Central Radio Propagation Laboratory

IONOSPHERIC PREDICTIONS

for

August

1964

TB 11–499–17/TO 31–3–28

U. S. DEPARTMENT of COMMERCE

National Bureau of Standards

Number 17/Issued May 1964

Ionospheric Predictions

for August 1964

The CRPL Ionospheric Predictions are issued monthly as an aid in determining the best sky-wave frequencies over any transmission path, at any time of day, for average conditions for the month. Issued three months in advance, each issue provides tables of numerical coefficients that define the functions describing the predicted worldwide distribution of foF2 and M(3000)F2 and maps for each even hour of universal time of MUF(Zero)F2 and MUF(4000)F2.

NOTE: Department of Defense personnel see back cover.

National Bureau of Standards

The functions of the National Bureau of Standards are set forth in an Act of Congress, March 3, 1901, as amended. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to government agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. The Bureau also serves as the Federal technical research center in a number of specialized fields.

Central Radio Propagation Laboratory

The Central Radio Propagation Laboratory at Boulder, Colorado, is the central agency of the Federal Government for the collection, analysis, and dissemination of information on propagation of radio waves at all frequencies along the surface of the earth, in the atmosphere, and in space, and performs scientific studies looking toward new techniques for the efficient use and conservation of the radio spectrum. To carry out this responsibility, the CRPL—

1. Acts as the central agency for the conduct of basic research on the nature of radio waves, the pertinent properties of the media through which radio waves are transmitted, the interaction of radio waves with those media, and on the nature of radio noise and interference effects. This includes compilation of reports by other foreign and domestic agencies conducting research in this field and furnishing advice to government and nongovernment groups conducting propagation research.

2. Performs studies of specific radio propagation mechanisms and performs scientific studies looking toward the development of techniques for efficient use and conservation of the radiofrequency spectrum as part of its regular program or as requested by other government agencies. In an advisory capacity, coordinates studies in this area undertaken by other government agencies.

3. Furnishes advisory and consultative service on radio wave propagation, on radiofrequency utilization, and on radio systems problems to other organizations within the United States, public and private.

4. Prepares and issues predictions of radio wave propagation and noise conditions and warnings of disturbances in these conditions.

5. Acts as a central repository for data, reports, and information in the field of radio wave propagation.

6. Performs scientific liaison and exchanges data and information with other countries to advance knowledge of radio wave propagation and interference phenomena and spectrum conservation techniques, including that liaison required by international responsibilities and agreements.

Introduction

The "Central Radio Propagation Laboratory Ionospheric Predictions" is the successor to the former "Basic Radio Propagation Predictions," CRPL Series D. To make effective use of these predictions, National Bureau of Standards Handbook 90, "Handbook for CRPL Ionospheric Predictions Based on Numerical Methods of Mapping," should be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, price 40 cents. This Handbook includes required additional data, nomographs and graphical aids, as well as methods for the use of the predictions. The Handbook supersedes the obsolete NBS Circular 465.

The basic prediction appears in tables 1 and 2, presenting predicted coefficients for foF2 and M(3000)F2 defining the numerical map functions describing the predicted worldwide variation of these characteristics. With additional auxiliary information, these coefficients may be used as input data for electronic computer programs solving specific high frequency propagation problems. The basic equations, their interpretation, and methods of using the numerical maps are described in two papers by W. B. Jones and R. M. Gallet, "The Representation of Diurnal and Geographic Variations of Ionospheric Data by Numerical Methods," Volume 66D, Number 4, July–August 1962, pages 419–438, and "Methods for Applying Numerical Maps of Ionospheric Characteristics," Volume 66D, Number 6, November–December 1962, pages 649–662, both in the Journal of Research of the National Bureau of Standards, Section D. Radio Propagation. The predicted numerical map coefficients of tables 1 and 2 may be purchased in the form of a tested set of punched cards. Write to the Prediction Services Section, Central Radio Propagation Laboratory, National Bureau of Standards, Boulder, Colorado, to arrange for the purchase of the set of punched cards and for further information and assistance in the application of computer methods and numerical prediction maps to specific propagation problems.

The graphical prediction maps, derived from the basic prediction, are provided for those unable to make use of an electronic computer. Figures 1 to 12 present world maps of MUF (Zero) F2 and MUF (4000) F2 for each even hour of universal time. Figures 13 to 16 present the same predictions for hours 00 and 12 universal time for the North and South Polar areas. Predicted polar maps for each even hour of universal time may be obtained by special arrangements with the Central Radio Propagation Laboratory. Handbook 90 describes methods for including regular E–F1 propagation. Figure A is a graph of predicted and observed Zürich sunspot numbers which shows the recent trend of solar activity. Table A lists observed and predicted Zürich smoothed relative sunspot numbers and includes the sunpot number used for the current prediction.

Members of the U.S. Army, Navy, or Air Force desiring the Handbook and the Ionospheric Predictions should send requests to the proper service address; for the Navy: The Director, Naval Communications, Department of the Navy, Washington, D.C., 20350; for the Air Force: Directorate of Command Control and Communications, Headquarters, United States Air Force, Washington, D.C., 20330. Attention: AFOCCAA. Army personnel should refer to the Handbook as TM-11–499 and to the monthly predictions as TB 11–499–( ), predictions for the month of August 1964 being distributed in May 1964 and designated TB 11–499–(17), and should requisition these through normal publication channels.

Information concerning the theory of radio wave propagation and such important problems as absorption, field intensity, lowest useful high frequencies, etc., is given in National Bureau of Standards Circular 462, "Ionospheric Radio Propagation." A revised work is in preparation which will be announced in the Ionospheric Prediction series when available. Additional information about radio noise may be found in C.C.I.R. Report Number 65, "Revision of Atmospheric Noise Data," International Telecommunication Union, Geneva, 1957.

Reports to this Laboratory of experience with these predictions would be appreciated. Correspondence should be addressed to the Prediction Services Section, Central Radio Propagation Laboratory, National Bureau of Standards, Boulder, Colorado.

Table A

Observed and Predicted Zurich Smoothed Relative
Sunspot Numbers

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1952	43	42	39	36	34	32	31	29	28	28	27	26
	(53)	(51)	(52)	(52)	(52)	(52)	(51)	(49)	(46)	(43)	(38)	(33)
1953	24	22	20	19	17	15	13	12	11	10	9	7
	(30)	(29)	(27)	(24)	(22)	(21)	(20)	(18)	(18)	(17)	(16)	(15)
1954	6	6	4	3	4	4	5	7	8	8	10	12
	(14)	(12)	(11)	(10)	(10)	(9)	(8)	(8)	(8)	(10)	(10)	(11)
1955	14	16	20	23	29	35	40	46	55	64	73	81
	(12)	(14)	(14)	(13)	(16)	(18)	(22)	(27)	(30)	(31)	(35)	(42)
1956	89	98	109	119	127	137	146	150	151	156	160	164
	(48)	(53)	(60)	(68)	(77)	(89)	(95)	(105)	(119)	(135)	(147)	(150)
1957	170	172	174	181	186	188	191	194	197	200	201	200
	(150)	(150)	(150)	(150)	(150)	(150)	(150)	(150)	(150)	(150)	(150)	(150)
1958	199	201	201	197	191	187	185	185	184	182	181	180
	(150)	(150)	(150)	(150)	(150)	(150)	(150)	(150)	(150)	(150)	(150)	(150)
1959	179	177	174	169	165	161	156	151	146	141	137	132
	(150)	(150)	(150)	(150)	(146)	(143)	(141)	(142)	(141)	(139)	(137)	(137)
1960	129	125	122	120	117	114	109	102	98	93	88	84
	(136)	(135)	(133)	(130)	(125)	(120)	(118)	(115)	(110)	(108)	(105)	(100)
1961	80	75	69	64	60	56	53	52	52	51	50	49
	(100)	(90)	(90)	(90)	(85)	(85)	(80)	(75)	(70)	(70)	(65)	(60)
1962	45	42	40	39	39	38	37	35	33	31	30	30
	(60)	(50)	(48)	(45)	(42)	(37)	(34)	(31)	(29)	(28)	(27)	(34)
1963	29	30	30	29	29	28	28	27				
	(31)	(28)	(26)	(25)	(25)	(25)	(23)	(21)	(20)	(18)	(18)	(17)
1964												
	(17)	(17)	(17)	(17)	(17)	(17)	(17)	(17)*				

Note: Final numbers are listed through June 1963, the succeeding values
being based on provisional data. The predicted numbers are in
parentheses.
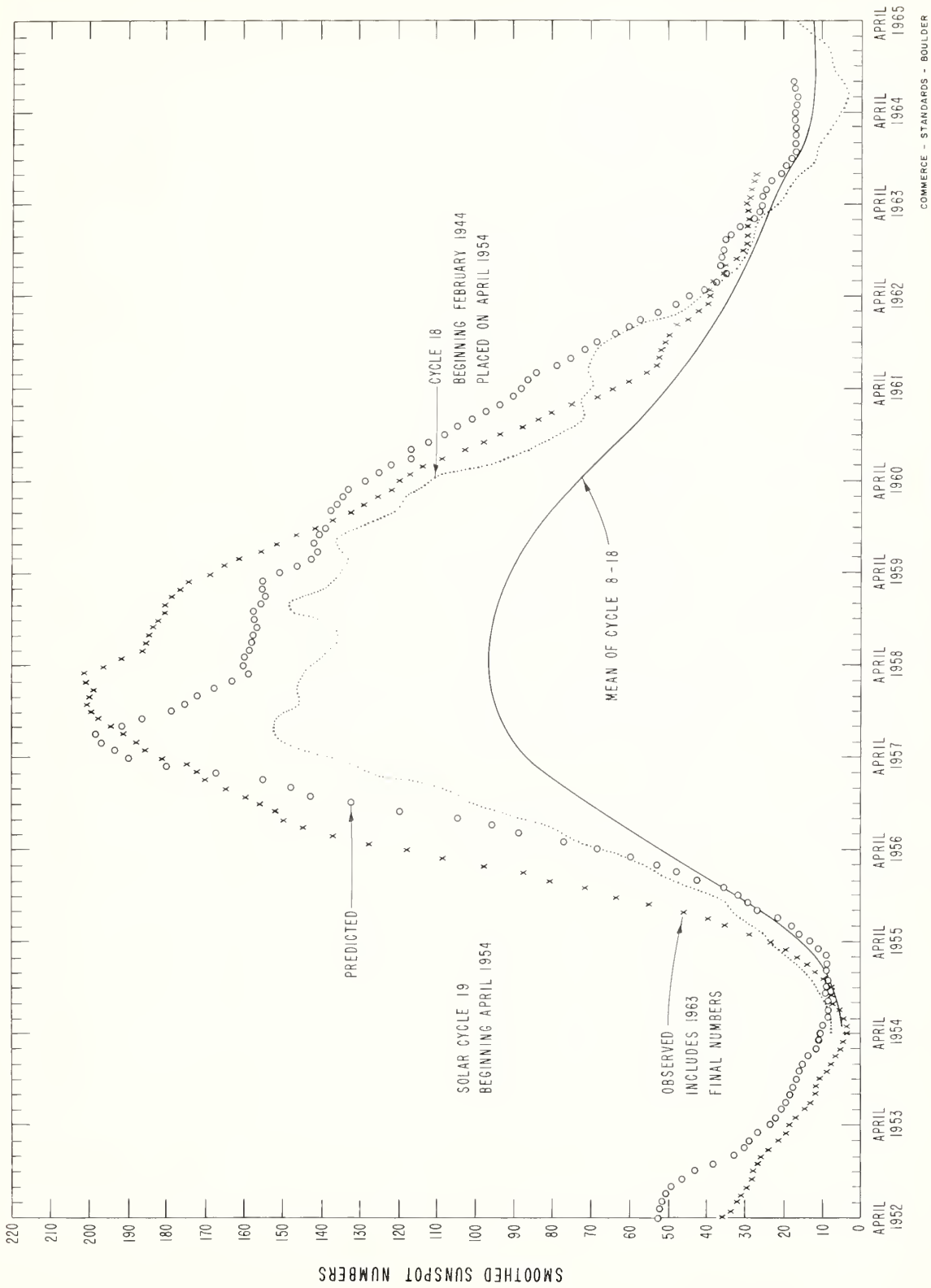
* Number used for predictions in this issue.

FIG. A. PREDICTED AND OBSERVED SUNSPOT NUMBERS

TABLE I

TIME VARIATION

GEOGRAPHICAL VARIATION

Harmonic		0	1	2	3	4
	k \ s	0	1	2	3	4

I - Main latitudinal variation. Mixed latitudinal and longitudinal variation: II - First order in longitude, III - Second order in longitude

Notation: For each entry the number given by the first eight digits and sign is multiplied by the power of ten defined by the last two digits and sign.

PREDICTED COEFFICIENTS D_{sk} DEFINING THE FUNCTION $\Gamma(\lambda,\theta,t)$ FOR MONTHLY MEDIAN $f_o F2$ (Mc/s)

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TABLE 2

GEOGRAPHICAL VARIATION

TABLE 2

TIME VARIATION

GEOGRAPHICAL VARIATION

Harmonic	k	0	1	2	3	4	5	6
I	0	3.0151307E 00	-1.2534418E-01	-2.5861804E-01	-2.7398260E-02	-1.1125978E-01	2.1289236E-02	-3.7625548E-03
	1	-5.4938437E-01	-1.3903764E-01	-3.3447554E-01	1.3124341E-01	-6.1930190E-01	1.0158272E-01	7.3276213E-02
	2	1.8893099E 00	9.3596407E-01	2.6282034E 00	1.2835444E-01	-4.1410339E-01	-5.2034497E-01	-2.7849781E-01
	3	2.1246885E 00	4.8835698E-01	1.1549680E 00	-9.4218744E-01	3.0330604E 00	-3.8916093E-01	-3.3163015E-01
	4	-5.8396695E 00	-2.3112462E-01	-6.9112032E-01	-9.0958877E-01	2.4804165E 00	1.9557813E 00	6.2163628E-01
	5	-3.4186546E 00	-4.1568241E-01	-1.8768544E 00	1.6683770E 00	-4.6789086E 00	5.6368920E-01	6.7909600E-01
	6	6.4486922E 00	2.5535478E 00	7.4565811E 00	1.6030899E 00	-3.7006882E 00	-2.6753557E 00	-3.6447056E-01
	7	1.8079000E 00	9.8083251E-02	9.3134985E-01	-8.5690526E-01	2.2515048E 00	-2.7324293E-01	-4.0371004E-01
	8	-2.4888639E 00	-1.0413850E 00	-2.9601714E 00	-7.8644449E-01	1.7333184E 00	1.2306927E 00	1.7478493E-02
II	9	1.4980735E-02	7.0362478E-03	4.3335888E-02	-3.4948801E-02	4.1802807E-03	1.6201783E-02	-6.2226968E-03
	10	9.6998891E-02	4.7517506E-02	7.2484629E-02	-5.1623387E-02	8.7325644E-02	-5.2985532E-03	5.2352490E-03
	11	1.5999440E-01	-6.1213404E-02	1.5960182E-01	-1.0898106E-01	2.0197557E-02	-4.5319620E-02	-3.8681519E-02
	12	-5.2910379E-01	-3.2517987E-01	-9.3488866E-01	-1.1582766E-02	-8.4725314E-02	-1.5375195E-01	1.9768486E-02
	13	-1.3037487E-01	-2.6616982E-01	-8.6677357E-01	4.7179306E-01	-3.2429731E-01	-1.3306553E-01	-1.5297586E-01
	14	-1.1304664E 00	-8.1089986E-01	-9.3781896E-02	6.8481017E-01	-1.6240093E 00	8.2509475E-02	7.5102203E-02
	15	-1.3467724E 00	4.5027808E-01	-6.0028578E-01	-8.2608835E-02	2.7088207E-01	8.5710984E-01	2.5233705E-01
	16	3.7755155E 00	1.9207768E 00	5.6247949E 00	-2.4962996E-01	1.6102918E 00	-1.2362399E 00	-1.1141610E 00
	17	7.8490378E-01	1.7863714E 00	3.4464206E 00	-2.2104112E 00	7.1282127E 00	4.6739779E-01	9.4933026E-01
	18	3.0456927E 00	3.7496807E 00	-1.7294401E 00	-2.8798410E 00	-1.0511321E 00	-2.3972695E-01	-1.0262097E 00
	19	2.9234525E 00	-1.2573850E 00	7.2873259E-01	2.1810407E-02	-4.4958563E-01	3.2451348E-01	1.8261140E 00
	20	-6.5689470E 00	-3.4655872E 00	-9.1431919E-01	8.9127626E-01	-2.7580267E 00	2.4978641E 00	-1.3571662E 00
	21	-5.6703155E-01	-3.7971431E 00	-4.5463033E 00	3.5098505E 00	-1.0739256E 01	-3.9118610E-01	2.1618701E 00
	22	-2.5509247E 00	-6.4032912E 00	4.5211514E 00	5.9804607E 00	9.1633779E 00	2.5625588E-01	2.7861410E-01
	23	-1.8273603E 00	8.4326869E-01	-1.1985028E-01	5.9950158E 00	2.2686482E-01	-3.6956308E-01	-9.4806100E-01
	24	3.3807658E 00	2.0346687E 00	4.7756156E 00	-6.9324502E-01	1.5048401E 00	-1.4799971E 00	
	25	1.3122960E-01	2.4820209E 00	2.2046485E 00	-1.8314800E 00		-2.9873543E-02	
	26	3.2645362E-01	3.5599796E 00	-2.8893361E 00	-2.3563876E 00	5.2814576E 00	-7.3102164E-02	-1.2583549E 00
III	27	-2.8939878E-03	-1.8112767E-02	1.5219374E-02	-2.1698030E-02	5.1434256E-03	-4.4176655E-04	-8.8829310E-04
	28	-2.9598730E-03	-9.8274168E-03	1.7957323E-02	-1.2955273E-02	1.2460016E-02	3.8315205E-04	2.4494043E-03
	29	-1.4204415E-01	-1.0820169E-02	-2.7553371E-02	1.0709111E-02			-3.1042417E-02
	30	-1.1028799E-01	-5.2673899E-02	-2.8002308E-02	4.2806908E-02			1.4001915E-02
	31	-3.0912975E-02	4.6182581E-02	3.3841642E-02	1.3244651E-01			1.6847648E-02
	32	-2.3258054E-02	1.2751131E-01	-1.6596618E-01	5.0802625E-02			-1.3349258E-02
	33	2.9199528E-01	2.1922485E-01	4.9485977E-03	-6.0923414E-02			1.0399680E-01
	34	-3.1767082E-01	2.1571910E-01	1.0500611E-02	-3.3979361E-03			
	35			2.5837717E-02	-2.4289807E-01			

GEOGRAPHICAL VARIATION

Harmonic	s	7	8	9	10	11	12
I	0	3.5074923E-02	2.0060577E-03	4.3221167E-03	2.8975351E-02	-1.1590486E-02	3.8048451E-03
	1	3.7273195E-03	3.4718229E-02	-3.5069415E-02	-1.5862664E-02	3.1392451E-03	-2.5882834E-02
	2	-4.6400184E-02	-5.0329212E-03	6.0118475E-04	-3.5063443E-02	1.5700815E-02	-2.7728175E-02
	3	-1.1760941E-03	-2.6267028E-02	2.9777813E-02	1.1796475E-02	1.0641623E-03	2.0582519E-02

I - Main latitudinal variation. Mixed latitudinal and longitudinal variation: II - First order in longitude, III - Second order in longitude

Notation: For each entry the number given by the first eight digits and sign is multiplied by the power of ten defined by the last two digits and sign.

PREDICTED COEFFICIENTS D_{sk} DEFINING THE FUNCTION $\Gamma(\lambda, \theta, t)$ FOR MONTHLY MEDIAN M(3000)F2

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FIG 1A   PREDICTED MEDIAN MUF(ZERO)F2 (Mc/s)

FIG. 1B.   PREDICTED MEDIAN MUF(4000)F2 (Mc/s)
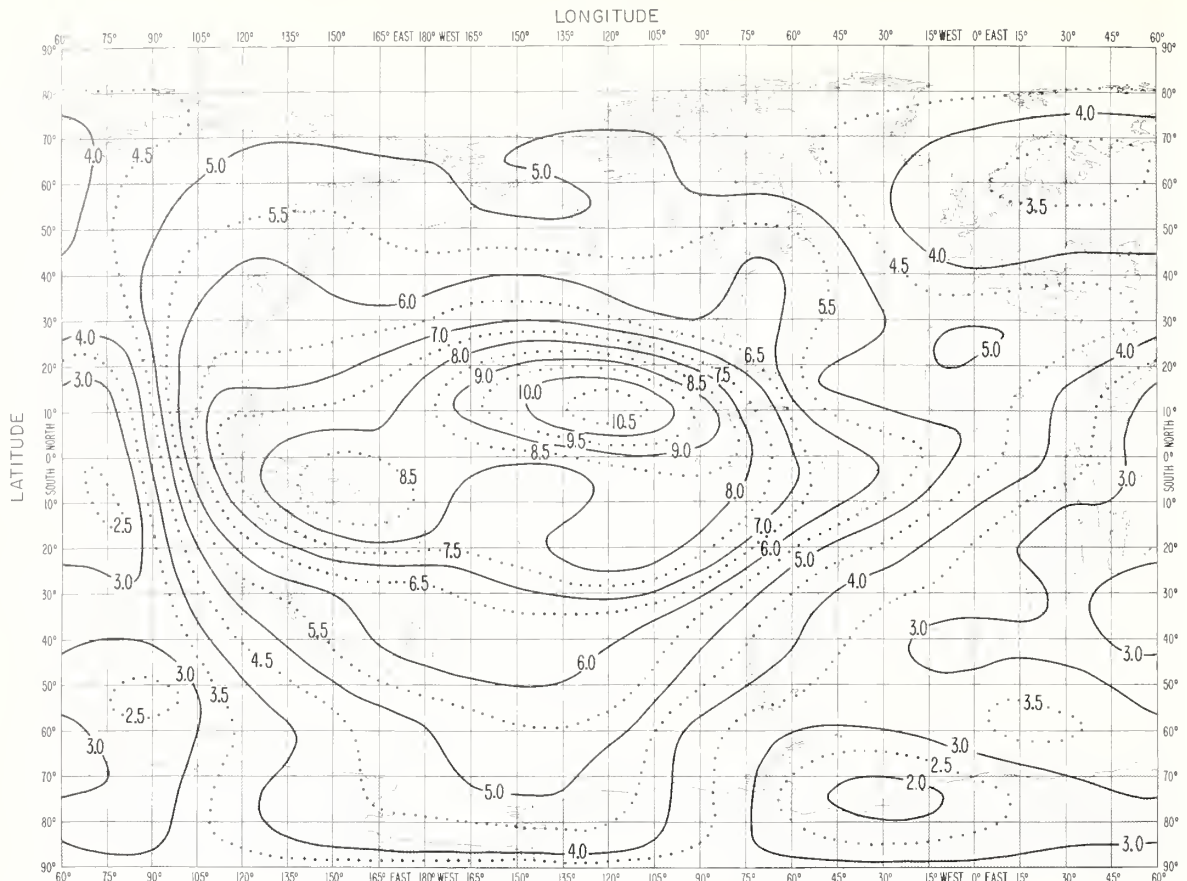
AUGUST 1964   UT=02

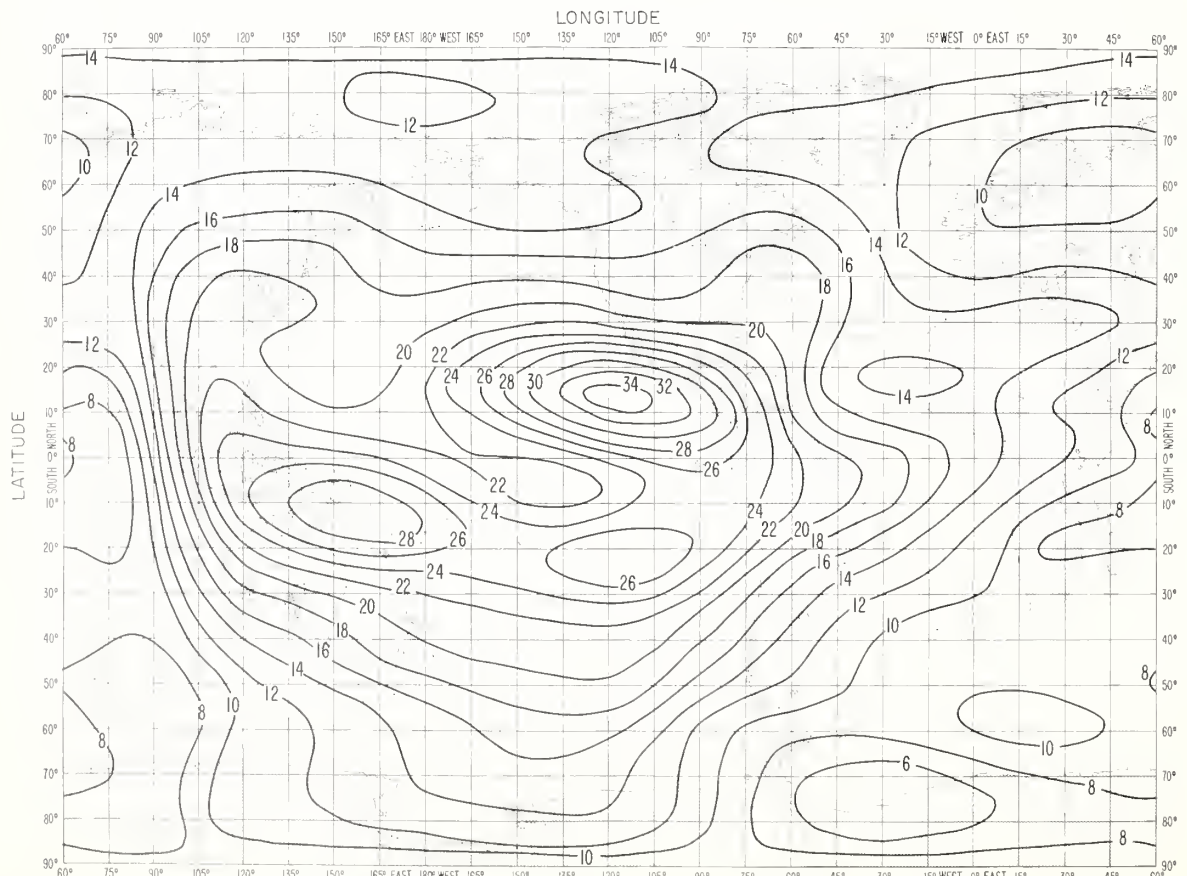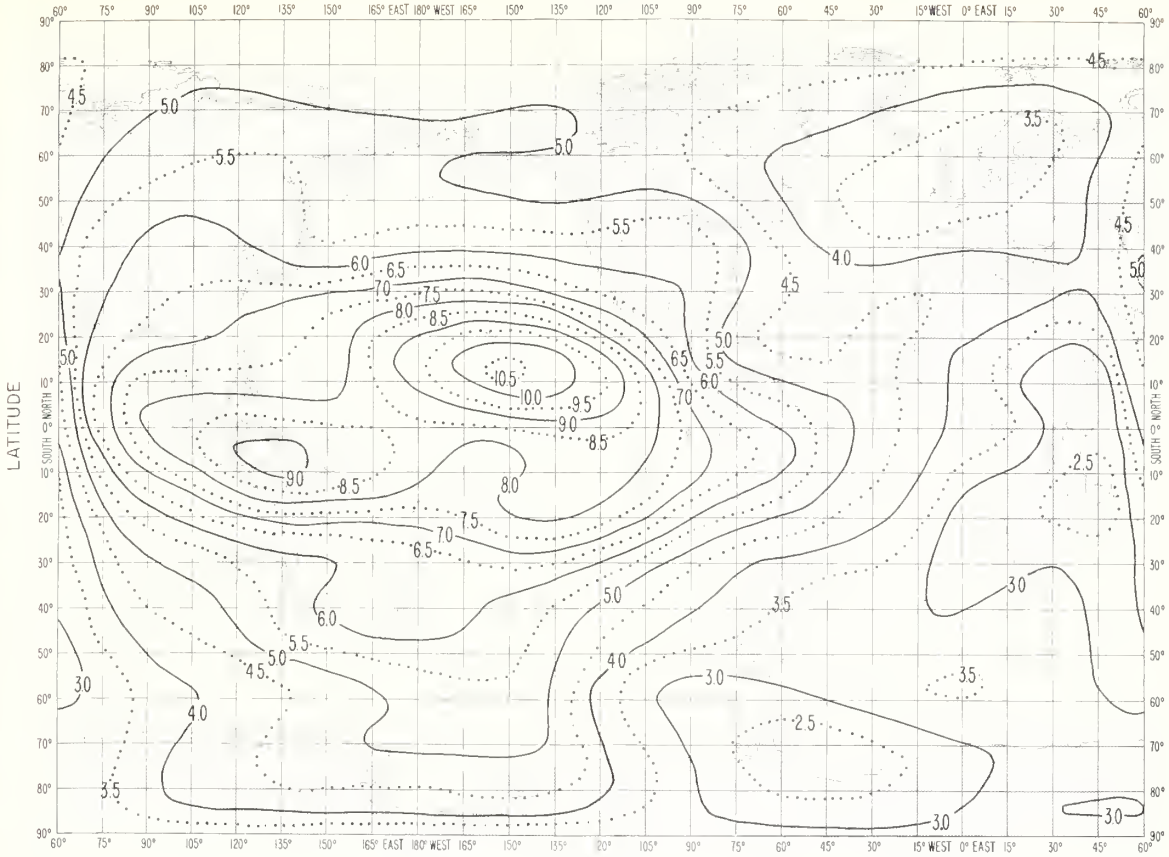FIG. 2A. PREDICTED MEDIAN MUF(ZERO)F2 (Mc/s)

FIG. 2B. PREDICTED MEDIAN MUF(4000)F2 (Mc/s)

AUGUST 1964   UT=04

LONGITUDE

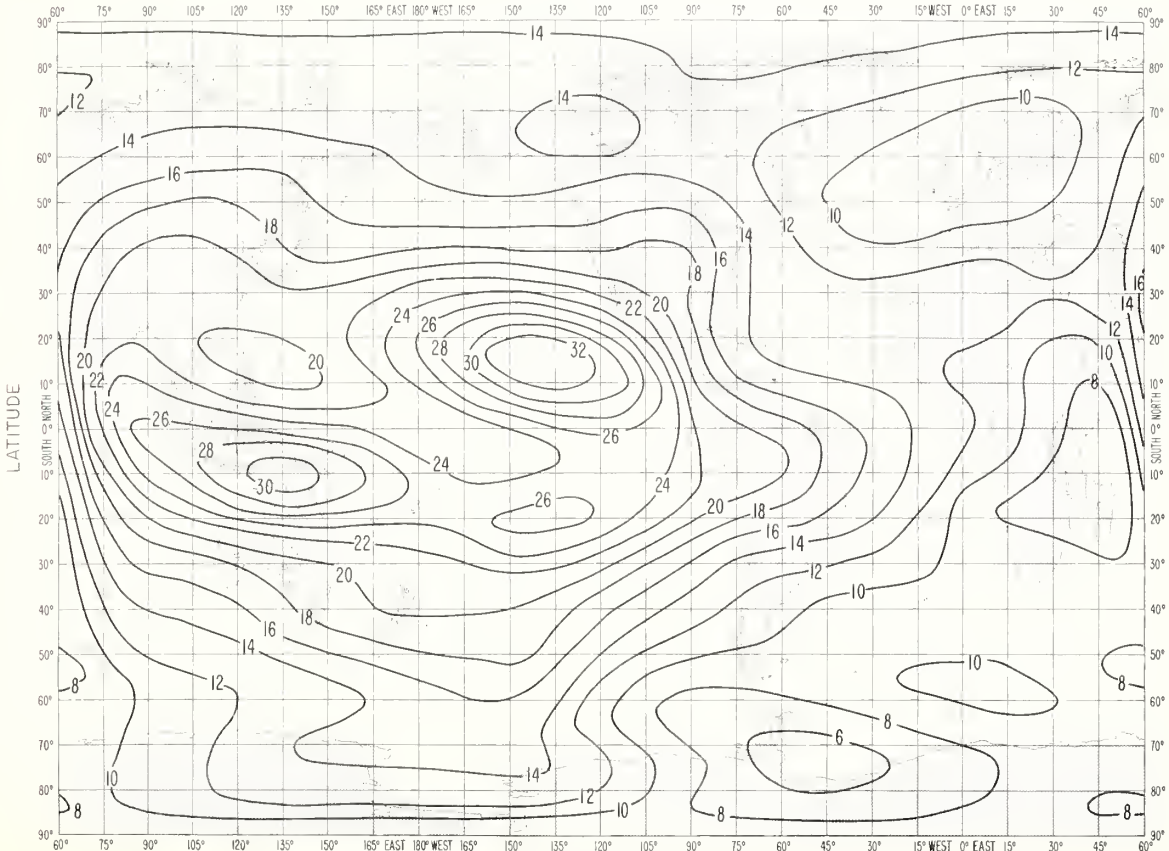FIG 3A   PREDICTED MEDIAN MUF (ZERO)F2 (Mc/s)

LONGITUDE

FIG. 3B.   PREDICTED MEDIAN MUF (4000)F2 (Mc/s)
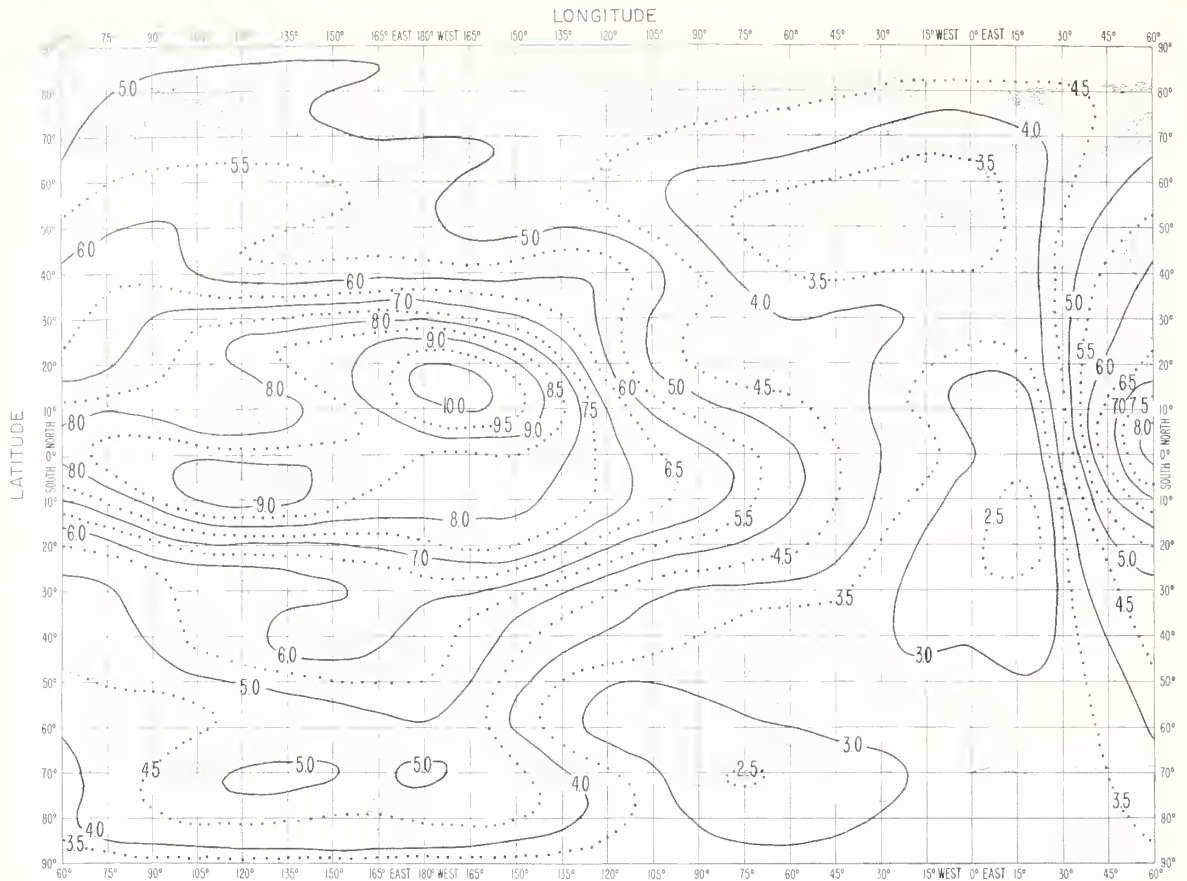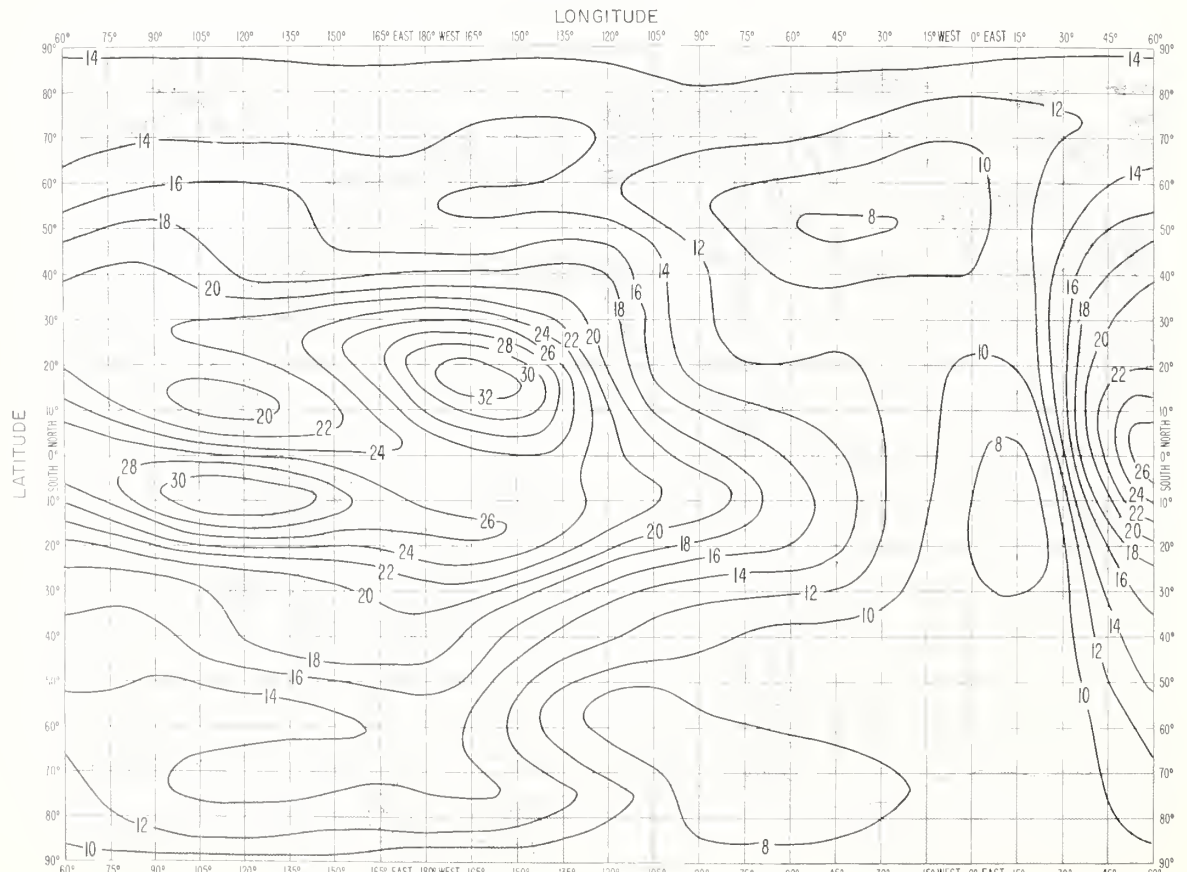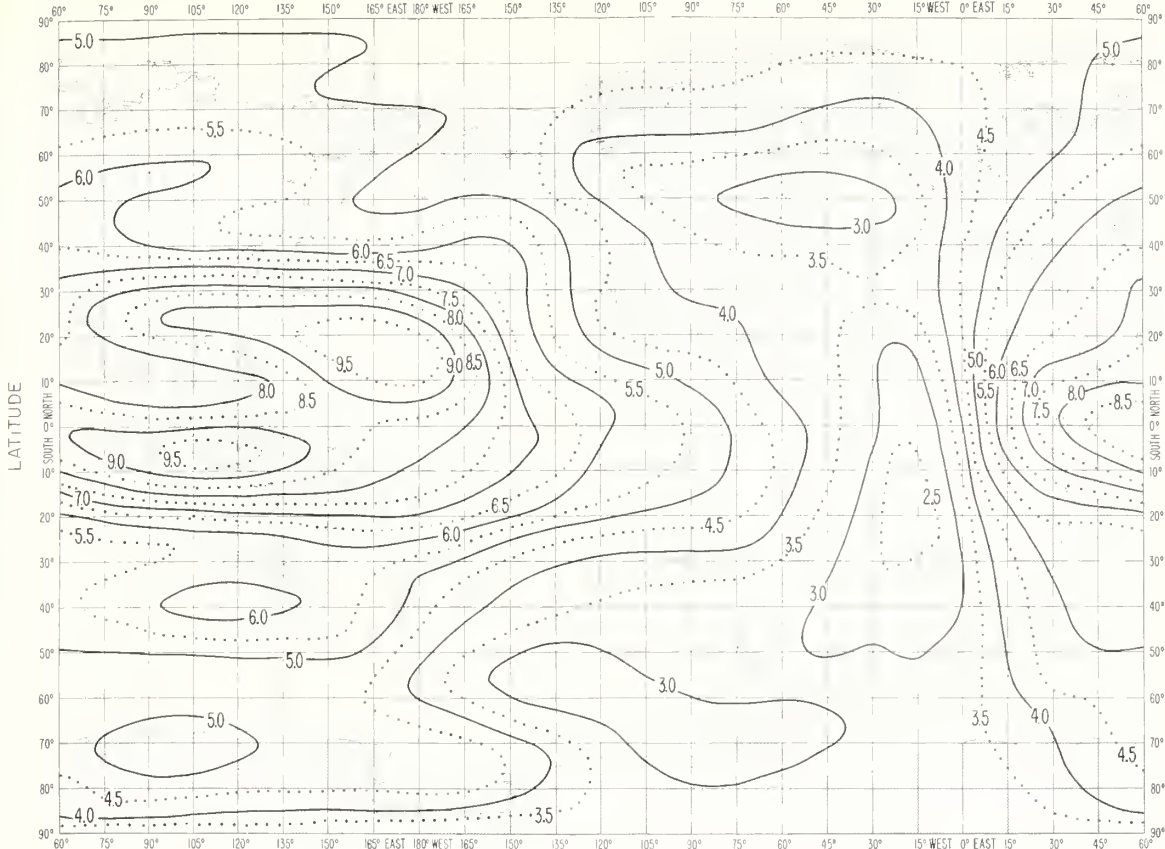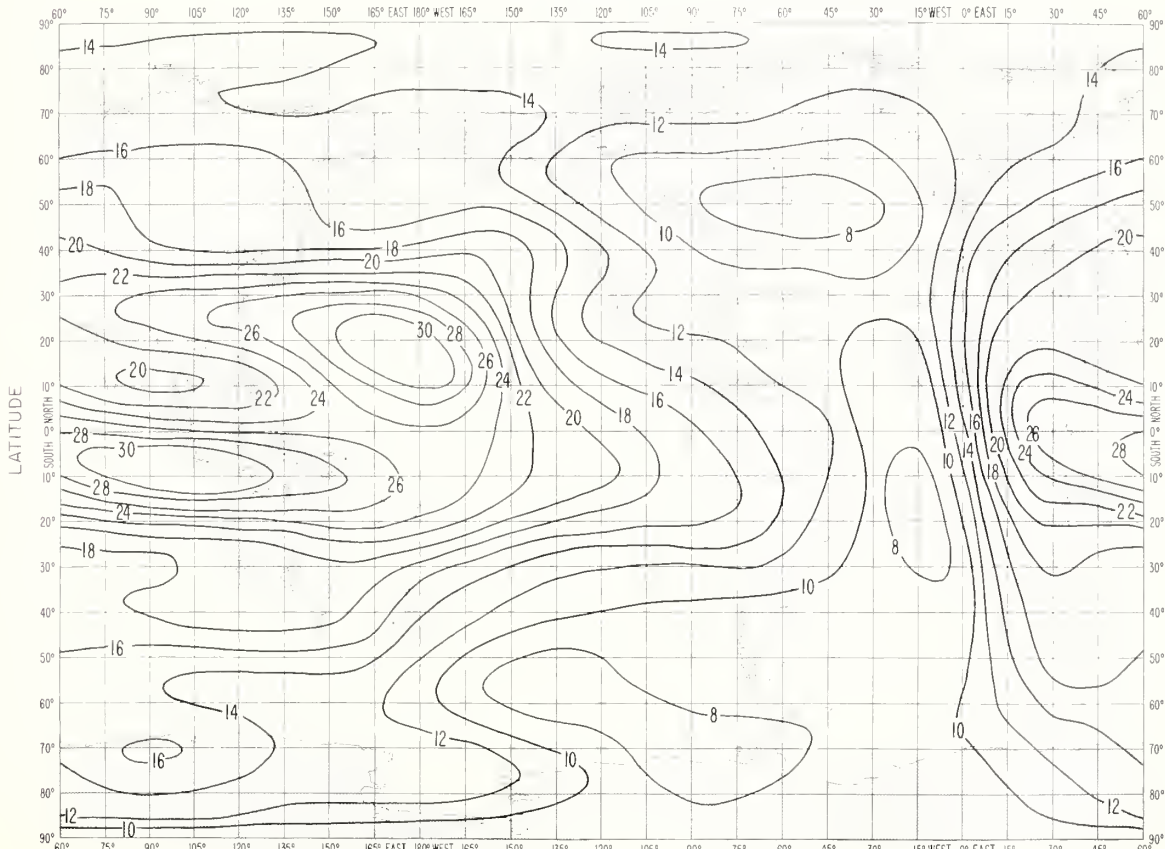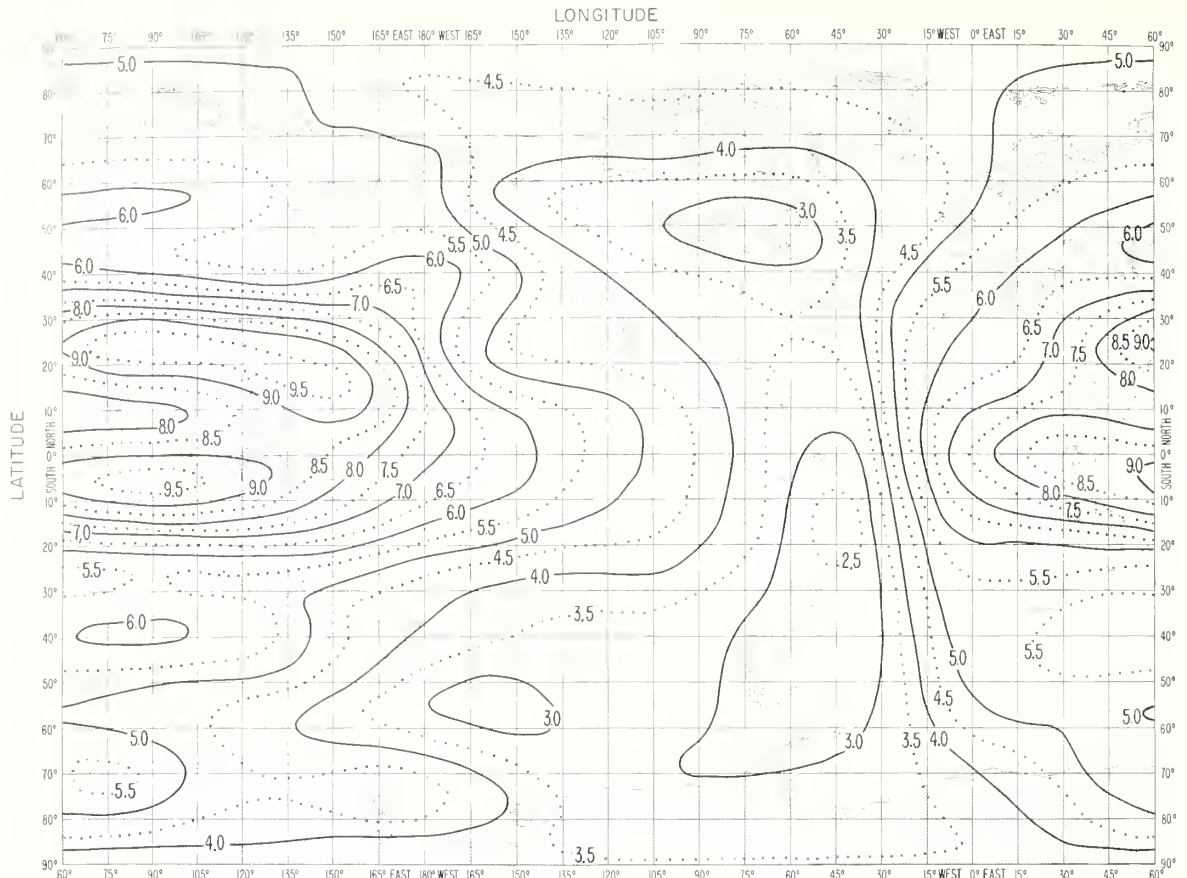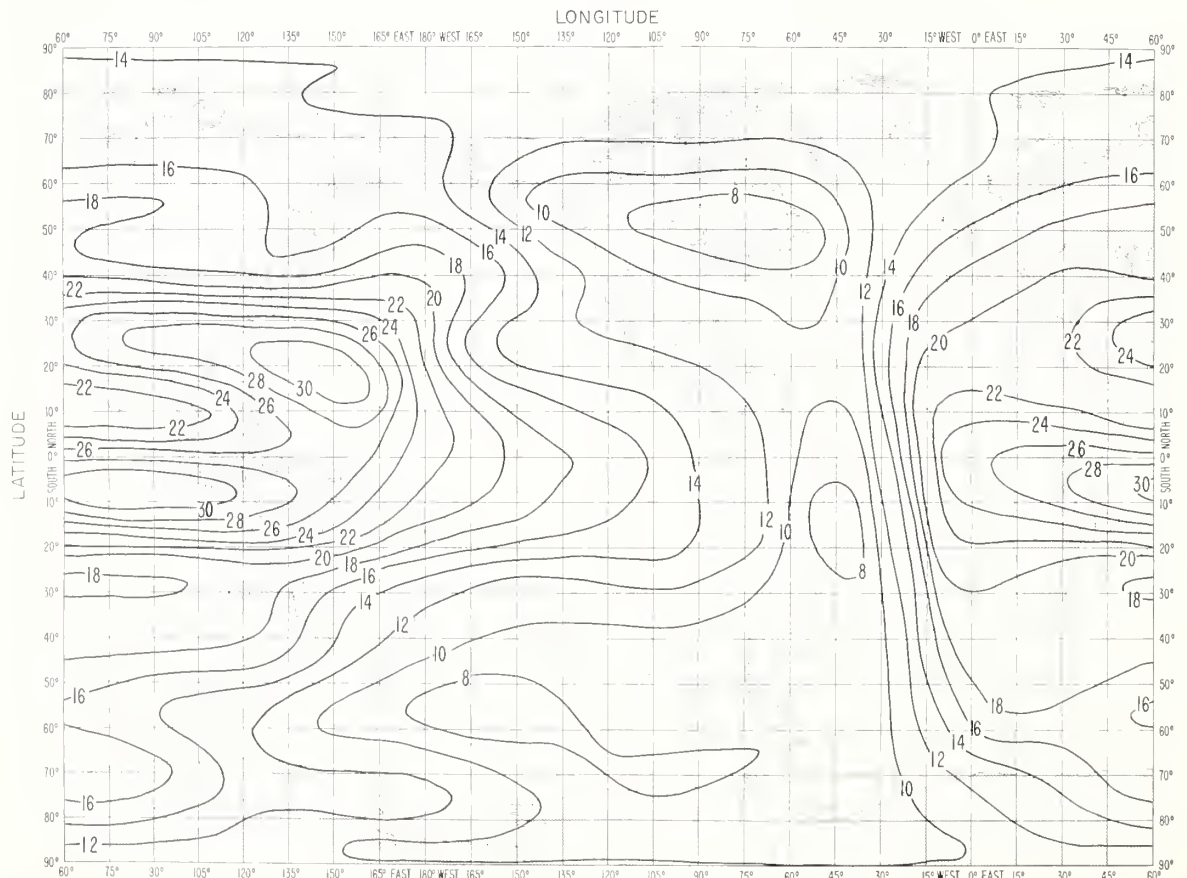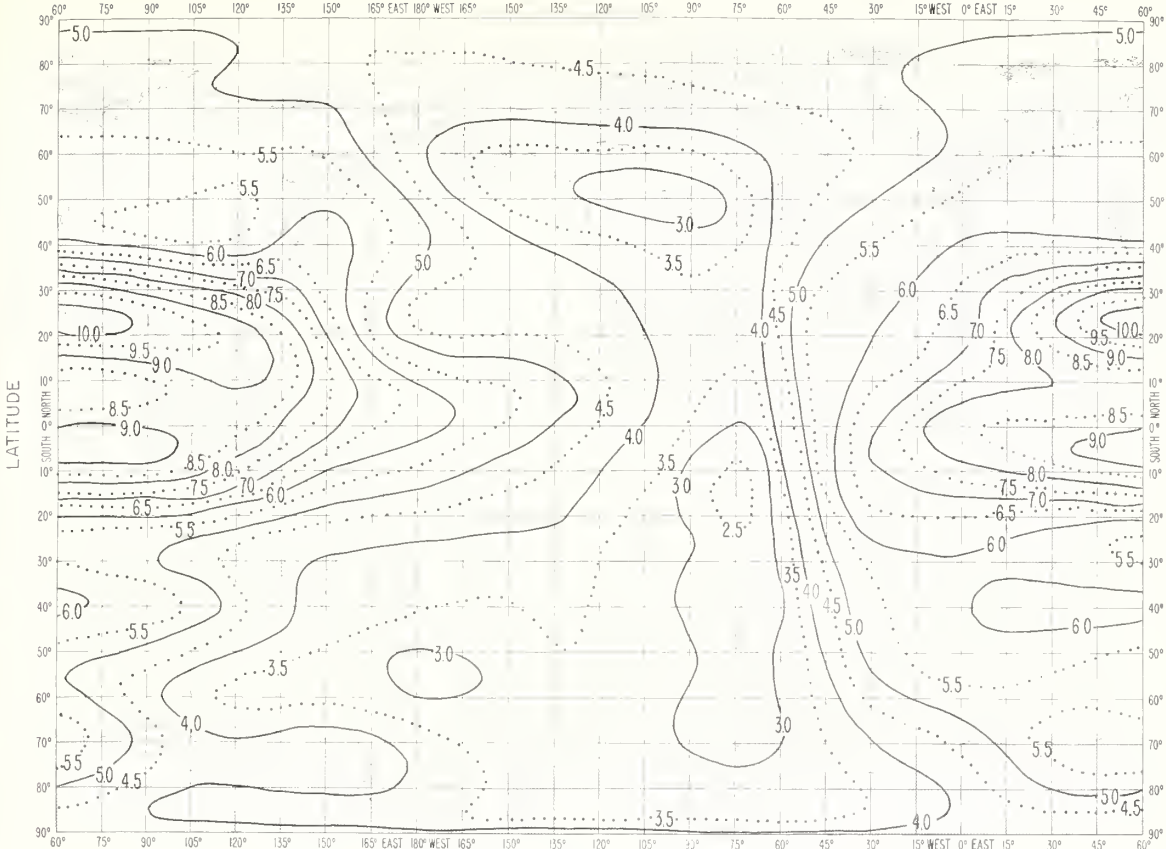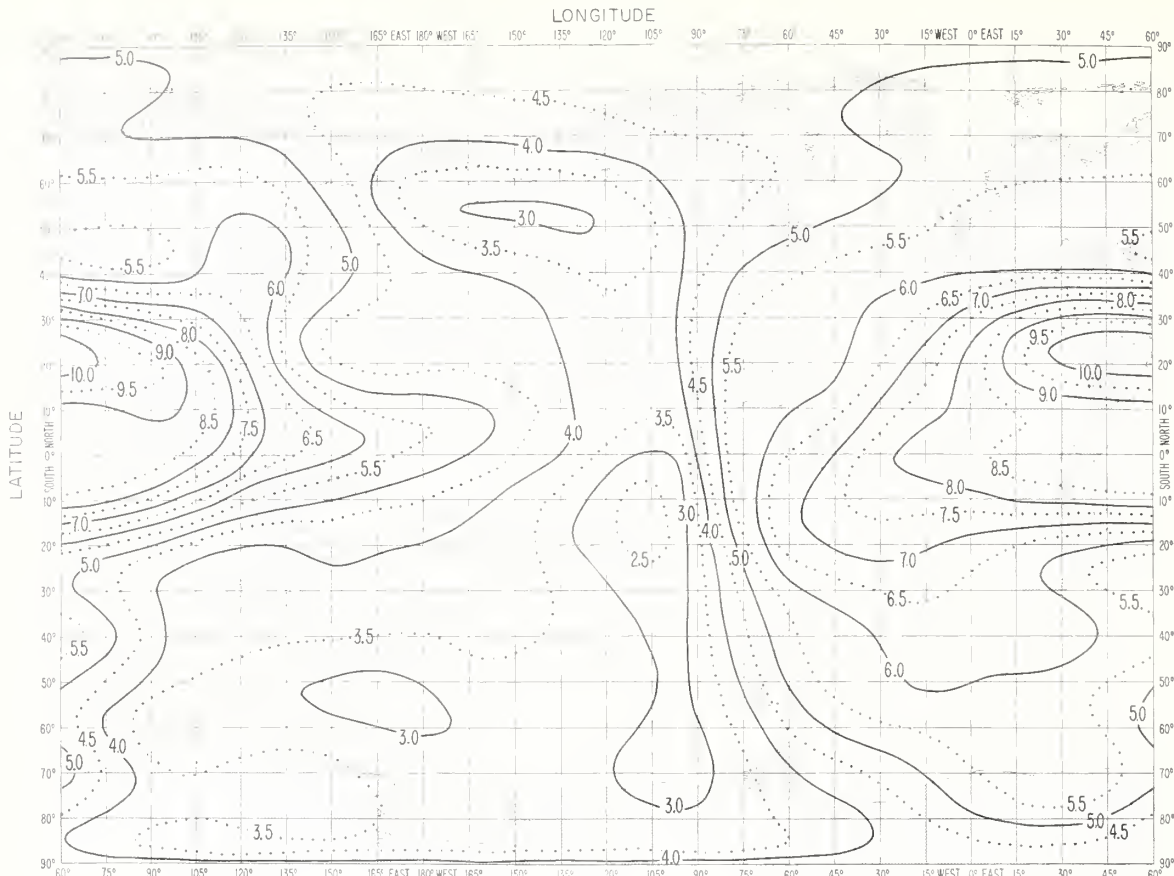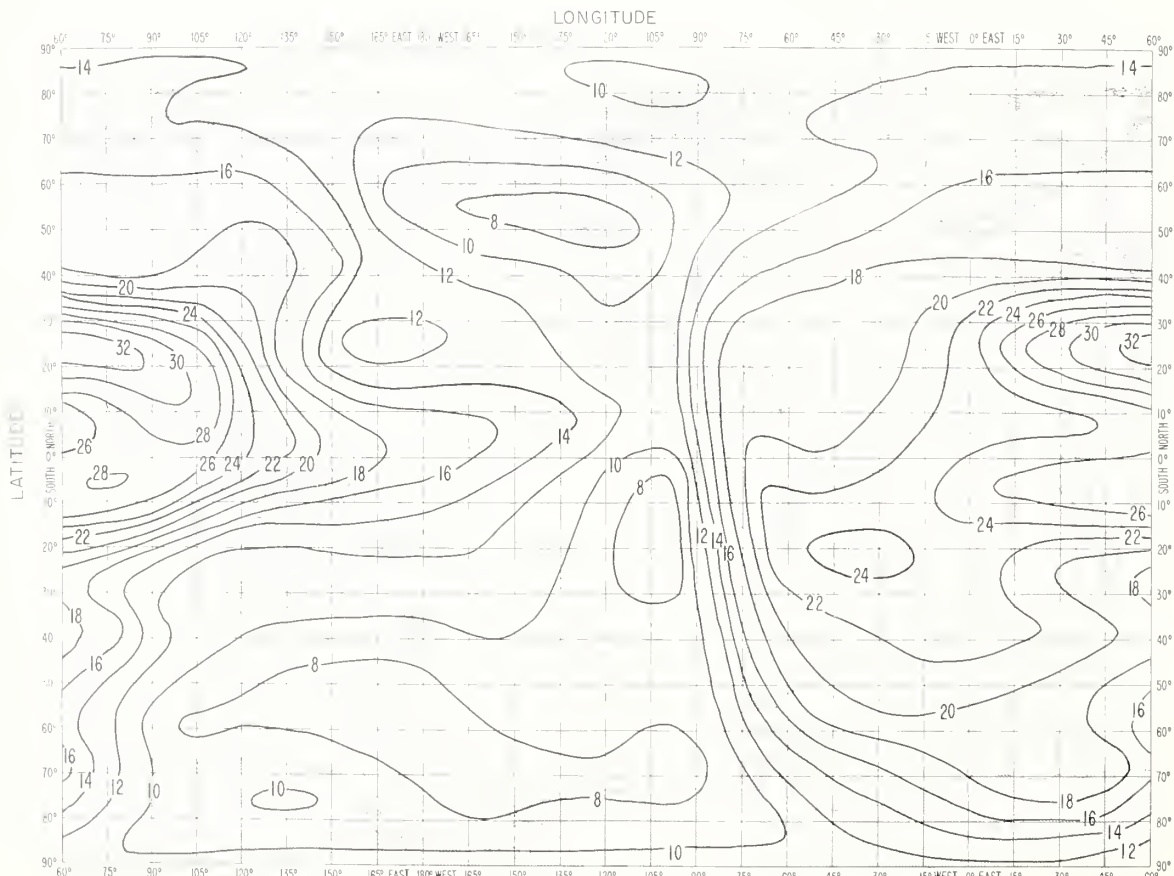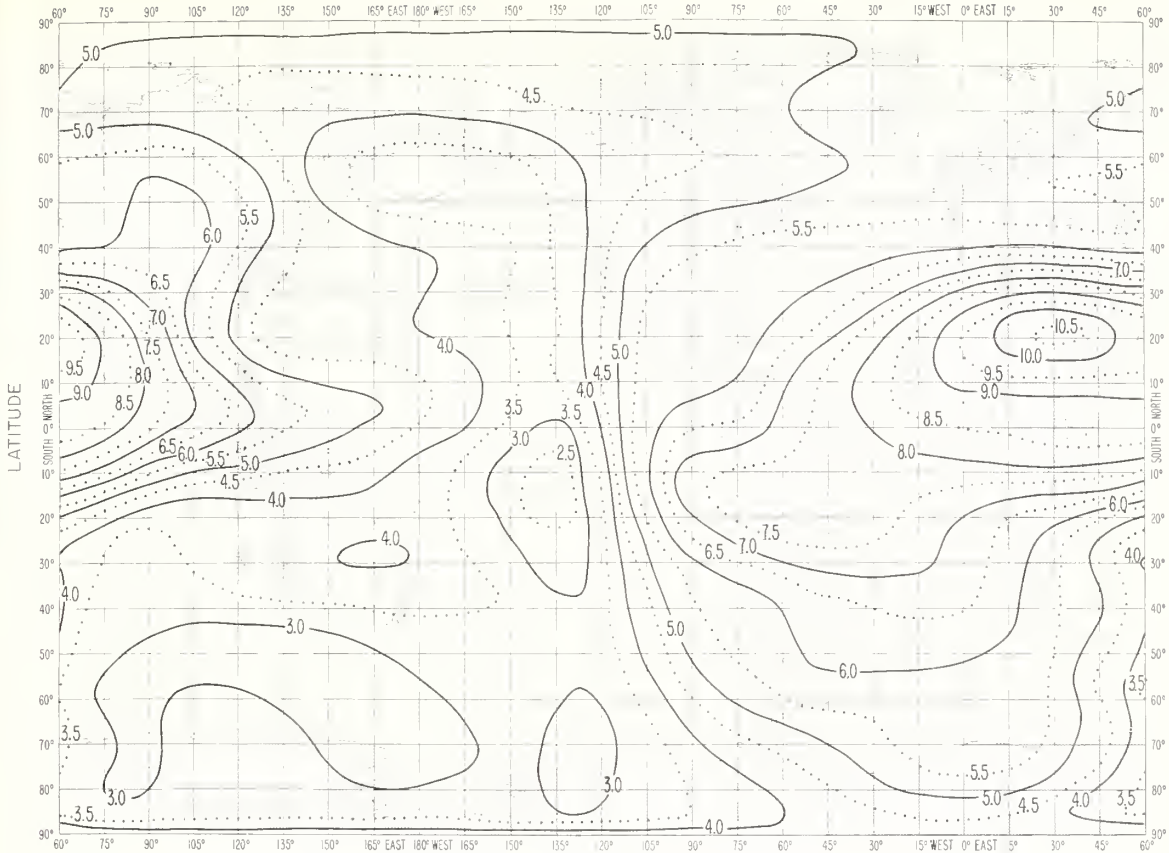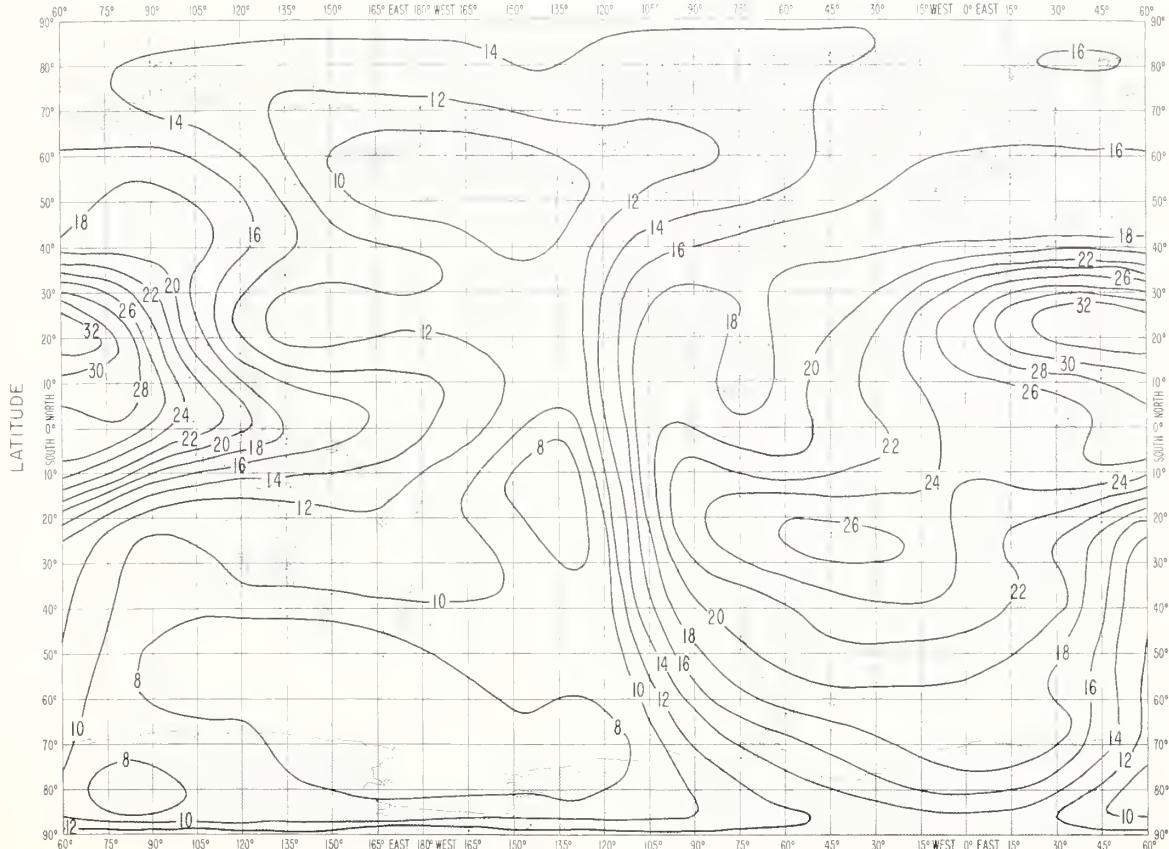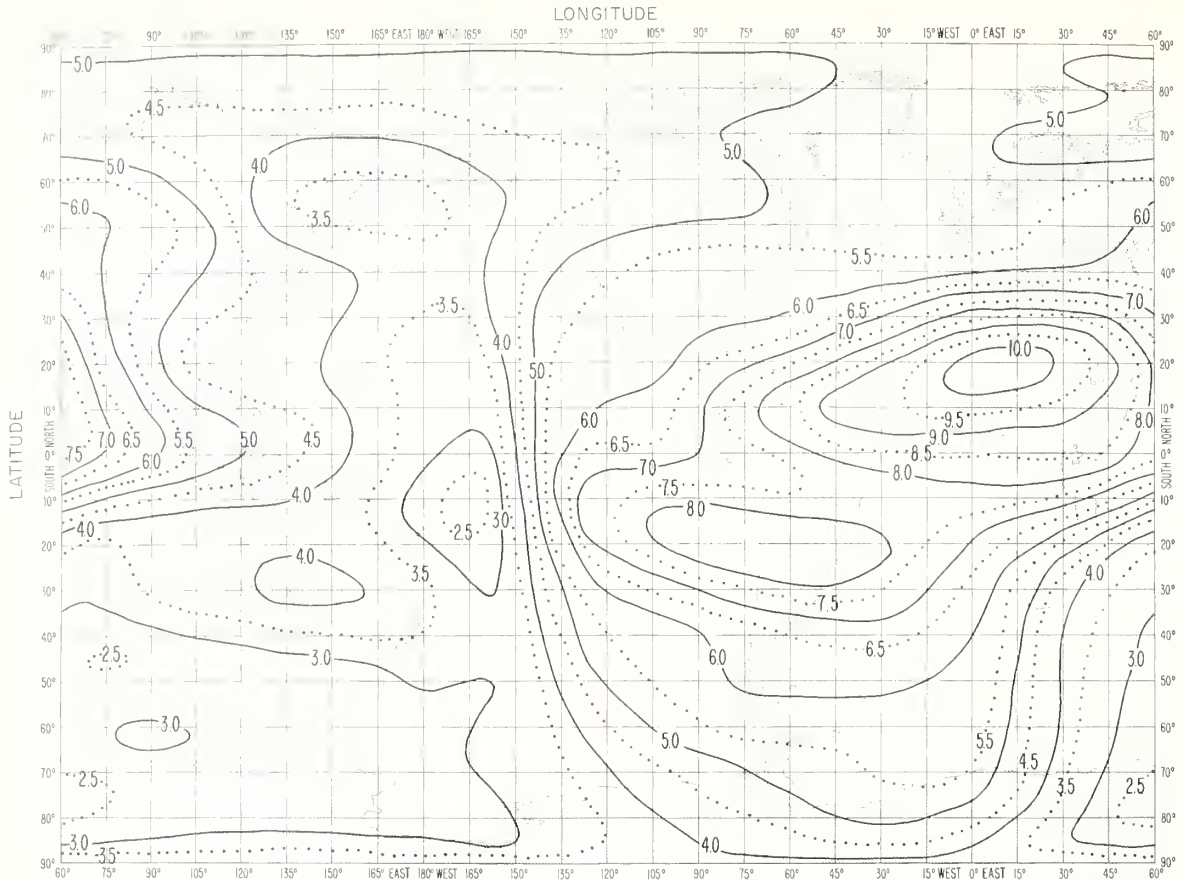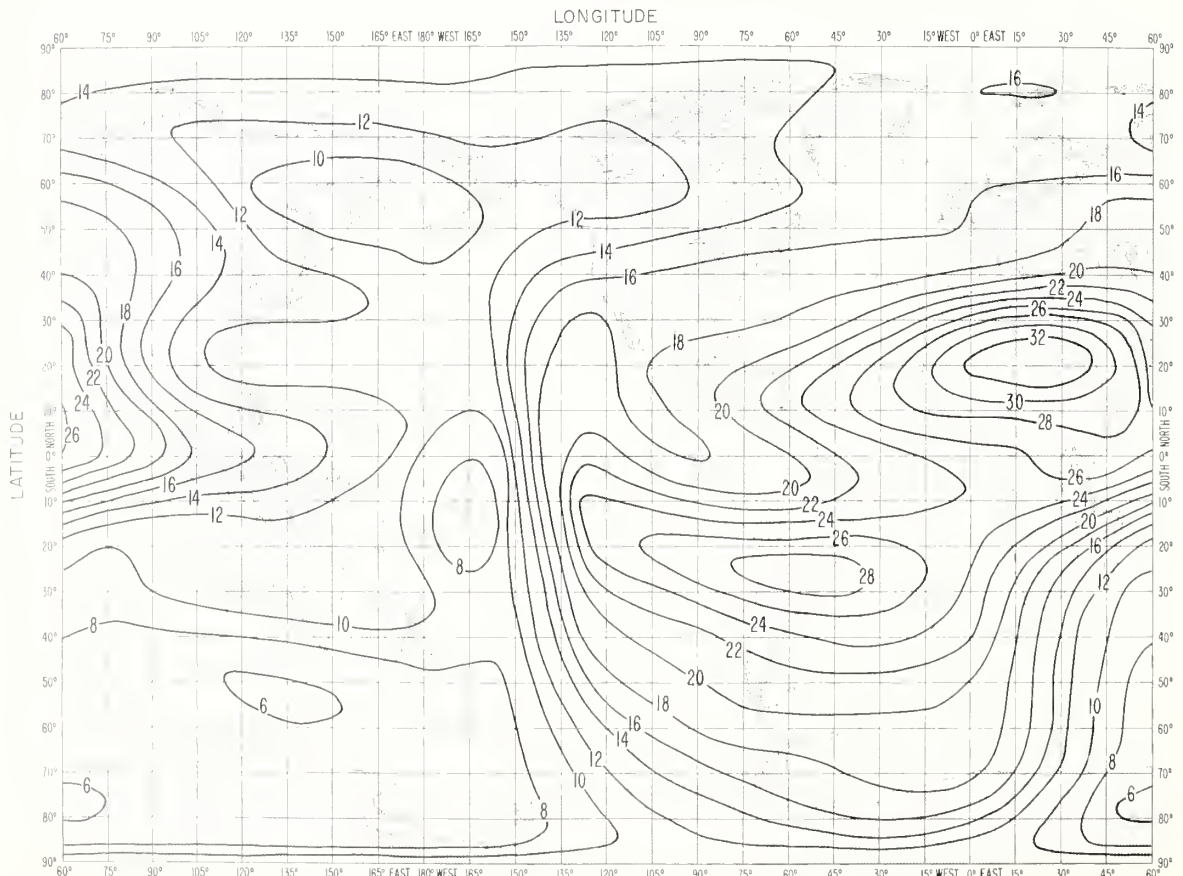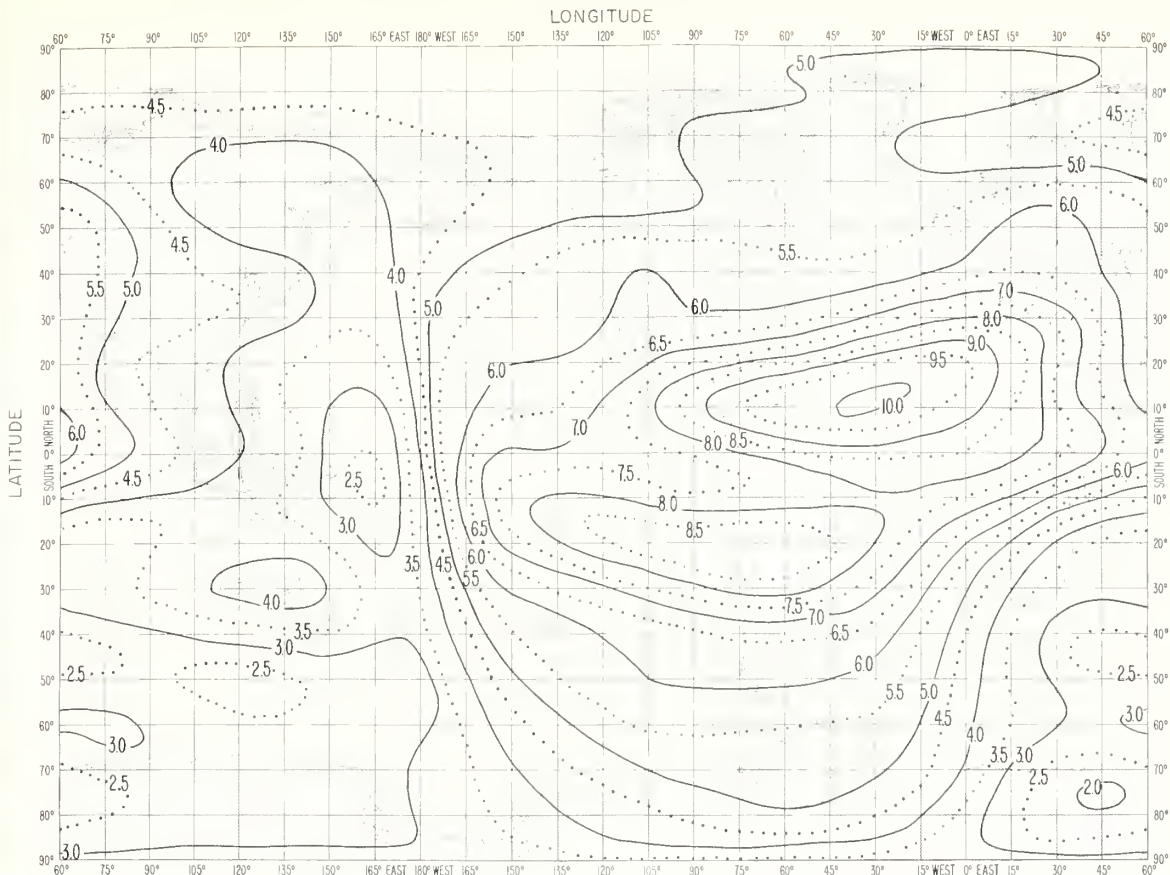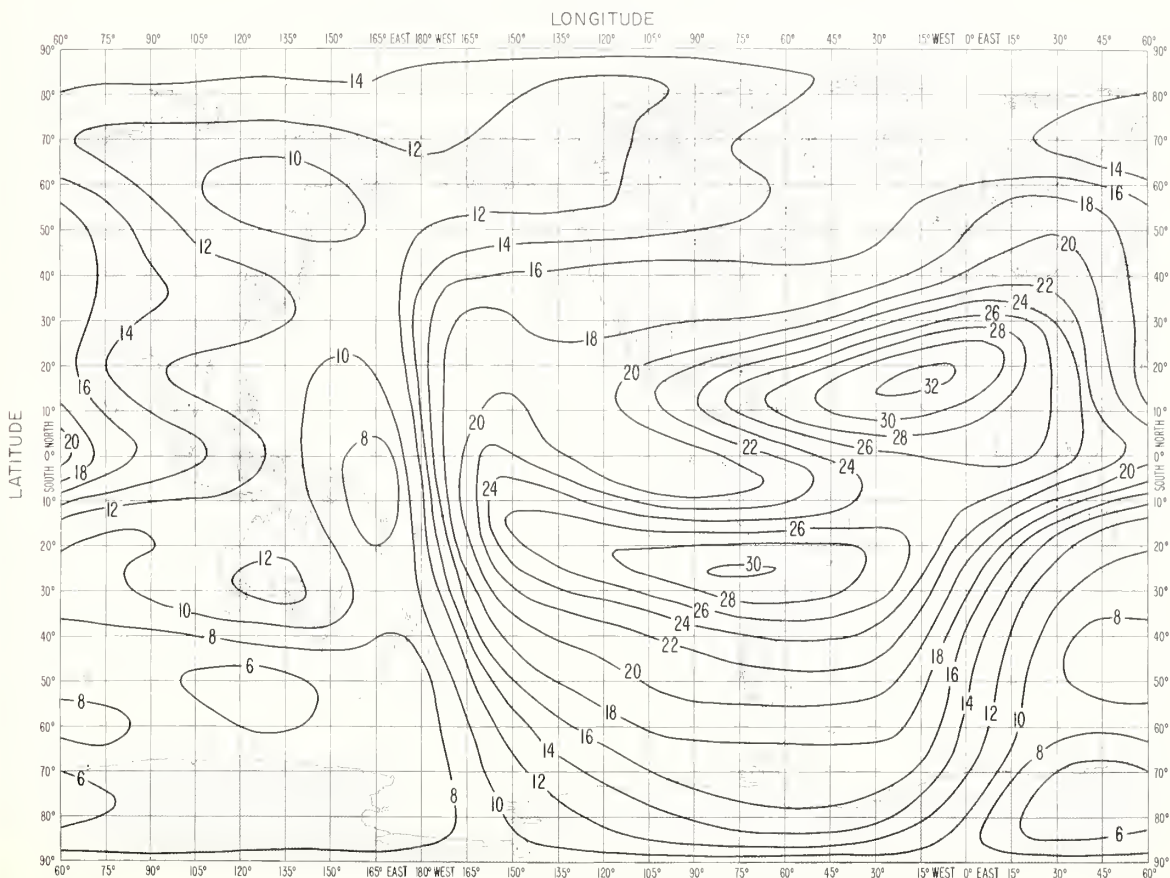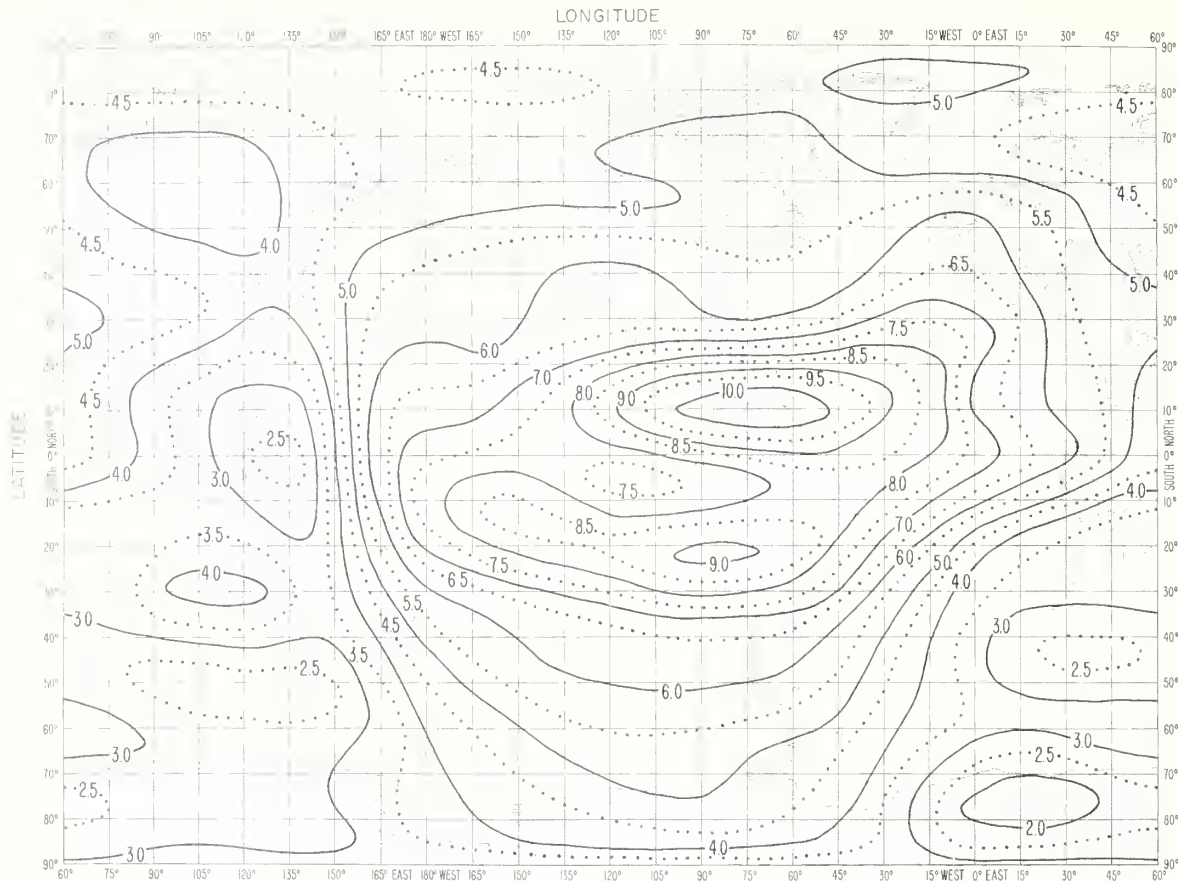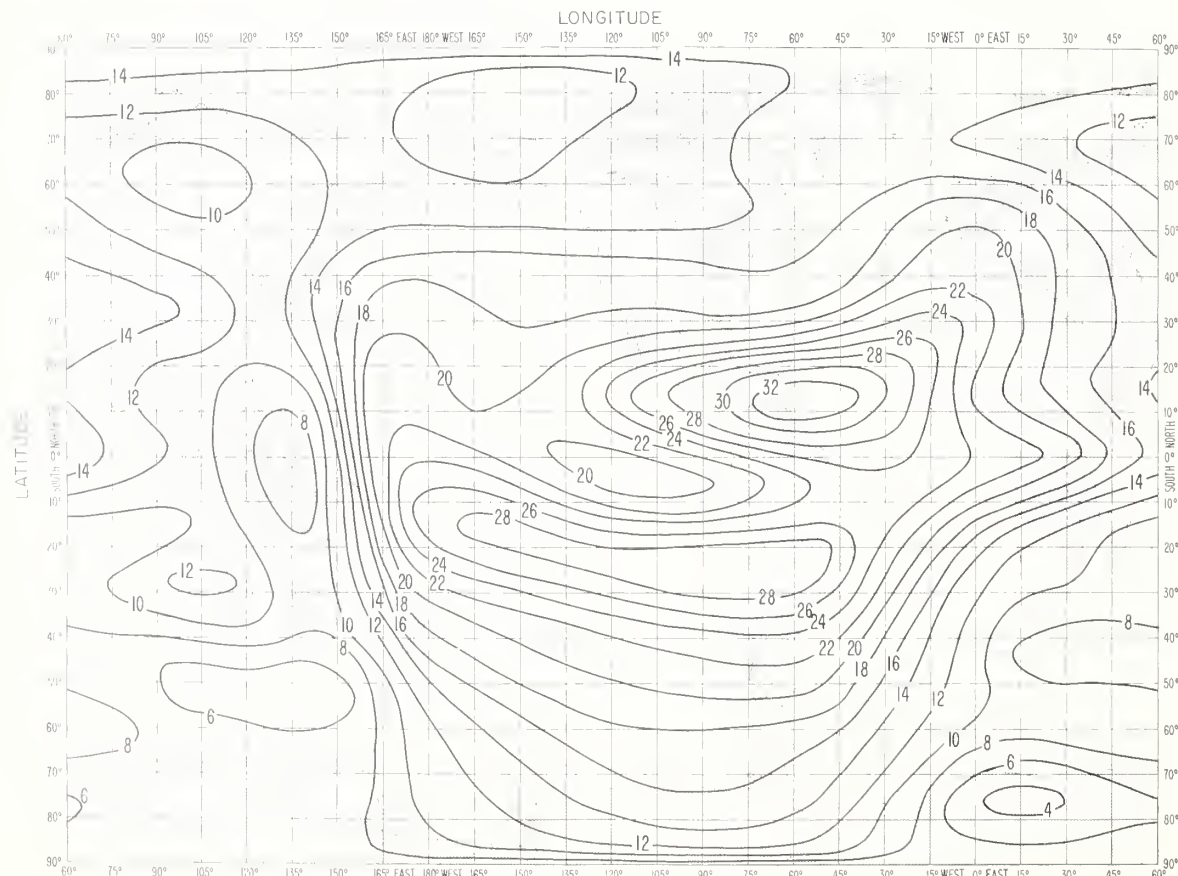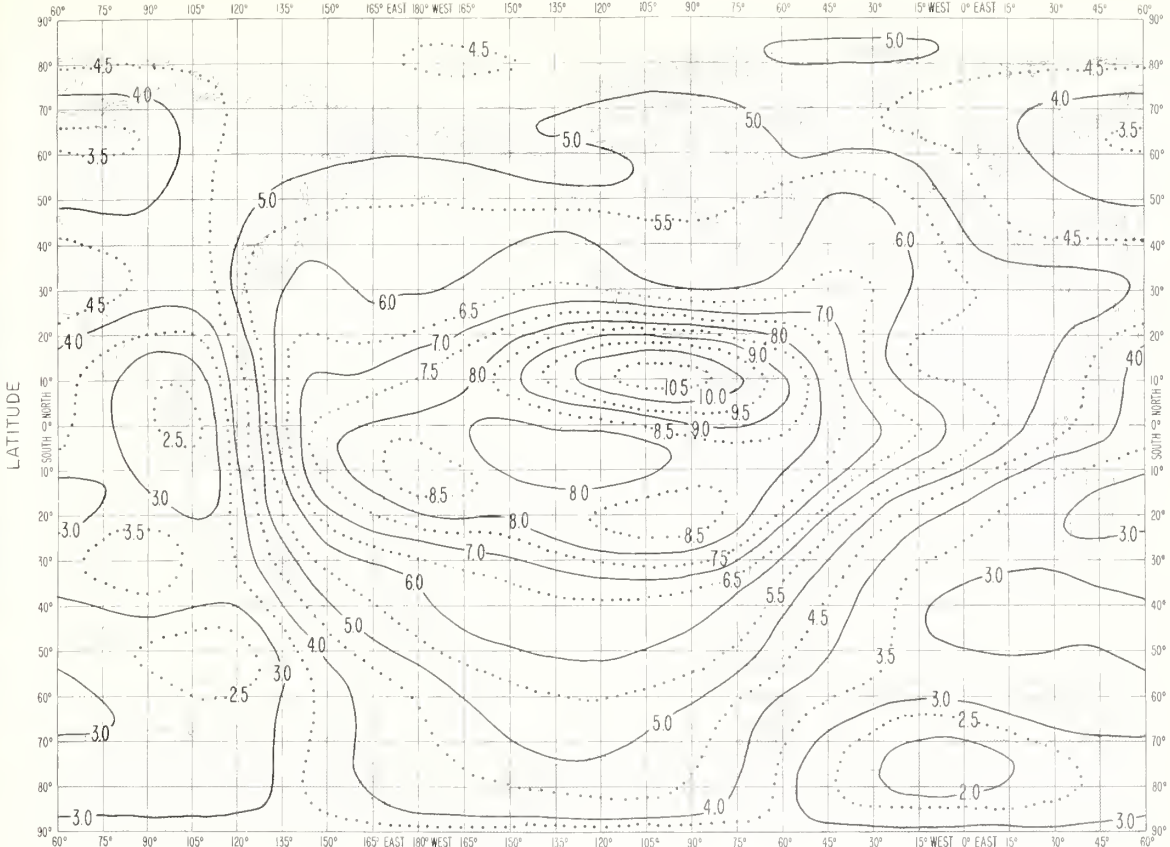
AUGUST 1964   UT=06

FIG 4A   PREDICTED MEDIAN MUF(ZERO)F2 (Mc/s)

FIG. 4B. PREDICTED MEDIAN MUF(4000)F2 (Mc/s)

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LONGITUDE

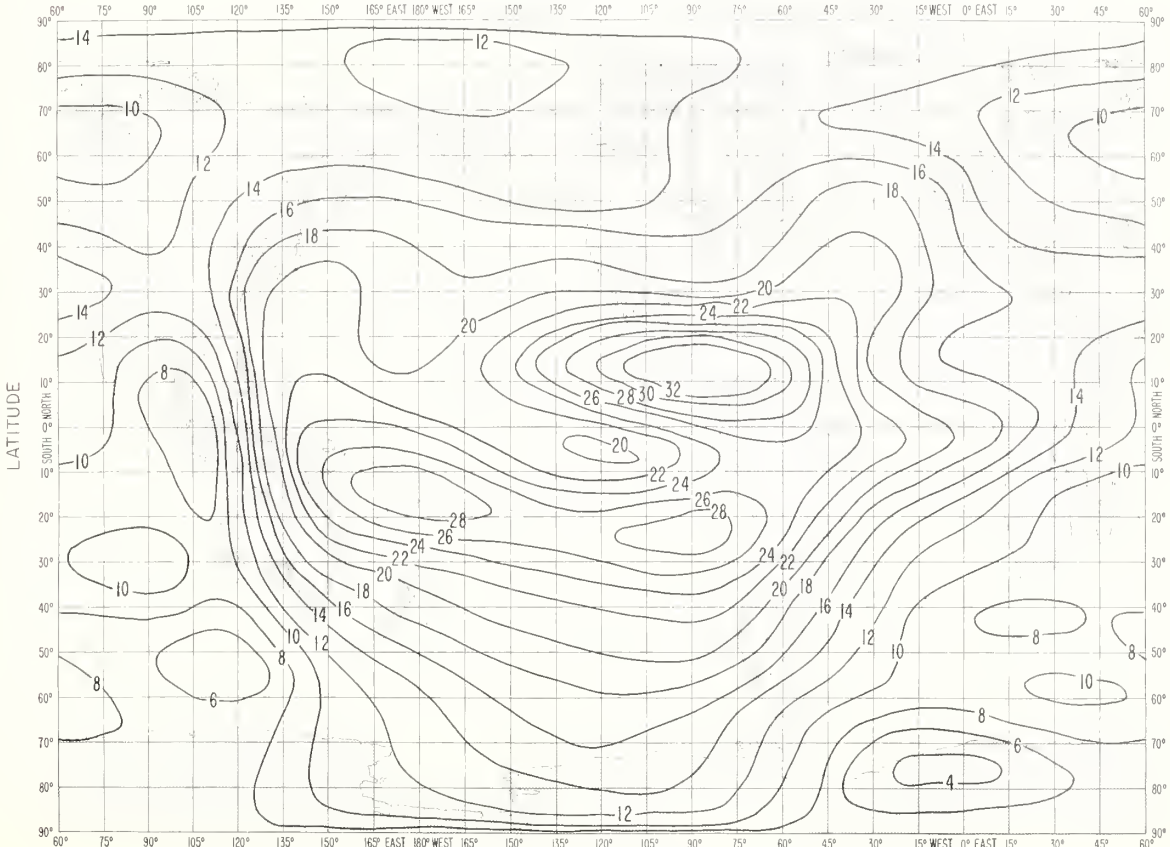FIG 5A   PREDICTED MEDIAN MUF(ZERO)F2 (Mc/s)

LONGITUDE

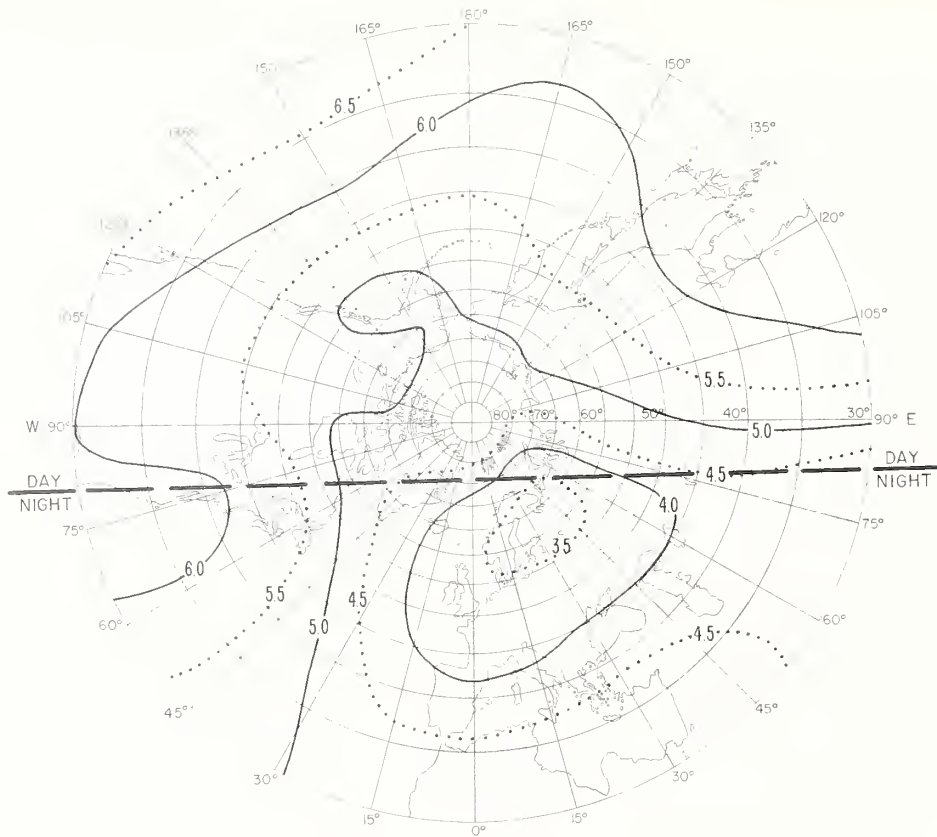FIG. 5B.   PREDICTED MEDIAN MUF(4000)F2 (Mc/s)

AUGUST 1964   UT = 10
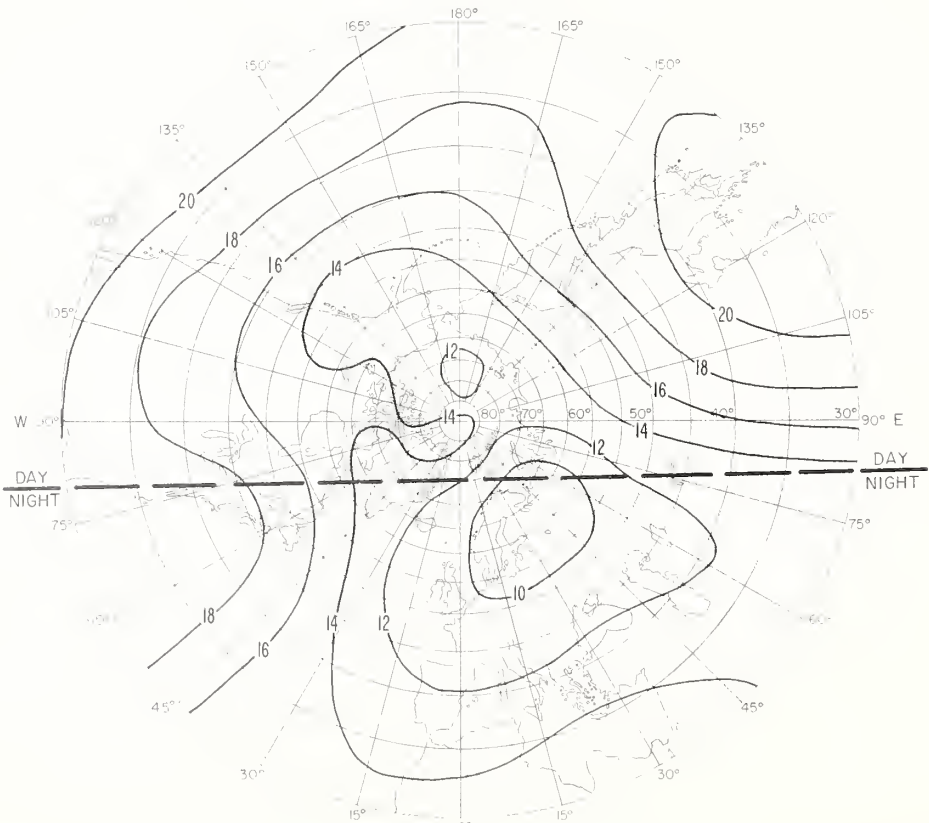

FIG 6A   PREDICTED MEDIAN MUF(ZERO)F2 (Mc/s)

FIG. 6B. PREDICTED MEDIAN MUF(4000)F2 (Mc/s)

AUGUST 1964 UT=12

FIG. 7A. PREDICTED MEDIAN MUF(ZERO)F2 (Mc/s)

FIG. 7B. PREDICTED MEDIAN MUF(4000)F2 (Mc/s)
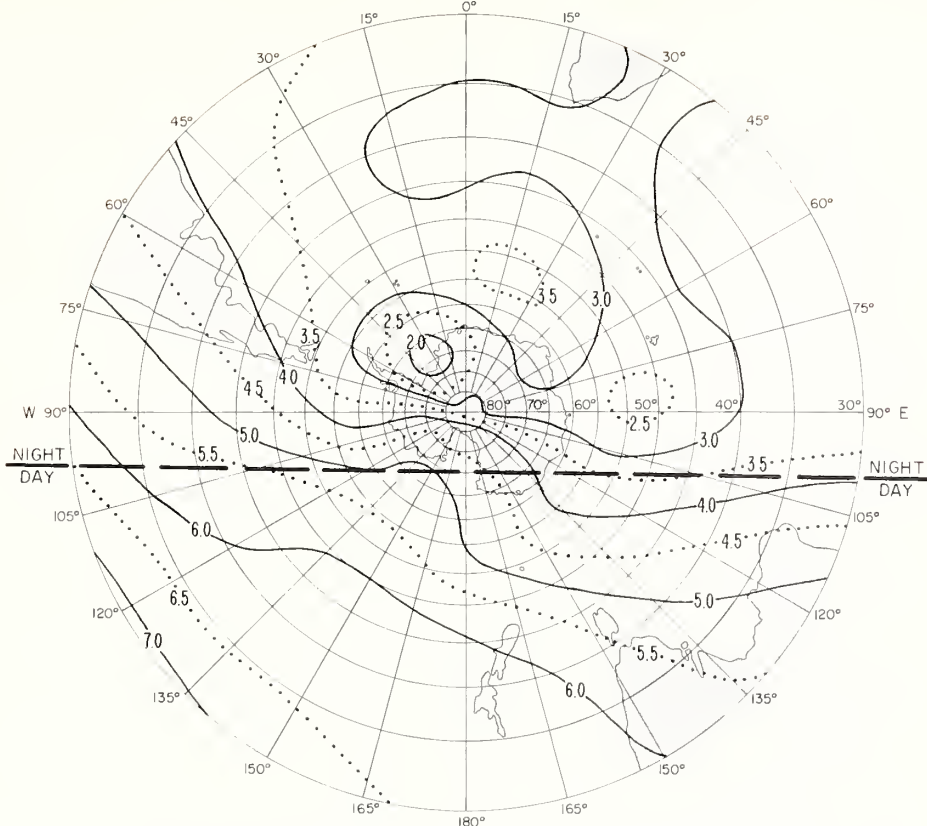
FIG. 8A. PREDICTED MEDIAN MUF (ZERO)F2 (Mc/s)

FIG. 8B. PREDICTED MEDIAN MUF (4000)F2 (Mc/s)

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FIG. 9A.   PREDICTED MEDIAN MUF (ZERO)F2 (Mc/s)

FIG. 9B.   PREDICTED MEDIAN MUF(4000)F2 (Mc/s)

FIG 10A.   PREDICTED MEDIAN MUF (ZERO) F2 (Mc/s)

FIG. 10B.   PREDICTED MEDIAN MUF (4000) F2 (Mc/s)
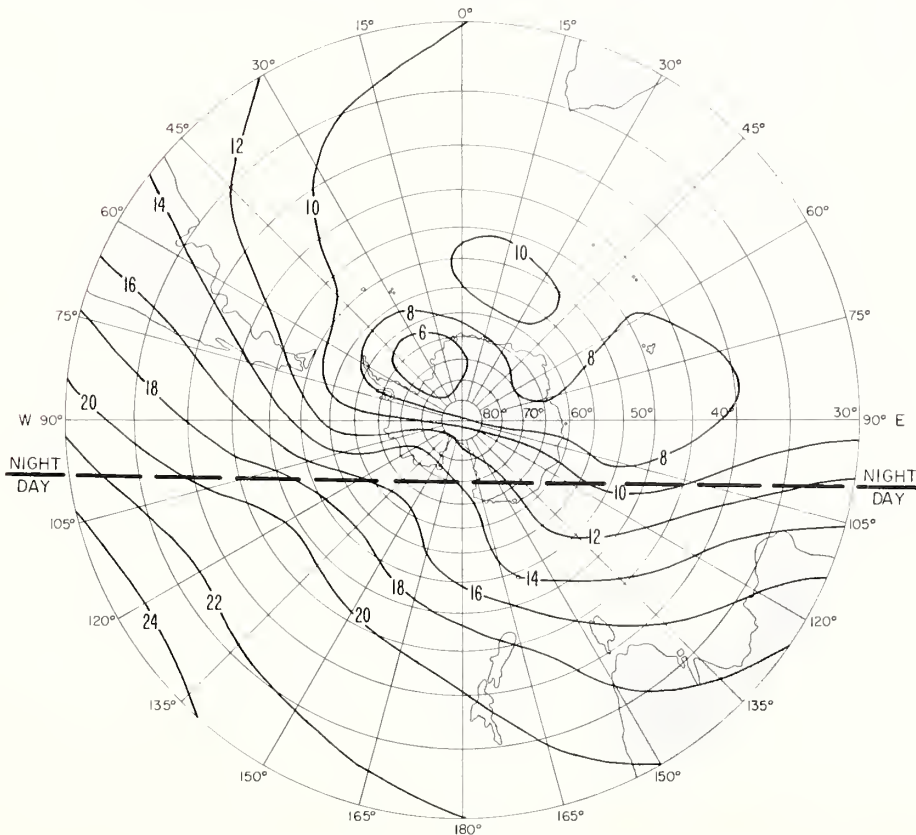
FIG 11A. PREDICTED MEDIAN MUF (ZERO) F2 (Mc/s)

FIG 11B. PREDICTED MEDIAN MUF (4000) F2 (Mc/s)

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FIG 12A   PREDICTED MEDIAN MUF (ZERO) F2 (Mc/s)

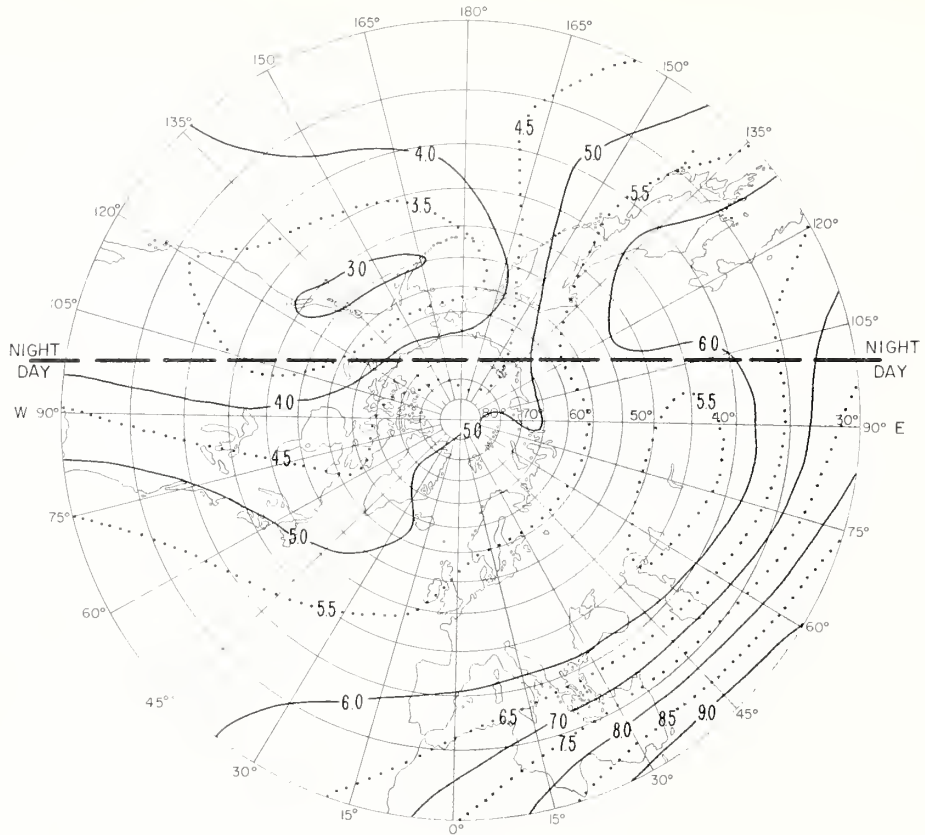FIG. 12B.   PREDICTED MEDIAN MUF (4000) F2 (Mc/s)

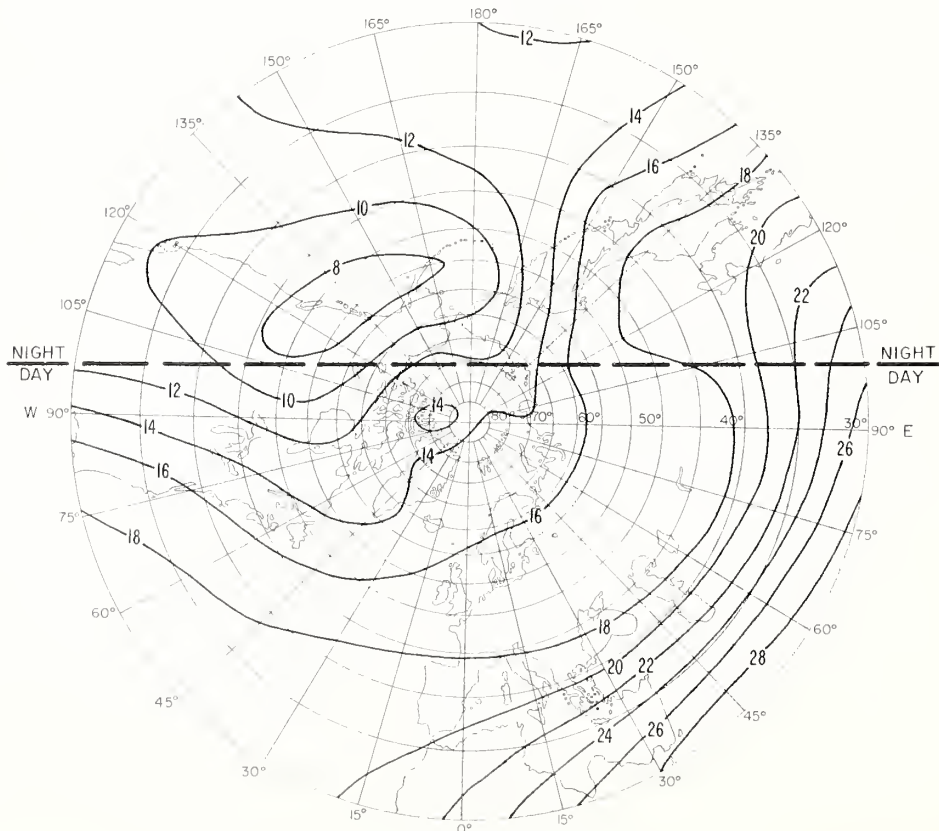FIG. 13A. PREDICTED MEDIAN MUF (ZERO)F2 (Mc/s)

FIG. 13B. PREDICTED MEDIAN MUF (4000)F2 (Mc/s)

SOUTH POLAR AREA
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FIG. 14A. PREDICTED MEDIAN MUF(ZERO)F2 (Mc/s)

FIG. 14B. PREDICTED MEDIAN MUF(4000)F2 (Mc/s)

FIG. 15A. PREDICTED MEDIAN MUF (ZERO)F2 (Mc/s)

FIG. 15B. PREDICTED MEDIAN MUF (4000)F2 (Mc/s)

SOUTH POLAR AREA

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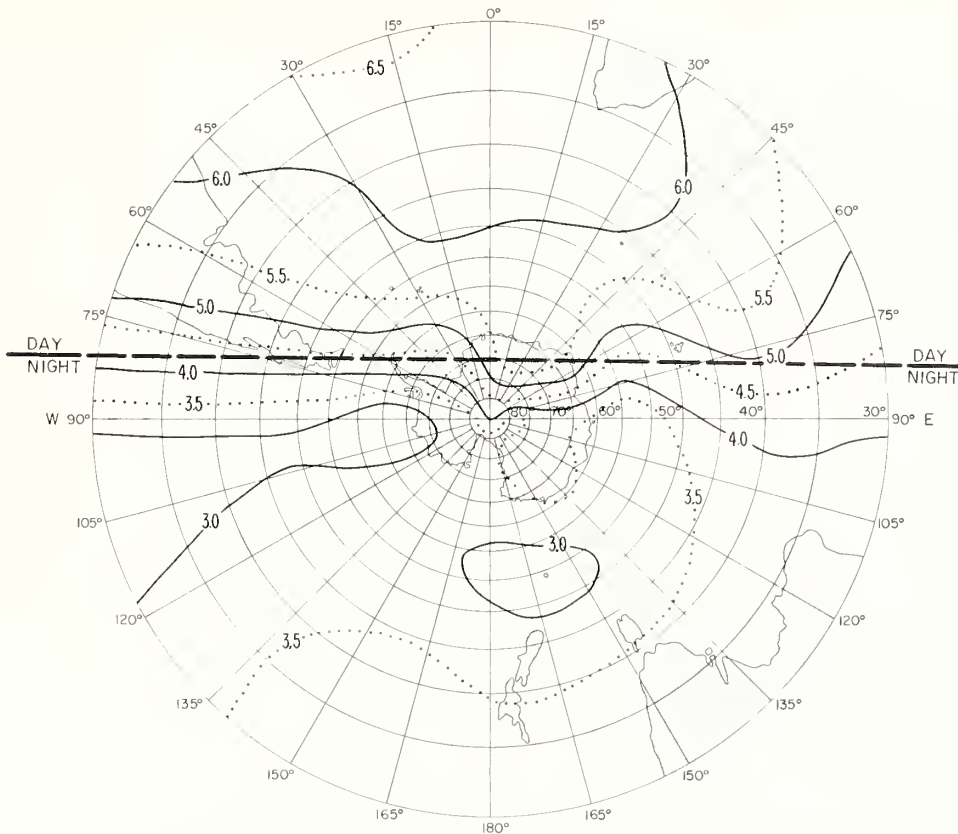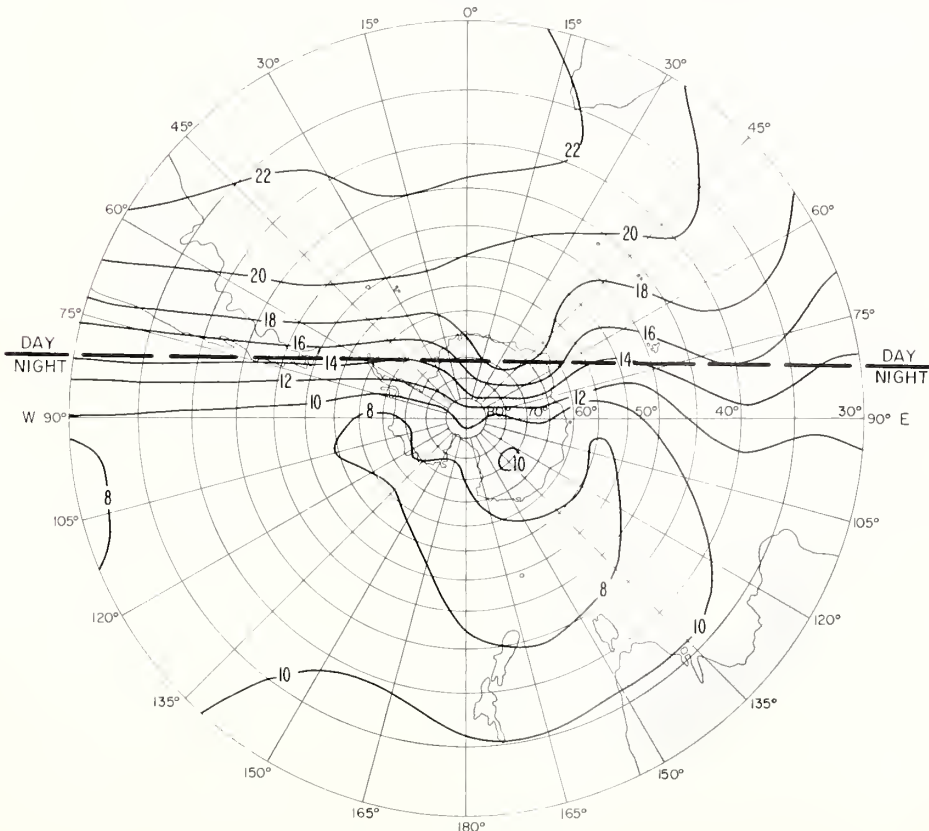FIG. 16A. PREDICTED MEDIAN MUF(ZERO)F2 (Mc/s)

FIG. 16B. PREDICTED MEDIAN MUF(4000)F2 (Mc/s)

DEPARTMENTS OF THE ARMY
AND THE AIR FORCE
WASHINGTON, D. C., 20301, *1 May 1964*

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NG: None.
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For explanation of abbreviations used, see AR 320–50.