Discrepancy between c1 and c 2

necessitated duplicating

both copies

Zohrab Kaprielian

1943

Harmonic Analysis of Atmospheric Pressure & Temperature for (Ksara and Bagdad)

Introduction

The original aim of this work was the study of the harmonic analyses of the Pressure and Temperature in the Near-East, to be represented by the following Stations:

Beirut.	(Characterizing sea shore climate)
Bagdad.	(" desert ")
Ksara.	(" mountain ")

But due to the war circumstance it was impossible to obtain the necessary material and information for all the three Stations, and so the work was carried for Bagdad and Ksara only.

It would be very helpful and interesting to complete this work in future.

Chapter I

Material for the Analyses

The material for Ksara was obtained from the official yearly bulletins of the Observatory.
The Ksara[1] observatory is situated
Latitude 33°49'25" N
Longitude 35°53'25" E ($2^h 23^m 35^s$)

The meteorological office of Iraq could provide us only with the thermograms and the barograms of Hinaidi.[2]
Hinaidi is situated
Latitude 33°17' N
Longitude 44°29' E (2^h 57' 56")

To eliminate the effect of the disturbances which are not of a diurnal or of a still shorter period, character, the hourly means of periods of ten years was carried, namely from (1928–1938). Because of the long time required for the reading of the thermograms and the barograms the work was carried only for the year of (1934).

(1) Ksara is an observatory of first order in Lebanon.

(2) Hinaidi is near Bagdad. The meteorological station of Hinaidi is transfered to Habbaniya in (1937)

Reading of the records:

The most important of the difficulties met in reading the graphs were two.

a.) the irregularities of the clock (instruments)
b.) the possible errors of the observer.

The thermograms contained 3 readings of the standard thermometer at specified hours. These were enough to take care of the instrument error and the irregularities of the clock. The instrument error and other errors were corrected using the appropriate method according to the conditions imposed. The space between the curvilinear line was one hour, so that the reading could be carried without any possibility of confusion.

For the barograms the space between the successive curvilinear lines was 3 hrs. so that there was the necessity of using transparent paper divided into lines of one hour interval according to the scale of the barograms. The error of the instrument and specified hours on the graph were recorded. The clock did not have any irregularities like that of the thermograph and records were more clean.

Chapter II

Computation of the Coefficients

The computational work connected with Fourier Analyses is based on the following formula.

$$P = A_0 + A_1 \sin(\theta + \varphi_1) + A_2 \sin(2\theta + \varphi_2) + A_3 \sin(3\theta + \varphi_3) \ldots A_n(\sin n\theta + \varphi_n)$$

For a series of 24 equidistant observations t_1, t_2, t_3 ..... t_{24} in the cycle, the numerical computations may be made directly from the following equations:

$$A_0 = \frac{1}{24}\left(t_1 + t_2 + t_3 \ldots\ldots\ldots t_{23} + t_{24}\right)$$

$$\begin{aligned}
12a_1 = {} & 0.966(t_1 - t_{11} - t_{13} + t_{23}) + 0.866(t_2 - t_{10} - t_{14} + t_{22}) \\
& + 0.707(t_3 - t_9 - t_{15} + t_{21}) + 0.500(t_4 - t_8 - t_{16} + t_{20}) \\
& + 0.259(t_5 - t_7 - t_{17} + t_{19}) + t_{24} - t_{12}
\end{aligned}$$

$$\begin{aligned}
12b_1 = {} & 0.259(t_1 + t_{11} - t_{15} - t_{23}) + 0.500(t_2 + t_{10} - t_{14} - t_{22}) \\
& + 0.707(t_3 + t_9 - t_{15} - t_{21}) + 0.866(t_4 + t_8 - t_{16} - t_{20}) \\
& + 0.966(t_5 + t_7 - t_{17} - t_{19}) + t_6 - t_{18}
\end{aligned}$$

$$\begin{aligned}
12a_2 = {} & 0.866(t_1 - t_5 - t_7 + t_{11} + t_{13} - t_{17} - t_{19} + t_{23}) \\
& + 0.500(t_2 - t_4 - t_8 + t_{10} + t_{14} - t_{16} - t_{20} + t_{22}) \\
& - t_6 + t_{12} - t_{18} + t_{24}
\end{aligned}$$

$$\begin{aligned}
12b_2 = {} & 0.500(t_1 + t_5 - t_7 - t_{11} + t_{13} + t_{17} - t_{19} - t_{23}) \\
& + 0.866(t_2 + t_4 - t_8 - t_{10} + t_{14} + t_{16} - t_{20} - t_{22}) \\
& - t_3 + t_{4} - t_{15} + t_{21}
\end{aligned}$$

$$\begin{aligned}
12a_3 = {} & 0.707(t_1 - t_3 - t_5 + t_7 + t_9 - t_{11} - t_{13} + t_{15} + t_{17} - t_{19} - t_{21} + t_{23}) \\
& - t_4 + t_8 - t_{12} + t_{16} - t_{20} + t_{24}
\end{aligned}$$

$$12b_3 = 0.707(t_1 + t_3 - t_5 - t_7 + t_9 + t_{11} - t_{13} - t_{15} + t_{17} + t_{19} - t_{21} - t_{23})$$

$$\begin{aligned}
12a_4 = {} & 0.500(t_1 - t_2 - t_4 + t_5 + t_7 - t_8 - t_{10} + t_{11} + t_{13} - t_{14} - t_{16} + t_{17} + t_{19} \\
& - t_{20} - t_{22} + t_{23}) - t_3 + t_6 - t_9 + t_{12} - t_{15} + t_{18} - t_{21} + t_{24}
\end{aligned}$$

$$\begin{aligned}
12b_4 = {} & 0.866(t_1 + t_2 - t_4 - t_5 + t_7 + t_8 - t_{10} - t_{11} + t_{13} + t_{14} - t_{16} - t_{17} \\
& + t_{19} + t_{20} - t_{22} - t_{23})
\end{aligned}$$

and other expressions of like character for terms of higher order. For most practical purposes the series is not in general improved by the addition of terms beyond the fourth. On the solution of these equations by substitution of the observed values the coefficients A_1, A_2, A_3, A_4 & φ_1, φ_2, φ_3, φ_4 the phase angles, may be determined by the following relations:

$A_1 = \sqrt{a_1^2 + b_1^2}$ $\quad A_2 = \sqrt{a_2^2 + b_2^2}$ $\quad A_3 = \sqrt{a_3^2 + b_3^2}$ $\quad A_4 = \sqrt{a_4^2 + b_4^2}$

$\tan\varphi_1 = a_1/b_1$ $\quad \tan\varphi_2 = a_2/b_2$ $\quad \tan\varphi_3 = a_3/b_3$ $\quad \tan\varphi_4 = a_4/b_4$

Check Work:

The computations being very tedious it is essential to apply a check on the computations which is of an independent nature & does not consist in simply going over the computations a second time.

Examination for 24 equidistant values shows that for a four-term series t_1 is multiplied once by + 0.966, twice by 0.866, twice by 0.707, twice by +0.500 & once by + 0.259, the sum of these multipliers being 5.371; likewise t_2 is multiplied once by + 1.000 three times by 0.866, twice by + 0.500 & once by - 0.50 their sum being + 4.098. In this manner has bee obtained the following table, which gives the multipliers (f) of each of the 24 values t.

1	2	3	4	5	6	7	8
+5.371	+4.098	+1.414	-0.6340	-0.9215	0.000	+0.7071	+.3660
9	**10**	**11**	**12**	**13**	**14**	**15**	**16**
-0.5858	-1.098	-0.7071	0.000	+0.0931	+6.340	+1.414	-1.366
17	**18**	**19**	**20**	**21**	**22**	**23**	**24**
-0.5426	0.000	-0.7071	-2.366	-3.414	-2.366	+0.2071	+4.00

It is quite apparent then, that in order to obtain a check on the various operations of the harmonic analyses by which are computed the Fourier coefficients a & b, it is only necessary to multiply the separate ordinates t_1, t_2 .... t_{24} by their respective values of f as given in table. The algebraic sum of the resulting product should be equal to the algebraic sum of the coefficients a & b.

In practice three significant figures of f quantities gives ample refinement, but due to the relatively small variation of the pressure, the coefficients of the third & fourth terms were very small both for Ksara & Bagdad, so that to avoid possible mistakes I carried the computations without the dropping of decimals beyond the third significant figure.

The next step is to check the amplitudes A & the phase angles φ:

$$A = (a^2 + b^2)^{1/2} \qquad \tan\varphi = \frac{a}{b}$$

The expressions for these quantities lend themselves to a simple graphical solution, A being considered the hypotenuse & φ one of the acute angles of a right triangle.

The device suggested to carry on the check consists of a network of horizontal & vertical lines according to any suitable size & scale depending on the magnitude of the coefficients that appear in the Fourier computations. A quadrant of a circle is devided into degrees is laid laid down on the paper, & at its center a graduated revolving arm is fixed, the arm being made of celluloid or similar transparant material having a line scored on its underneath surface & passing truly through the center of the hole into which a clamp screw fits which holds the arm in place truly centered with respect to the system of coordinates. The center line of the revolving arm is graduated according to the same scale as that of the system.

To check the amplitude & phase angles, plot the point (a, b), the vertical scale being used for the a coefficient & the horizontal scale for the b coefficient. then swing the arm around the center until the center line coincides with the point (a, b). The amplitude A can be read on the center line scale, & the intersection of the center line & the circle determines the phase angle. The ideal arrangment would be to use a complete circle instead of a quadrant of a circle, so that the proper quadrant for fixing the angles would be automatically determined.

To carry on the check of the amplitudes & the phase angles I used a large sheet of squared paper. Putting in the center of the paper the origin of my coordinate scales. After plotting the different points (a, b), by the use of a ruler and a good celluloid protractor the amplitudes & the phase angles were determined very satisfactorily.

The Computation.

The specimen computation to be presented is a complete example of the harmonic analysis of the mean hourly values of the barometric pressure at Ksara for the August of (1928 - 1938).

The conveniently arranged form on which the computations are made was devised by W. J. Peters and C. R. Duvall of the Department of Terrestrial Magnetism. In the specimen suggested the functional quantities entering in the analyses have been divided by 12 instead of taking $\frac{1}{12}$th of the finally determined coefficients (a) and (b).

I thought it was more convenient to multiply the functional quantities as they stand, rather than by $\frac{1}{12}$th of their values. The increase of the numerical computational work is questionable. The only extra work is eight divisions by 12, which can be done mentally, on the other hand due to the fact that, some of the functional multipliers are unity, the computation in carrying on the multiplications becomes simplified. Moreover, due to the fact that, the amplitudes of the $\frac{1}{3}$ and $\frac{1}{4}$ diurnal waves are very small, possible errors might be hidden if the difference between $\Sigma f x t$ and $\Sigma(a+b)$ is not considered as a mistake beyond the second decimal place; and to avoid this it is advisable to multiply the functional quantities as they stand.

A second point is to be considered is the following: Instead of the mean values of the quantities to be used as my (t) quantities, it is better to choose the smallest whole number among the 24(t) quantities and calculating the difference of the (t) quantities and the smallest number found, to use these differences as the 24 (t)s. This will facilitate enormously the check work and the rest of the computation.

In the specimen the devison of the method considers the mean of the 24 values but it is not necessary to use the mean of the 24 (t) values in the calculations. It is just as good to choose any convenient number according to the given data and carry on the computations accordingly. The main point I like to emphasize, is the fact that it is not necessary to carry the quotient of the summation of the (t) quantities by 24 to many decimal places, thinking that the results might be improved and this way increasing the labour in the computation work.

Check of (a) and (b) Coefficients.

	+f	t	+(f×t)		-f	t	-(f×t)
1	5.371	1.09	5.85439	4	-0.6340	0.97	0.61498
2	4.098	1.00	4.09800	5	-0.9215	1.10	1.01365
3	1.414	0.95	1.34330	6	0.000	1.30	0.890416
7	0.7071	1.51	1.067721	9	-0.5858	1.52 ↗	1.48230
8	0.3660	1.55	0.56730	10	-1.098	1.35 ↗	0.756597
12	0.0000	0.87	0.00000	11	-0.7071	1.07 ↗	0.27896
13	0.0931	0.64	0.059584	14	-0.6340	0.44 ↗	0.48076
18	0.0000	0.48	0.000000	15	-1.414	0.34 ↗	0.39614
23	0.7071	1.42	1.004082	16	-1.366	0.29 ↗	0.168206
24	4.000	1.30	5.2	17	-0.5426	0.31 ↗	0.544467
				19	-0.7071	0.77 ↗	2.74456
				20	-2.366	1.16 ↗	4.71132
				21	-3.414	1.38 ↗	3.40704
				22	-2.366	1.44 ↗	
			19.194377				17.489396

$\Sigma fxt = 1.704981$

$\Sigma\, 12a + 12b = 1.70493$

Difference = 0.00051

$\frac{1}{12} \Sigma fxt = 0.142082$

$\Sigma a + b = 0.142170$

Difference = 0.000088

August Asara (Pressure)

0		
1	680.09	1.09
2	680.00	1.00
3	679.95	0.95
4	679.97	0.97
5	680.10	1.10
6	680.30	1.30
7	680.51	1.51
8	680.55	1.55
9	680.52	1.52
10	680.35	1.35
11	680.07	1.07
12	679.87	0.87
13	679.64	0.64
14	679.44	0.44
15	679.34	0.34
16	679.24	0.29
17	679.31	0.31
18	679.48	0.48
19	679.77	0.77
20	680.16	1.16
21	680.38	1.38
22	680.44	1.44
23	680.42	1.42
24	680.30	1.30
Σ		24.25
1/24		1.01

	Ordinate less mean		3	4
	(1)	(2)	(1) +	(2).
	1-12	24-13	2-3	m-h
a		0.29	0.29	-0.14
b	0.08	0.41	0.49	-0.31
c	-0.01	0.43	0.42	-0.23
d	-0.06	0.37	0.31	-0.16
e	-0.04	0.15	0.11	-0.18
f	0.09	-0.24	-0.15	-0.20
g	0.29	-0.53	-0.24	
h	0.50	-0.70		
i	0.54	-0.72		
j	0.51	-0.67		
k	0.34	-0.57		
l	0.06	-0.37		
m	-0.14			

	11	12 (3)-(4)
a	1	0.43
b	0.966	0.80
c	0.866	0.65
d	0.707	0.47
e	0.500	0.29
f	0.259	0.05
		$12a_1$

	19	20	21	Comp
	(1) -	(2)	(19)+(20)	22
	b-g	l-h	b-g	
b	-0.33	0.43	0.10	0.259
c	-0.44	0.91	0.47	0.500
d	-0.43	1.18	0.75	0.707
e	-0.19	1.26	1.07	0.866
f	0.33	1.20	1.53	0.966
g	0.82		0.82	1
				$12b_1$

Time (G.M.T. + 2)

(5)	(6)	(7)	(8)	(9)	(10)
(3) +	(4)	(5) +	(6)	(7)-(8)	
a-d	g-e	a-b	d-c	a-b	
0.15	-0.24	-0.09	0.15	-0.24	1
0.18	-0.35	-0.17	0.12	-0.29	0.500
0.19	-0.07				
0.15					

Comp of a_2

	13	13x14	14 (5)-(6)
a	1	0.39000	0.39
b	0.866	0.45898	0.53
c	0.500	0.13000	0.26

Note: The rectangular components of the amplitudes are the sums of of the columns, in their respective compartments divided by twelve.

11x12
0.43000
0.77280
0.56290
0.33229
0.14500
0.01295

Comp. of a_3

From 12	15	16	15x16
a-e	0.14	1	0.14
b-d-f	0.28	0.707	0.19796

Comp of a_4

	9x10
a	-0.24
b	-0.145

= 2.25594 $12a_2$ = 0.97898 $12a_3$ = 0.33796 $12a_4$ = -0.385

of b_1 21x22
0.02590
0.23500
0.53025
0.92662
1.47798
0.82000

23	24
(19) -	(20)
b-d	f-e
-0.76	-0.87
-1.35	-1.45
-1.61	

Comp of b_4

29 (23)-(24)	30	29x30
b-c		
0.11	0.866	0.09526
0.10	0.866	0.08660

Comp of b_3

From 21	27	27x28	28
b+d-f	-0.68	-0.48076	0.707
c-g	-0.35	-0.35000	1.000

= 4.01575 $12b_2$ = -4.8498 $12b_3$ = -0.83076 $12b_4$ = 0.18186

comp b_2

	25	(23)+(24)	25x26
b	0.500	-1.63	-0.8150
c	0.866	-2.80	-2.4248
d	1	-1.61	-1.6100

a_1 = 0.18799 a_2 = 0.08158 a_3 = 0.02896 a_4 = -0.03200

b_1 = 0.33466 b_2 = -0.40415 b_3 = -0.06923 b_4 = 0.01516

Amplitudes and Phase Angles.

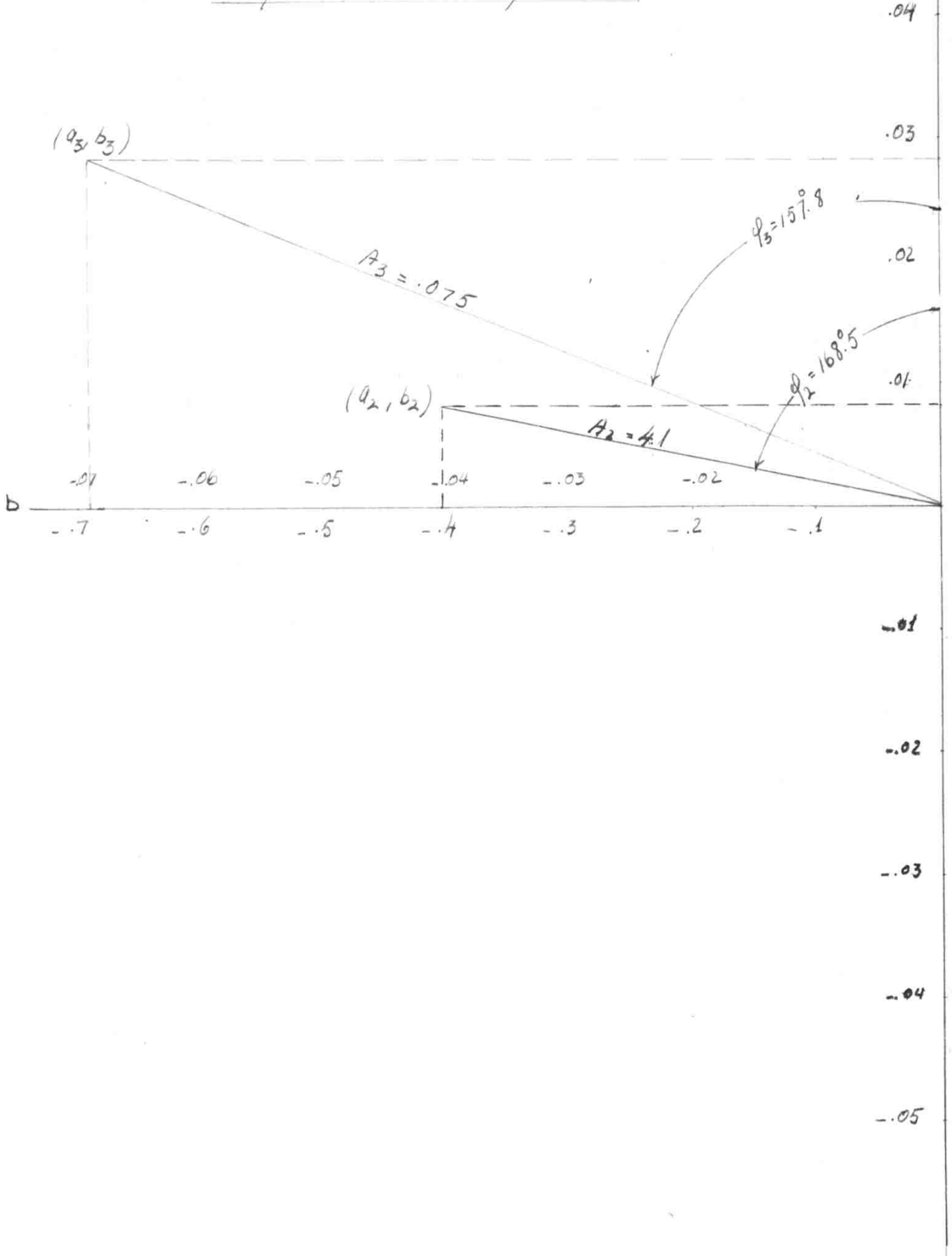
	Diurnal Wave	1/2 Diurnal Wave	1/3 Diurnal Wave	1/4 Diurnal Wave
a	0.1880	0.0816	0.0282	-0.0320
b	0.3347	-0.4041	-0.0692	0.0152
a^2	0.03534400	0.00665856	0.00079524	0.00102400
b^2	0.11202409	0.16329681	0.00478864	0.00023104
a^2+b^2	0.14736809	0.16995537	0.00558388	0.00125504
$\sqrt{a^2+b^2}$	0.3839	0.4123	0.0747	0.0354
$\tan\varphi = \frac{a}{b}$	0.56170	0.20193	0.40751	2.10526
φ	29°.322	168°.583	157°.83	295°.408
h	4^h.05	9^h.38	6^h.49	2^h.58

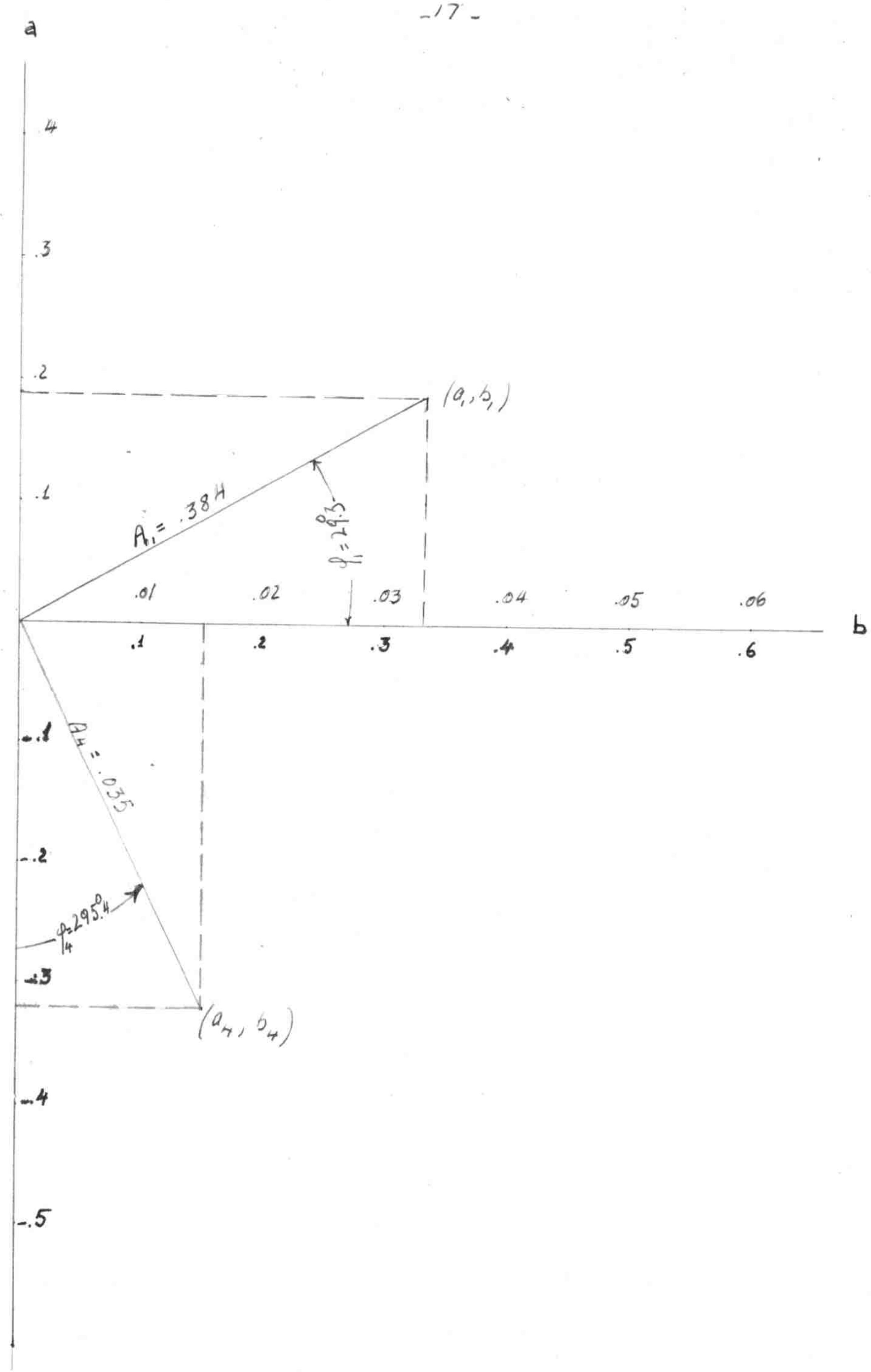
Result:

$$680.01 + 0.3839 \sin[\theta + 29°.322]$$
$$0.4123 \sin[2\theta + 168°.583]$$
$$0.0747 \sin[3\theta + 157.830]$$
$$0.0354 \sin[4\theta + 295.408]$$

[1] (h) represents the time for the first maximum, of the specified wave. The time used is (G.M.T. + 2).

Graphical Check for the Amplitudes and phases.





Chapter III

Results of the Analysis

Time:

The time used for all the computations of Ksara is (G.M.T+2) but after the computations, all the results were reduced to G.M.T.

For Bagdad the computations were based on (G.M.T)

Throughout the discussion, whenever there is any reference of time, it is (G.M.T,) unless it is specified.

The results obtained are put in the form of tables followed by the graphs of the most characteristic results.

The first four tables represent the diurnal variation of pressure and Temperature for Ksara and Bagdad, followed by the seasonal averages.

Table V gives the seasonal averages of the diurnal variation of the temperature and pressure of Bagdad, in degrees centigrade and in mm of mercury respectively, because for Bagdad Temperature unit used was the F. degree, and the pressure unit the millibar.(1)

For the harmonic analysis only the diurnal and the ½ diurnal waves wer graphed.

---

(1) 1 millibar = 1/1000 bar, 1 bar = 1000000 baryes
1 barye = 1 dyne/cm², 1 millibar = 0.750059 mm.Hg. approx. depending on the value of (g).

Chapter III

Results of the Analysis

Time:

The time used for all the computations of Ksara is (G.M.T+2) but after the computations, all the results were reduced to G.M.T.

For Bagdad the computations were based on (G.M.T)

Throughout the discussion, whenever there is any reference of time, it is (G.M.T,) unless it is specified.

The results obtained are put in the form of tables followed by the graphs of the most characteristic results.

The first four tables represent the diurnal variation of pressure and Temperature for Ksara and Bagdad, followed by the seasonal averages.

Table V gives the seasonal averages of the diurnal variation of the temperature and pressure of Bagdad, in degrees centigrade and in mm of mercury respectively, because for Bagdad Temperature unit used was the F. degree, and the pressure unit the millibar.(1)

For the harmonic analysis only the diurnal and the 1/2 diurnal waves wer graphed.

---

(1) 1 millibar = 1/1000 bar, 1 bar = 1000000 baryes
1 barye = 1 dyne/cm^2 1 millibar = 0.750059 mm.Hg. approx. depending on the value of (g).

To facilate the understanding of the results, the meaning of the symbols used are as follows.

M = maximum value of the diurnal variation

m = minimum " " " " "

N = The mean of the 24 hourly values

(%) = $\frac{M-m}{N}$ always given in $\frac{deg.C}{deg.C}$ and $\frac{mm.Hg}{mm.Hg}$

A = Amplitude of the waves

φ = the phase angle in degrees

(h) = Time of first max. (G.M.T. +2)

h = " " (G.M.T)

% = $\frac{100A}{N}$ the ratio of the amplitudes to the mean values of the variable times 100.

For graphs, the red is always used to represent the variations of Bagdad and the blue the variations of Ksara.

For Graphs See Copy I.

Pages: (30 – 34)
(40 – 48)

Table I. Diurnal Variation of Pressure for Ksara (1928–1938)

mm. of Hg.	1	2	3	4	5	6	7	8	9	10
	600+	600+	600+	600+	600+	600+	600+	600+	600+	600+
Jan	84.22	84.05	84.03	84.20	84.43	84.69	84.89	84.88	84.41	83.92
Feb	81.71	81.60	81.61	81.74	81.99	82.21	82.33	82.34	82.16	81.75
March	82.72	82.67	82.75	82.93	83.21	83.38	83.48	83.43	83.21	82.91
April	81.88	81.83	81.93	82.16	82.41	82.51	82.58	82.56	82.38	82.17
May	82.11	82.21	82.24	82.46	82.70	82.75	82.72	82.67	82.50	82.30
June	80.32	80.34	80.46	80.64	80.86	80.85	80.74	80.65	80.51	80.30
July	79.11	79.14	79.25	79.42	79.62	79.59	79.49	79.36	79.17	78.97
August	79.95	79.97	80.10	80.30	80.51	80.55	80.52	80.35	80.07	79.87
Sept	82.25	82.26	82.37	82.56	82.78	82.90	82.92	82.74	82.44	82.17
Oct.	84.60	84.64	84.73	84.88	85.17	85.40	85.39	85.21	85.17	84.43
Nov	84.90	84.84	84.89	85.05	85.33	85.51	85.60	85.45	85.06	84.66
Dec	84.78	84.65	84.61	84.78	85.02	85.17	85.48	85.41	84.97	84.50
	11	12	13	14	15	16	17	18	19	20
Jan	83.58	83.49	83.65	84.64	83.78	84.11	84.31	84.47	84.52	84.52
Feb	81.38	81.24	81.27	81.38	81.51	81.78	81.97	82.13	82.23	82.26
March	82.56	82.36	82.22	82.22	82.32	82.55	82.78	83.08	83.19	83.23
April	81.95	81.70	81.54	81.49	81.57	81.75	81.99	82.32	82.51	82.55
May	82.11	81.91	81.76	82.18	81.66	81.80	82.01	82.29	82.55	82.61
June	80.10	79.96	79.81	79.64	79.68	79.87	80.05	80.32	80.61	80.70
July	78.77	78.61	78.45	78.34	78.58	78.80	78.80	79.12	79.46	79.56
August	79.64	79.44	79.34	79.29	79.31	79.48	79.77	80.16	80.38	80.44
Sept	81.95	81.61	81.49	81.49	81.56	81.79	82.14	82.51	82.68	82.71
Oct.	84.03	83.86	83.79	83.81	83.94	84.26	84.52	84.76	84.93	84.98
Nov.	84.22	84.10	84.09	84.18	84.37	84.74	84.97	85.12	85.24	85.28
Dec	84.19	84.09	84.18	84.29	84.43	84.77	84.98	85.10	85.14	85.19

	21	22	23	24	Av. N	M-m	%
	600+	600+	600+	600+	600+		
Jan.	84.43	84.33	84.39	84.34	84.22	1.40	.0020
Feb.	82.23	82.15	81.99	81.75	81.86	1.10	.0016
March	83.18	83.09	83.08	82.88	82.89	1.26	.0018
April	82.54	82.44	82.17	81.99	82.12	1.09	.0016
May	82.56	82.43	82.28	82.15	82.29	1.09	.0016
June	80.66	80.53	80.51	80.38	80.35	1.22	.0018
July	79.55	79.42	79.27	79.16	79.11	1.28	.0019
August	80.42	80.30	80.09	80.00	80.01	1.26	.0018
Sept.	82.69	82.61	82.43	82.32	82.31	1.43	.0021
Oct.	84.94	84.88	84.81	84.69	84.66	1.61	.0023
Nov.	85.24	85.17	85.08	85.04	84.92	1.51	.0022
Dec.	85.14	85.03	84.90	84.88	84.82	1.39	.0020

Diurnal variation per season

DS	1	2	3	4	5	6	7	8	9	10
Winter	83.57	83.43	83.42	83.57	83.81	84.02	84.23	84.21	83.85	83.39
Spring	82.24	82.24	82.31	82.52	82.77	82.88	82.93	82.89	82.70	82.46
Summer	79.79	79.82	79.94	80.12	80.33	80.33	80.25	80.12	79.92	79.71
Autumn	83.92	83.91	84.00	84.16	84.43	84.60	84.64	84.37	84.22	83.75

	11	12	13	14	15	16	17	18	19	20
Winter	83.05	82.94	83.03	83.10	83.24	83.55	83.75	83.90	83.96	83.99
Spring	82.21	81.99	81.84	81.96	81.85	82.03	82.26	82.56	82.75	82.80
Summer	79.50	79.34	79.20	79.09	79.11	79.31	79.54	79.87	80.15	80.23
Autumn	83.40	83.19	83.12	83.16	83.29	83.60	83.88	84.13	84.28	84.32

	21	22	23	24	25	M-m	%
Winter	83.93	83.84	83.76	83.66	83.63	1.30	.0019
Spring	82.76	82.65	82.51	82.34	82.43	1.15	.0017
Summer	80.21	80.08	79.96	79.85	79.82	1.25	.0018
Autumn	84.29	84.22	84.11	84.02	83.96	1.52	.0022

Table II. Diurnal variation of Temperatude for Ksara (1928–1938)

Degrees C.	1	2	3	4	5	6	7	8	9	10
Jan.	2.94	2.77	2.59	2.40	2.35	3.39	4.89	6.46	7.63	8.51
Feb.	4.51	4.39	4.20	4.06	4.22	5.36	6.76	8.11	9.98	9.77
March	6.77	6.11	5.72	5.38	6.55	8.84	11.08	12.87	14.30	15.11
April	9.78	9.37	9.02	9.24	11.07	13.61	15.91	16.73	18.98	19.75
May	13.02	12.44	12.12	12.94	15.88	18.61	20.95	22.73	23.98	24.58
June	15.34	14.66	14.53	16.49	20.10	24.10	26.16	28.22	29.07	29.68
July	17.83	17.18	16.85	17.57	21.01	24.07	26.76	28.99	30.10	30.54
August	18.45	17.79	17.25	17.60	20.59	23.97	27.05	29.62	31.17	31.88
Sept.	16.02	15.43	14.82	14.90	17.75	21.05	24.03	26.60	28.35	29.17
Oct.	13.22	12.67	12.28	11.94	14.04	17.27	20.16	22.44	24.02	24.80
Nov.	9.14	8.79	8.45	8.21	8.92	10.87	13.45	15.58	17.04	17.99
Dec.	4.97	4.78	4.62	4.49	4.68	5.82	6.95	9.14	10.49	11.28

	11	12	13	14	15	16	17	18	19	20
Jan.	9.19	9.30	9.08	8.33	6.94	5.98	5.25	4.72	4.34	4.05
Feb.	10.24	10.29	9.97	9.42	8.42	7.47	6.85	6.38	6.04	5.67
March	15.80	15.71	15.43	14.72	13.59	11.96	10.86	10.07	9.30	8.71
April	20.24	20.10	19.76	19.07	17.98	16.34	15.00	14.05	13.31	12.59
May	24.84	24.63	24.14	23.44	22.44	20.82	19.36	18.24	17.29	16.40
June	29.76	29.42	28.74	27.60	25.86	24.13	22.49	21.23	20.18	19.21
July	30.47	30.11	29.41	28.68	27.59	26.17	24.88	23.94	22.94	21.99
August	32.02	31.62	30.89	30.11	28.92	27.00	25.61	24.52	23.41	22.33
Sept.	29.45	29.13	28.49	27.62	26.07	24.01	22.55	21.46	20.52	19.43
Oct.	25.21	25.00	24.45	23.48	21.61	19.98	18.80	17.91	16.96	16.16
Nov.	18.52	18.44	17.91	16.77	15.01	13.75	12.83	12.10	11.52	10.96
Dec.	11.88	11.91	11.48	10.45	8.98	8.01	7.39	6.79	6.33	6.07

	21	22	23	24	μ	M-m	%
Jan	3.77	3.58	3.42	3.18	5.21	6.95	1.33
Feb	5.41	5.17	4.92	4.67	6.76	6.23	0.92
March	8.16	7.66	7.20	6.80	10.36	10.42	1.01
April	11.86	11.43	10.67	10.20	14.42	11.22	0.78
May	15.79	15.07	14.27	13.59	18.65	12.72	0.68
June	18.30	17.56	16.67	16.00	22.31	15.23	0.68
July	21.07	20.30	19.38	18.58	24.00	13.69	0.57
August	21.47	20.66	19.92	19.13	24.71	14.77	0.60
Sept.	18.69	17.98	17.33	16.66	21.98	14.63	0.67
Oct.	15.53	14.88	14.35	13.62	18.37	13.27	0.72
Nov	10.49	10.04	9.85	9.49	12.76	10.31	0.81
Dec.	5.81	5.55	5.41	5.14	7.43	7.42	1.00

Diurnal variation per Season

	1	2	3	4	5	6	7	8	9	10
Winter	4.14	3.98	3.80	3.65	3.75	4.86	6.20	7.90	9.37	9.85
Spring	9.86	9.31	8.95	9.19	11.17	13.69	15.98	17.44	19.09	19.81
Summer	17.21	16.54	16.21	17.22	20.57	24.05	26.66	28.94	30.11	30.70
Autumn	12.79	12.30	11.85	11.68	13.57	16.40	19.21	21.54	23.14	23.99

	11	12	13	14	15	16	17	18	19	20
Winter	10.44	10.50	10.18	9.40	8.11	7.15	6.50	5.96	5.57	5.26
Spring	20.29	20.15	19.78	19.08	18.00	16.37	15.07	14.12	13.30	12.57
Summer	30.75	30.38	29.68	28.80	27.46	25.77	24.33	23.23	22.18	21.18
Autumn	24.39	24.19	23.62	22.62	20.90	19.25	18.06	17.16	16.33	15.52

	21	22	23	24	μ	M-m	%
Winter	5.00	4.77	4.58	4.33	6.47	6.87	1.08
Spring	11.94	11.39	10.71	10.20	14.48	11.45	0.82
Summer	20.28	19.51	18.66	17.90	23.68	14.56	0.62
Autumn	14.90	14.30	13.84	13.26	17.70	12.74	0.73

Table III Diurnal Variation of Pressure for Hinaidi (Bagdad) (1934)

Millibars	1	2	3	4	5	6	7	8	9	10
		1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+
Jan	1019.7	19.6	19.6	20,1	20.5	21.1	21.9	20.9	20.3	19.7
Feb	1016.2	16.2	16.6	16.9	17.3	17.6	17.8	17.8	17.1	16.4
March	1013.4	13.6	14.0	14.4	14.7	15.0	15.1	14.8	14.3	13.7
April	1009.1	9.4	9.8	10.1	10.2	9.8	11.1	11.0	10.6	9.7
May	1009.0	9.3	9.6	10.1	10.4	10.7	10.7	10.6	10.2	9.8
June	1002.7	3.1	3.5	3.7	4.0	4.1	3.6	3.8	3.5	3.0
July	997.5	998.0	998.2	998.6	998.7	998.8	998.8	998.6	997.9	997.7
August	998.8	999.1	999.5	999.9	1000.3	1000.3	1000.1	999.7	999.7	999.2
Sept.	1005.3	5.6	5.7	6.4	6.7	6.9	6.9	6.6	6.1	5.8
Oct.	1012.4	12.6	12.9	12.9	13.7	14.0	14.0	14.2	13.1	12.4
Nov.	10.16.8	16.9	17.2	17.4	17.9	18.2	18.3	18.0	17.3	16.8
Dec.	1017.3	17.4	17.6	18.0	18.4	18.8	18.5	18.5	18.0	16.9

	11	12	13	14	15	16	17	18	19	20
Jan.	19.4	19.1	19.5	19.4	20.2	20.2	20.4	20.5	20.5	20.5
Feb.	15.8	15.6	15.4	15.7	15.8	16.1	16.4	16.6	16.6	16.6
March	13.0	12.6	12.4	12.3	12.4	12.7	13.0	13.3	13.2	13.4
April	9.5	9.0	8.6	8.4	8.5	8.9	9.4	9.8	9.8	9.8
May	9.3	8.8	8.4	8.2	8.2	8.5	8.9	9.3	9.5	9.5
June	2.5	2.1	1.6	1.4	1.5	1.7	2.0	2.4	2.6	2.6
July	997.3	996.8	996.5	996.4	996.4	996.6	997.0	997.5	997.6	997.6
August	998.8	998.4	998.1	998.0	997.9	998.3	998.6	999.1	999.2	999.1
Sept.	5.2	4.8	4.6	4.7	4.6	4.8	5.3	5.6	5.7	5.7
Oct.	12.0	11.8	11.6	11.6	11.8	12.2	12.4	12.6	12.7	12.7
Nov.	16.3	16.3	16.2	16.2	16.5	16.4	17.0	17.2	17.2	17.3
Dec.	16.6	16.5	16.7	16.9	17.0	17.3	17.5	17.5	17.6	17.5

	21	22	23	24	μ mbs	μ mm. Hg	M-m mbs	M-m mm. Hg	%
	1000+	1000+	1000+	1000+					
Jan	20.4	20.3	20.2	19.8	1020.2	765.2	2.8	2.1	.0027
Feb	16.5	16.4	16.3	16.1	1016.5	762.4	2.4	1.8	.0024
March	13.3	13.2	13.2	13.0	1013.5	760.2	2.8	2.1	.0028
April	9.7	9.6	9.3	9.2	1009.6	757.3	2.7	2.0	.0026
May	9.4	9.3	9.2	9.1	1009.4	757.1	2.5	1.9	.0026
June	2.4	2.2	2.1	2.2	1002.7	752.1	2.7	2.0	.0026
July	997.5	997.3	997.2	997.3	997.6	748.3	2.4	1.8	.0024
August	999.1	998.9	998.8	998.8	999.1	749.4	2.4	1.8	.0024
Sept.	5.6	5.6	5.5	5.4	1005.6	754.3	2.3	1.7	.0022
Oct.	12.6	12.6	12.2	12.2	1012.6	759.5	2.6	2.0	.0026
Nov	17.3	17.2	17.1	17.0	1017.1	762.9	2.1	1.6	.0021
Dec.	17.4	17.4	17.3	17.3	1017.5	763.2	2.3	1.7	.0022

Diurnal variation per season

	1	2	3	4	5	6	7	8	9	10
Winter	10 17.7	17.7	17.9	18.3	18.7	19.2	19.4	19.1	18.5	17.7
Spring	10 10.5	10.8	11.1	11.5	11.8	11.8	12.3	12.1	11.7	11.1
Summer	999.7	1000.1	1000.4	1000.7	1000.9	1001.1	1000.9	1000.8	1000.4	999.9
Autumn	10 11.5	11.7	11.9	12.2	12.8	13.0	13.1	12.9	12.2	11.7

	11	12	13	14	15	16	17	18	19	20
Winter	10 17.3	17.1	17.2	17.3	17.7	17.9	18.1	18.2	18.2	18.2
Spring	10 10.6	10.1	9.8	9.6	9.7	10.0	10.4	10.8	10.8	10.9
Summer	999.5	999.1	998.7	998.6	998.6	998.9	998.2	999.7	999.8	999.8
Autumn	1011.2	11.0	10.8	10.8	11.0	11.1	11.6	11.8	11.9	11.9

	21	22	23	24	μ	M-m (mbs)	M-m (mm Hg)	μ mm. Hg	%
Winter	10 18.1	18.0	17.9	17.7	10 18.1	2.5	1.9	763.6	.0024
Spring	1010.8	10.7	10.6	10.4	10 10.8	2.7	2.0	758.2	.0027
Summer	999.7	999.5	999.4	999.4	999.8	2.5	1.9	749.9	.0025
Autumn	10 11.8	11.8	11.6	11.5	1011.8	2.3	1.8	758.9	.0023

Table IV

Diurnal variation of Temperature of Bagdad (1934)

Degrees F.	1	2	3	4	5	6	7	8	9	10
Jan.	39.5	38.4	38.1	37.9	38.6	41.3	45.1	47.7	50.7	52.6
Feb.	43.7	42.9	42.9	42.4	44.1	47.8	51.3	54.6	57.2	58.6
March	51.6	50.6	49.8	50.4	54.4	60.1	65.6	69.9	73.1	73.9
April	60.8	60.1	59.2	61.7	66.3	71.6	75.5	78.3	80.5	82.2
May	67.3	66.2	67.3	70.9	75.7	80.6	83.8	86.1	88.0	86.3
June	77.3	75.9	76.6	80.2	85.8	90.8	95.6	98.9	101.5	102.9
July	80.4	79.0	79.2	82.1	87.1	92.5	97.3	101.7	105.2	106.8
August	76.0	76.9	76.2	78.8	84.6	90.8	96.3	101.6	105.0	107.0
Sept	72.8	70.7	69.9	72.1	78.8	86.3	93.7	97.5	100.6	102.3
Oct.	63.2	62.6	61.9	63.1	64.8	75.6	81.3	86.3	90.5	91.4
Nov.	53.6	52.5	52.2	52.0	55.8	61.7	66.6	70.9	73.4	75.1
Dec.	44.7	43.9	43.4	43.2	44.6	48.2	51.8	54.8	57.4	59.0

	11	12	13	14	15	16	17	18	19	20
Jan.	53.4	53.8	53.4	51.6	48.4	46.4	45.3	44.2	43.6	42.7
Feb.	59.7	60.0	59.8	58.7	55.8	53.0	51.1	49.9	48.8	48.0
March	75.1	78.6	75.4	74.4	69.5	65.4	62.7	60.7	58.9	57.6
April	82.9	83.1	82.6	81.5	78.6	74.3	71.4	69.3	67.8	66.1
May	90.3	90.6	90.1	88.8	85.2	82.2	79.2	77.3	75.3	73.6
June	103.9	104.4	103.7	102.8	100.5	96.3	91.5	88.3	86.6	84.9
July	104.4	108.1	108.7	106.9	104.9	97.6	93.1	89.0	89.1	87.6
August	107.9	108.0	107.5	105.9	102.0	95.3	91.5	89.0	86.9	85.4
Sept.	103.3	103.1	102.4	97.5	93.8	88.3	85.4	83.8	82.0	81.0
Oct.	92.6	92.3	91.2	88.0	82.1	78.2	75.8	73.2	71.4	69.9
Nov.	75.9	75.7	74.7	71.0	67.0	63.6	61.7	60.3	61.1	57.4
Dec.	60.3	60.7	60.2	58.0	55.1	52.9	51.6	50.4	49.3	48.4

	21	22	23	24	M°F	M°C	M-m°F	M-m°C	%	
Jan.	41.8	41.2	40.7	40.2	44.8	7.1	15.9	8.8	1.24	
Feb.	47.0	46.2	45.5	44.4	50.6	10.3	17.6	9.8	0.95	
March	56.7	55.8	54.4	53.2	62.4	16.9	28.8	16.0	0.95	
April	65.0	63.5	63.1	61.8	71.1	21.7	23.9	13.3	0.61	
May	72.3	71.2	70.0	68.7	78.6	25.9	24.4	13.6	0.52	
June	83.8	83.2	81.1	79.5	90.7	32.6	28.5	15.8	0.48	
July	88.7	83.6	82.4	81.4	93.2	34.0	29.7	16.5	0.48	
August	84.0	82.9	79.2	79.9	91.6	33.1	32.0	17.8	0.54	
Sept.	78.6	77.1	75.8	74.2	86.3	30.2	33.4	18.6	0.62	
Oct.	69.1	66.8	65.4	64.4	75.9	24.4	30.7	17.1	0.70	
Nov.	56.4	55.4	54.4	53.7	62.6	17.0	23.9	13.3	0.78	
Dec	47.5	46.7	46.0	45.5	51.0	10.6	17.5	9.7	0.91	

Diurnal variation per season

	1	2	3	4	5	6	7	8	9	10
Winter	42.6	41.7	41.5	41.2	42.4	45.8	49.4	52.4	55.1	56.7
Spring	59.9	59.0	58.8	61.0	65.5	70.8	75.0	78.1	80.5	80.8
Summer	77.9	77.3	77.3	80.4	85.8	91.4	96.4	100.7	103.9	105.6
Autumn	63.2	61.9	61.3	62.4	66.5	74.5	80.5	84.9	88.2	89.6

	11	12	13	14	15	16	17	18	19	20
Winter	57.8	58.2	57.8	56.1	53.1	50.8	49.3	48.2	47.2	46.4
Spring	82.8	84.1	82.7	81.6	77.8	74.0	71.1	69.1	67.3	65.8
Summer	105.4	106.8	106.6	105.2	102.5	96.4	92.0	88.8	87.5	86.0
Autumn	90.6	90.4	89.4	85.5	81.0	76.4	74.3	72.4	71.5	69.4

	21	22	23	24	M°F	M°C	M-m°F	M-m°C	%	
Winter	45.4	44.7	44.1	43.4	48.8	9.3	17	9.4	1.09	
Spring	64.7	63.5	62.5	61.2	70.7	21.5	25.7	14.3	0.69	
Summer	85.5	83.2	80.9	80.3	91.8	33.2	30.1	16.7	0.50	
Autumn	68.0	66.4	65.2	64.1	74.9	23.8	29.3	16.3	0.70	

Table Va The diurnal variation of Pressure for Bagdad per season in millimeters of Mercury.

	1	2	3	4	5	6	7	8	9	10
Winter	763.3	63.3	63.5	63.8	64.1	64.5	64.6	64.4	63.9	63.3
Spring	57.9	58.2	58.4	58.7	58.9	58.9	59.3	59.1	58.8	58.4
Summer	49.8	50.1	50.4	50.6	50.7	50.9	50.7	50.7	50.4	50.0
Autumn	58.7	58.8	59.0	59.2	59.7	59.8	59.9	59.7	59.2	58.8

	11	12	13	14	15	16	17	18	19	20
Winter	63.0	62.9	63.0	63.0	63.3	63.5	63.6	63.7	63.7	63.7
Spring	58.0	57.6	57.4	57.3	57.3	57.6	57.9	58.2	58.2	58.2
Summer	49.7	49.4	49.1	49.0	49.0	49.2	49.5	49.8	49.9	49.9
Autumn	58.5	58.3	58.2	58.2	58.3	58.4	58.8	58.9	59.0	59.0

	21	22	23	24	M	m-m	%			
Winter	63.6	63.6	63.5	63.3	63.6	1.9	.0024			
Spring	58.2	58.1	58.0	57.9	58.2	2.0	.0027			
Summer	49.8	49.7	49.6	49.6	49.9	1.9	.0025			
Autumn	58.9	58.9	58.8	58.7	58.9	1.8	.0023			

Table V_b Diurnal variation of temperature of Bagdad per season in degrees Centigrade.

	1	2	3	4	5	6	7	8	9
Winter	5.9	5.4	5.3	5.1	5.8	7.7	9.7	11.3	12.8
Spring	15.5	15.0	14.9	16.2	18.6	21.6	23.9	25.6	26.9
Summer	25.5	25.2	25.2	26.9	29.9	33.0	35.8	38.2	39.9
Autumn	17.3	16.6	16.3	16.9	19.2	23.6	26.9	29.4	31.2
	10	11	12	13	14	15	16	17	18
Winter	13.7	14.3	14.6	14.3	13.4	11.7	10.4	9.6	9.0
Spring	27.1	28.2	28.9	28.2	27.6	25.4	23.3	21.7	20.6
Summer	40.9	40.8	41.6	41.4	40.7	39.2	35.8	33.3	31.6
Autumn	32.0	32.6	32.4	31.9	29.7	27.2	24.8	23.5	22.4
	19	20	21	22	23	24	μ	M-m	(%)
Winter	8.4	8.0	7.4	7.1	6.7	6.3	9.3	9.4	1.09
Spring	19.6	18.8	18.2	17.5	16.9	16.2	21.5	14.3	0.69
Summer	30.8	30.0	29.7	28.4	27.2	26.8	33.2	16.7	0.50
Autumn	21.9	20.8	20.0	19.1	18.4	17.8	23.8	16.3	0.70

Table IV. Harmonic Analysis (Ksara Pressure)

	A_1	%	φ_1	(h_1)	h_1	A_2	%	φ_2	(h_2)	h_2	A_2/A_1
Jan	0.260	.04	37°70	$3^h.49$	$1^h.49$	0.424	.06	175°99	$9^h.13$	$7^h.13$	1.63
Feb.	0.175	.02	56°80	2.21	0.21	0.433	.06	167°.74	9.41	7.41	2.47
March	0.262	.04	21°.57	4.56	2.56	0.451	.07	162.39	9.59	7.59	1.72
April	0.197	.03	28°.54	4.10	2.10	0.453	.07	158°.30	9.72	7.72	2.30
May	0.240	.04	7°79	5.48	3.48	0.328	.05	162°.97	9.57	7.57	1.37
June	0.375	.06	20°.50	4.63	2.63	0.335	.05	162°.12	9.60	7.60	0.88
July	0.418	.06	30°.97	3.93	1.93	0.367	.05	162°.93	9.57	7.57	0.88
August	0.384	.06	29°.32	4.05	2.05	0.412	.06	168°.58	9.38	7.38	1.08
Sept	0.409	.06	28°.44	4.10	2.10	0.466	.07	168°.55	9.38	7.38	1.14
Oct.	0.443	.06	20°.70	4.62	2.62	0.502	.07	172°.88	9.24	7.24	1.13
Nov	0.376	.05	36°.42	3.57	1.57	0.470	.07	178°.12	9.06	7.06	1.25
Dec.	0.245	.04	49°.60	2.69	0.69	0.435	.06	176.72	9.11	7.11	1.78
	A_3	%	φ_3	(h_3)	h_3	A_4	%	φ_4	(h_4)	h_4	N
Jan.	0.180	.03	15°.41	1.66	7.66	0.090	.01	268°.15	$3^h.03$	$1^h.03$	684.22
Feb.	0.115	.02	18°.73	1.58	7.58	0.035	.005	202°.59	4.11	2.11	681.86
March	0.060	.009	18°.56	1.60	7.60	0.029	.004	322°.76	2.12	0.12	682.89
April	0.034	.005	36°.13	1.20	7.20	0.014	.002	1°.67	1.47	5.47	682.12
May	0.088	.01	140°.35	6.88	4.88	0.052	.008	233°63	3.61	1.61	682.29
June	0.076	.01	166°.77	6.29	4.29	0.031	.004	336°78	1.89	5.89	680.35
July	0.097	.01	191°.54	5.74	3.74	0.022	.003	318°.67	2.19	0.19	679.11
August	0.075	.01	157°.83	6.49	4.49	0.035	.005	295°.41	2.58	0.58	680.01
Sept.	0.017	.002	154.48	6.57	4.57	0.037	.005	317°.62	2.21	0.21	682.31
Oct.	0.090	.01	16°.32	1.64	7.64	0.027	.004	190°.16	4.36	2.36	684.66
Nov	0.132	.02	20°.00	1.55	7.55	0.033	.005	277°.54	2.88	0.88	684.99
Dec.	0.165	.02	17°.07	1.62	7.62	0.069	.01	247°.95	3.37	1.37	684.82

(h) represents the time of first maximum based on (G.M.T.+2)

Table VII Harmonic Analysis (Ksara Temp.)

	A_1	%	φ_1	(h_1)	h_1	A_2	%	φ_2	(h_2)	h_2	A_2/A_1
Jan.	3.067	59	231°.61	14h.56	12h.56	1.204	23	53°.17	1h.23	11h.23	0.39
Feb.	2.882	43	233°.84	14.41	12.41	0.895	13	61°.32	0.96	10.96	0.31
March	4.738	46	232°.33	14.51	12.51	1.345	13	70°.05	0.67	10.67	0.28
April	5.235	36	234.96	14.34	12.34	1.255	9	81°.04	0.30	10.30	0.24
May	5.940	32	237°.15	14.14	12.14	1.327	7	101°.88	11.61	9.61	0.22
June	7.257	32	244°.37	13.71	11.71	1.696	8	113°.82	11.21	9.21	0.23
July	6.507	27	237°.61	14.16	12.16	1.712	7	117°.33	11.09	9.09	0.26
August	6.881	28	236°.05	14.26	12.26	1.823	7	98°.00	11.73	9.73	0.26
Sept.	6.809	31	236°.46	14.24	12.24	1.860	8	89°.02	0.03	10.03	0.27
Oct.	6.055	33	236°.21	14.25	12.25	1.793	10	84°.83	0.17	10.17	0.30
Nov.	4.633	36	235.88	14.27	12.27	1.626	13	69°.60	0.68	10.68	0.35
Dec.	3.321	45	235.49	14.30	12.30	1.314	18	58°.23	1.09	11.09	0.39

	A_3	%	φ_3	(h_3)	h_3	A_4	%	φ_4	(h_4)	h_4	N
Jan.	0.148	3	260°.10	4h.22	2h.22	0.166	3	221°.01	3h.82	1h.82	5.21
Feb.	0.200	3	299°.73	3.34	1.34	0.193	3	178°.87	4.52	2.52	6.76
March	0.324	3	351°.25	2.19	0.19	0.323	3	238°.29	3.53	1.53	10.36
April	0.321	2	24°.42	1.46	7.46	0.210	1	256°.85	3.22	1.22	14.42
May	0.593	3	33°.04	1.27	7.27	0.613	3	271°.46	2.98	0.98	18.65
June	0.761	3	48°.55	0.92	6.92	0.402	2	294°.60	2.59	0.59	22.31
July	0.515	2	28°.16	1.37	7.37	0.252	1	234°.54	3.59	1.59	23.93
August	0.681	3	8°.53	1.81	7.81	0.322	1	253°.52	3.27	1.27	24.71
Sept	0.596	3	8.42	1.81	7.81	0.368	2	251°.35	3.31	1.31	21.98
Oct.	0.462	2	0.03	2.00	0.00	0.405	2	249°.22	3.35	1.35	18.37
Nov.	0.283	2	312°.08	3.06	1.06	0.289	2	238°.88	3.52	1.52	12.76
Dec.	0.231	3	257°.27	4.28	2.28	0.117	2	215°.63	3.91	1.91	7.43

(h) represents the time of first max, based on (G.M.T.+2)

Table VIII Harmonic Analysis (Bagdad Pressure)

	A_1	%	φ_1	h_1	A_2	%	φ_2	h_2	A_2/A_1
Jan.	0.127	0.02	44°.21	1h.02	0.547	0.07	245°.22	6h.82	4.31
Feb.	0.401	0.05	18°.66	4.76	0.534	0.07	243°.66	6.88	1.33
March	0.697	0.09	14°.40	5.04	0.513	0.07	244°.61	6.84	0.74
April	0.409	0.05	12°.38	5.17	0.542	0.07	225°.73	7.47	1.32
May	0.570	0.08	13°.02	5.13	0.521	0.07	228°.81	7.37	0.91
June	0.722	0.10	14°.28	5.05	0.415	0.06	246°.77	6.77	0.57
July	0.647	0.09	22°.54	4.50	0.432	0.06	246°.20	6.79	0.67
August	0.555	0.07	18°.92	4.74	0.492	0.06	240°.46	6.98	0.89
Sept.	0.520	0.07	21°.13	4.59	0.486	0.06	238°.99	7.03	0.93
Oct.	0.493	0.06	17°.94	4.80	0.549	0.07	245°.42	6.82	1.11
Nov.	0.385	0.05	35°.75	3.62	0.464	0.06	242°.08	6.93	1.20
Dec.	0.376	0.05	27°.46	4.17	0.471	0.06	258°.86	6.37	1.25

	A_3	%	φ_3	h_3	A_4	%	φ_4	h_4	P
Jan.	0.272	0.04	133°.20	7h.06	0.078	0.01	33°.92	0h.93	765.2
Feb.	0.503	0.06	112°.49	7.50	0.409	0.05	337°.62	1.87	762.4
March	0.042	0.006	86°.39	0.08	0.019	0.002	329°.94	2.00	760.2
April	0.108	0.01	16°.15	1.64	0.054	0.007	300°.01	2.50	757.3
May	0.037	0.005	305°.33	3.21	0.038	0.005	115°.35	5.58	757.1
June	0.155	0.02	321°.28	2.86	0.022	0.003	299°.94	2.50	752.1
July	0.097	0.01	309°.15	3.13	0.038	0.005	29°.00	1.02	748.3
August	0.050	0.007	300°.64	3.32	0.017	0.002	70°.91	0.32	749.4
Sept	0.039	0.005	176°.15	6.09	0.045	0.006	103°.85	5.77	754.3
Oct	0.108	0.01	120°.72	7.32	0.076	0.01	4°.83	5.68	759.5
Nov	0.128	0.02	149°.51	6.68	0.067	0.009	49°.81	0.67	762.9
Dec	0.169	0.02	131°.63	7.07	0.055	0.007	6°.60	1.39	763.2

Table IX Harmonic Analysis (Bagdad Temp.)

	A_1	%	φ_1	h_1	A_2	%	φ_2	h_2	A_2/A_1
Jan.	3.893	55	261°.00	12h.6	1.434	20	124°.56	10h.85	0.36
Feb	4.523	44	261°.75	12.55	1.328	13	128°.35	10h.72	0.29
March	6.857	40	265°.74	12.28	1.940	11	135°.03	10.50	0.28
April	6.324	29	269°.93	12.00	1.250	6	146°.95	10.10	0.20
May	6.249	24	271°.36	11.91	0.914	4	166°.96	9.43	0.15
June	7.460	23	268°.21	12.12	1.313	4	153°.46	9.88	0.18
July	7.776	23	267°.93	12.14	1.436	4	140°.57	10.31	0.18
August	8.607	26	269°.19	12.05	1.898	6	144°.71	10.18	0.22
Sept	8.458	28	271°.57	11.90	2.509	8	153.69	9.88	0.30
Oct	8.107	33	270°.89	11.94	2.427	10	144°.97	10.17	0.30
Nov	6.218	36	272°.10	11.86	1.919	11	144°.53	10.18	0.31
Dec	4.324	41	262°.89	12.47	1.408	13	128°.60	10.71	0.32
	A_3	%	φ_3	h_3	A_4	%	φ_4	h_4	N
Jan	0.138	2	9°.00	1h.80	0.242	3	11°.35	1h.31	7.1
Feb	0.162	2	113°.02	7.49	0.292	3	350°.89	1.65	10.3
March	0.497	3	142°.29	6.84	0.505	3	19°.01	1.18	16.9
April	0.625	3	144°.64	6.79	0.343	2	31°.34	0.98	21.7
May	0.835	3	168°.27	6.26	0.413	2	59°.44	0.51	25.9
June	0.997	3	151°.68	6.63	0.049	0.2	49°.14	0.68	32.6
July	1.016	3	160°.80	6.43	0.670	2	324°.50	2.09	34.0
August	0.711	2	154°.34	6.57	0.379	1	349.80	1.67	33.1
Sept	0.636	2	140°.06	6.89	0.698	2	33°.64	0.94	30.2
Oct	0.418	2	103°.72	7.69	0.638	3	6°.67	1.39	24.4
Nov	0.186	1	61°.41	0.64	0.610	3	23°.96	1.10	17.0
Dec	0.108	1	51.24	0.86	0.291	3	20°.48	1.14	10.6

Table Xa Harmonic Analysis (Seasonal Averages) Ksara Pressure

	A_1	%	φ_1	(h_1)	h_1	A_2	%	φ_2	(h_2)	h_2	A_2/A_1
Winter	0.227	.03	48°.03	2h.80	0.80	0.431	.06	173°.48	9h.22	7.22	1.96
Spring	0.233	.04	19°.30	4.71	2.71	0.411	.06	161°.22	9h.63	7.63	1.80
Summer	0.392	.06	26°.93	4.20	2.20	0.371	.05	164°.54	9.52	7.52	0.95
Autumn	0.409	.06	28°.52	4.10	2.10	0.479	.07	173°.18	9.23	7.23	1.17
	A_3	%	φ_3	(h_3)	h_3	A_4	%	φ_4	(h_4)	h_4	N
Winter	0.153	.02	17°.07	1h.62	7h.62	0.065	.01	239°.56	3h.50	1h.50	683.63
Spring	0.061	.01	65°.01	3.23	1.23	0.032	.01	186°.02	2.40	0.40	682.43
Summer	0.083	.01	172°.05	6.17	4.17	0.029	.004	316°.95	2.22	0.22	679.82
Autumn	0.080	.01	63°.60	3.25	1.25	0.032	.01	261°.77	3.15	1.15	683.99

Table Xb Harmonic Analysis (Seasonal Averages) Ksara Temperature

	A_1	%	φ_1	(h_1)	h_3	A_2	%	φ_2	(h_2)	h_2	A_2/A_1
Winter	3.090	49	233°.65	14h.42	12.42	1.138	18	57°.57	1h.09	11h.09	0.36
Spring	5.304	38	234°.81	14.33	12.33	1.309	10	84°.32	4.19	2.19	0.25
Summer	6.882	29	239°.34	14.04	12.04	1.744	7	109°.72	11.34	9.34	0.25
Autumn	5.832	33	236°.18	14.25	12.25	1.760	10	81°.15	0.29	10.29	0.31
	A_3	%	φ_3	(h_3)	h_3	A_4	%	φ_4	(h_4)	h_4	
Winter	0.193	3	272°.33	3h.95	1h.95	0.159	3	205°.17	4h.08	2.08	6.47
Spring	0.413	3	136°.24	1h.64	7.64	0.382	2	255°.53	3.24	1.24	14.48
Summer	0.652	3	28.41	1h.37	7.37	0.325	1	260°.89	3.15	1.15	23.65
Autumn	0.447	2	106.84	2h.29	0.29	0.354	2	246°.48	3.39	1.39	17.70

Table X_c Harmonic Analysis (Seasonal Averages)
Bagdad Pressure.

	A_1	%	φ_1	h_1	A_2	%	φ_2	h_2	A_2/A_1
Winter	0.301	0.04	30°.11	3h.32	0.517	0.07	249°.25	6h.69	2.30
Spring	0.559	0.07	13°.27	5.11	0.525	0.07	233°.05	7.23	0.99
Summer	0.641	0.09	18°.58	4.76	0.446	0.06	244°.48	6.85	0.71
Autumn	0.466	0.06	24°.94	4.34	0.500	0.06	242°.16	6.93	1.08
	A_3	%	φ_3	h_3	A_4	%	φ_4	h_4	μ
Winter	0.315	0.04	125°.77	7h.21	0.181	0.02	126°.05	1h.40	763.6
Spring	0.062	0.01	135°.96	1.64	0.037	0.01	248°.43	3.36	758.2
Summer	0.101	0.01	310°.30	3.10	0.026	0.003	133°.28	1.28	749.9
Autumn	0.092	0.01	148°.79	6.70	0.063	0.01	52°.83	4.04	758.9

Table X_d Harmonic Analysis (Seasonal Averages)
Bagdad Temperature

	A_1	%	φ_1	h_1	A_2	%	φ_2	h_2	A_2/A_1
Winter	4.247	47	261°.88	12h.54	1.390	15	127°.17	10h.76	0.32
Spring	6.477	31	269°.01	12.06	1.368	7	149°.60	10.01	0.21
Summer	7.948	24	268°.44	12.10	1.549	5	146°.25	10.12	0.19
Autumn	7.594	32	241°.52	11.90	2.285	10	147°.73	10.08	0.30
	A_3	%	φ_3	h_3	A_4	%	φ_4	h_4	N
Winter	0.136	2	57°.75	3h.38	0.275	3	127°.57	1h.37	9.3
Spring	0.652	3	151°.73	6.63	0.420	2	36°.60	0.89	21.5
Summer	0.908	3	155°.61	6.54	0.366	1	241°.15	1.81	33.2
Autumn	0.413	2	101°.73	5.07	0.649	3	21°.42	1.14	23.9

Chapter IV

Discussion of the Results

Diurnal Variation of Pressure & Temperature.

Pressure:

The diurnal variation of pressure is characterized by two distinct regions of unequal periods with their distinct maxima and minima, both at Ksara and Bagdad, the following table will present a comparison of their maxima and minima and the times of their occurence.

		M_1	t	M_2	t	m_1	t	m_2	t	M_1-M_2	m_1-m_2
Winter	Bagdad	764.6	7	763.7	20	763.3	1	762.9	12	0.9	0.4
	Ksara	684.2	7	684.0	20	683.4	3	682.9	12	0.2	0.5
Spring	Bagdad	759.3	7	758.2	20	757.9	1	757.3	14	1.1	0.6
	Ksara	682.9	7	682.8	20	682.2	1	681.8	13	0.1	0.4
Summer	Bagdad	750.9	6	749.9	20	749.6	24	749.0	14	1.0	0.6
	Ksara	680.3	6	680.2	20	679.8	1	679.1	14	0.1	0.7
Autumn	Bagdad	759.9	7	759.0	20	758.7	1	758.2	14	0.9	0.5
	Ksara	684.6	7	684.3	20	683.9	2	683.1	13	0.3	0.8

(t) time of occurence of the corresponding maxima & minima.

The amplitude of variation of pressure, during the first cyclic change is greater for Bagdad.

$$\frac{1}{12}\left[\frac{M-m}{\mu}_{Jan} + \frac{M-m}{\mu}_{Feb} \cdots\cdots \frac{M-m}{\mu}_{Dec}\right] =$$

0. 0025 for Bagdad

0. 0019 for Ksara

In general the variations for Ksara resemble more a smooth curve than these of Bagdad, which might be due to the fact that the analyses of pressure for Bagdad is based on the records for one year only, and most of the disturbances which effect the barometric pressure and which are not of a short period character, such as storm etc., cannot be eliminated unless the work is carried based on the averages for 10 years at least.

The curves bring out another characteristic about the difference of variation at the two localities, that is the differences of the two maxima are greater for Bagdad and the differences of minima are greater for Ksara.

It is interesting to note that the 24 hour swing of the barometer, has almost the same intervals for the two localities, the ratio of the intervals is about 11/13 as can be seen from the table at the beginning of the chapter.

Temperature:

The diurnal variation of temperature, like that of pressure has similar characteristics at both places, except for the fact that the average temperature throughout the year is higher at Bagdad due to its desert climate, the difference being maximum in summer and minimum in winter.

	μ Bagdad	μ Ksara	Difference
Winter	9.3	6. 47	2. 83
Spring	21.5	14. 48	7. 02
Summer	33.2	23. 68	9. 52
Autumn	23.8	17. 70	6. 10

(μ) represents the average of the thermometric readings for one season.

The variation is characterized by one maximum and one minimum, occuring around 11 - 12 and 4 - 5 (G.M.T.) respectively.

The amplitude of variation at Ksara is higher than that of Bagdad, just the reverse of the phenomenon observed for the pressure variation.

$$\frac{1}{12}\left[\frac{M-m}{\mu}_{Jan} + \cdots \frac{M-m}{\mu}_{Dec}\right] =$$

0. 73 for Bagdad

0. 81 for Ksara

Harmonic Analyses

The discussion of the results of the harmonic Analyses is preceeded by graphs representing the annual variations of the amplitudes and the times of first maxima (h), of pressure and temperature for the diurnal and the semi-diurnal waves only. See Copy I. PP (52 – 55)

Diurnal Waves of Pressure and Temperature.

Pressure:

The amplitudes of the diurnal waves of Bagdad are higher than those of Ksara, with the exception of the month of January when the amplitude of the wave falls down to a minimum of 0.127 mm. of Hg (Bagdad). The same holds true for the times of first maxima, that is, it is always higher in Bagdad except for the month of January. The difference of phase for Bagdad & Ksara waves is more or less constant. The annual fluctuations in the amplitude of the waves are more irregular for Bagdad, on the other hand, the fluctuations of h_1 (time of first maximum) are more irregular for Ksara, as it is very obvious from the diagrams.

In general the annual variations of (A_1)

and (h_1) are more or less parallel except for the month of January, which might be due to a disturbance affecting the barometric pressure. The amplitude of the annual variation of (A_1) is greater for Bagdad and the amplitude of (h_1) is greater for Ksara.

Mean Yearly Amplitude (Pressure) = 0.492 mm. Hg. Bagd. / 0.315 mm. Hg. Ksara

Mean Yearly (h_1) (Pressure = 4^h38 (G.M.T.) (B) / 1^h95 (G.M.T.) (K)

Temperature:

Compared with the higher harmonies, the diurnal wave is the most characteristic one of the variation of temperature both for Ksara and Bagdad as might be seen from table (   ) giving the percentage of the amplitudes to the mean values of the respective months.

The amplitudes for Bagdad are higher than those for Ksara. The phase difference is almost negligible.

The annual variation of the amplitude is very similar for the two stations approaching a maximum value during the summer months and a minimum during the winter months.

The annual variation of (h_1) is very

slight. Most probably, it would have been possible to observe some regular oscillations if the work had been based on the averages of a longer period of time.

Mean yearly (A_1) Temperature = 6.566°C Bagdad; 5.277°C Ksara

Mean Yearly (h_1) Temperature = $12^h.15$ (G.M.T.) Bagd; $12^h.26$ (G.M.T.) Ksara.

The following table will present a comparison of the times of maxima for the diurnal waves of pressure and Temperature.

		(h_1) Press.	(h_1) Temp.	Difference
Winter	Bagdad	3.32	12.54	9.22
	Ksara	0.80	12.42	11.62
Spring	Bagdad	5.11	12.06	6.95
	Ksara	2.71	12.33	9.62
Summer	Bagdad	4.76	12.10	7.34
	Ksara	2.20	12.04	9.84
Autumn	Bagdad	4.34	11.90	7.56
	Ksara	2.10	12.25	10.15

For Ksara the times of maxima for the pressure waves are nearer the times of minima for the temperature waves than those of Bagdad

as might be seen from the table. On the other hand, in the mountainous regions, a thermometric maximum should coincide with a barometric maximum due to the fact that, the air in contact with the side of the earth exposed to insolation, becomes heated and the center of mass is raised and conversely the center of mass is lowered when the atmosphere is cooled.

Ksara in this respect behaves like sea level or low stations, where barometric maxima coincide with thermometric minima.

Semi-Diurnal Waves of Pressure and Temp.

Pressure:

The amplitudes of these waves indicate that they constitute the most important element of variation of pressure for the two stations.

The amplitudes for Bagdad are always higher than those for Ksara, but the percentage of variation is higher for Ksara.

The annual variation of the amplitudes is the same for both stations, undergoing a double oscillation with two maxima and two minima, the maxima occuring in April and October.

April max. = $\begin{cases} 0.542 \text{ mm. Hg. (Bagdad)} \\ 0.453 \text{ mm. Hg. (Ksara)} \end{cases}$

October max. = $\begin{cases} 0.549 \text{ mm. Hg. (Bagdad)} \\ 0.502 \text{ mm. Hg. (Ksara)} \end{cases}$

The annual variation of (h_2), time of the first maximum, is very slight and does not show any important characteristic; (h_2) is always greater for Ksara, the reverse of the behaviour of the amplitudes.

Mean Yearly Amplitude (Press) = $\begin{cases} 0.497 \text{ mm. Hg. (Bagdad)} \\ 0.423 \text{ mm. Hg. (Ksara)} \end{cases}$ $\begin{cases} 6^h.92 \text{ (G.M.T) (Bagdad)} \\ 7^h.40 \text{ (G.M.T) (Ksara)} \end{cases}$

According to Simpson(1) and Whipple, the maximum of the semi-diurnal wave of pressure takes place everywhere about $9^h.30$ (local time).

(h_2) for Bagdad = $6^h.92 + 3^h.04 = 9^h.96$ (local time)
(h_2) for Ksara = $7^h.40 + 2^h.44 = 9^h.84$ (local time)

For both localities the results are in fair agreement with the statements of Simpson and Whipple.

For the amplitude (A_2) of the ½ diurnal wave of pressure, Simpson suggests the

(1) [G.E. Simpson, the twelve hourly barometer oscillation Quart. Journ. Roy. Met. Soc. Vol. 44, 1918 p. 1]. (2) [F. J. Whipple, A note on the propagation of ½ diurnal wave Ibid. p. 20]

theoretical formula:

$$A_2 = \left[b^2 + c^2 + 2bc\cos(49^\circ + 2\lambda) \right]$$

$b = .937\cos^3\varphi$ $\quad \varphi$ = the latitude of the station.

$c = .137(\sin^2\varphi - \frac{1}{3})$ $\quad \lambda$ = the longitude of the station.

According to this formula:

A_2 = $\begin{cases} 0.54 \text{ mm. Hg. for (Ksara)} \\ 0.56 \text{ mm. Hg. for (Bagdad)} \end{cases}$

Compared with the yearly means of the amplitude:

A_2 = $\begin{cases} .42 \text{ mm. Hg. Ksara} \\ .50 \text{ mm. Hg. Bagdad} \end{cases}$ (observed)

The differences of the theoretical and observed

= 1.2 mm. Hg. for (Ksara)
= 0.6 mm. Hg for (Bagdad)

The theoretical formula yielding a higher value than the theoretical.

Temperature:

The behaviour of these waves is almost the same at the two stations, the amplitudes for Bagdad are higher than those of Ksara except during the summer months, when the amplitude for Ksara becomes greater. On the other hand (h_2) is greater for Ksara with the exception of the summer months, when (h_2) is greater for Bagdad.

The following table is a comparison of (h_2) for pressure and temperature.

		(h_2) Pressure	(h_2) Temp.	Difference
Winter	Bagdad	6.69	10.76	4.07
	Ksara	7.22	11.09	3.87
Spring	Bagdad	7.23	10.01	2.78
	Ksara	7.63	2.19	5.44
Summer	Bagdad	6.85	10.12	3.27
	Ksara	7.52	9.34	1.82
Autumn	Bagdad	6.93	10.08	3.15
	Ksara	7.23	10.29	3.06

The comparison indicates that the difference of the phases differs for the two stations during summer and Spring months which might be due to a change of the factors affecting the double swing of the thermometric and barometric changes during the above mentioned seasons.

$\frac{1}{3}$ Diurnal and $\frac{1}{4}$ Diurnal Waves of Press. & Temp

Pressure:

These waves resemble each other. they have an amplitude which is greater in Bagdad. (h_3) and (h_4) also, are greater for Bagdad during all the seasons except winter, when Ksara has the higher values for (h_3) and (h_4). The peculiar fact about these waves is that they have their maximum intensity during the winter months for both stations.

Temperature:

The $\frac{1}{3}$ diurnal wave has a greater amplitude at Ksara for the winter and autumn seasons, and (h_3) is less for Ksara during these seasons. On the other hand, during Spring and Summer, the amplitude of the waves is greater for Bagdad but (h_3) is less compared to Ksara.

The $\frac{1}{4}$ diurnal is almost of the same magnitude as the $\frac{1}{3}$th diurnal, the amplitude in general is higher for Bagdad, and (h_4) is less for Bagdad except for the autumn months.

Discrepancy between c1 and c 2

necessitated duplicating

both copies

T
39

Harmonic Anolysis
of
Pressure & Temperature for
(Ksara and Bagdad)

Introduction

The original aim of this work was the study of the harmonic Analysis of the pressure and temperature in the Near-East, to be represented by the following stations:

Beirut . (characterizing sea shore climate.)
Bagdad . (" desert " .)
Ksara . (" mountain " .)

But due to the war circumstances it was impossible to obtain the necessary material and information for all the three stations and the work was carried for Bagdad and Ksara only.

It will be very interesting to compl this work in future.

Chapter I

Material for the Analysis

The material for Ksara[1] was obtained from the official annual bulletins of the observatory.

The observatory of Ksara is situated,

(latitude 33° 49' 25" N)
(longitude 35° 53' 25" E or $2^h 23^m 35^s$ E)
(920 metres above sea shore)

The meteorological station of Bagdad could provide us only with the thermograms and the barograms of Hinaidi[2].

The meteorological station of Hinaidi is situated:

(latitude 33° 17' N)
(longitude 44° 29' E) or (2^h 57' 56" E)
(Altitude 32 meters above above seashore)

To eliminate the effect of the atmospheric disturbances, which are not of a diurnal, or of a still shorter period character, on the barometric and the thermometric variations, the hourly means for a period of 10 years were computed for Ksara. The period was (1928 - 1938).

---

(1) Ksara is a village in Lebanon, with an observratory, directed by monks.

(2) Hinaidi is a locality near Bagdad. The meteorological station at Hinaidi is transfered to Habbaniya in (1937).

Reading of the records:

The most important of the difficulties met in reading the graphs of temperature and pressure were two, namely

a.. The irregularities of the clock of the instrument (such as slowing, stopping etc)

b.. The possible errors committed by the observ[er]

The thermograms contained 3 readings of the standard thermometer at the specified hours. These reading were enough to take care of the instrument error but not enough for other possible errors mentioned above. In such cases after careful study, common sense was used. The different corrections were made according to the conditions imposed. The interval between the curvilinear lines was one hour, so that the readings could be carried without confusion.

For the barograms the interval betwee[n] the successive lines represented a 3 hr. period, so that resort was made to transparent paper, divided into lines of one hour interval, accor[ding] to the scale of the barograms. The instrument error was always recorded on the graph, with some specified hours indicated on the graphs, so that by shifting the transparent paper where necessary the readings of the pressure could be recorde[d] very easily.

Chapter II

Computation of the Coefficients

The computational work connected with Fourier Analyses is based on the following formula.

$$P = A_0 + A_1 \sin(\theta + \varphi_1) + A_2 \sin(2\theta + \varphi_2) \ldots A_n(\sin n\theta + \varphi_n)$$

For a series of 24 equidistant observations t_1, t_2, t_3 .... t_{24} in the cycle, the numerical computations may be made directly from the following equations.

$$A_0 = \frac{1}{24}(t_1 + t_2 + t_3 \ldots\ldots t_{23} + t_{24})$$

$$12a_1 = 0.966(t_1 - t_{11} - t_{13} + t_{23}) + 0.866(t_2 - t_{10} - t_{14} + t_{22})$$
$$+ 0.707(t_3 - t_9 - t_{15} + t_{21}) + 0.500(t_4 - t_8 - t_{16} + t_{20})$$
$$+ 0.259(t_5 - t_7 - t_{17} + t_{19}) + t_{24} - t_{12}$$

$$12b_1 = 0.259(t_1 + t_{11} - t_{15} - t_{23}) + 0.500(t_2 + t_{10} - t_{14} - t_{22})$$
$$+ 0.707(t_3 + t_9 - t_{15} - t_{21}) + 0.866(t_4 + t_8 - t_{16} - t_{20})$$
$$+ 0.966(t_5 + t_7 - t_{17} - t_{19}) + t_6 - t_{18}$$

$$12a_2 = 0.866(t_1 - t_5 - t_7 + t_{11} + t_{13} - t_{17} - t_{19} + t_{23})$$
$$+ 0.500(t_2 - t_4 - t_8 + t_{10} + t_{14} - t_{16} - t_{20} + t_{22})$$
$$- t_6 + t_{12} - t_{18} + t_{24}$$

$$12b_2 = 0.500(t_1 + t_5 - t_7 - t_{11} + t_{13} + t_{17} - t_{19} - t_{23})$$
$$+ 0.866(t_2 + t_4 - t_8 - t_{10} + t_{14} + t_{16} - t_{20} - t_{22})$$
$$- t_3 + t_4 - t_{15} + t_{21}$$

$$12a_3 = 0.707(t_1 - t_3 - t_5 + t_7 + t_9 - t_{11} - t_{13} + t_{15} + t_{17} - t_{19} - t_{21} + t_{23})$$
$$- t_4 + t_8 - t_{12} + t_{16} - t_{20} + t_{24}$$

$$12b_3 = 0.707(t_1 + t_3 - t_5 - t_7 + t_9 + t_{11} - t_{13} - t_{15} + t_{17} + t_{19} - t_{21} + t_{23})$$
$$+ t_2 - t_6 + t_{10} - t_{14} + t_{18} - t_{22}$$

$$12a_4 = 0.500(t_1 - t_2 - t_4 + t_5 + t_7 - t_8 - t_{10} + t_{11} + t_{13} - t_{14} - t_{16}$$
$$+ t_{17} + t_{19} - t_{20} - t_{22} + t_{23}) - t_3 + t_6 - t_9 + t_{12} - t_{15} + t_{18} - t_{21} + t_{24}$$

$$12b_4 = 0.866(t_1 + t_2 - t_4 - t_5 + t_7 + t_8 - t_{10} - t_{11} + t_{13} + t_{14}$$
$$- t_{16} - t_{17} + t_{19} + t_{20} - t_{22} - t_{23})$$

etc..

and other expressions of like character for terms of higher order. For most practical purposes the series is not in general improved by the addition of terms beyond the fourth. After the solution of these equations, the amplitudes A_1, A_2, A_3 & A_4 & the phase angles φ_1, φ_2, φ_3 & φ_4 can be computed according to the following formulas:

$A_1 = \sqrt{a_1^2 + b_1^2}$ $\quad A_2 = \sqrt{a_2^2 + b_2^2}$ $\quad A_3 = \sqrt{a_3^2 + b_3^2}$ $\quad A_4 = \sqrt{a_4^2 + b_4^2}$

$\tan\varphi_1 = a_1/b_1$ $\quad \tan\varphi_2 = a_2/b_2$ $\quad \tan\varphi_3 = a_3/b_3$ $\quad \tan\varphi_4 = a_4/b_4$

Check:

The computations being very tedious it is essential to apply a check on the numerical computations which is of an independent nature & does not consist in simply going over the computations a second time.

Examination for 24 equidistant values shows that for a four-term series t_1 is multiplied once by +0.966, twice by 0.866, twice by 0.707, twice by 0.500 and once by +0.259, the sum of these multipliers being +5.371; likewise t_2 is multiplied once by 1.000, three times by +0.866, twice by +0.500 & once by -0.500,

their sum being +4.098. In this manner has been obtained the following table which gives the multipliers (f) of each of the 24 values (t)

1	2	3	4	5	6
+5.3710	+4.098	+1.414	-0.6340	-0.9215	+0.000
7	8	9	10	11	12
+0.7071	+0.3660	-0.5858	-1.098	-0.7071	+0.000
13	14	15	16	17	18
+0.0931	-0.6340	-1.414	-1.366	-0.5426	0.000
19	20	21	22	23	24
-0.7071	-2.366	-3.414	-2.366	+0.7071	+4.00

It is quite apparent then, that in order to obtain a check on the various operations of the harmonic analyses by which are computed the Fourier coefficients a and b, it is only necessary to multiply the separate ordinates t_1, t_2, t_3 .... t_{24} by their respective values of (f) as given in the upper table. The algebraic sum of the resulting product should be equal to the algebraic sum of the coefficients a and b

In practice three significant figures of (f) quantities gives ample refinement, but due to the relatively small variation of the pressure both at Ksara & Bagdad, the coefficients of the third & fourth terms of the series came out to be very small, so that, to avoid possible mistakes the computations were carried without the dropping of the decimals of higher order.

The next step in the check work is the verification of the amplitudes & phase angles:

$A = \sqrt{a^2 + b^2}$ $\tan \varphi = a/b$

The expressions for these quantities lend themselves to a simple graphical solution, A being considered the hypotenuse & φ one of the acute angles of a right triangle whose legs are a and b.

The device suggested to carry on the check consists of a network of horizontal & vertical lines according to any suitable size & scale depending on the magnitude of the coefficients that appear in the Fourier computations. A quadrant of a circle divided into degrees is laid down on the paper & at its center a graduated revolving arm is fixed the arm being made of celluloid or similar trasparent material, having a line scored on its underneath surface & passing through the center of the hole into which a clamp screw fits which holds the arm in place truly centered with respect to the system of coordinates. The center line of the revolving arm is graduated according to the same scale as that of the system.

To check the amplitude and phase angles, the point (a, b) is plotted, the vertical scale being used for the (a) coefficient and the horizontal scale for the (b) coefficient, then swinging the arm around the center, until the center line coincides

with the point (a, b). The amplitude (A) can be read on the center line scale, and the intersection of the center line & the circle determines the phase angle. The four quadrants are figured on the diagram and the quadrant into which the angle falls can be mentally noted according to the sings of (a) and (b) as determined by the usual trigonometric relations.

The ideal arrangment would be to use a complete circle instead of a quadrant of a circle, so that the proper quadrant for fixing the angles would be automatically determined, without resort to the trigonometric relations, which might introduce a source of error in the check work.

To carry on the check work of the amplitudes and phases angles, I used a large sheet of squarea paper. Putting in the central position of the paper the origin of my coordinates axes of (a) and (b), I plotted the different points (a, b) and by the use of a good ruler & a celluloid protractor the amplitudes and the phase angles were determined to the first decimal place very satisfactorily.

<u>The computation</u>

The specimen computation to be presented is a complete example of the harmonic analyses of the mean hourly values of the barometric pressure at Ksara for the august of (1928 – 1938).

The conveniently arranged form on which the computations are made was devised by W. J. Peters and C. R. Duvall of the Department of Terrestrial Magnetism. In the specimen suggested the functional quantities entering in the analyses have been divided by 12 instead of taking $\frac{1th}{12}$ of the finally determined coefficients (a) and (b).

I thought it was more convenient to multiply the functional quantities as they stand rather than by $\frac{1th}{12}$ of their values. The increase of the numerical computational work is questionable. The only extra work is eight divisions by 12, which can be done mentally, on the other hand due to the fact that, some of the functional multipliers are unity, the computation in carrying on the multiplications becomes simplified. Moreover, due to the fact that the amplitudes of $\frac{1}{3}$ diurnal and $\frac{1}{4}$ diurnal waves are very small, possible errors might

be hidden if the difference between the Σfxt and $\Sigma(a+b)$ is not considered as a mistake beyond the second decimal place, and to avoid this it is advisable to multiply the functional quantities as they stand.

A second point to be considered is the following: Instead of the mean values of the quantities to be used as my (t) quantities, it is better to choose the smallest whole number among the 24 (t) quantities and calculating the difference of the (t) quantities and the smallest number found, to use these differences as the 24 (t)s. This will facilitate enormously the check work and the rest of the computations.

In the specimen the devisor of the method considers the mean of the 24 values but it is not necessary to use the mean of the 24 (t) values in the calculations. It is just as good to choose any convenient number according to the given data and carry on the computations accordingly. The main point I like to emphasize, is the fact that it is not necessary to carry the quotient of the summation of the (t) quantities by 24 to many decimal places, thinking that the results might be improved and this way increasing the labour in the computation work.

(1)

August (Ksara Pressure)

				Ordinate less mean (1) 1-12	(2) 24-13	(3) (1) + (2) a-g	(4) (1) − (2) m-h
0			a	1	0.29	0.29	-0.14
1	680.09	1.09	b	0.08	0.41	0.49	-0.31
2	680.00	1.00	c	-0.01	0.43	0.42	-0.23
3	679.95	0.95	d	-0.06	0.37	0.31	-0.16
4	679.97	0.97	e	-0.04	0.15	0.11	-0.18
5	680.10	1.10	f	0.09	-0.24	-0.15	-0.20
6	680.30	1.30	g	0.29	-0.53	-0.24	
7	680.51	1.51	h	0.50	-0.70		
8	680.55	1.55	i	0.54	-0.72		
9	680.52	1.52	j	0.51	-0.67		
10	680.35	1.35	k	0.34	-0.57		
11	680.07	1.07	l	0.06	-0.37		
12	679.87	0.87	m	-0.14			
13	679.64	0.64					
14	679.44	0.44					
15	679.34	0.34					
16	679.24	0.29					
17	679.31	0.31	b				
18	679.48	0.48	c				
19	679.77	0.77	d				
20	680.16	1.16	e				
21	680.38	1.38	f				
22	680.44	1.44	g				
23	680.42	1.42					
24	680.30	1.30					
Σ		24.25					
Σ/24		1.01					

	11	12 (3) − (4)
a	1.000	0.43
b	0.966	0.80
c	0.866	0.65
d	0.707	0.47
e	0.500	0.29
f	0.259	0.05
		$12a_1$

	19 (1) − (2) b-g	20 l-h	21 (19)+(20) b-g	Comp 22
b	-0.33	0.43	0.10	0.259
c	-0.44	0.91	0.47	0.500
d	-0.43	1.18	0.75	0.707
e	-0.19	1.26	1.07	0.866
f	0.33	1.20	1.53	0.966
g	0.82		0.82	1.000
				$12b_1$

(1) Time (G.M.T.+2)

(5) (3) + (4) a-d	(6) (3) + (4) g-e	(7) (5) + (6) a-b	(8) (5) + (6) d-c	(9) (7) − (8) a-b	(10)
0.15	-0.24	-0.09	0.15	-0.24	1.000
0.18	-0.35	-0.17	0.12	-0.29	0.500
0.19	-0.07				
0.15					

11x12	Comp of b_1 (21)x(22)
0.43000	0.02590
0.77280	0.23500
0.56290	0.53025
0.33229	0.92662
0.14500	1.47798
0.01295	0.82000
=2.25594	=4.01575

Comp. of a_2

	(13)	(13)x(14)	(14) (5) − (6)
a	1.000	0.39000	0.39
b	0.866	0.45898	0.53
c	0.500	0.13000	0.26

$12a_2$ = 0.97898

Comp of a_3

From 12	(15)	(16)	(15)x(16)
a-e	0.14	1	0.14
b-d-f	0.28	0.707	0.19796

$12a_3$ = 0.33796

Comp of a_4

	9x10
a	-0.240
b	-0.145

$12a_4$ = -0.385

Note: The rectangular components of the amplitudes namely a, b, etc are the sums of the columns in their respective compartments devided by 12.

23 (19) − (20) b-d	24 (19) − (20) f-e
-0.76	-0.87
-1.35	-1.45
-1.61	

$12b_2$ = -4.8498

Comp of b_4

29 (23)-(24) b-e	30	29x30
0.11	0.866	0.09526
0.10	0.866	0.08660

$12b_4$ = 0.18186

Comp of b_3

From 21	(27)	(27)x(28)	(28)
b+d-f	-0.68	-0.48076	0.707
c-g	-0.35	-0.35000	1.000

$12b_3$ = -0.83076

Comp of b_2

	25	(23)+(24)	25x26
b	0.500	-1.63	-0.8150
c	0.866	-2.80	-2.4248
d	1	-1.61	-1.6100

a_1 = 0.18789 a_2 = 0.08158 a_3 = 0.02896 a_4 = -0.03200

b_1 = 0.33466 b_2 = -0.40415 b_3 = -0.06923 b_4 = 0.01516

Check of (a) and (b) Coefficients

	+f	t	f x t		-f	t	-fxt
1	5.371	1.09	5.854390	4	-0.6340	0.97	-0.614980
2	4.098	1.00	4.098000	5	-0.9215	1.10	-1.013650
3	1.414	0.95	1.343300	9	-0.5858	1.52	-0.890416
6	0.000	1.30	0.000000	10	-1.0980	1.35	-1.482300
7	0.7071	1.51	1.067721	11	-0.7071	1.07	-0.756597
8	0.3660	1.55	0.567320	14	-0.6340	0.44	-0.278960
12	0.000	0.87	0.000000	15	-1.4140	0.34	-0.480760
13	0.0931	0.64	0.059584	16	-1.3660	0.29	-0.396140
18	0.000	0.48	0.000000	17	-0.5426	0.31	-0.168206
23	0.7071	1.42	1.004082	19	-0.7071	0.77	-0.544467
24	4.000	1.30	5.200000	20	-2.3660	1.16	-2.744560
				21	-3.4140	1.38	-4.711320
				22	-2.3660	1.44	-3.407040
			19.194377				-17.489396

$\Sigma f \times t$ = 1.704981

$\Sigma 12a + 12b$ = 1.704930

Difference = 0.000051

$\frac{1}{12} \Sigma f \times t$ = 0.142082

$\Sigma a + b$ = 0.142170

Difference = 0.000088

Amplitudes and Phase Angles

	Diurnal Wave	½ Diurnal Wave	⅓ Diurnal Wave	¼ Diurnal Wave
a	0.1880	0.0816	0.0282	-0.0320
b	0.3347	-0.4041	-0.0692	0.0152
a^2	0.03 5344 00	0.00 665856	0.00 079524	0.00 102400
b^2	0.11 2024 09	0.16 329681	0.00 478864	0.00 02 31 04
a^2+b^2	0.14 73 68 09	0.16 99 55 37	0.00 55 83 88	0.00 12 55 04
a^2+b^2	0.3839	0.4123	0.0747	0.0354
$\tan\varphi = \frac{a}{b}$	0.56170	0.20193	0.40751	2.10526
φ	29°.322	168°.583	157°.83	295°.408
h	(*) $4^h.05$	$9^h.38$	$6^h.49$	$2^h.58$

Result $680.01 + 0.3839 \sin[\theta + 29°.322]$

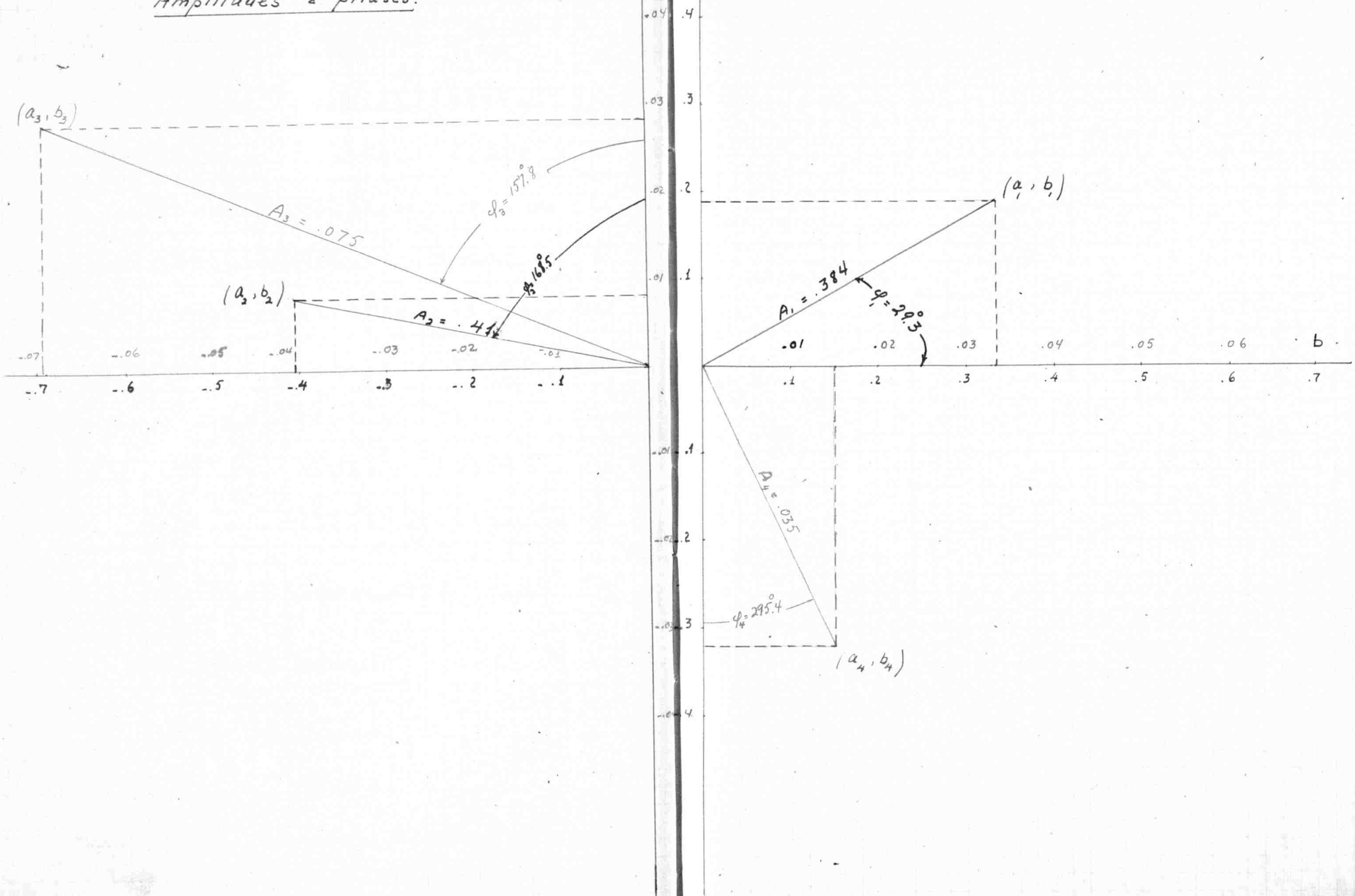
$+ 0.4123 \sin[2\theta + 168°.583]$

$+ 0.0747 \sin[3\theta + 157°.830]$

$+ 0.0354 \sin[4\theta + 295°.408]$

(*) (h) represents the time for the first maximum, of the specified wave. The time used (G. M. T. +2).

Graphical Check for the Amplitudes & phases.



Chapter III

Results of the Analysis

Time:

The time used for all the computations of Ksara is (G.M.T. + 2). but after the computations, all the results were reduced to G.M.T.

For Bagdad the computations were based on (G.M.T.)

Throughout the discussion, whenever there is any reference of time, it is (G.M.T.), unless it is specified.

The results obtained are put in the form of tables followed by the graphs of the most characteristic results.

The first four tables represent the diurnal variation of pressure and temperature for Ksara and Bagdad, followed by the seasonal averages.

Table V gives the seasonal averages, of the diurnal variation of pressure and temperature of Bagdad, in degrees Centigrade and in millimeters of mercury respectively, because for Bagdad Temperature unit used was the Fahrenheit and the pressure unit, the millibar.(1)

---

(1) 1 millibar = $\frac{1}{1000}$ bar　　1 bar = 10^6 baryes

1 barye = 1 dyne/cm^2　　1 millibar = 0.750059 mm. Hg. (approx) depending on the value of g)

To facilitate the understanding of the results, the meaning of symbols used are as follows:

M = maximum value of the diurnal variation
m = minimum " " "
μ = the mean of the 24 hourly values
(%) = $\frac{M-m}{\mu}$ (the same unit is used in the denominator and numerator. $\frac{deg.°C}{deg.°C}$ $\frac{mm.Hg.}{mm.Hg.}$)

A = Amplitude of the waves.
φ = the phase angle in degrees.
(h) = Time of first maximum (G.M.T. +2)
h = Time of first maximum (G.M.T.)

% = $100 \times \frac{A}{\mu}$

For graphs, the red coulour is always used to represent the variations of Bagdad, and the blue the variations of Ksara.

Table I. Diurnal Variation of Pressure for Ksara

	1	2	3	4	5	6	7	8	9	10
	600+	600+	600+	600+	600+	600+	600+	600+	600+	600+
Jan.	84.22	84.05	84.03	84.20	84.43	84.69	84.89	84.88	84.41	83.92
Feb.	81.71	81.60	81.61	81.74	81.99	82.21	82.33	82.34	82.16	81.75
March	82.72	82.67	82.75	82.93	83.21	83.38	83.48	83.43	83.21	82.91
April	81.88	81.83	81.93	82.16	82.41	82.51	82.58	82.56	82.38	82.17
May	82.11	82.21	82.24	82.46	82.70	82.75	82.72	82.67	82.50	82.30
June	80.32	80.34	80.46	80.64	80.86	80.85	80.74	80.65	80.51	80.30
July	79.11	79.14	79.25	79.42	79.62	79.59	79.49	79.36	79.17	78.97
August	79.95	79.97	80.10	80.30	80.51	80.55	80.52	80.35	80.07	79.87
Sept.	82.25	82.26	82.37	82.56	82.78	82.90	82.92	82.74	82.44	82.17
Oct.	84.60	84.64	84.73	84.88	85.17	85.40	85.39	85.21	85.17	84.43
Nov.	84.90	84.84	84.89	85.05	85.33	85.51	85.60	85.45	85.06	84.66
Dec.	84.78	84.65	84.61	84.78	85.02	85.17	85.48	85.41	84.97	84.50

	11	12	13	14	15	16	17	18	19	20
Jan	83.58	83.49	83.65	83.64	83.78	84.11	84.31	84.47	84.52	84.52
Feb	81.38	81.24	81.27	81.38	81.51	81.78	81.97	82.13	82.23	82.26
March	82.56	82.36	82.22	82.22	82.32	82.55	82.78	83.08	83.19	83.23
April	81.95	81.70	81.54	81.49	81.57	81.75	81.99	82.32	82.51	82.55
May	82.11	81.91	81.76	81.68	81.66	81.80	82.01	82.29	82.55	82.61
June	80.10	79.96	79.81	79.64	79.68	79.87	80.05	80.32	80.61	80.70
July	78.77	78.61	78.45	78.34	78.34	78.58	78.80	79.12	79.46	79.56
August	79.64	79.44	79.34	79.29	79.31	79.48	79.77	80.16	80.38	80.44
Sept	81.95	81.61	81.49	81.49	81.56	81.79	82.14	82.51	82.68	82.71
Oct	84.03	83.86	83.79	83.81	83.94	84.26	84.52	84.76	84.93	84.98
Nov	84.22	84.10	84.09	84.18	84.37	84.74	84.97	85.12	85.24	85.28
Dec	84.19	84.09	84.18	84.29	84.43	84.77	84.98	85.10	85.14	85.19

	21	22	23	24	μ	M-m	%
Jan.	84.43	84.33	84.39	84.34	84.22	1.40	.0020
Feb.	82.23	82.15	81.99	81.75	81.86	1.10	.0016
March	83.18	83.09	83.08	82.88	82.89	1.26	.0018
April	82.54	82.44	82.17	81.99	82.12	1.09	.0016
May	82.56	82.43	82.28	82.15	82.29	1.09	.0016
June	80.66	80.53	80.51	80.38	80.35	1.22	.0018
July	79.55	79.42	79.27	79.16	79.11	1.28	.0019
August	80.42	80.30	80.09	80.00	80.01	1.26	.0018
Sept	82.69	82.61	82.43	82.32	82.31	1.43	.0021
Oct.	84.94	84.88	84.81	84.69	84.66	1.61	.0023
Nov.	85.24	85.17	85.08	85.04	84.92	1.51	.0022
Dec.	85.14	85.03	84.90	84.88	84.82	1.39	.0020

Diurnal Variation per season

	1	2	3	4	5	6	7	8	9	10
Winter	83.57	83.43	83.42	83.57	83.81	84.02	84.23	84.21	83.85	83.39
Spring	82.24	82.24	82.31	82.52	82.77	82.88	82.93	82.89	82.70	82.46
Summer	79.79	79.82	79.94	80.12	80.33	80.33	80.25	80.12	79.92	79.71
Autumn	83.92	83.91	84.00	84.16	84.43	84.60	84.64	84.37	84.22	83.75

	11	12	13	14	15	16	17	18	19	20
Winter	83.05	82.94	83.03	83.10	83.24	83.55	83.75	83.90	83.96	83.99
Spring	82.21	81.99	81.84	81.96	81.85	82.03	82.26	82.56	82.75	82.80
Summer	79.50	79.34	79.20	79.09	79.11	79.31	79.54	79.87	80.15	80.23
Autumn	83.40	83.19	83.12	83.16	83.29	83.60	83.88	84.13	84.28	84.32

	21	22	23	24	μ	M-m	%
Winter	83.93	83.84	83.76	83.66	83.63	1.30	.0019
Spring	82.76	82.65	82.51	82.34	82.43	1.15	.0017
Summer	80.21	80.08	79.96	79.85	79.82	1.25	.0018
Autumn	84.29	84.22	84.11	84.02	83.96	1.52	.0022

Table II. Diurnal Variation of Temperature at Ksara.

	1	2	3	4	5	6	7	8	9	10
Jan.	2.94	2.77	2.59	2.40	2.35	3.39	4.89	6.46	7.63	8.51
Feb.	4.51	4.39	4.20	4.06	4.22	5.36	6.76	8.11	9.98	9.77
March	6.77	6.11	5.72	5.38	6.55	8.84	11.08	12.87	14.30	15.11
April	9.78	9.37	9.02	9.24	11.07	13.61	15.91	16.73	18.98	19.75
May	13.02	12.44	12.12	12.94	15.88	18.61	20.95	22.73	23.98	24.58
June	15.34	14.66	14.53	16.49	20.10	24.10	26.16	28.22	29.07	29.68
July	17.83	17.18	16.85	17.57	21.01	24.07	26.76	28.99	30.10	30.54
August	18.45	17.79	17.25	17.60	20.59	23.97	27.05	29.62	31.17	31.88
Sept.	16.02	15.43	14.82	14.90	17.75	21.05	24.03	26.60	28.35	29.17
Oct.	13.22	12.67	12.28	11.94	14.04	17.27	20.16	22.44	24.02	24.80
Nov.	9.14	8.79	8.45	8.21	8.92	10.87	13.45	15.58	17.04	17.99
Dec.	4.97	4.78	4.62	4.49	4.68	5.82	6.95	9.14	10.49	11.28

	11	12	13	14	15	16	17	18	19	20
Jan.	9.19	9.30	9.08	8.33	6.94	5.98	5.25	4.72	4.34	4.05
Feb.	10.24	10.29	9.97	9.42	8.42	7.47	6.85	6.38	6.04	5.67
March	15.80	15.71	15.43	14.72	13.59	11.96	10.86	10.07	9.30	8.71
April	20.24	20.10	19.76	19.07	17.98	16.34	15.00	14.05	13.31	12.59
May	24.84	24.63	24.14	23.44	22.44	20.82	19.36	18.24	17.29	16.40
June	29.76	29.42	28.74	27.60	25.86	24.13	22.49	21.23	20.18	19.21
July	30.47	30.11	29.41	28.68	27.59	26.17	24.88	23.94	22.94	21.99
August	32.02	31.62	30.89	30.11	28.92	27.00	25.61	24.52	23.41	22.33
Sept.	29.45	29.13	28.49	27.62	26.07	24.01	22.55	21.46	20.52	19.43
Oct.	25.21	25.00	24.45	23.48	21.61	19.98	18.80	17.91	16.96	16.16
Nov.	18.52	18.44	17.91	16.77	15.01	13.75	12.83	12.10	11.52	10.96
Dec.	11.88	11.91	11.48	10.45	8.98	8.01	7.39	6.79	6.33	6.07

	21	22	23	24	μ	M-m	%
Jan.	3.77	3.58	3.42	3.18	5.21	6.95	1.33
Feb.	5.41	5.17	4.92	4.67	6.76	6.23	0.92
March	8.16	7.66	7.20	6.80	10.36	10.42	1.01
April	11.86	11.43	10.67	10.20	14.42	11.22	0.78
May	15.79	15.07	14.27	13.59	18.65	12.72	0.68
June	18.30	17.56	16.67	16.00	22.31	15.23	0.68
July	21.07	20.30	19.38	18.58	24.00	13.69	0.57
August	21.47	20.66	19.92	19.13	24.71	14.77	0.60
Sept.	18.69	17.98	17.33	16.66	21.98	14.63	0.67
Oct.	15.53	14.88	14.35	13.62	18.37	13.27	0.72
Nov.	10.49	10.04	9.85	9.49	12.76	10.31	0.81
Dec	5.81	5.55	5.41	5.14	7.43	7.42	1.00

Diurnal Variation per Season

	1	2	3	4	5	6	7	8	9	10
Winter	4.14	3.98	3.80	3.65	3.75	4.86	6.20	7.90	9.37	9.85
Spring	9.86	9.31	8.95	9.19	11.17	13.69	15.98	17.44	19.09	19.81
Summer	17.21	16.54	16.21	17.22	20.57	24.05	26.66	28.94	30.11	30.70
Autumn	12.79	12.30	11.85	11.68	13.57	16.40	19.21	21.54	23.14	23.99
	11	12	13	14	15	16	17	18	19	20
Winter	10.44	10.50	10.18	9.40	8.11	7.15	6.50	5.96	5.57	5.26
Spring	20.29	20.15	19.78	19.08	18.00	16.37	15.07	14.12	13.30	12.57
Summer	30.75	30.38	29.68	28.80	27.46	25.77	24.33	23.23	22.18	21.18
Autumn	24.39	24.19	23.62	22.62	20.90	19.25	18.06	17.16	16.33	15.52
	21	22	23	24	μ	M-m	%			
Winter	5.00	4.77	4.58	4.33	6.47	6.87	1.08			
Spring	11.94	11.39	10.71	10.20	14.48	11.45	0.82			
Summer	20.28	19.51	18.66	17.90	23.68	14.56	0.62			
Autumn	14.90	14.30	13.84	13.26	17.70	12.74	0.73			

Table III Diurnal Variation of Pressure for Bagdad (1934)

millibars	1	2	3	4	5	6	7	8	9	10
		1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+	1000+
Jan.	1019.7	19.6	19.6	20.1	20.5	21.1	21.9	20.9	20.3	19.7
Feb.	1016.2	16.2	16.6	16.9	17.3	17.6	17.8	17.8	17.1	16.4
March.	1013.4	13.6	14.0	14.4	14.7	15.0	15.1	14.8	14.3	13.7
April	1009.1	9.4	9.8	10.1	10.2	9.8	11.1	11.0	10.6	9.7
May	1009.0	9.3	9.6	10.1	10.4	10.7	10.7	10.6	10.2	9.8
June	1002.7	3.1	3.5	3.7	4.0	4.1	3.6	3.8	3.5	3.0
July	997.5	998.0	998.2	998.6	998.7	998.8	998.8	998.6	997.9	997.7
August	998.8	999.1	999.5	999.9	1000.3	1000.3	1000.1	999.7	999.7	999.2
Sept.	1005.3	5.6	5.7	6.4	6.7	6.9	6.9	6.6	6.1	5.8
Oct.	1012.4	12.6	12.9	12.9	13.7	14.0	14.0	14.2	13.1	12.4
Nov.	1016.8	16.9	17.2	17.4	17.9	18.2	18.3	18.0	17.3	16.8
Dec	1017.3	17.4	17.6	18.0	18.4	18.8	18.5	18.5	18.0	16.9
	11	12	13	14	15	16	17	18	19	20
Jan.	19.4	19.1	19.5	19.4	20.2	20.2	20.4	20.5	20.5	20.5
Feb.	15.8	15.6	15.4	15.7	15.8	16.1	16.4	16.6	16.6	16.6
March	13.0	12.6	12.4	12.3	12.4	12.7	13.0	13.3	13.2	13.4
April	9.5	9.0	8.6	8.4	8.5	8.9	9.4	9.8	9.8	9.8
May	9.3	8.8	8.4	8.2	8.2	8.5	8.9	9.3	9.5	9.5
June	2.5	2.1	1.6	1.4	1.5	1.7	2.0	2.4	2.6	2.6
July	997.3	996.8	996.5	996.4	996.4	996.6	997.0	997.5	997.6	997.6
August	998.8	998.4	998.1	998.0	997.9	998.3	998.6	999.1	999.2	999.1
Sept.	5.2	4.8	4.6	4.7	4.6	4.8	5.3	5.6	5.7	5.7
Oct.	12.0	11.8	11.6	11.6	11.8	12.2	12.4	12.6	12.7	12.7
Nov.	16.3	16.3	16.2	16.2	16.5	16.4	17.0	17.2	17.2	17.3
Dec.	16.6	16.5	16.7	16.9	17.0	17.3	17.5	17.5	17.5	17.5

	21	22	23	24	N mbs	N mm. Hg.	M-m mbs.	M-m mm. Hg	%
	1000+	1000+	1000+	1000+					
Jan.	20.4	20.3	20.2	19.8	1020.2	765.2	2.8	2.1	.0027
Feb.	16.5	16.4	16.3	16.1	1016.5	762.4	2.4	1.8	.0024
March	13.3	13.2	13.2	13.0	1013.5	760.2	2.8	2.1	.0028
April	9.7	9.6	9.3	9.2	1009.6	757.3	2.7	2.0	.0026
May	9.4	9.3	9.2	9.1	1009.4	757.1	2.5	1.9	.0026
June	2.4	2.2	2.1	2.2	1002.7	752.1	2.7	2.0	.0026
July	997.5	997.3	997.2	997.3	997.6	748.3	2.4	1.8	.0024
August	999.1	998.9	99.88	998.8	999.1	749.4	2.4	1.8	.0024
Sept.	5.6	5.6	5.5	5.4	1005.6	754.3	2.3	1.7	.0022
Oct.	12.6	12.6	12.2	12.2	1012.6	759.5	2.6	2.0	.0026
Nov.	17.3	17.2	17.1	17.0	1017.1	762.9	2.1	1.6	.0021
Dec.	17.4	17.4	17.3	17.3	1017.5	763.2	2.3	1.7	.0022

Diurnal variation per Season.

	1	2	3	4	5	6	7	8	9	10
Winter	1017.7	17.7	17.9	18.3	18.7	19.2	19.4	19.1	18.5	17.7
Spring	1010.5	10.8	11.1	11.5	11.8	11.8	12.3	12.1	11.7	11.1
Summer	999.7	1000.1	1000.4	1000.7	1000.9	1000.1	1001.9	1000.8	1000.4	999.9
Autumn	1011.5	11.7	11.9	12.2	12.8	13.0	13.1	12.9	12.2	11.7

	11	12	13	14	15	16	17	18	19	20
Winter	1017.3	17.1	17.2	17.3	17.7	17.9	18.1	18.2	18.2	18.2
Spring	1010.6	10.1	9.8	9.6	9.7	10.0	10.4	10.8	10.8	10.9
Summer	999.5	999.1	998.7	998.6	998.6	998.9	998.9	999.7	999.8	999.8
Autumn	1011.2	11.0	10.8	10.8	11.0	11.1	11.6	11.8	11.9	11.9

	21	22	23	24	N mbs	M-m mbs	M-m mm. Hg.	N mm. Hg	%
Winter	1018.1	18.0	17.9	17.7	1018.1	2.5	1.9	763.6	.0024
Summer	1010.8	10.7	10.6	10.4	1010.8	2.7	2.0	758.2	.0027
Spring	999.7	999.5	999.4	999.4	999.8	2.5	1.9	749.9	.0025
Autumn	1011.8	11.8	11.6	11.5	1011.8	2.3	1.8	758.9	.0023

Table IV Diurnal Variation of Temp. for Bagdad (1934)

Degrees F.	1	2	3	4	5	6	7	8	9	10
Jan.	39.5	38.4	38.1	37.9	38.6	41.3	45.1	47.7	50.7	52.6
Feb.	43.7	42.9	42.9	42.4	44.1	47.8	51.3	54.6	57.2	58.6
March	51.6	50.6	49.8	50.4	54.4	60.1	65.6	69.9	73.1	73.9
April	60.8	60.1	59.2	61.7	66.3	71.6	75.5	78.3	80.5	82.2
May	67.3	66.2	67.3	70.9	75.7	80.6	83.8	86.1	88.0	86.3
June	77.3	75.9	76.6	80.2	85.8	90.8	95.6	98.9	101.5	102.9
July	80.4	79.0	79.2	82.1	87.1	92.5	97.3	101.7	105.2	106.8
August	76.0	76.9	76.2	78.8	84.6	90.8	96.3	101.6	105.0	107.0
Sept.	72.8	70.7	69.9	72.1	78.8	86.3	93.7	97.5	100.6	102.3
Oct.	63.2	62.6	61.9	63.1	64.8	75.6	81.3	86.3	90.5	91.4
Nov.	53.6	52.5	52.2	52.0	55.8	61.7	66.6	70.9	73.4	75.1
Dec.	44.7	43.9	43.4	43.2	44.6	48.2	51.8	54.8	57.4	59.0

	11	12	13	14	15	16	17	18	19	20
Jan.	53.4	53.8	53.4	51.6	48.4	46.4	45.3	44.2	43.6	42.7
Feb.	59.7	60.0	59.8	58.7	55.8	53.0	51.1	49.9	48.8	48.0
March	75.1	78.6	75.4	74.4	69.5	65.4	62.7	60.7	58.9	57.6
April	82.9	83.1	82.6	81.5	78.6	74.3	77.4	69.3	67.8	66.1
May	90.3	90.6	90.1	88.8	85.2	82.2	79.2	77.3	75.3	73.6
June	103.9	104.4	103.7	102.8	100.5	96.3	91.5	88.3	86.6	84.9
July	104.4	108.1	108.7	106.9	104.9	97.6	93.1	89.0	89.1	87.6
August	107.9	108.0	107.5	105.9	102.0	95.3	91.5	89.0	86.9	85.4
Sept.	103.3	103.1	102.4	97.5	93.8	88.3	85.4	83.8	82.0	81.0
Oct.	92.6	92.3	91.2	88.0	82.1	78.1	78.2	73.2	71.4	69.9
Nov.	75.9	75.7	74.7	71.0	67.0	63.6	61.7	60.3	61.1	57.4
Dec	60.3	60.7	60.2	58.0	55.1	52.9	51.6	50.4	49.3	48.4

	21	22	23	24	μ°F	μ°C	M-m°F	M-m°C	%
Jan.	41.8	41.2	40.7	40.2	44.8	7.1	15.9	8.8	1.24
Feb.	47.0	46.2	45.5	44.4	50.6	10.3	17.6	9.8	0.95
March	56.7	55.8	54.4	53.2	62.4	16.9	28.8	16.0	0.95
April	65.0	63.5	63.1	61.8	71.1	21.7	23.9	13.3	0.61
May	72.3	71.2	70.0	68.7	78.6	25.9	24.4	13.6	0.52
June	83.8	83.2	81.1	79.5	90.7	32.6	28.5	15.8	0.48
July	88.7	83.6	82.4	81.4	93.2	34.0	29.7	16.5	0.48
August	84.0	82.9	79.2	79.9	91.6	33.1	32.0	17.8	0.54
Sept.	78.6	77.1	75.8	74.2	86.3	30.2	33.4	18.6	0.62
Oct.	69.1	66.8	65.4	64.4	75.9	24.4	30.7	17.1	0.70
Nov.	56.4	55.4	54.4	53.7	62.6	17.0	23.9	13.3	0.78
Dec	47.5	46.7	46.0	45.5	51.0	10.6	17.5	9.7	0.91

Diurnal Variation per Season

	1	2	3	4	5	6	7	8	9	10
Winter	42.6	41.7	41.5	41.2	42.4	45.8	49.4	52.4	55.1	56.7
Spring	59.9	59.0	58.8	61.0	65.5	70.8	75.0	78.1	80.5	80.8
Summer	77.9	77.3	77.3	80.4	85.8	91.4	96.4	100.7	103.9	105.6
Autumn	63.2	61.9	61.3	62.4	66.5	74.5	80.5	84.9	88.2	89.6
	11	12	13	14	15	16	17	18	19	20
Winter	57.8	58.2	57.8	56.1	53.1	50.8	49.3	48.2	47.2	46.4
Spring	82.8	84.1	82.7	81.6	77.8	74.0	71.1	69.1	67.3	65.8
Summer	105.4	106.8	106.6	105.2	102.5	96.4	92.0	88.8	87.5	86.0
Autumn	90.6	90.4	89.4	85.5	81.0	76.4	74.3	72.4	71.5	69.4
	21	22	23	24	μ°F	μ°C	M-m°F	M-m°C	%	
Winter	45.4	44.7	44.1	43.4	48.8	9.3	17	9.4	1.09	
Spring	64.7	63.5	62.5	61.2	70.7	21.5	25.7	14.3	0.69	
Summer	85.5	83.2	80.9	80.3	91.8	33.2	30.1	16.7	0.50	
Autumn	68.0	66.4	65.2	64.1	74.9	23.8	29.3	16.3	0.70	

Table V_b. Diurnal Variation of Temperature for Bagdad per season in degrees Centigrade.

	1	2	3	4	5	6	7	8	9	10
Winter	5.9	5.4	5.3	5.1	5.8	7.7	9.7	11.3	12.8	13.7
Spring	15.5	15.0	14.9	16.2	18.6	21.6	23.9	25.6	26.9	27.1
Summer	25.5	25.2	25.2	26.9	29.9	33.0	35.8	38.2	39.9	40.9
Autumn	17.3	16.6	16.3	16.9	19.2	23.6	26.9	29.4	31.2	32.0
	11	12	13	14	15	16	17	18	19	20
Winter	14.3	14.6	14.3	13.4	11.7	10.4	9.6	9.0	8.4	8.0
Spring	28.2	28.9	28.2	27.6	25.4	23.3	21.7	20.6	19.6	18.8
Summer	40.8	41.6	41.4	40.7	39.2	35.8	33.3	31.6	30.8	30.0
Autumn	32.6	32.4	31.9	29.7	27.2	24.8	23.5	22.4	21.9	20.8
	21	22	23	24	μ	M-m	%			
Winter	7.4	7.1	6.7	6.3	9.3	9.4	1.09			
Spring	18.2	17.5	16.9	16.2	21.5	14.3	0.69			
Summer	29.7	28.4	27.2	26.8	33.2	16.7	0.50			
Autumn	20.0	19.1	18.4	17.8	23.8	16.3	0.70			

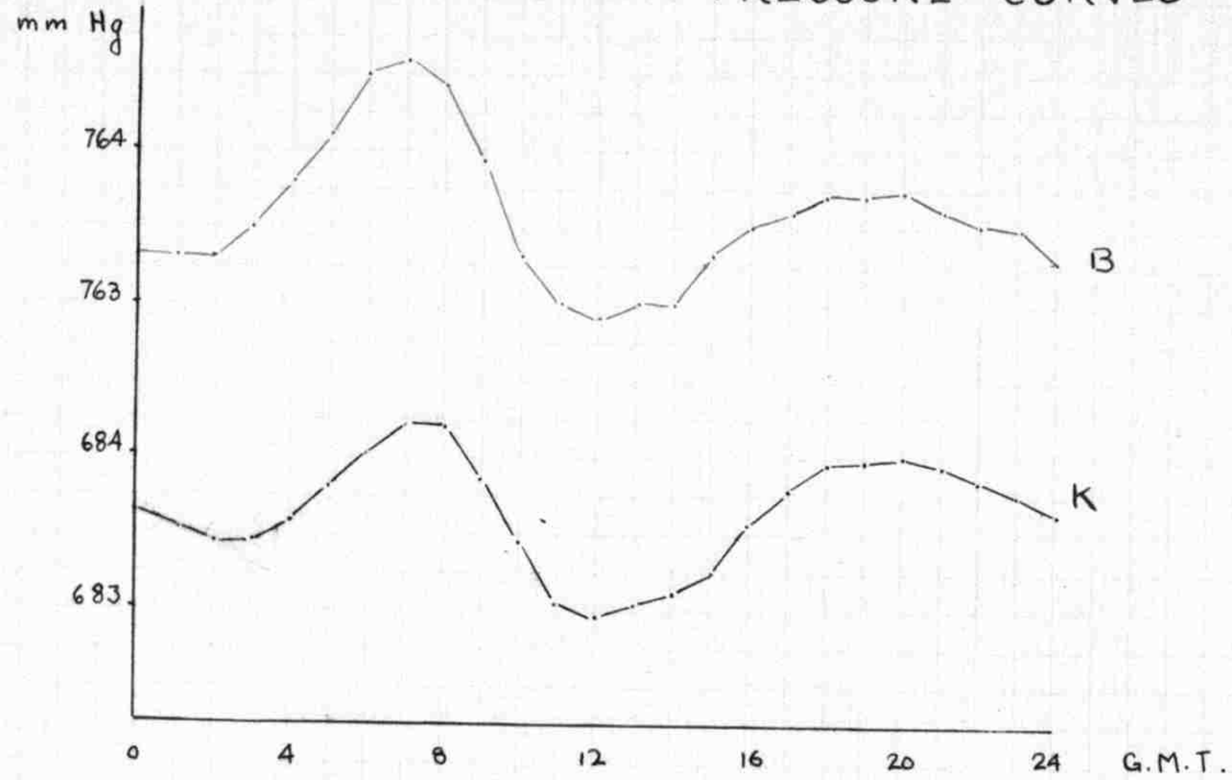
Table Va. The diurnal variation of Pressure for Bagdad per season, in millimeters of mercury.

	1	2	3	4	5	6	7	8	9	10
Winter	700+ 63.3	700+ 63.3	700+ 63.5	700+ 63.8	700+ 64.1	700+ 64.5	700+ 64.6	700+ 64.4	700+ 63.9	700+ 63.3
Spring	57.9	58.2	58.4	58.7	58.9	58.9	59.3	59.1	58.8	58.4
Summer	49.8	50.1	50.4	50.6	50.7	50.9	50.7	50.7	50.4	50.0
Autumn	58.7	58.8	59.0	59.2	59.7	59.8	59.9	59.7	59.2	58.8

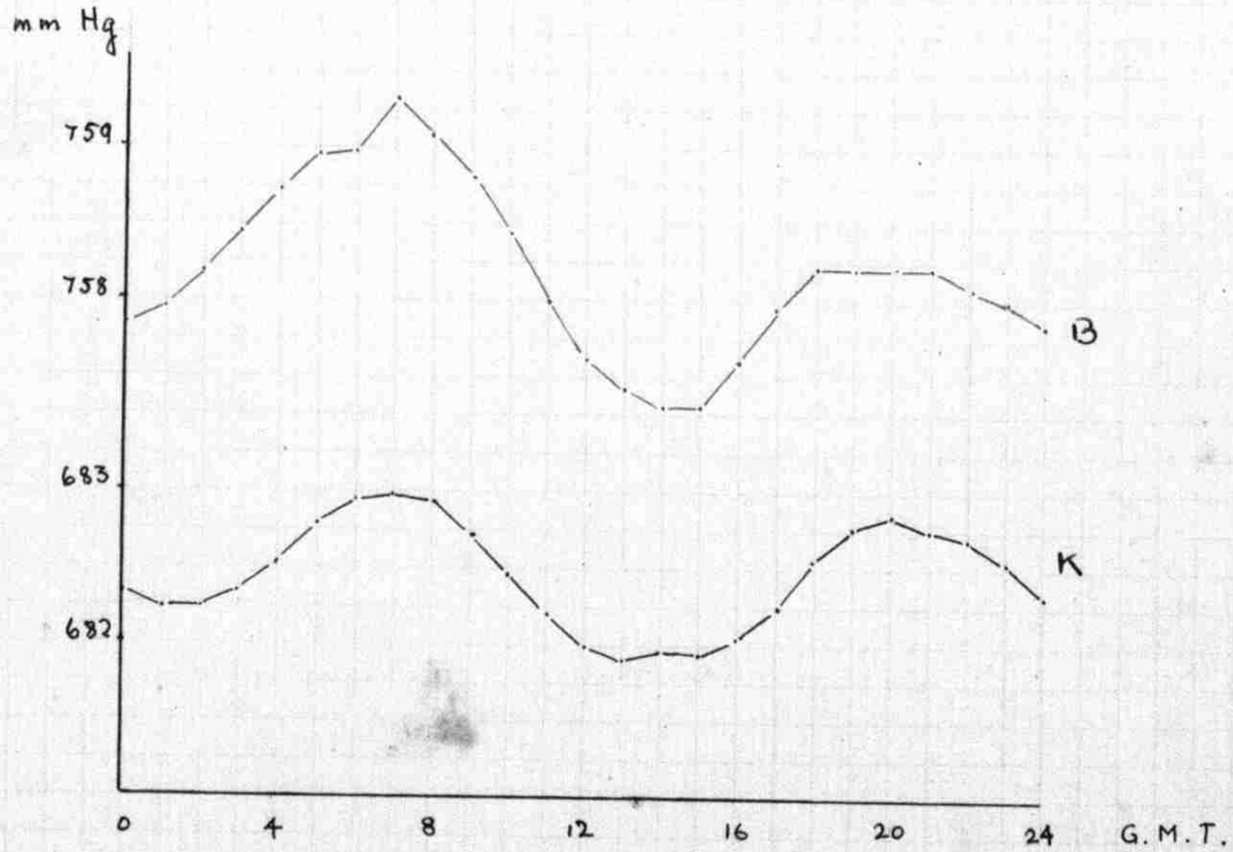
	11	12	13	14	15	16	17	18	19	20
Winter	63.0	62.9	63.0	63.0	63.3	63.5	63.6	63.7	63.7	63.7
Spring	58.0	57.6	57.4	57.3	57.3	57.6	57.9	58.2	58.2	58.2
Summer	49.7	49.4	49.1	49.0	49.0	49.2	49.5	49.8	49.9	49.9
Autumn	58.5	58.3	58.2	58.2	58.3	58.4	58.8	58.9	59.0	59.0

	21	22	23	24	N	M-m	%
Winter	63.6	63.6	63.5	63.3	63.6	1.9	.0024
Spring	58.2	58.1	58.0	57.9	58.2	2.0	.0027
Summer	49.8	49.7	49.6	49.6	49.9	1.9	.0025
Autumn	58.9	58.9	58.8	58.7	58.9	1.8	.0023

PRESSURE CURVES



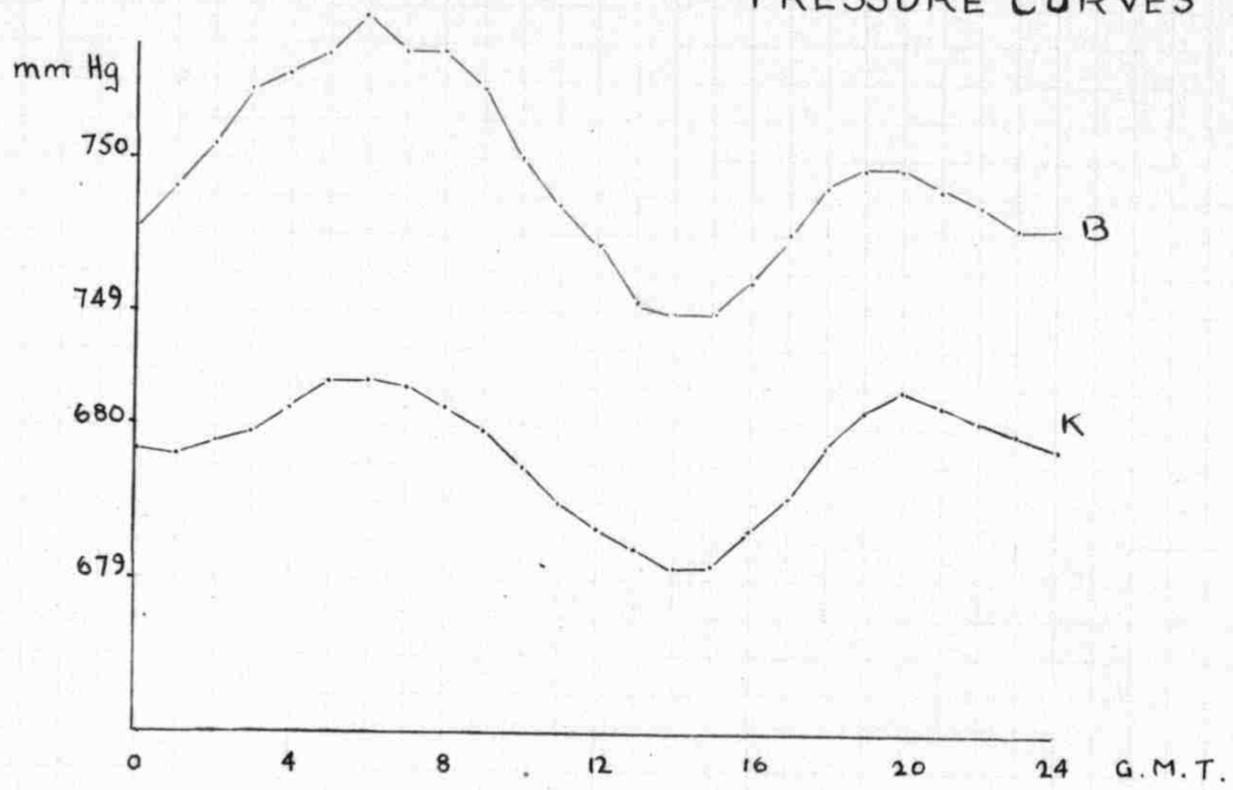
WINTER (Dec. Jan. Feb.)



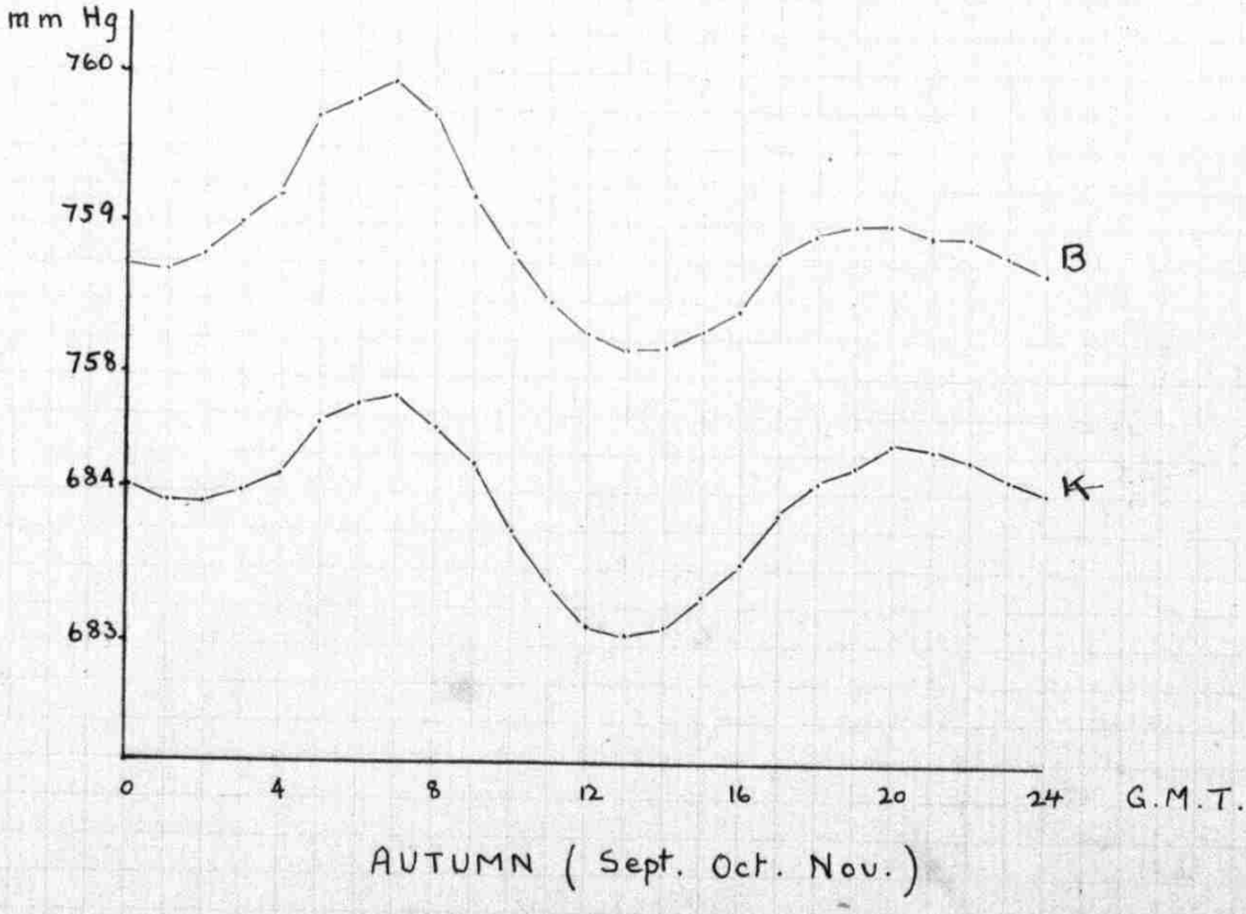
SPRING (March, April, May)

Graph 1.

PRESSURE CURVES



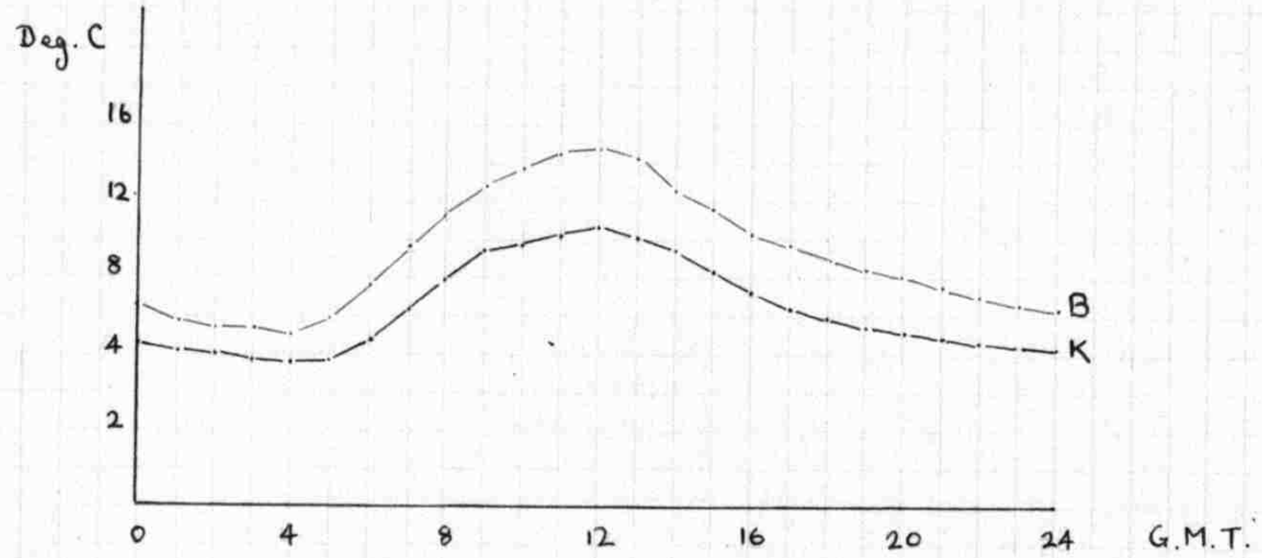
SUMMER (June, July, Aug.)



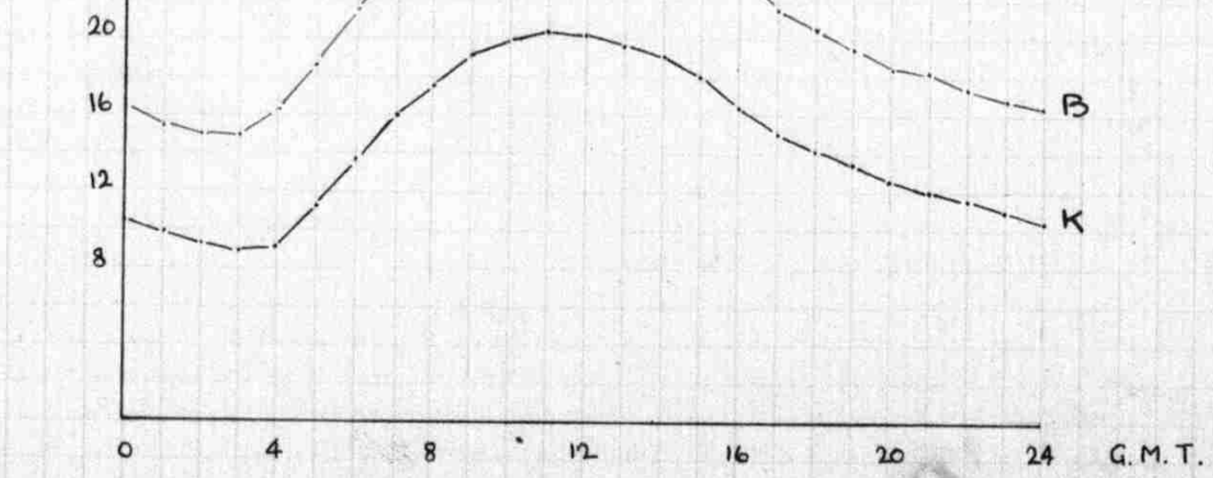
AUTUMN (Sept. Oct. Nov.)

Graph 2.

TEMPERATURE CURVES



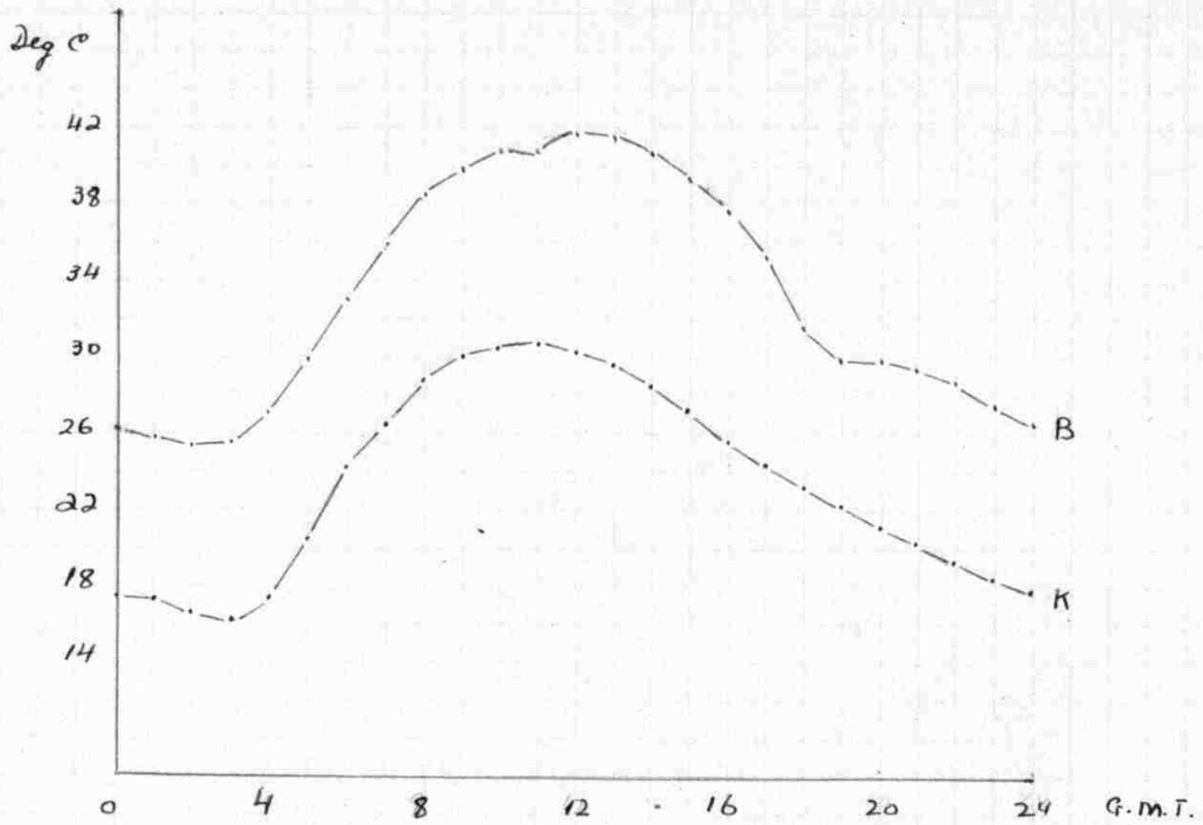
WINTER (Dec. Jan. Feb.)



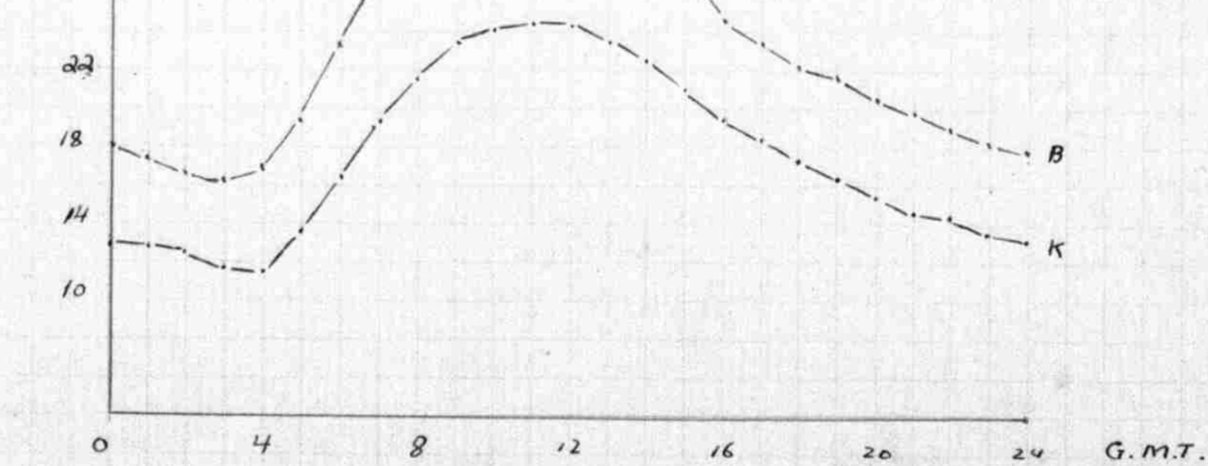
SPRING (March, April, May)

Graph 3.

TEMPERATURE CURVES



SUMMER (June, July, Aug.)



AUTUMN (Sept. Oct. Nov.)

Graph 4.

Table VI. Harmonic Analysis (Ksara Pressure)

	A_1	%	φ_1	(h_1)	h_1	A_2	%	φ_2	(h_2)	h_2	A_2/A_1
Jan	0.260	.04	37°.70	$3^h.49$	$1^h.49$	0.424	.06	175°.99	$9^h.13$	$7^h.13$	1.63
Feb	0.175	.02	56°.80	2.21	0.21	0.433	.06	167°.74	9.41	7.41	2.47
March	0.262	.04	21°.57	4.56	2.56	0.451	.07	162°.39	9.59	7.59	1.72
April	0.197	.03	28°.54	4.10	2.10	0.453	.07	158°.30	9.72	7.72	2.30
May	0.240	.04	7°.79	5.48	3.48	0.328	.05	162°.97	9.57	7.57	1.37
June	0.375	.06	20°.50	4.63	2.63	0.335	.05	162°.12	9.60	7.60	0.88
July	0.418	.06	30°.97	3.93	1.93	0.367	.05	162°.93	9.57	7.57	0.88
August	0.384	.06	29°.32	4.05	2.05	0.412	.06	168°.58	9.38	7.38	1.08
Sept	0.409	.06	28°.44	4.10	2.10	0.466	.07	168°.55	9.38	7.38	1.14
Oct	0.443	.06	28°.70	4.62	2.62	0.502	.07	172°.88	9.24	7.24	1.13
Nov	0.376	.05	36°.42	3.57	1.57	0.470	.07	178°.12	9.06	7.06	1.25
Dec	0.245	.04	49°.60	2.69	0.69	0.435	.06	176.72	9.11	7.11	1.78

	A_3	%	φ_3	(h_3)	h_3	A_4	%	φ_4	(h_4)	h_4	μ
Jan	0.180	.03	15°.41	1.66	7.66	0.090	.01	268°.15	$3^h.03$	$1^h.03$	684.22
Feb	0.115	.02	18°.73	1.58	7.58	0.035	.005	202°.59	4.11	2.11	681.86
March	0.060	.009	18°.56	1.60	7.60	0.029	.004	322°.76	2.12	0.12	682.89
April	0.034	.005	36°.13	1.20	7.20	0.014	.002	1°.67	1.47	5.47	682.12
May	0.088	.01	140°.35	6.88	4.88	0.052	.008	233°.63	3.61	1.61	682.29
June	0.076	.01	166°.77	6.29	4.29	0.031	.004	336°.78	1.89	5.89	680.35
July	0.097	.01	191°.54	5.74	3.74	0.022	.003	318°.67	2.19	0.19	679.11
August	0.075	.01	157°.83	6.49	4.49	0.035	.005	295°.41	2.58	0.58	680.01
Sept	0.017	.002	154°.48	6.57	4.57	0.037	.005	317°.62	2.21	0.21	682.31
Oct	0.090	.01	16°.32	1.64	7.64	0.027	.004	190°.16	4.36	2.36	684.66
Nov	0.132	.02	20°.00	1.55	7.55	0.033	.005	277°.54	2.88	0.88	684.99
Dec	0.165	.02	17°.07	1.62	7.62	0.069	.01	247°.95	3.37	1.37	684.82

(h) represents the time of first maximum based on (G.M.T.+2)

Table VII Harmonic Analysis (Ksara Temp.)

	A_1	%	φ_1	(h)$_1$	h_1	A_2	%	φ_2	(h)$_2$	h_2	A_2/A_1
Jan.	3.067	59	231°.61	14h.56	12.56	1.204	23	53°.17	1h.23	11h.23	0.39
Feb.	2.882	43	233°.84	14.41	12.41	0.895	13	61°.32	0.96	10.96	0.31
March	4.738	46	232°.33	14.51	12.51	1.345	13	70°.05	0.67	10.67	0.28
April	5.235	36	234°.96	14.34	12.34	1.255	9	81°.04	0.30	10.30	0.24
May	5.940	32	237°.15	14.14	12.14	1.327	7	101°.88	11.61	9.61	0.22
June	7.257	32	244°.37	13.71	11.71	1.696	8	113°.82	11.21	9.21	0.23
July	6.507	27	237°.61	14.16	12.16	1.712	7	117°.33	11.09	9.09	0.26
August	6.881	28	236.05	14.26	12.26	1.823	7	98.00	11.73	9.73	0.26
Sept.	6.809	31	236°.46	14.24	12.24	1.860	8	89°.02	0.03	10.03	0.27
Oct.	6.055	33	236.21	14.25	12.25	1.793	10	84°.83	0.17	10.17	0.30
Nov.	4.633	36	235°.88	14.27	12.27	1.626	13	69°.60	0.68	10.68	0.35
Dec.	3.321	45	235°.49	14.30	12.30	1.314	18	58.23	1.09	11.09	0.39

	A_3	%	φ_3	(h)$_3$	h_3	A_4	%	φ_4	(h)$_4$	h_4	μ
Jan.	0.148	3	260°.10	4h.22	2h.22	0.166	3	221°.01	3h.82	1h.82	5.21
Feb	0.200	3	299°.73	3.34	1.34	0.193	3	178°.87	4.52	2.52	6.76
March	0.324	3	351°.25	2.19	0.19	0.323	3	238°.29	3.53	1.53	10.36
April	0.321	2	24°.42	1.46	7.46	0.210	1	256°.85	3.22	1.22	14.42
May	0.593	3	33°.04	1.27	7.27	0.613	3	271°.46	2.98	0.98	18.65
June	0.761	3	48°.55	0.92	6.92	0.402	2	294°.60	2.59	0.59	22.31
July	0.515	2	28°.16	1.37	7.37	0.252	1	234°.54	3.59	1.59	23.93
August	0.681	3	8°.53	1.81	7.81	0.322	1	253°.52	3.27	1.27	24.71
Sept	0.596	3	8°.42	1.81	7.81	0.368	2	251°.35	3.31	1.31	21.98
Oct	0.462	2	0°.03	2.00	0.00	0.405	2	249°.22	3.35	1.35	18.37
Nov	0.283	2	312°.08	3.06	1.06	0.289	2	238.88	3.52	1.52	12.76
Dec	0.231	3	257°.27	4.28	2.28	0.117	2	215°.63	3.91	1.91	7.43

(h) represents the time of first max. based (G.M.T + 2)

Table VIII Harmonic Analysis (Bagdad Pressure)

	A_1	%	φ_1	h_1	A_2	%	φ_2	h_2	A_2/A_1
Jan.	0.127	0.02	44°.21	1h.02	0.547	0.07	245°.22	6h.82	4.31
Feb.	0.401	0.05	18°.66	4.76	0.534	0.07	243°.66	6.88	1.33
March	0.697	0.09	14°.40	5.04	0.513	0.07	244.61	6.84	0.74
April	0.409	0.05	12°.38	5.17	0.542	0.07	225.73	7.47	1.32
May	0.570	0.08	13°.02	5.13	0.521	0.07	228.81	7.37	0.91
June	0.722	0.10	14°.28	5.05	0.415	0.06	246.77	6.77	0.57
July	0.647	0.09	22°.54	4.50	0.432	0.06	246.20	6.79	0.67
August	0.555	0.07	18°.92	4.74	0.492	0.06	240.46	6.98	0.89
Sept	0.520	0.07	21°.13	4.59	0.486	0.06	238.99	7.03	0.93
Oct.	0.493	0.06	17°.94	4.80	0.549	0.07	245.42	6.82	1.11
Nov.	0.385	0.05	35°.75	3.62	0.464	0.06	242.08	6.93	1.20
Dec.	0.376	0.05	27°.46	4.17	0.471	0.06	258.86	6.37	1.25

	A_3	%	φ_3	h_3	A_4	%	φ_4	h_4	μ
Jan.	0.272	0.04	133°.20	7h.06	0.078	0.01	33°.92	0h.93	765.2
Feb.	0.503	0.06	112°.49	7.50	0.409	0.05	337°.62	1.87	762.4
March	0.042	0.006	86°.39	0.08	0.019	0.002	329°.94	2.00	760.2
April	0.108	0.01	16°.15	1.64	0.054	0.007	300°.01	2.50	757.3
May	0.037	0.005	305°.33	3.21	0.038	0.005	115°.34	5.58	757.1
June	0.155	0.02	321°.28	2.86	0.022	0.003	299°.94	2.50	752.1
July	0.097	0.01	309°.15	3.13	0.038	0.005	29°.00	1.02	748.3
August	0.050	0.007	300°.64	3.32	0.017	0.002	70°.91	0.32	749.4
Sept.	0.039	0.005	176°.15	6.09	0.045	0.006	103°.85	5.77	754.3
Oct.	0.108	0.01	120°.72	7.32	0.076	0.01	4°.83	5.68	759.5
Nov.	0.128	0.02	149°.51	6.68	0.067	0.009	49°.81	0.67	762.9
Dec.	0.169	0.02	131°.63	7.07	0.055	0.007	6°.60	1.39	763.2

Table IX Harmonic Analysis (Bagdad Temp.)

	A_1	%	φ_1	h_1	A_2	%	φ_2	h_2	A_2/A_1
Jan.	3.893	55	261°.00	$12^h.6$	1.434	20	124°.56	$10^h.85$	0.36
Feb.	4.523	44	261°.75	12.55	1.328	13	128°.35	10.72	0.29
March	6.857	40	265°.74	12.28	1.940	11	135°.03	10.50	0.28
April	6.324	29	269°.93	12.00	1.250	6	146.95	10.10	0.20
May	6.249	24	271°.36	11.91	0.914	4	166°.96	9.43	0.15
June	7.460	23	268°.21	12.12	1.313	4	153°.46	9.88	0.18
July	7.776	23	267°.93	12.14	1.436	4	140°.57	10.31	0.18
August	8.607	26	269°.19	12.05	1.898	6	144°.71	10.18	0.22
Sept.	8.458	28	271°.57	11.90	2.509	8	153°.69	9.88	0.30
Oct.	8.107	33	270°.89	11.94	2.427	10	144°.97	10.17	0.30
Nov.	6.218	36	272°.10	11.86	1.919	11	144°.53	10.18	0.31
Dec.	4.324	41	262°.89	12.47	1.408	13	128°.60	10.71	0.32
	A_3	%	φ_3	h_3	A_4	%	φ_4	h_4	μ
Jan.	0.138	2	9°.00	$1^h.80$	0.242	3	11°.35	$1^h.31$	7.1
Feb.	0.162	2	113°.02	7.49	0.292	3	350°.89	1.65	10.3
March	0.497	3	142°.29	6.84	0.505	3	19°.01	1.18	16.9
April	0.625	3	144°.64	6.79	0.343	2	31°.34	0.98	21.7
May	0.835	3	168°.27	6.26	0.413	2	59°.44	0.51	25.9
June	0.997	3	151°.68	6.63	0.049	0.2	49°.14	0.68	32.6
July	1.016	3	160°.80	6.43	0.670	2	324°.50	2.09	34.0
August	0.711	2	154°.34	6.57	0.379	1	349°.80	1.67	33.1
Sept.	0.636	2	148°.06	6.89	0.698	2	53°.64	0.94	30.2
Oct.	0.418	2	103°.72	7.69	0.638	3	6°.67	1.39	24.4
Nov.	0.186	1	61°.41	0.64	0.610	3	23°.96	1.10	17.0
Dec.	0.108	1	51°.24	0.86	0.291	3	20°.48	1.14	10.6

Table X_a Harmonic Analysis (Seasonal Averages) Ksara Temp.

	A_1	%	φ_1	(h_1)	h_1	A_2	%	φ_2	(h_2)	h_2	A_2/A_1
Winter	3.090	49	233°.65	$14^h.42$	$12^h.42$	1.138	18	57°.57	$1^h.09$	$11^h.09$	0.36
Spring	5.304	38	234°.81	$14^h.33$	$12^h.33$	1.309	10	84°.32	$4^h.19$	$2^h.19$	0.25
Summer	6.882	29	239°.34	$14^h.04$	$12^h.04$	1.744	7	109°.72	$11^h.34$	$9^h.34$	0.25
Autumn	5.832	33	236°.18	$14^h.25$	$12^h.25$	1.760	10	81.15	$0^h.29$	$10^h.29$	0.31
	A_3	%	φ_3	(h_3)	h_3	A_4	%	φ_4	(h_4)	h_4	μ
Winter	0.193	3	272°.33	$3^h.95$	$1^h.95$	0.159	3	205°.17	$4^h.08$	$2^h.08$	6.47
Spring	0.413	3	136°.24	$1^h.64$	$7^h.64$	0.382	2	255°.53	$3^h.24$	$1^h.24$	14.48
Summer	0.652	3	28°.41	$1^h.37$	$7^h.37$	0.325	1	260°.89	$3^h.15$	$1^h.15$	23.65
Autumn	0.447	2	106°.84	$2^h.29$	$0^h.29$	0.354	2	246°.48	$3^h.39$	$1^h.39$	17.70

Table X_b Harmonic Analysis (seasonal averages) Ksara pressure.

	A_1	%	φ_1	(h_1)	h_1	A_2	%	φ_2	(h_2)	h_2	A_2/A_1
Winter	0.227	.03	48°.03	$2^h.80$	$0^h.80$	0.431	.06	173°.48	$9^h.22$	$7^h.22$	1.96
Spring	0.233	.04	19°.30	$4^h.71$	$2^h.71$	0.411	.06	161°.22	$9^h.63$	$7^h.63$	1.80
Summer	0.392	.06	26°.93	$4^h.20$	$2^h.20$	0.371	.05	164°.54	$9^h.52$	$7^h.52$	0.95
Autumn	0.409	.06	28°.52	$4^h.10$	$2^h.10$	0.479	.07	173°.18	$9^h.23$	$7^h.23$	1.17
	A_3	%	φ_3	(h_3)	h_3	A_4	%	φ_4	(h_4)	h_4	μ
Winter	0.153	.02	17°.07	$1^h.62$	$7^h.62$	0.065	.01	239°.56	$3^h.50$	$1^h.50$	683.63
Spring	0.061	.01	65°.01	$3^h.23$	$1^h.23$	0.032	.01	186°.02	$2^h.40$	$0^h.40$	682.43
Summer	0.083	.01	172°.05	$6^h.17$	$4^h.17$	0.029	.004	316°.95	$2^h.22$	$0^h.22$	679.82
Autumn	0.080	.01	63°.60	$3^h.25$	$1^h.25$	0.032	.01	261°.77	$3^h.15$	$1^h.15$	683.99

Table X_c Harmonic Analysis (seasonal averages) Bagdad Temp.

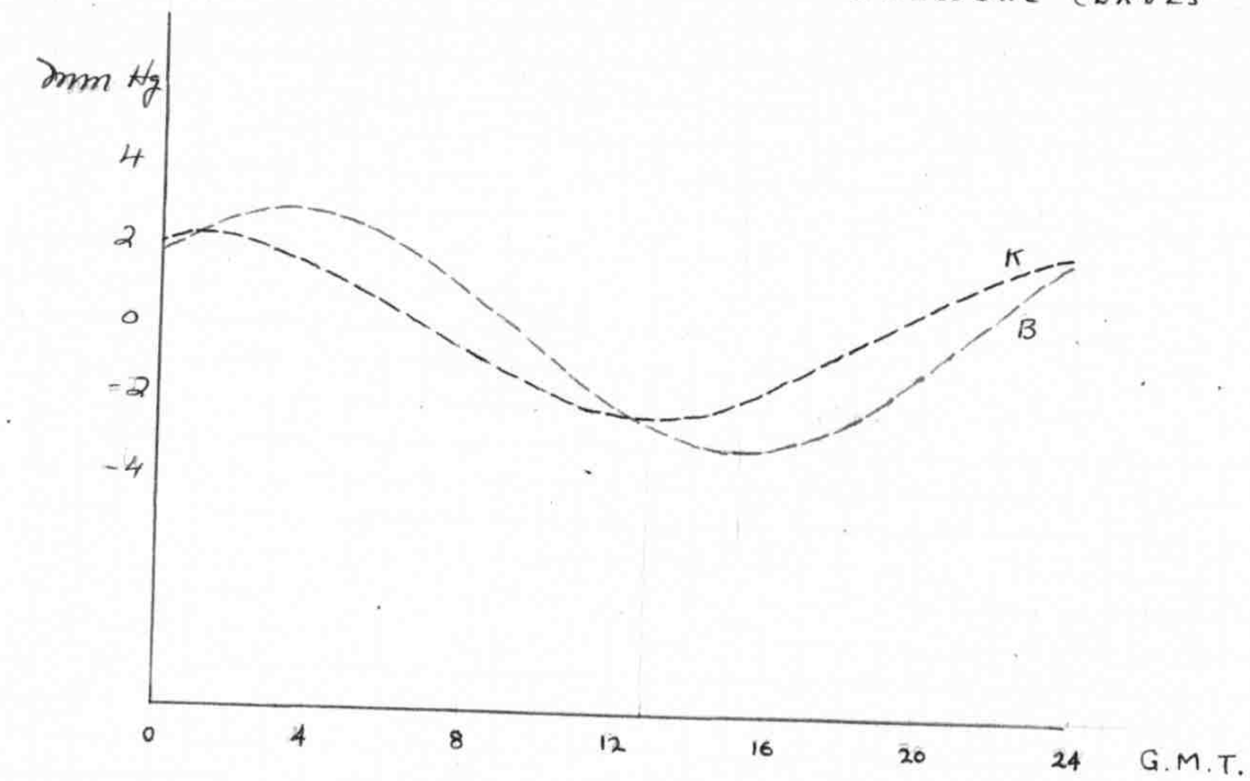
	A_1	%	φ_1	h_1	A_2	%	φ_2	h_2	A_2/A_1
Winter	4.247	·47	$261^\circ.88$	$12^h.54$	1.390	15	$127^\circ.17$	$10^h.76$	0.32
Spring	6.477	31	$269^\circ.01$	$12^h.06$	1.368	7	$149^\circ.60$	$10^h.01$	0.21
Summer	7.948	24	$268^\circ.44$	$12^h.10$	1.549	5	$146^\circ.25$	$10^h.12$	0.19
Autumn	7.594	32	$241^\circ.52$	$11^h.90$	2.285	10	$147^\circ.73$	$10^h.08$	0.30
	A_3	%	φ_3	h_3	A_4	%	φ_4	h_4	μ
Winter	0.136	2	$57^\circ.75$	$3^h.38$	0.275	3	$127^\circ.57$	$1^h.37$	9.3
Spring	0.652	3	$151^\circ.73$	$6^h.63$	0.420	2	$36^\circ.60$	$0^h.89$	21.5
Summer	0.908	3	$155^\circ.61$	$6^h.54$	0.366	1	$241^\circ.15$	$1^h.81$	33.2
Autumn	0.413	2	$101^\circ.73$	$5^h.07$	0.649	3	$21^\circ.42$	$1^h.14$	23.9

Table X_d Harmonic Analysis (seasonal Averages) Bagdad Pressure.

	A_1	%	φ_1	h_1	A_2	%	φ_2	h_2	A_2/A_1
Winter	0.301	0.04	$30^\circ.11$	$3^h.32$	0.517	0.07	$249^\circ.25$	$6^h.69$	2.30
Spring	0.559	0.07	$13^\circ.27$	$5^h.11$	0.525	0.07	$233^\circ.05$	$7^h.23$	0.99
Summer	0.641	0.09	$18^\circ.58$	$4^h.76$	0.446	0.06	$244^\circ.48$	$6^h.85$	0.71
Autumn	0.466	0.06	$24^\circ.94$	$4^h.34$	0.500	0.06	$242^\circ.16$	$6^h.93$	1.08
	A_3	%	φ_3	h_3	A_4	%	φ_4	h_4	μ
Winter	0.315	0.04	$125^\circ.77$	$7^h.21$	0.181	0.02	$126^\circ.05$	$1^h.40$	763.6
Spring	0.062	0.01	$135^\circ.96$	$1^h.64$	0.037	0.01	$248^\circ.43$	$3^h.36$	758.2
Summer	0.101	0.01	$310^\circ.30$	$3^h.10$	0.026	0.003	$133^\circ.28$	$1^h.28$	749.9
Autumn	0.092	0.01	$148^\circ.79$	$6^h.70$	0.063	0.01	$52^\circ.83$	$4^h.04$	758.9

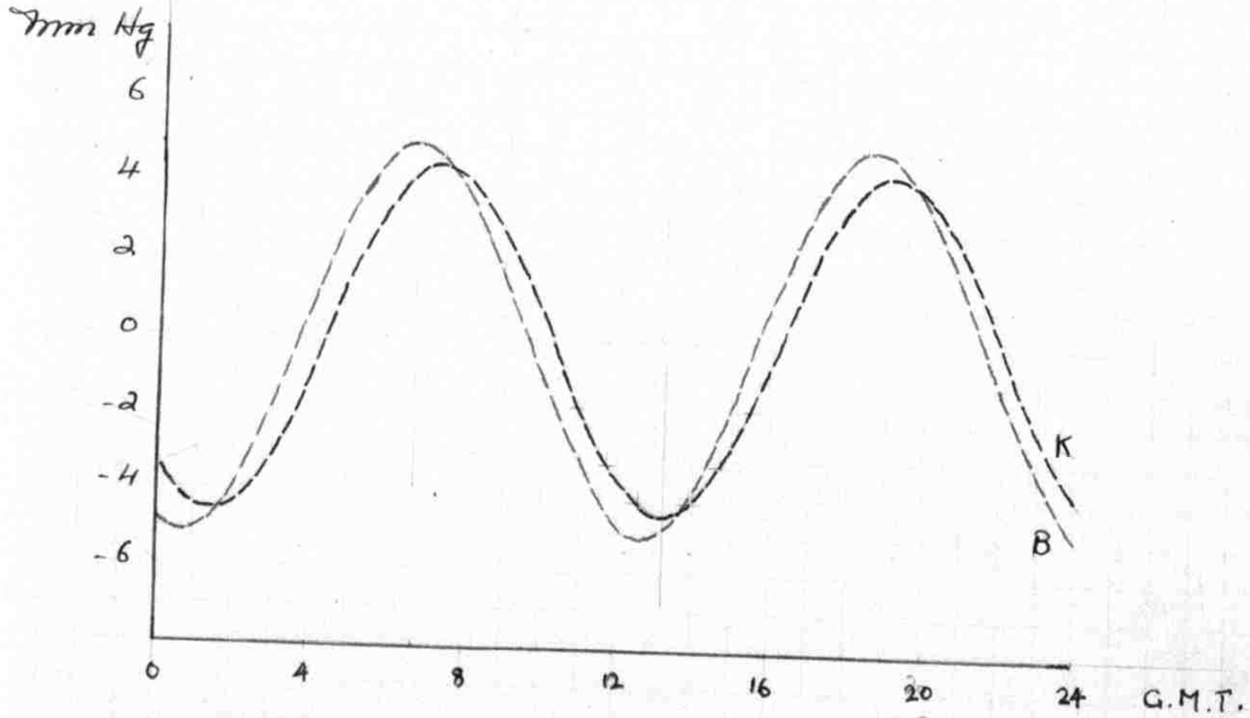
raph 5.

PRESSURE CURVES



WINTER (Dec. Jan. Feb.)

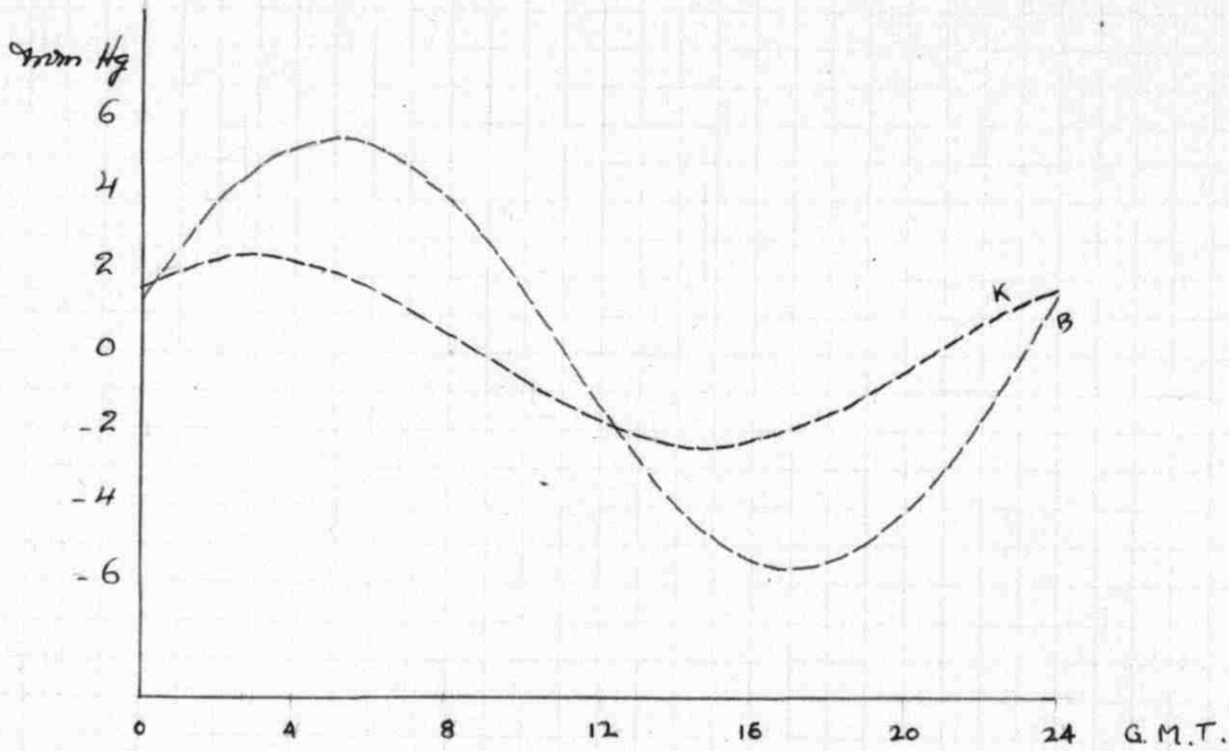
DIURNAL WAVES



WINTER

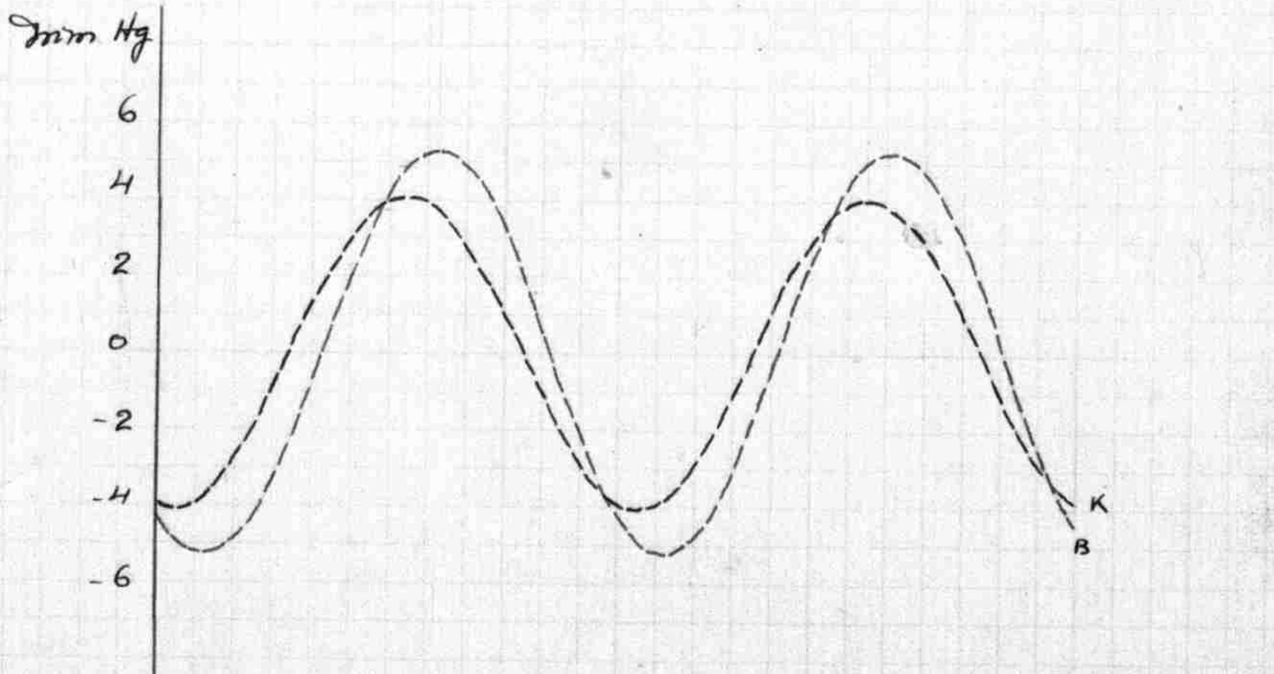
1/2 DIURNAL WAVES

PRESSURE CURVES



SPRING (March, April, May)

DIURNAL WAVES

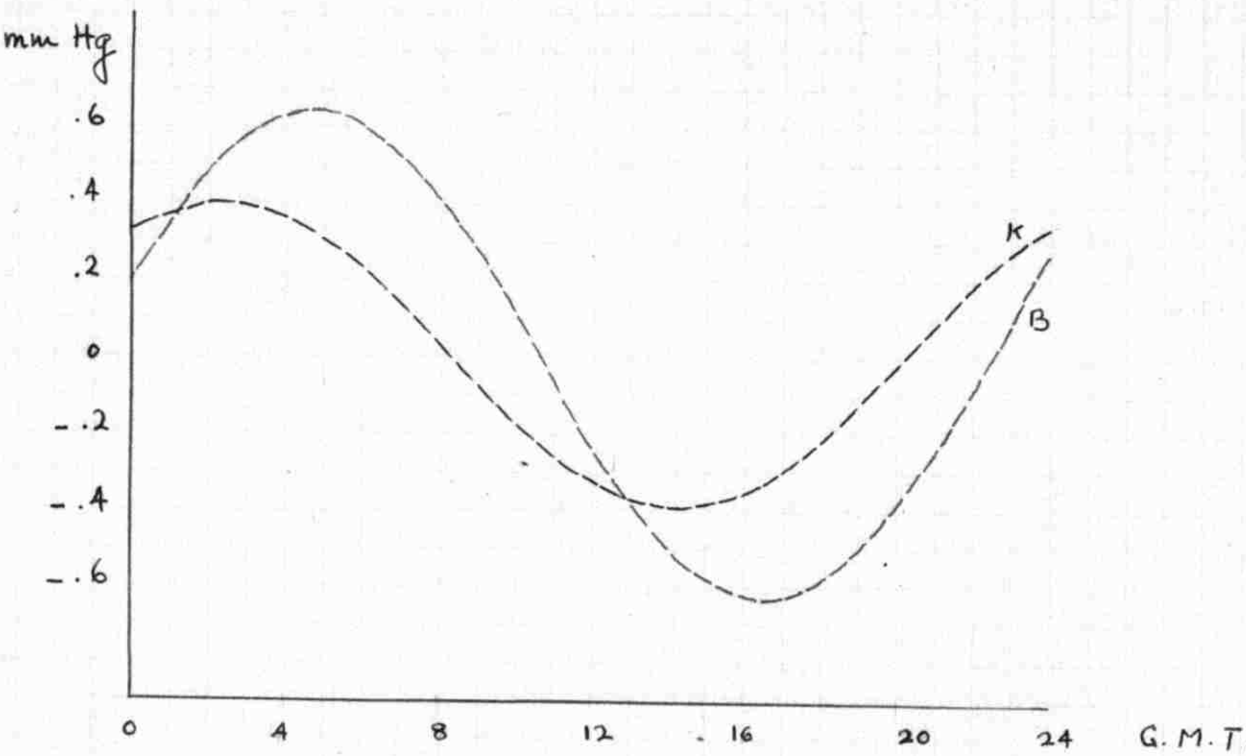


SPRING

½ DIURNAL WAVES

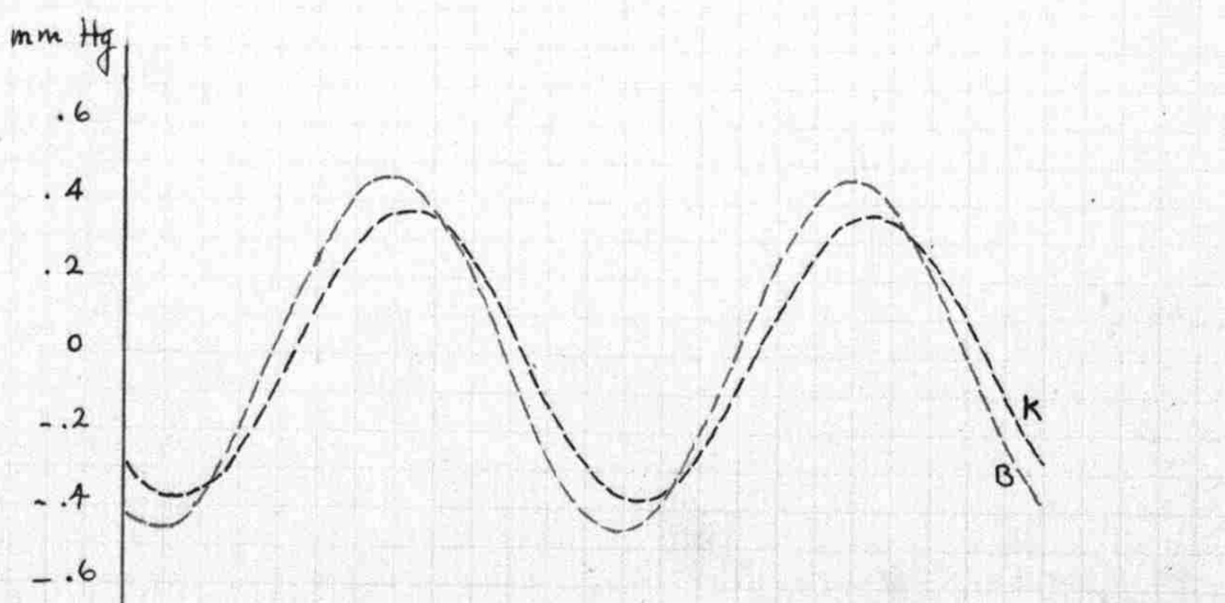
Graph 6.

PRESSURE CURVES



DIURNAL WAVES

SUMMER (June, July, Aug.)

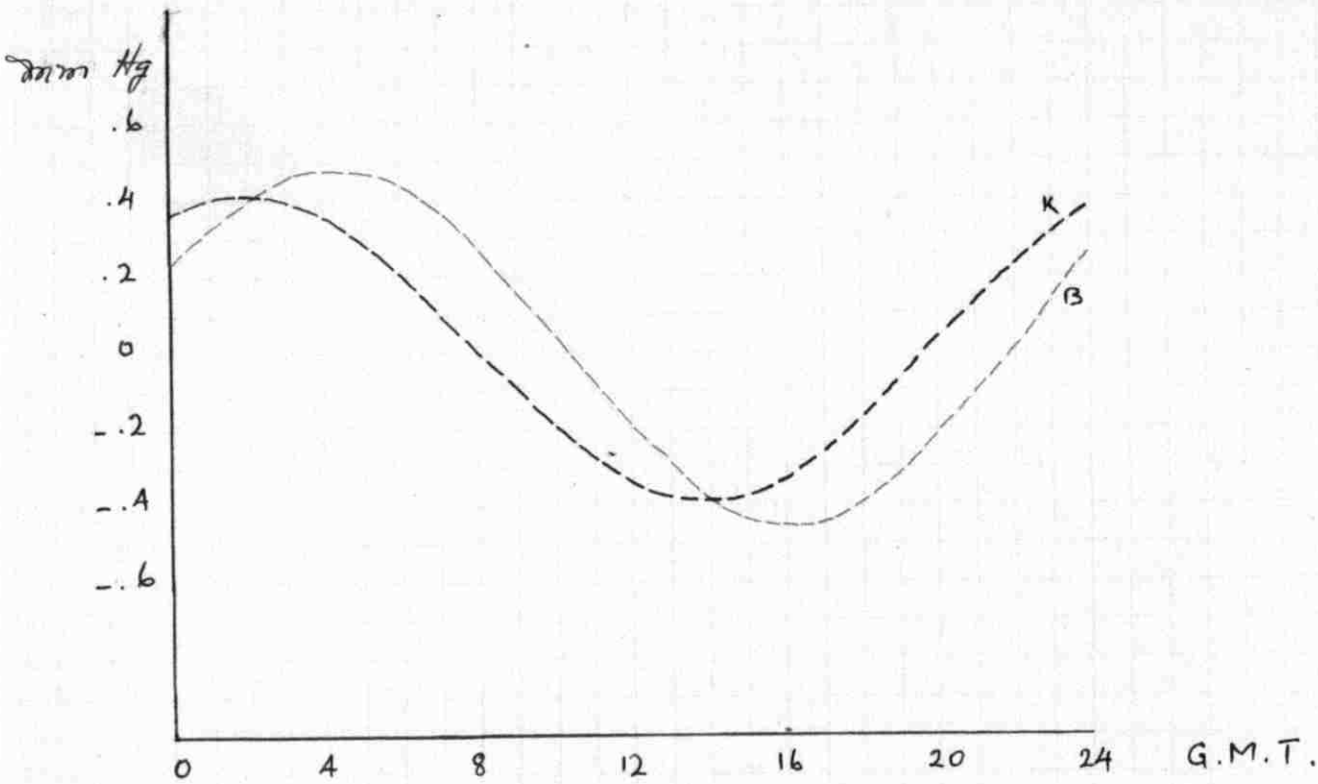


$\frac{1}{2}$ DIURNAL WAVES

SUMMER

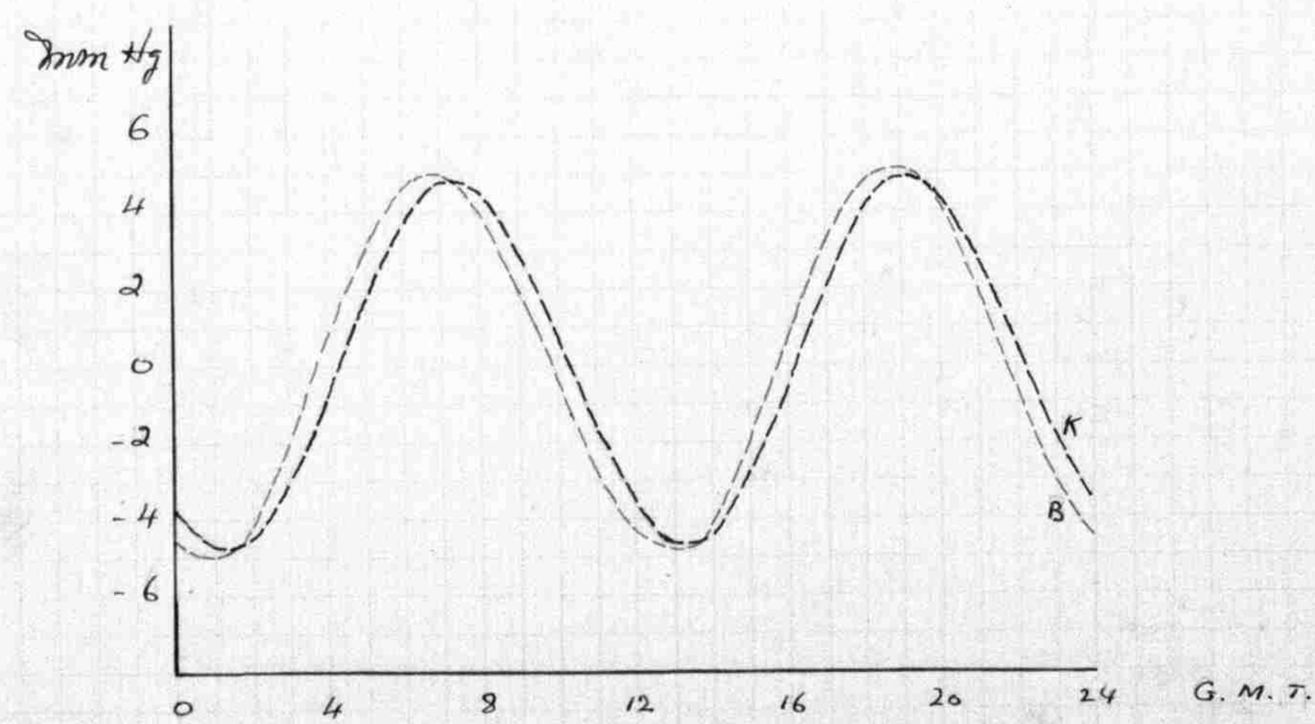
Graph 7.

PRESSURE CURVES



AUTUMN (Sept. Oct. Nov.)

DIURNAL WAVES

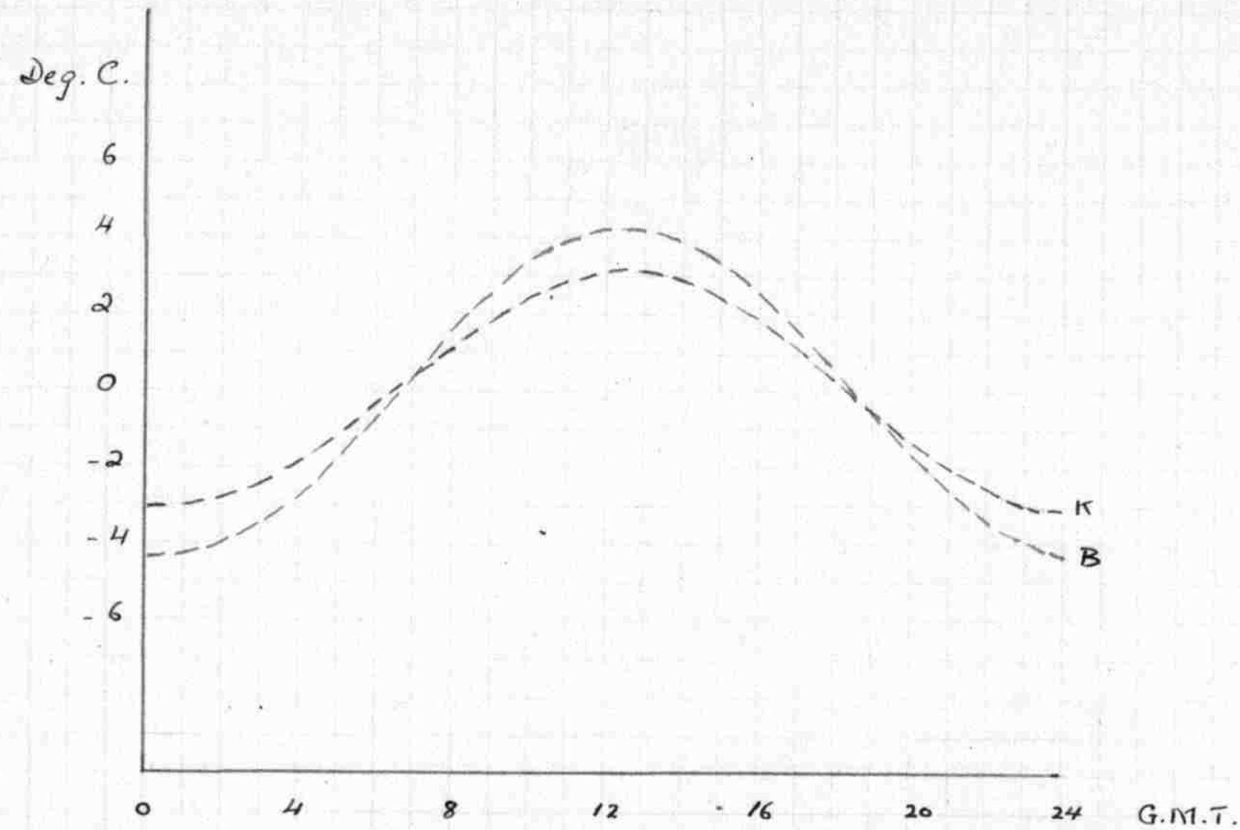


AUTUMN

Graph 8.

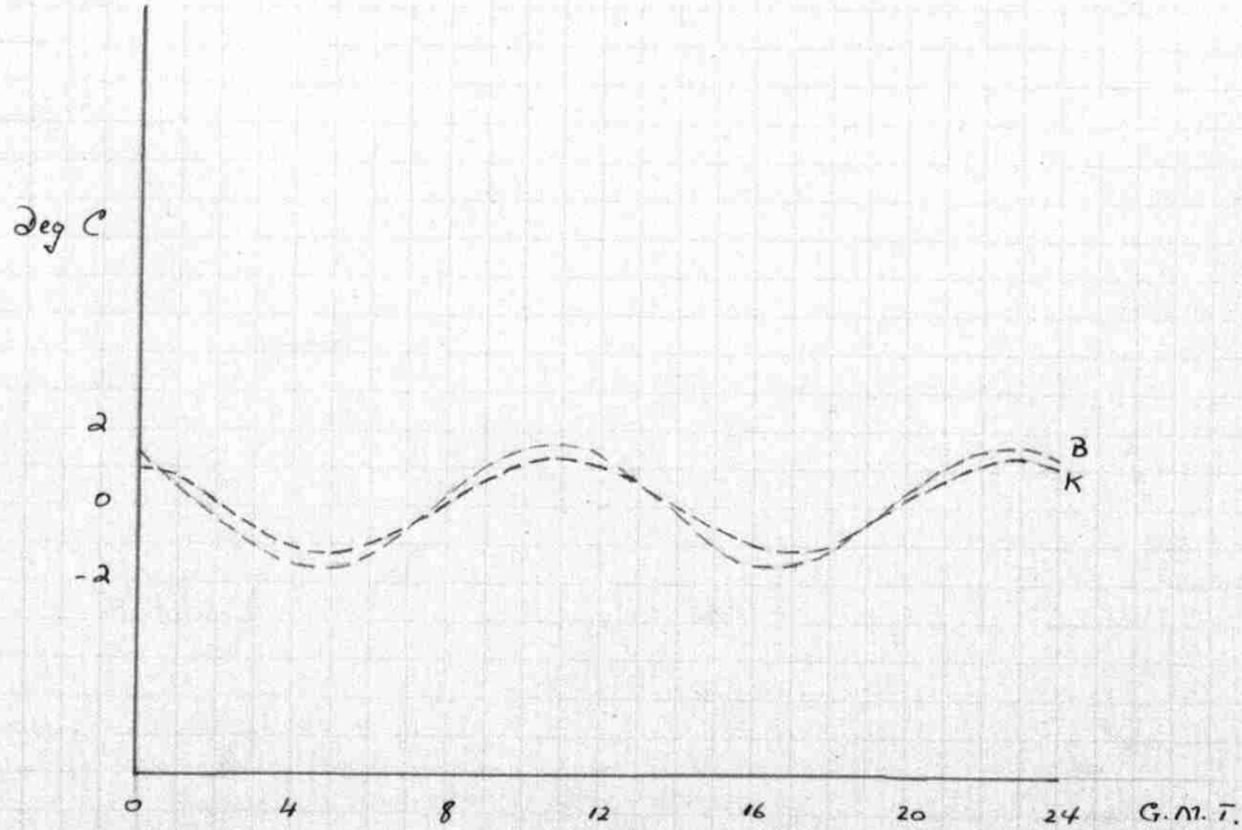
1/2 DIURNAL WAVES

TEMPERATURE CURVES



WINTER (Dec. Jan. Feb.)

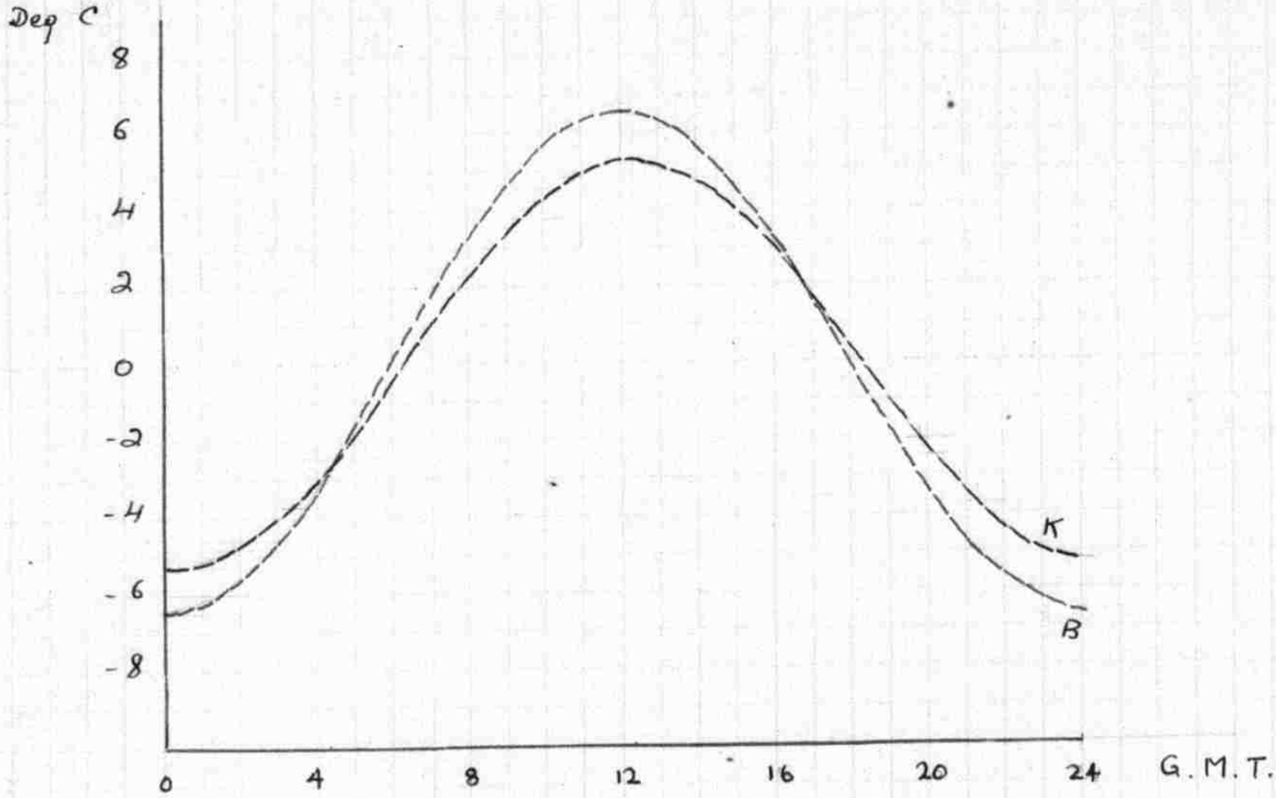
DIURNAL WAVES



WINTER

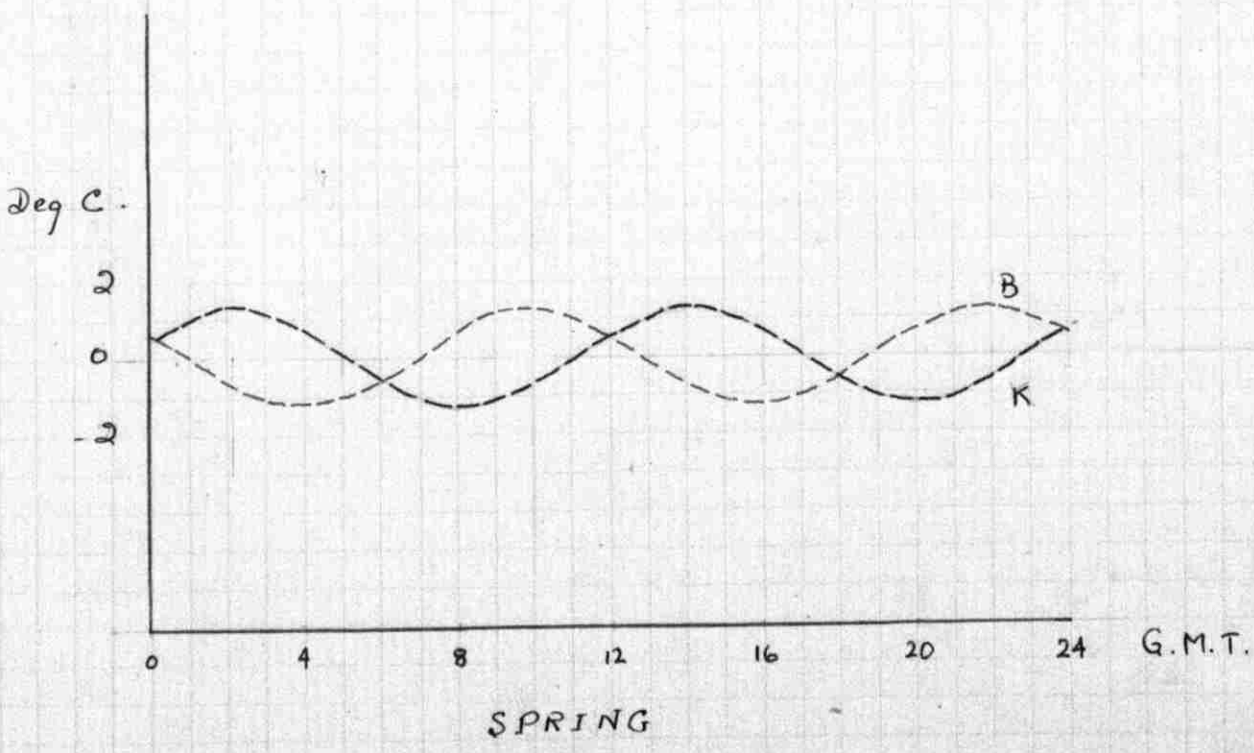
Graph 9. 1/2 DIURNAL WAVES

TEMPERATURE CURVES



SPRING (March. April, May)

DIURNAL WAVES

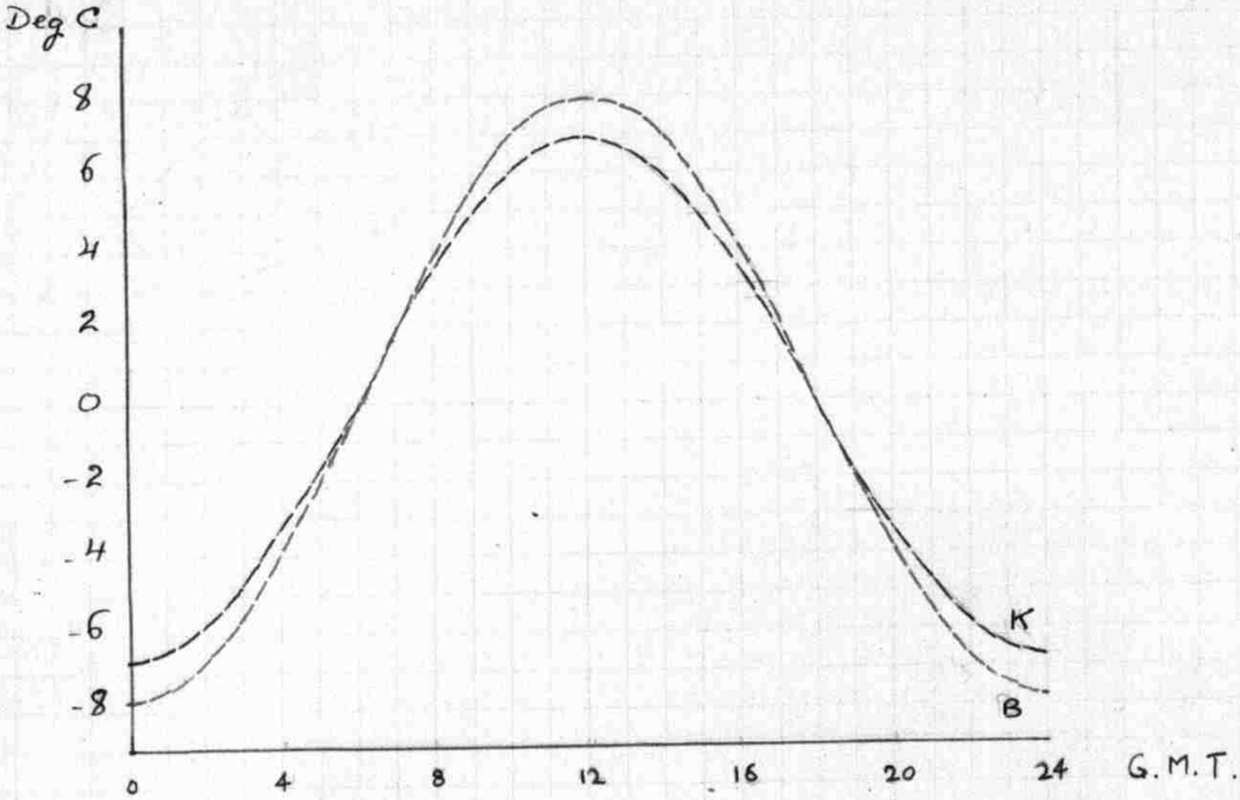


SPRING

½ DIURNAL WAVES

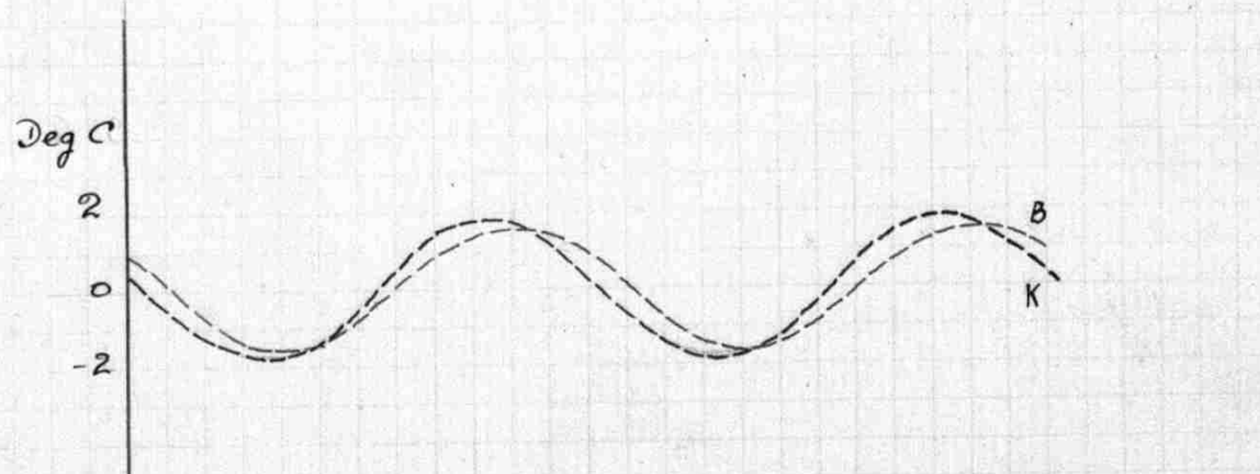
Graph 10.

TEMPERATURE CURVES



SUMMER (June, July, Aug.)

DIURNAL WAVES

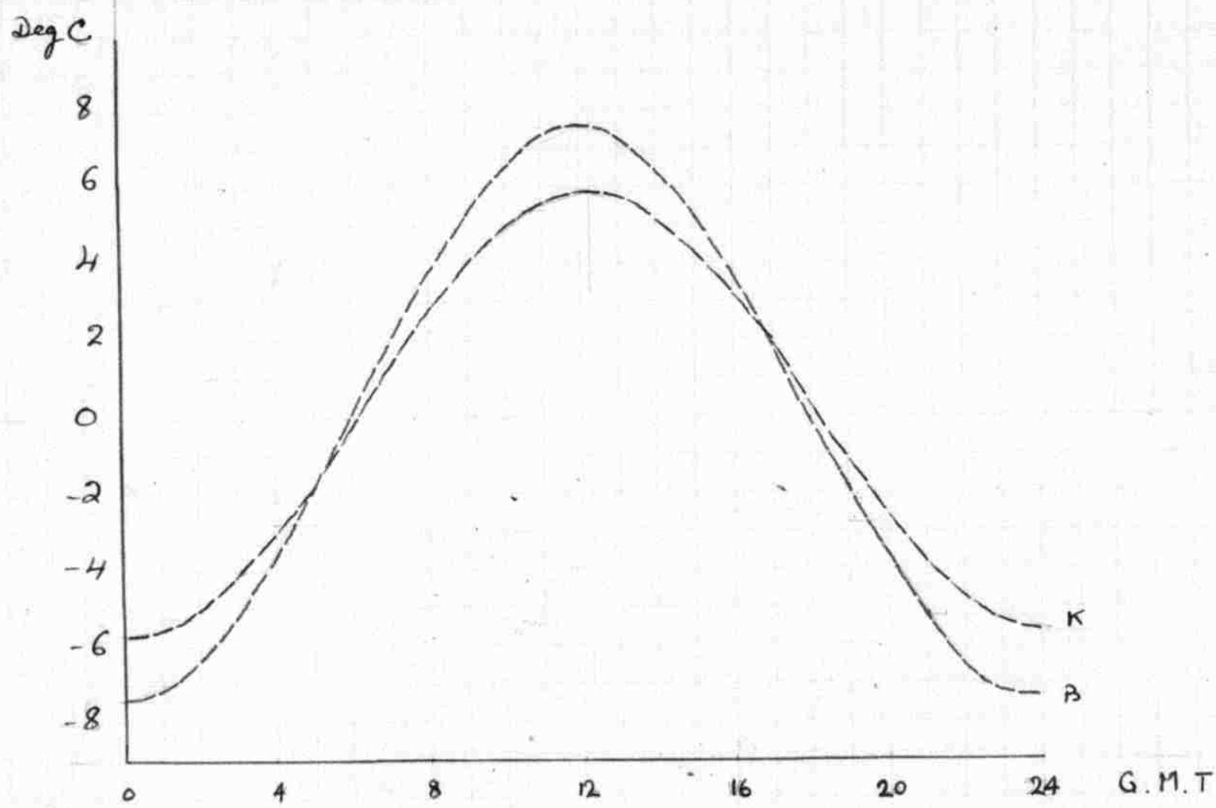


SUMMER

½ DIURNAL WAVES

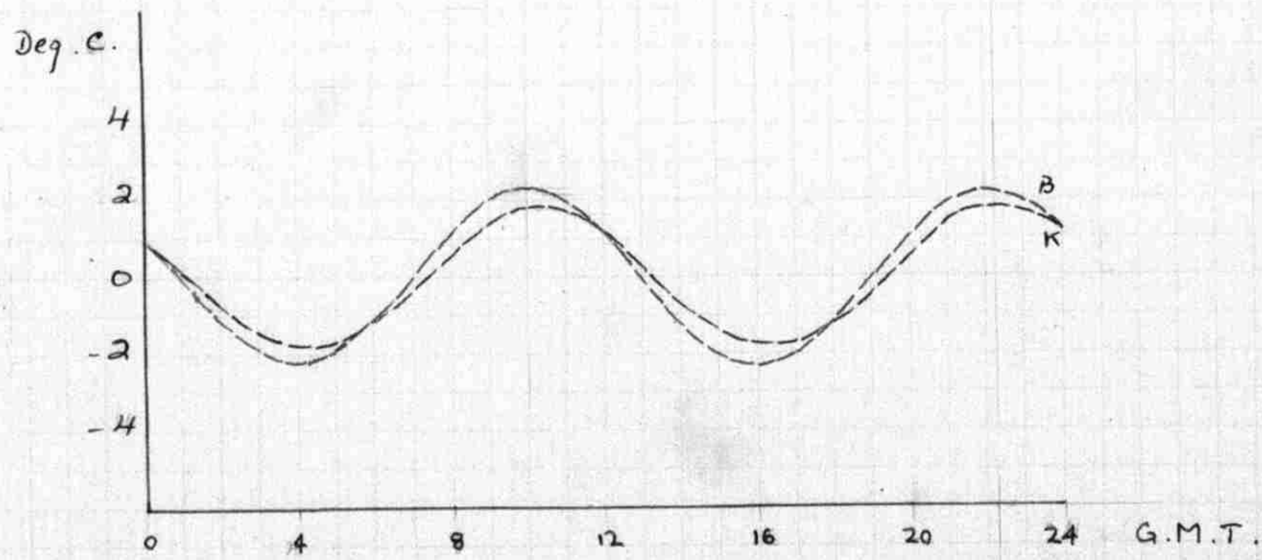
Graph 11.

TEMPERATURE CURVES



AUTUMN (Sept. Oct. Nov.)

DIURNAL WAVES



AUTUMN (Sept. Oct. Nov.)

½ DIURNAL WAVES

Graph 12.

Chapter IV

Discussion of the Results

Diurnal Variation of Pressude and Temperature

Pressude:

The diurnal variation of pressude is characterized by two distinct regions of unequal periods with their distinct maxima and minima, both at Ksara and Bagdad, the following table will present a comparison of their maxima and minima and the times of their occurence.

		M_1	t	M_2	t	m_1	t	m_2	t	M_1-M_2	m_1-m_2
Winter	Bagdad	764.6	7	763.7	20	763.3	1	762.9	12	0.9	0.4
	Ksara	684.2	7	684.0	20	683.4	3	682.9	12	0.2	0.5
Spring	Bagdad	759.3	7	758.2	20	757.9	1	757.3	14	1.1	0.6
	Ksara	682.9	7	682.8	20	682.2	1	681.8	13	0.1	0.4
Summer	Bagdad	750.9	6	749.9	20	749.6	24	749.0	14	1.0	0.6
	Ksara	680.3	6	680.2	20	679.8	1	679.1	14	0.1	0.7
Autumn	Bagdad	759.9	7	759.0	20	758.7	1	758.2	14	0.9	0.5
	Ksara	684.6	7	684.3	20	683.9	2	683.1	13	0.3	0.8

(t) time of occurence of the corresponding maxima or minima.

The amplitude of variation of pressure, during the first cyclic change is greater for Bagdad.

$$\frac{1}{12}\left[\frac{M-m}{\mu}_{Jan} + \frac{M-m}{\mu}_{Feb} \cdots \frac{M-m}{\mu}_{Dec}\right] =$$

0.0025 for Bagdad.
0.0019 for Ksara.

In general the variations for Ksara resemble more a smooth curve than those of Bagdad, which might be due to the fact that the analyses of pressure for Bagdad is based on the records for one year only, and most of the disturbances which affect the barometric pressure and which are not of a short period character, such as storms etc cannot be eliminated unless the work is carried based on the averages for 10 years at least.

The curves bring out another characteristic about the difference of variation at the two localities, that is the differences of the two maxima for Bagdad are greater than those of Ksara & the differences of minima are greater for Ksara.

It is interesting to note that the 24 hour swing of the barometer, has almost the same intervals for the two localities, the ratio of the intervals

is about 11/13 as can be seen from the table at the beginning of the chapter.

Temperature:

The diurnal variation of temperature, like that of pressure has similar characteristics at both places, except for the fact that average temperature throughout the year is higher at Bagdad due to its desert climate, the difference being maximum in summer and minimum in winter.

	μ Bagdad	μ Ksara	Diff.
Winter	9.3	6.47	2.83
Spring	21.5	14.48	7.02
Summer	33.2	23.68	9.52
Autumn	23.8	17.70	6.10

(μ) represents the average of the thermometric readings for one season.

The variation is characterized by one maximum and one minimum, occuring around 11-12 and 4-5 (G.M.T.) respectively.

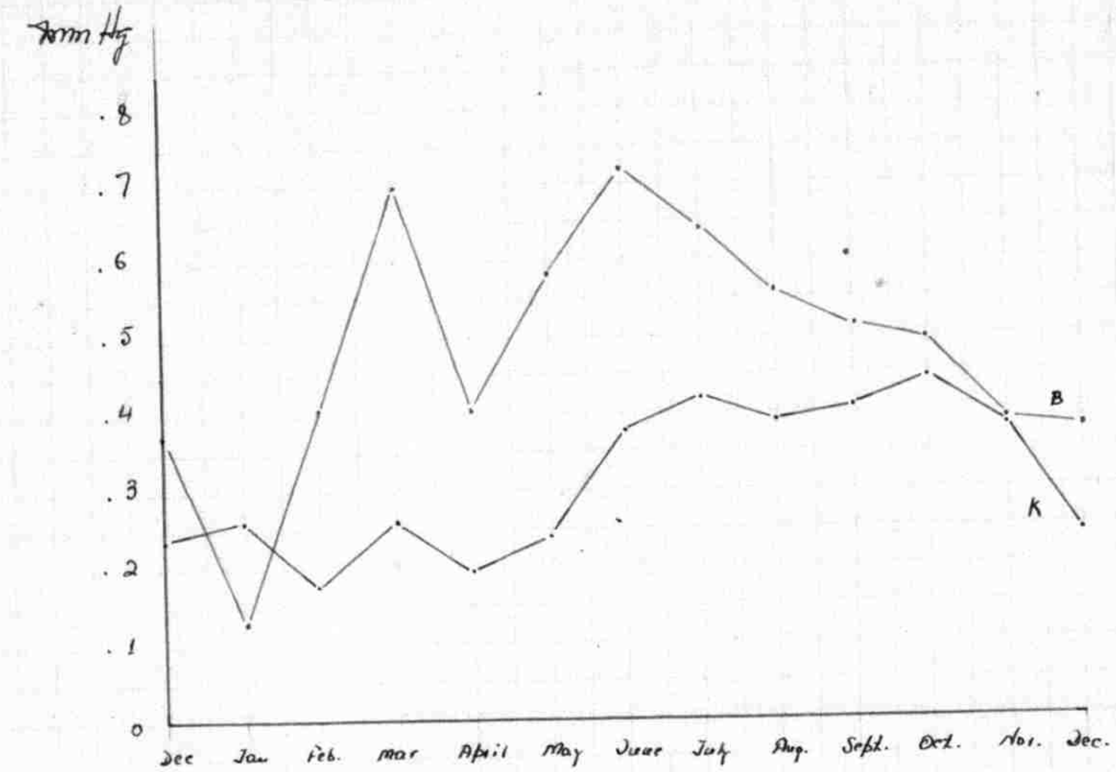
The amplitude of variation at Ksara is higher than that of Bagdad, just the reverse of the phenomenon observed for the pressure variation.

$$\frac{1}{12}\left[\frac{M-m}{\mu}_{Jan} + \cdots\cdots \frac{M-m}{\mu}_{Dec}\right] =$$

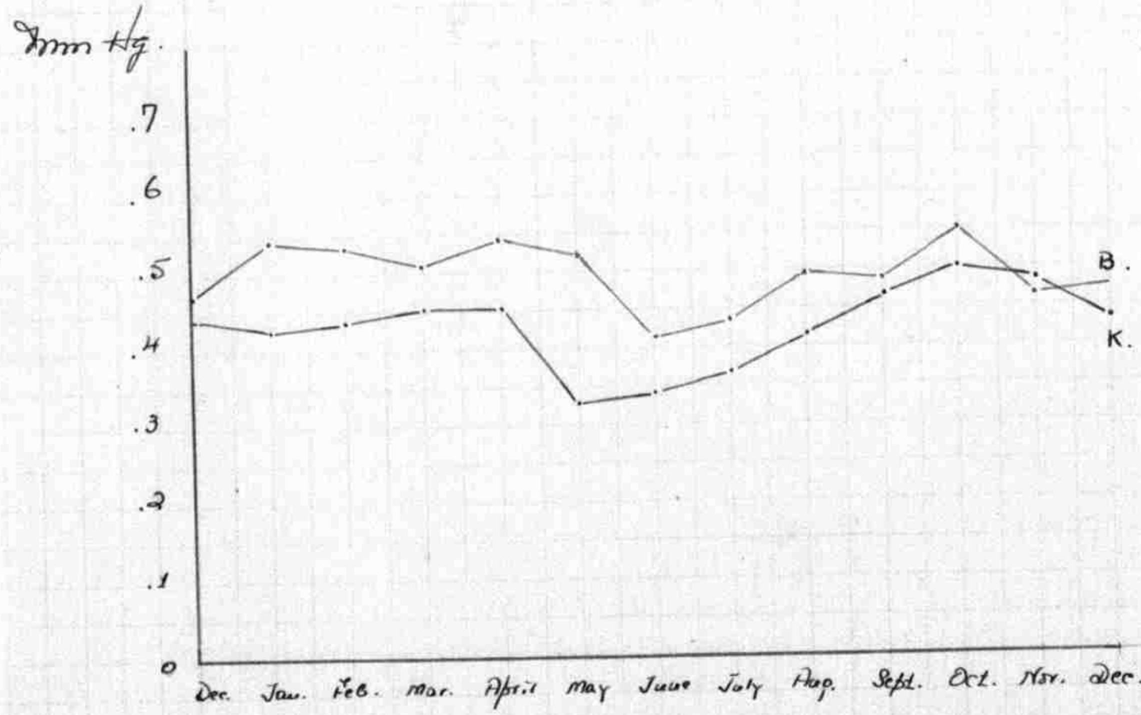
0. 73 for Bagdad
0. 81 for Ksara

Harmonic Analysis

The discussion of the results of the harmonic Analysis is preceeded by graphs representing the annual variations of the amplitudes and the (h-) values, (the time of the first maxima), of pressure and temperature for the diurnal and the semi-diurnal waves only.

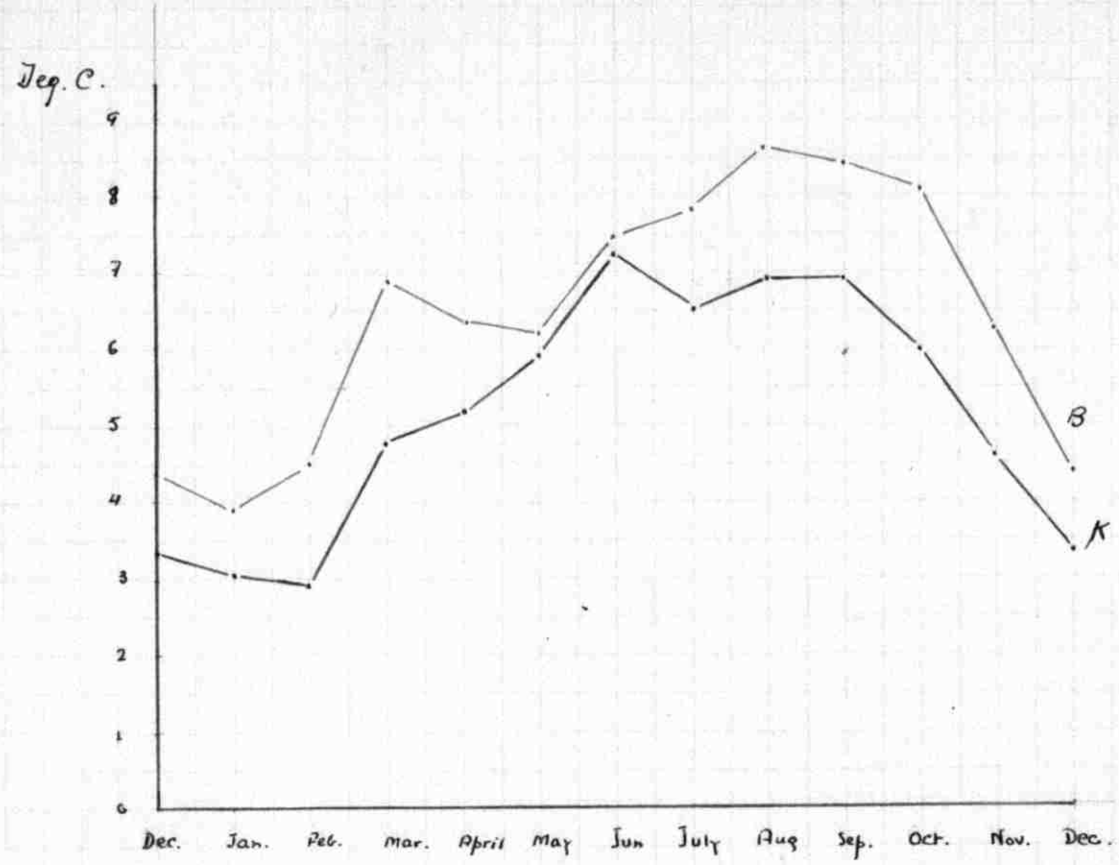


AMPLITUDES OF THE DIURNAL WAVES OF PRESSURE AGAINST THE MONTHS OF THE YEAR

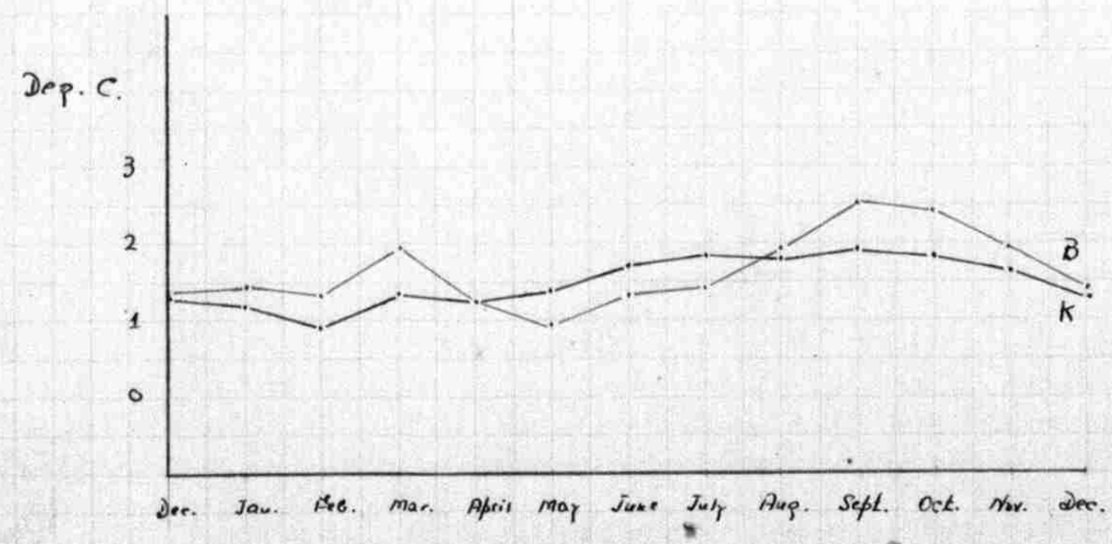


AMPLITUDES OF THE ½ DIURNAL WAVES OF PRESSURE AGAINST THE MONTHS OF THE YEAR

Graph 13.



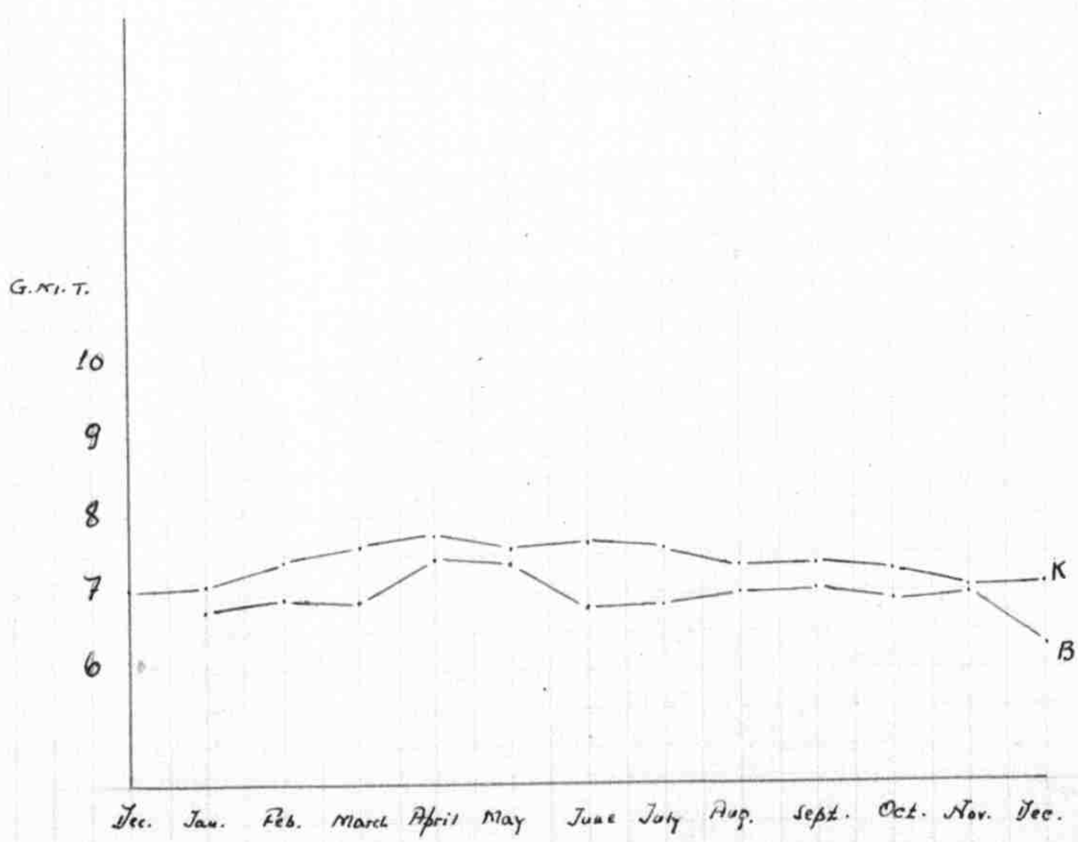
AMPLITUDES OF THE DIURNAL WAVES OF TEMPERATURE
AGAINST THE MONTHS OF THE YEAR



AMPLITUDES OF THE ½-DIURNAL WAVES OF TEMPERATURE
AGAINST THE MONTHS OF THE YEAR

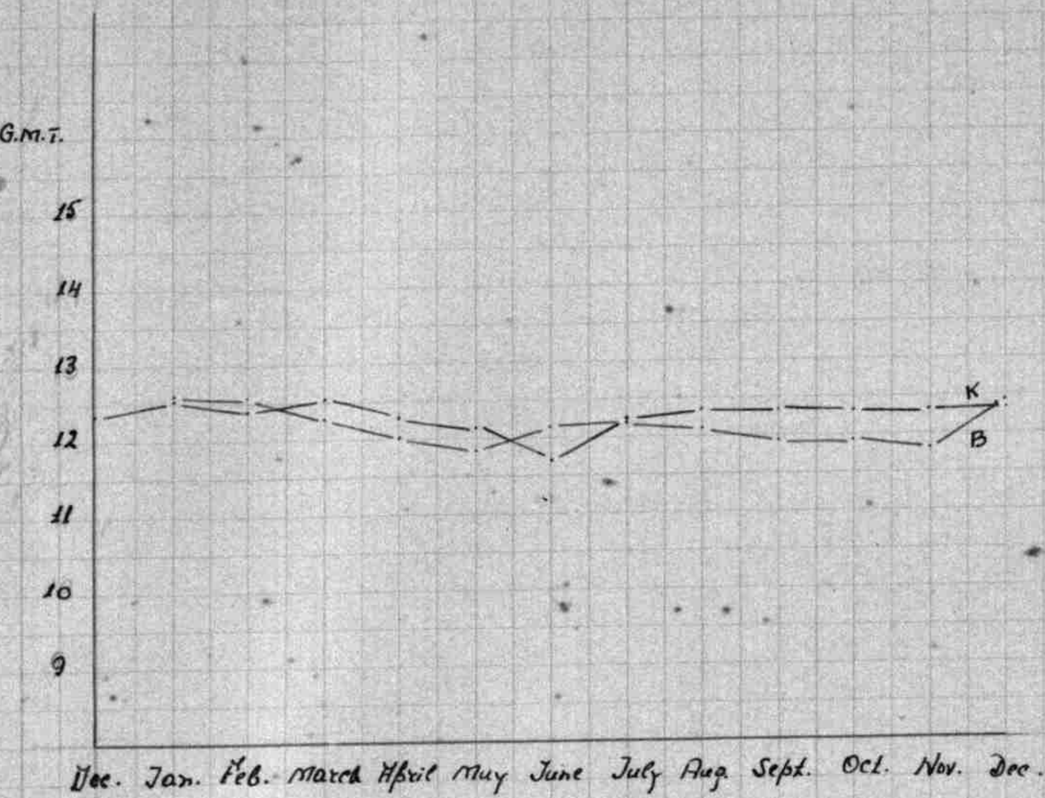
Graph 14.

TIMES OF THE FIRST MAXIMA OF THE DIURNAL WAVES OF PRESSURE AGAINST THE MONTHS OF THE YEAR.

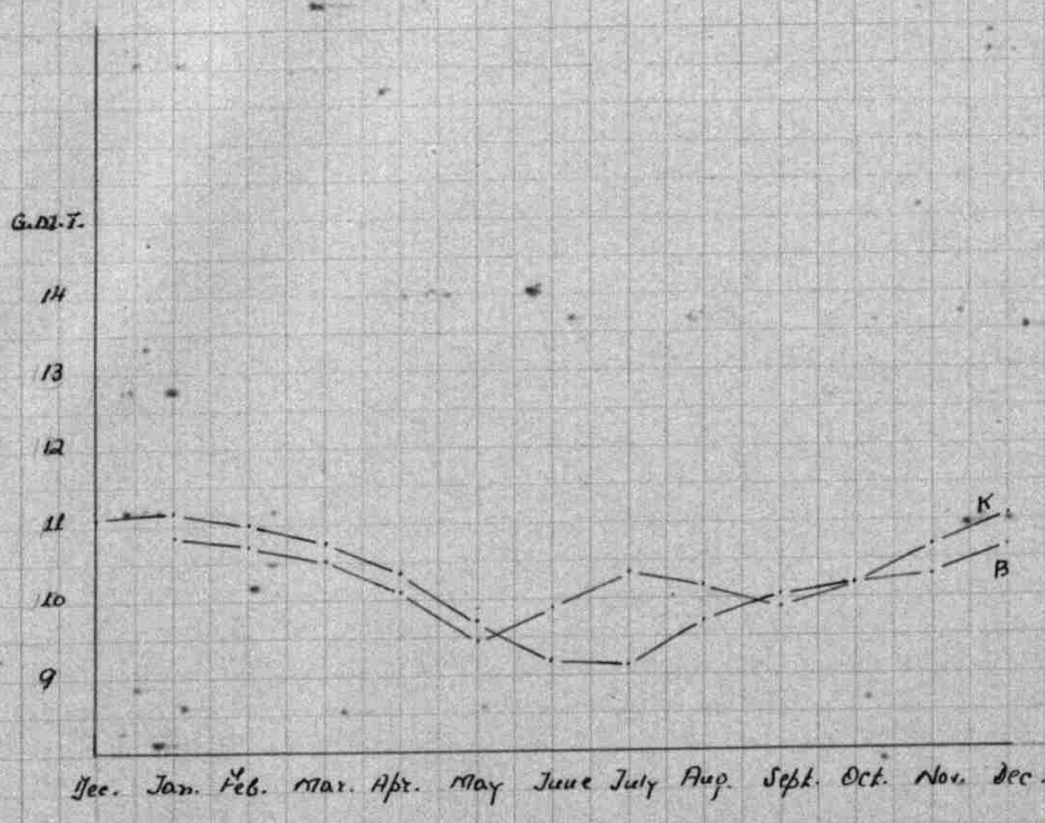


TIMES OF THE FIRST MAXIMA OF THE ½ DIURNAL WAVES OF PRESSURE AGAINST THE MONTHS OF THE YEAR

Graph 15.

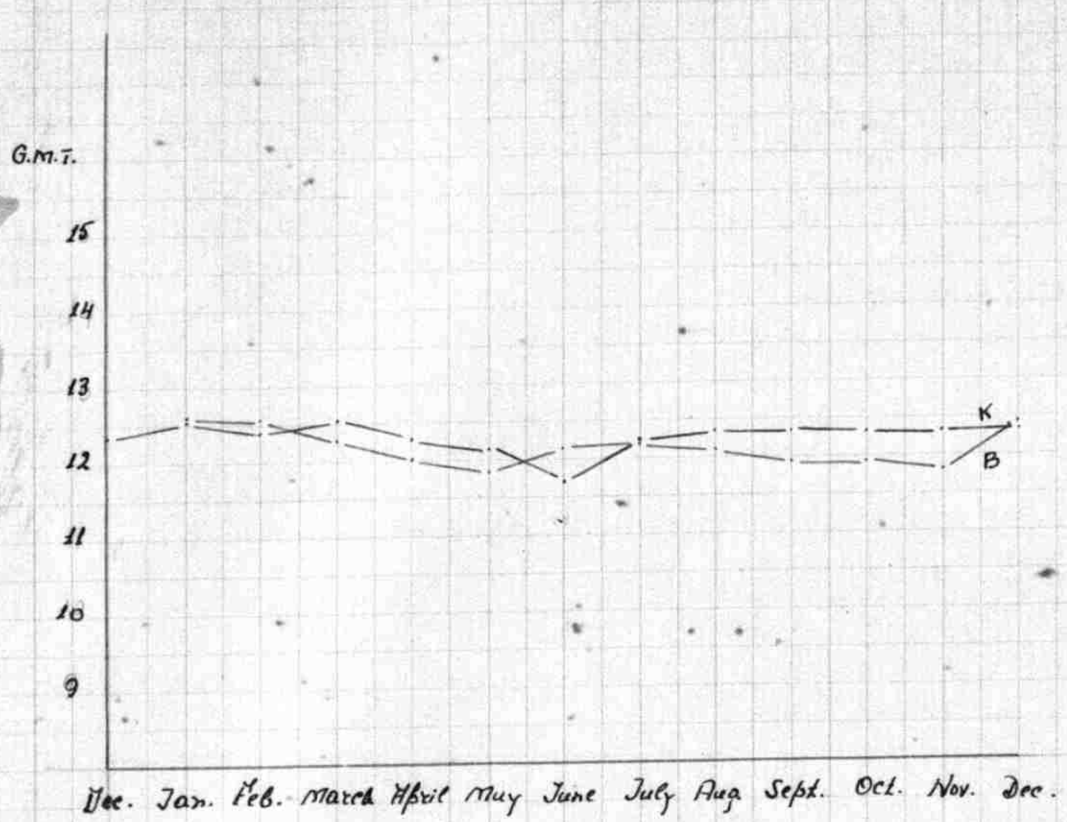


TIMES OF THE FIRST MAXIMA OF THE DIURNAL WAVES OF TEMPERATURE AGAINST THE MONTHS OF THE YEAR.

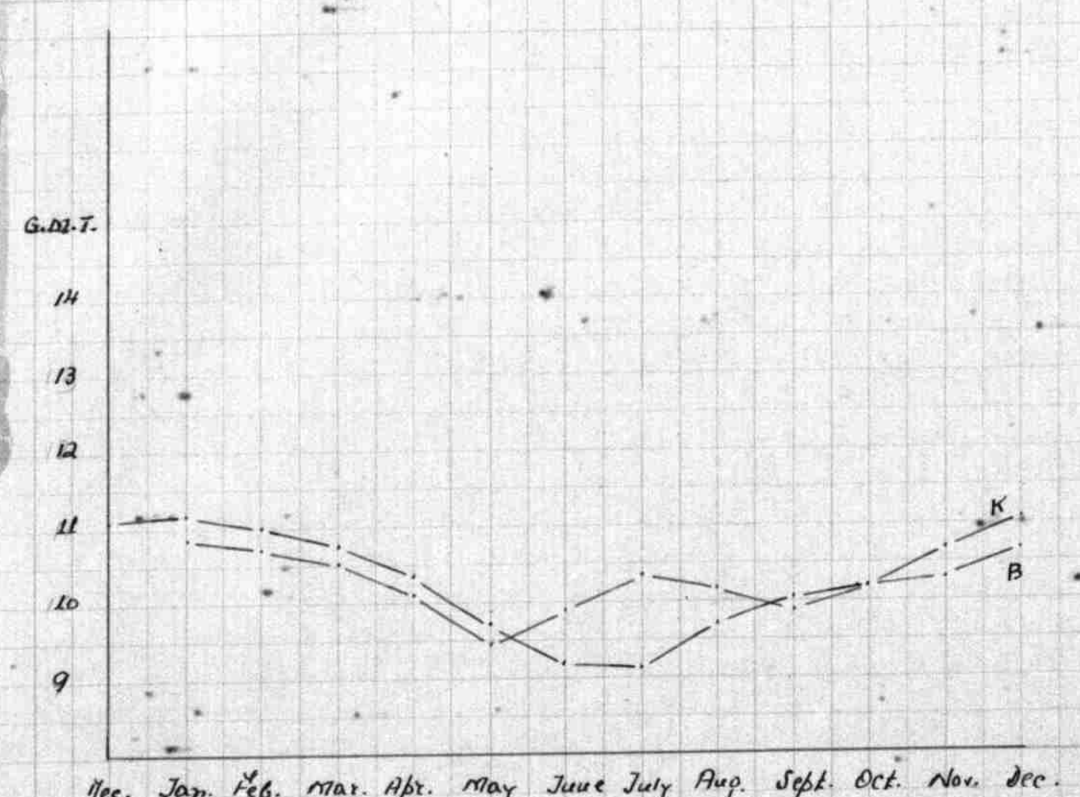


TIMES OF THE FIRST MAXIMA OF THE 1/2 DIURNAL WAVES OF TEMPERATURE AGAINST THE MONTHS OF THE YEAR

raph 16.



TIMES OF THE FIRST MAXIMA OF THE DIURNAL WAVES OF TEMPERATURE AGAINST THE MONTHS OF THE YEAR.



TIMES OF THE FIRST MAXIMA OF THE ½ DIURNAL WAVES OF TEMPERATURE AGAINST THE MONTHS OF THE YEAR

raph 16.

Diurnal Waves of Pressure and Temperature

Pressure:

The amplitudes of the diurnal waves of Bagdad are higher than those of Ksara, with the exception of the month of January when the amplitude of the wave falls down to a minimum of 0.127mm. of Hg.(B). The same holds true for the times of first maxima, that is, it is always higher in Bagdad except for the month of January. The difference of phase for Bagdad & Ksara waves is more or less constant. The annual fluctuations in the amplitude of the waves are more irregular for Bagdad on the other hand, the fluctuations of h_1 (time of first maximum) are more irregular for Ksara, as it is very obvious from the diagrams.

In general the annual variations of (A_1) and (h_1) are more or less parallel except for the month of January, which might be due to a disturbance affecting the barometric pressure. The amplitude of the annual variation of (A_1) is greater for Bagdad and the amplitude of (h_1) is greater for Ksara.

Mean Yearly Amplitude^P = 0.492 mm Hg Bagdad; 0.315 mm Hg Ksara

Diurnal Waves of Pressure and Temperature

Pressure:

The amplitudes of the diurnal waves of Bagdad are higher than those of Ksara, with the exception of the month of January when the amplitude of the wave falls down to a minimum of 0.127mm. of Hg.(B). The same holds true for the times of first maxima, that is, it is always higher in Bagdad except for the month of January. The difference of phase for Bagdad & Ksara waves is more or less constant. The annual fluctuations in the amplitude of the waves are more irregular for Bagdad on the other hand, the fluctuations of h_1 (time of first maximum) are more irregular for Ksara, as it is very obvious from the diagrams.

In general the annual variations of (A_1) and (h_1) are more or less parallel except for the month of January, which might be due to a disturbance affecting the barometric pressure. The amplitude of the annual variation of (A_1) is greater for Bagdad and the amplitude of (h_1) is greater for Ksara.

$$\text{Mean Yearly Amplitude}^{P} = \begin{cases} 0.492\text{ mm Hg} & \text{Bagdad} \\ 0.315\text{ mm Hg} & \text{Ksara} \end{cases}$$

$$\text{Mean yearly } (h_1)^T = \begin{cases} 12^h.15 & \text{Bagdad} \\ 12^h.26 & \text{Ksara} \end{cases}$$

The following table will present a comparison of the times of maxima for the diurnal waves of pressure and Temperature.

		(h_1) Press.	(h_1) Temp.	Difference
Winter	Bagdad	3.32	12.54	9.22
	Ksara	0.80	12.42	11.62
Spring	Bagdad	5.11	12.06	6.95
	Ksara	2.71	12.33	9.62
Summer	Bagdad	4.76	12.10	7.34
	Ksara	2.20	12.04	9.84
Autumn	Bagdad	4.34	11.90	7.56
	Ksara	2.10	12.25	10.15

For Ksara the times of maxima for the pressure waves are nearer the times of minima for the temperature waves than those of Bagdad, as might be seen from the table. On the other in the mountainous regions, a thermometric maximum should coincide with a barometric maximum due to the fact that, the air in contact with the side of the earth exposed to insolation, becomes heated and the center of mass is raised and conversely the center of mass is lowered when the atmosphere is cooled. Hence Ksara in this respect behaves like sea level or low stations, where barometric maxima coincide with thermometric minima.

Semi_Diurnal waves of pressure and Temp.

Pressure:

The amplitudes of these waves indicate that they constitute the most important element of variation of pressure for the two stations.

The amplitudes for Bagdad are always higher than those for Ksara, but compared with their monthly means, the percentage of variation is higher for Ksara.

The annual variation of the amplitudes is the same for both stations, undergoing a double oscillation with two maxima and two minima. the maxima occuring in April and October

April max. = { .542 mm.Hg (Bagdad) / .453 mm.Hg (Ksara) }

October max. = { .549 mm.Hg (Bagdad / .502 mm.Hg (Ksara) }

The annual variation of (h_2), time of the first maximum, is very slight and does not show any important characteristic; (h_2) is always greater for Ksara, the reverse of the behaviour of the amplitudes.

Mean yearly amplitude^p = { 0. 497 mm.Hg (Bagdad) / 0. 423 mm.Hg (Ksara) }

Mean yearly $(h_2)^p$ = { $6^h.92$ (G.M.T) (Bagdad) / $7^h.40$ (G.M.T) (Ksara) }

According to Simpson[1] and Whipple[2] the maximum of the semi-diurnal wave of pressure takes place everywhere about $9^h.30$ (local time)

(h_2) for Bagdad = $6^h.92 + 3^h.04 = 9^h.96$ (local tim

(h_2) for Ksara = $7^h.40 + 2^h.44 = 9.84$ (local tim

For both localities the results are in fair agreement with the statements of Simpson & Whippl

For the Amplitude (A_2) of the ½ diurnal wave of pressure, Simpson suggests the theoretical formula:

$$A_2 = \left[b^2 + c^2 + 2bc\cos(49^\circ + 2\lambda) \right]^{1/2}$$

$b = .937 \cos^3\varphi$ $\quad \varphi$ = the latitude of the

$c = .137(\sin^2\varphi - \frac{1}{3})$ $\quad \lambda$ = the longitude "

According to this formula:

$A_2 =$ .54 mm. Hg. for (Ksara)
.56 mm. Hg. for (Bagdad)

Compared with the yearly means of the amplitude:

$A_2 =$ .42 mm. Hg Ksara
.50 mm. Hg Bagdad (observed)

The differences of the theoretical and observed = 1.2 mm. Hg for (Ksara), 0.6 mm. Hg. for (Bagdad) the theoretical yielding a higher value than the observed

(1) [G.E. Simpson, The twelve-hourly barometer oscillation, Quar Journ. Roy. Met. Soc. Vol. 44, 1918 P. 1] (2) [F.J. Whipple, A note on the propagation of ½ diurnal wave. Ibid. P 20]

Temperature:

The behaviour of these waves is almost the same at the two stations, the amplitudes for Bagdad are higer than those of Ksara except during the summer months when the amplitude for Ksara becomes greater. On the other hand (h_2) is greater for Ksara with the exception of the summer months, when (h_2) is greater for Bagdad.

The following table is a comparison of (h_2) for pressure and temperature:

		h_2 (Pressure)	h_2 (Temp)	Difference
Winter	Bagdad	6.69	10.76	4.07
	Ksara	7.22	11.09	3.87
Spring	Bagdad	7.23	10.01	2.78
	Ksara	7.63	2.19	5.44
Summer	Bagdad	6.85	10.12	3.27
	Ksara	7.52	9.34	1.82
Autumn	Bagdad	6.93	10.08	3.15
	Ksara	7.23	10.29	3.06

mean yearly

$A_2^T =$ 1.648°C (B)
1.488°C (K)

$h_2^T =$ $10^h.24$ (B)
$2^h.23$ (K)

The comparison indicates that the difference of the phases differs for the two stations during summer and spring months which might be due to a change of the factors affecting the double swing of the thermometric and barometric readings during the above mention[ed] seasons.

$\frac{1}{3}$ Diurnal and $\frac{1}{4}$ Diurnal waves of press. and T[emp.]

Pressure:

These waves resemble each other, they have an amplitude which is greater in Bagdad. (h_3) and (h_4) also, is greater for Bagdad during all the seasons except winter, when Ksara has the higher (h_3) and (h_4). The peculiar fact about these waves is that they have their maximum intensity is during the winter months for both stations.

Temperature:

The $\frac{1}{3}$ diurnal wave has a greater amplitude at Ksara for the winter and autumn seasons, and (h_3) is less for Ksara during these seasons. On the other hand, during spring and summer, the amplitude of the waves is greater for Bagdad but (h_3) is less compared to Ksara.

The $\frac{1}{4}$ diurnal is almost of the same magnitude as the $\frac{1}{3}$th diurnal, the amplitude in general is higher for Bagdad; and (h_4) is less for Bagdad except for the autumn months.