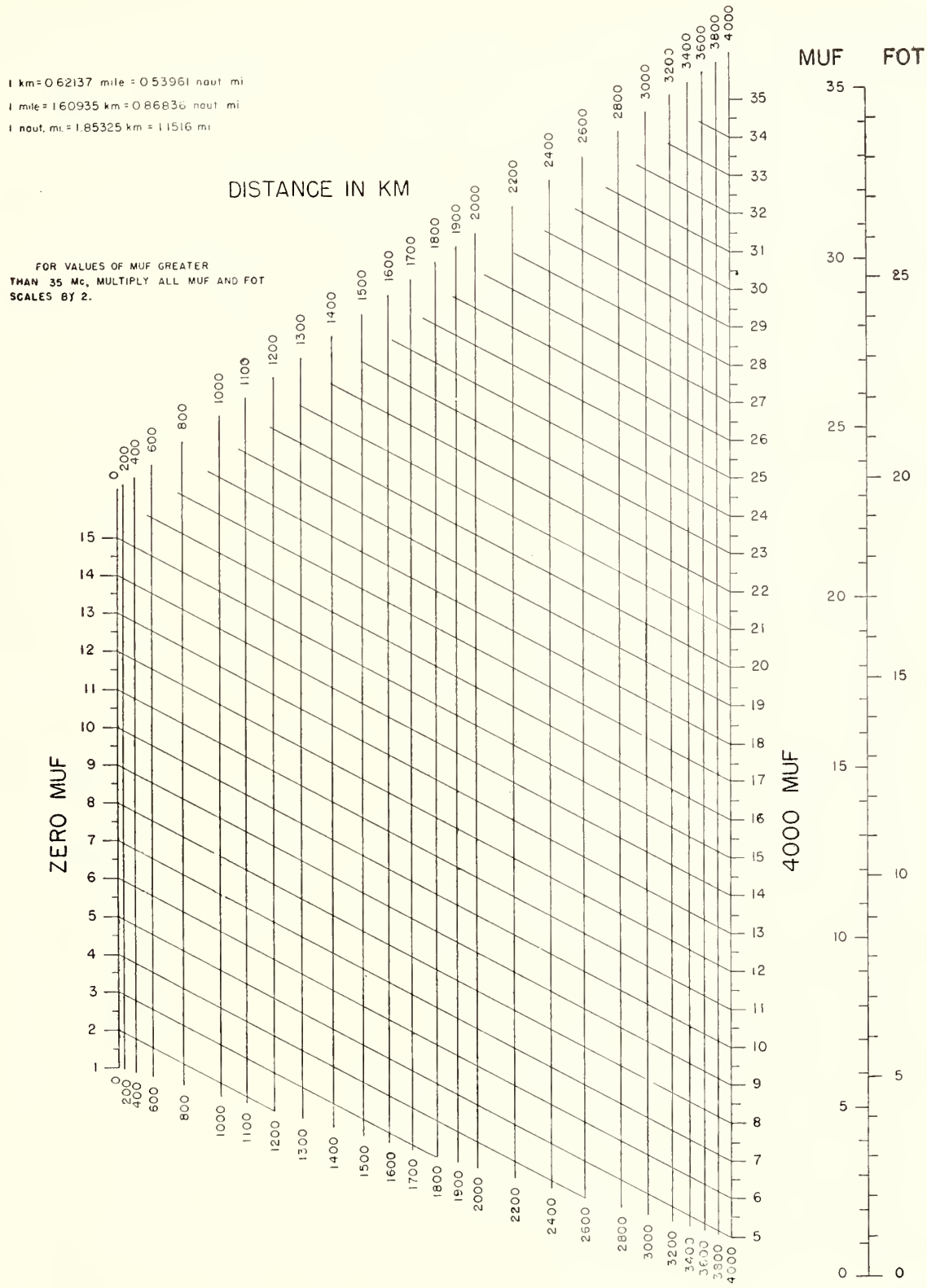
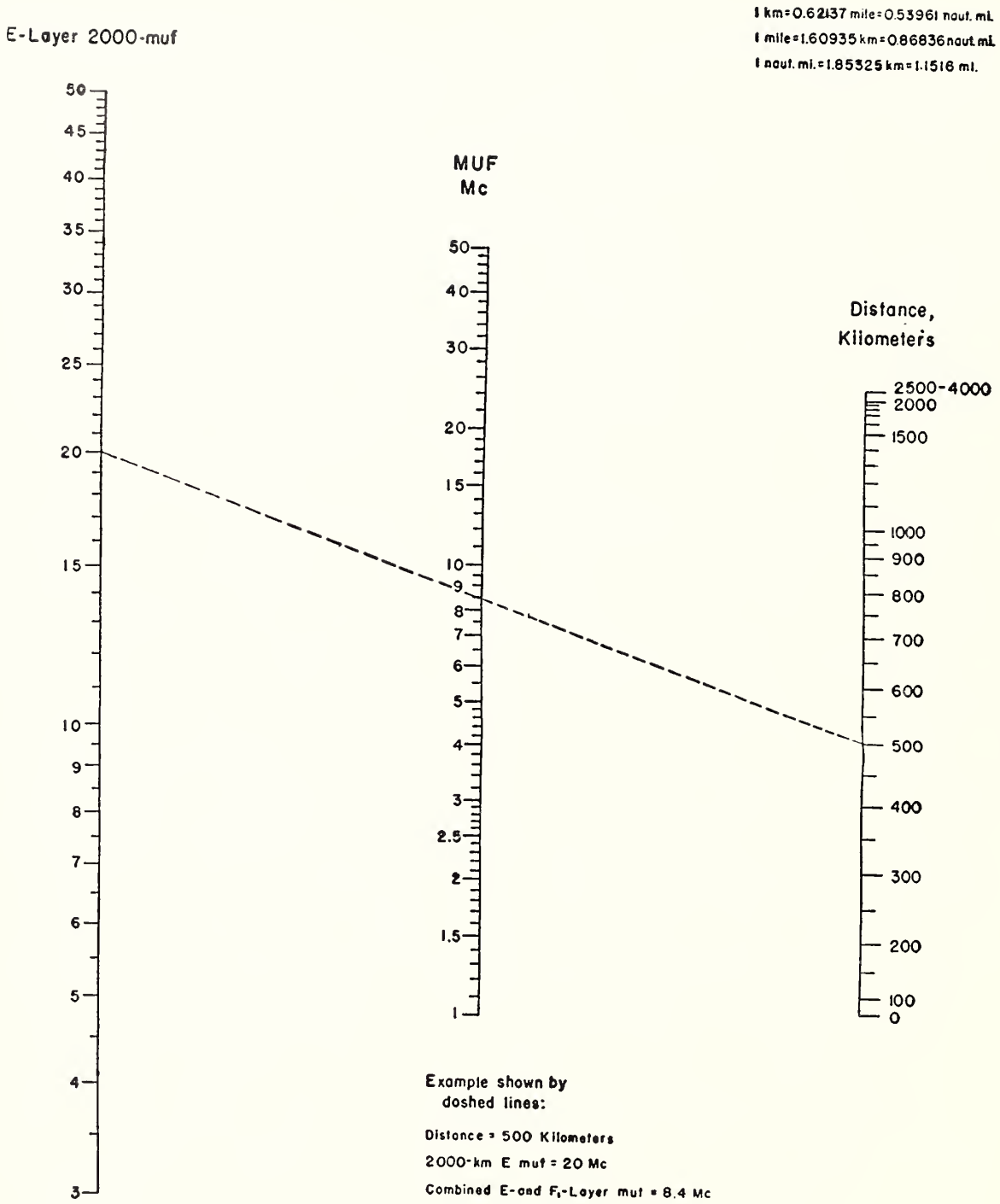


FIG. 11. PERCENTAGE OF TIME OCCURRENCE FOR Es-2000-MUF IN EXCESS OF 15 Mc, PREDICTED FOR MAY 1960



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 TRAFFIC FREQUENCY (FOT).



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

Notes on Use of Predictions

It is believed that these predictions are reasonably accurate for vertical incidence and for one-hop $F2$ transmission for average layer height for 4000-km distance over a great circle path. In practice, the picture is often more complicated. The effective antenna-radiated power at low angles of departure may not be sufficient for maximum single hop distance. Also, for a given distance various modes, or combinations of modes, of propagation are often possible, including combinations of E- and F-layer single or multiple hops. Ionospheric forward scatter, backscatter, off-great-circle transmission, and sporadic E may increase the actual MUF for a given circuit over that expected for the simplest great circle mode. Sporadic E may be particularly important during night hours in auroral zones, and during the middle of the day in the summer in temperate zones. Ionospheric layer tilt, horizontal ionization gradients, meteoric or auroral propagation may play an important part.

For many circuits, these may explain why the median MUF may give a better estimate of the FOT than the usual procedure of percentage reduction of the MUF. Use of operating experience in conjunction with these predictions will aid in maintaining the highest possible circuit efficiency.

Reports to this laboratory of discrepancies between predictions and experience are helpful in improving these predictions. Communications should be addressed to Central Radio Propagation Laboratory, National Bureau of Standards, Boulder, Colorado. Please note this is not an address for subscriptions. Subscription information is given elsewhere in this report.

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CRPL Reports

[A detailed list of CRPL publications is available from the Central Radio Propagation Laboratory upon request]

Daily:

Radio disturbance forcasts, every half hour from broadcast stations WWV and WWVH of the National Bureau of Standards.

Telephoned and telegraphed reports of ionospheric, solar, geomagnetic, and radio propagation data.

Semiweekly:

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

CRPL—Jp. North Atlantic Radio Propagation Forecast (of days most likely to be disturbed during following month).

Semimonthly:

CRPL—Ja. Semimonthly Frequency Revision Factors For CRPL Basic 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 Air Force, TO 31—3—28 series). On sale by Superintendent of Documents.* Members of the Armed Forces should address cognizant military office.

CRPL—F. (Part A). Ionospheric Data.
(Part B). Solar-Geophysical Data.
Limited distribution. These publications are in general disseminated only to those individuals or scientific organizations which collaborate in the exchange of ionospheric, solar, geomagnetic, or other radio propagation data.

Catalog of Data:

A catalog of records and data on file at the U. S. IGY World Data Center A for Airglow and Ionosphere, Boulder Laboratories, National Bureau of Standards, which includes a fee schedule to cover the cost of supplying copies, is available upon request.

The publications listed above may be obtained without charge from the Central Radio Propagation Laboratory, National Bureau of Standards, Boulder Laboratories, Boulder, Colorado, unless otherwise indicated. Please note that the F series is not generally available.

Circulars of the National Bureau of Standards pertaining to Radio Sky Wave Transmission:

NBS Circular 462. Ionospheric Radio Propagation. $1.25.
NBS Circular 465. Instructions for the Use of Basic Radio Propagation Predictions. 30 cents.
NBS Circular 557. Worldwide Radio Noise Levels Expected in the Frequency Band 10 Kilocycles to 100 Megacycles. 30 cents.
NBS Circular 582. Worldwide Occurrence of Sporadic *E*. $3.25.

These Circulars are on sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Members of the Armed Forces should address the respective military office having cognizance of radio wave propagation.

* For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D. C. Price 15 cents (single copy). Subscription price: $1.50 a year; 50 cents additional for foreign mailing.

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