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SOME OBSERVATIONS OF UPPER AIR TEMPERATURE IN IRAQ

By S. P. PETERS, B.Sc., A.Inst.P.

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SOME OBSERVATIONS OF UPPER AIR TEMPERATURE IN IRAQ

By S. P. PETERS, B.Sc., A.Inst.P.

In view of the scarcity of observations of upper air temperature in Iraq, it seems desirable to put on record the results of seven aeroplane ascents made there in July and September 1925 with the object of taking such observations. Particular interest attaches to three of these ascents by reason of the detailed information which they give concerning the morning inversion of temperature near the ground.

1. **Places and times of ascents.**—Six of the ascents were made during July 1925 at Hinaidi, near Baghdad ; the seventh was made at Shaibah, near Basra, on September 21, 1925. Of the Hinaidi ascents, five were made in the early morning, the time of start being approximately 0530 local time (0230 G.M.T.) ; the remaining one was an afternoon ascent commenced at 1750 local time (1450 G.M.T.). The Shaibah ascent was carried out between 0945 and 1145 (local time). Throughout this Note the term " local time " is to be interpreted as signifying " 45th meridian time " ; this differs little from the actual local time at Hinaidi and Shaibah.

2. **Method of observation.**—For the first three ascents made at Hinaidi, i.e. July 9, 10 and 13, a single-seater Siskin machine was utilised, carrying a strut thermometer lashed to an outer strut of the aeroplane clear of the slipstream. On the dates July 24, 30 and 31 a D.H.9A machine was used, having a Negretti and Zambra, Mark 1 air-temperature gauge exposed on the upper side of the lower port wing between the inner and outer front struts.

Temperature readings were taken at intervals of 500 ft. altimeter height upwards from the surface during the ascents on July 9, 10 and 13 ; in the remaining flights at Hinaidi, observations were made every 100 ft. from the surface up to 3,000 ft., then every 500 ft. up to 5,000 ft. and thence every 1,000 ft. up to 8,000 ft. At Shaibah readings were taken every 1,000 ft. from the surface up to 15,000 ft. All the heights just mentioned are uncorrected altimeter heights.

Errors due to lag of the thermometer were minimised in the first three ascents by giving the means of temperature readings taken while climbing and while descending steadily at approximately 1,000 ft. per minute. During the remaining ascents in July, the lag effect was avoided by the machine remaining at least one minute at each height before a reading was taken. In the Shaibah ascent readings during ascent and descent are given.

TABLE I.—UPPER AIR TEMPERATURES AT HINAIDI.

July 9, 1926. Time of start 1750 local time.			July 10, 1925. Time of start 0530 local time.			July 13, 1925. Time of start 0530 local time.		
Altimeter height.	True height.	Temperature.	Altimeter height.	True height.	Temperature.	Altimeter height.	True height.	Temperature.
Ft.	Ft.	°F.	Ft.	Ft.	°F.	Ft.	Ft.	°F.
Surface	Surface	112·0	Surface	Surface	74·0	Surface	Surface	83·0
500	560	110·0	500	520	95·0	500	530	96·0
1,000	1,120	104·0	1,000	1,080	97·0	1,000	1,100	98·0
1,500	1,670	102·0	1,500	1,620	95·0	1,500	1,630	97·0
2,000	2,230	99·0	2,000	2,160	94·0	2,000	2,190	94·0
2,500	2,750	99·0	2,500	2,700	92·0	2,500	2,720	93·0
3,000	3,330	96·0	3,000	3,240	90·0	3,000	3,260	90·0
3,500	3,860	92·0	3,500	3,800	87·0	3,500	3,800	87·0
4,000	4,380	87·0	4,000	4,310	85·0	4,000	4,320	84·0
4,500	4,940	87·0	4,500	4,850	83·0	4,500	4,870	84·0
5,000	5,450	82·0	5,000	5,390	80·0	5,000	5,400	80·0
5,500	6,000	80·0	5,500	5,900	78·0	5,500	5,920	77·0
6,000	6,530	76·0	6,000	6,430	76·0	6,000	6,450	74·0
6,500	7,050	74·0	6,500	6,950	73·0	6,500	6,960	71·0
7,000	7,590	71·0	7,000	7,470	70·0	7,000	7,480	69·0
7,500	8,100	70·0	7,500	8,000	68·0	7,500	8,000	67·0
8,000	8,610	69·0	8,000	8,500	64·0	8,000	8,510	63·0
						8,500	9,020	60·0

Note.—All heights are above ground level (i.e. about 100 ft. above mean sea level).
The temperatures given are the means of readings taken while climbing and while descending at approximately 1,000 ft. per minute.

TABLE II.—UPPER AIR TEMPERATURES AT HINAIDI.

July 24, 1925. Time of start 0530 local time.			July 30, 1925. Time of start 0525 local time.			July 31, 1925. Time of start 0525 local time.		
Altimeter height.	True height.	Temperature.	Altimeter height.	True height.	Temperature.	Altimeter height.	True height.	Temperature.
Ft.	Ft.	°F.	Ft.	Ft.	°F.	Ft.	Ft.	°F.
Surface	Surface	81·0	Surface	Surface	74·8	Surface	Surface	77·5
100	100	86·0	100	100	81·3	100	110	80·6
200	210	86·9	200	210	82·4	200	200	83·3
300	310	87·8	300	310	84·2	300	300	85·1
400	420	87·8	400	420	86·9	400	410	86·0
500	530	87·8	500	530	90·5	500	540	90·1
600	640	86·9	600	630	92·3	600	640	95·0
700	750	86·8	700	740	93·7	700	750	96·5
800	850	86·8	800	850	94·1	800	870	95·9
900	960	87·8	900	960	94·1	900	950	95·9
1,000	1,080	89·4	1,000	1,080	93·7	1,000	1,100	95·9
1,100	1,190	90·5	1,100	1,190	93·5	1,100	1,200	95·9
1,200	1,300	90·6	1,200	1,300	93·2	1,200	1,310	95·9
1,300	1,400	90·5	1,300	1,400	92·8	1,300	1,410	95·9
1,400	1,500	90·6	1,400	1,510	92·3	1,400	1,520	95·6
1,500	1,610	91·0	1,500	1,610	91·7	1,500	1,620	95·0

1,600	1,710	90·6	1,600	1,720	91·4	1,600	1,750	94·6
1,700	1,820	90·6	1,700	1,830	91·0	1,700	1,850	94·0
1,800	1,930	90·5	1,800	1,940	90·5	1,800	1,940	93·7
1,900	2,040	90·0	1,900	2,040	90·0	1,900	2,070	94·1
2,000	2,150	89·6	2,000	2,150	89·6	2,000	2,150	93·4
2,100	2,260	89·6	2,100	2,270	89·3	2,100	2,280	93·7
2,200	2,370	89·6	2,200	2,380	88·7	2,200	2,390	93·2
2,300	2,490	88·7	2,300	2,490	87·8	2,300	2,500	93·0
2,400	2,590	88·4	2,400	2,600	87·1	2,400	2,590	92·3
2,500	2,690	87·8	2,500	2,700	86·5	2,500	2,710	91·8
2,600	2,800	87·5	2,600	2,810	86·1	2,600	2,820	91·4
2,700	2,900	87·0	2,700	2,910	85·8	2,700	2,920	91·0
2,800	3,010	86·9	2,800	3,020	85·1	2,800	3,020	90·1
2,900	3,110	86·4	2,900	3,110	84·5	2,900	3,120	89·6
3,000	3,220	86·0	3,000	3,230	84·2	3,000	3,230	89·8
3,500	3,770	82·7	3,500	3,770	81·5	3,500	3,810	87·8
4,000	4,300	80·2	4,000	4,300	79·2	4,000	4,350	85·6
4,500	4,830	77·9	4,500	4,820	77·0	4,500	4,900	83·3
5,000	5,370	75·2	5,000	5,380	74·0	5,000	5,410	80·6
6,000	6,420	70·7	6,000	6,430	68·9	6,000	6,500	75·2
7,000	7,500	66·2	7,000	7,500	63·0	7,000	7,520	69·8
8,000	8,540	60·8	8,000	8,550	61·7	8,000	8,630	64·0

Note.—All heights are above ground level (i.e. about 100 ft. above mean sea level).

Temperatures are those taken during ascent, the machine remaining at least one minute at each level before reading.

TABLE III.—UPPER AIR TEMPERATURES AT SHAIBAH.

September 21, 1925. Time of start 0945 local time. Landed 1145 local time.

Altimeter height.	True height.		Temperature.	
Ft.	Ft.		°F.	
Ascent. Descent.	Ascent.	Descent.	Ascent.	Descent.
Surface	Surface	Surface	96·0	106·4
1,000	1,090	1,100	100·2	99·7
2,000	2,190	2,200	98·8	96·4
3,000	3,280	3,290	94·7	93·0
4,000	4,340	4,370	88·4	88·0
5,000	5,430	5,440	85·6	84·6
6,000	6,500	6,500	81·8	78·0
7,000	7,570	7,550	76·5	72·3
8,000	8,600	8,590	70·8	66·5
9,000	9,610	9,610	60·2	60·0
10,000	10,630	10,630	59·5	57·2
11,000	11,670	11,640	55·4	53·0
12,000	12,670	12,640	48·8	47·0
13,000	13,660	13,630	42·9	42·0
14,000	14,650	14,620	40·8	43·0
15,000	15,615		39·0	39·0

Note.—All heights are above ground level (i.e. 60 ft. above M.S.L.).

3. **Explanation of tables.**—The observed readings of temperature and altimeter height during the ascents are given in Tables I–III. The true heights above the surface corresponding to the given values of altimeter height have been calculated and included in the tables. The results are exhibited graphically in Figs. 1–3.

No wet-bulb temperature readings were taken, so that no data are available regarding relative humidities in the upper air on these occasions. Surface values near the times of ascents are, however, given in Table IV, whilst Table V gives screen minimum temperatures for nights preceding occasions of early-morning ascents. In Table VI are set out the results of upper wind observations made by the single-theodolite method of pilot-balloon ascents, near to the times of aeroplane ascents; the surface values taken from the anemobiagraph records are added, whilst the upper wind value at any height represents the average wind in a layer 1,000 ft. thick centred at that height.

4. **Discussion of results.**—(*a*) *Hinaidi ascents.*—All the Hinaidi ascents were made in the cloudless weather, with persistent north-westerly winds, which characterises that part of the year in Iraq.

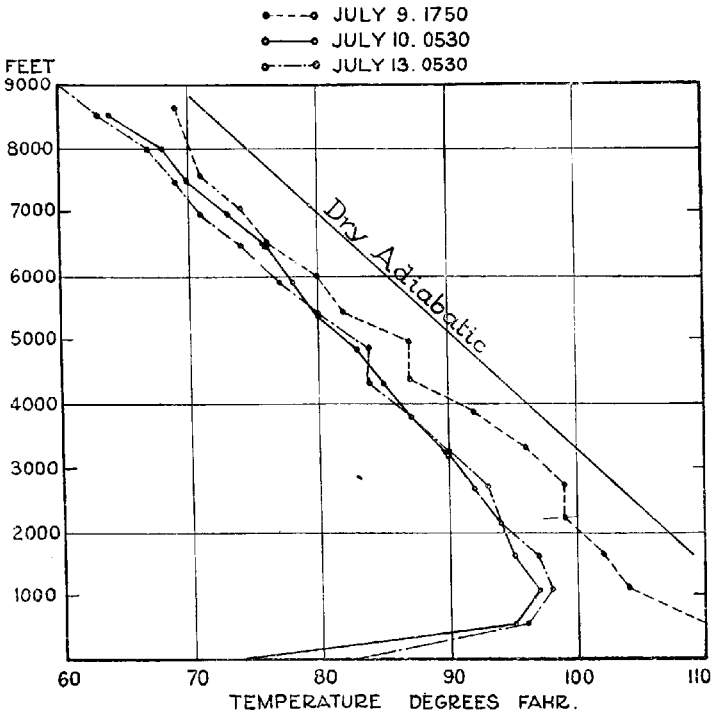

FIG. 1.—Upper air temperatures at Hinaidi, Iraq, 1925 (local time).

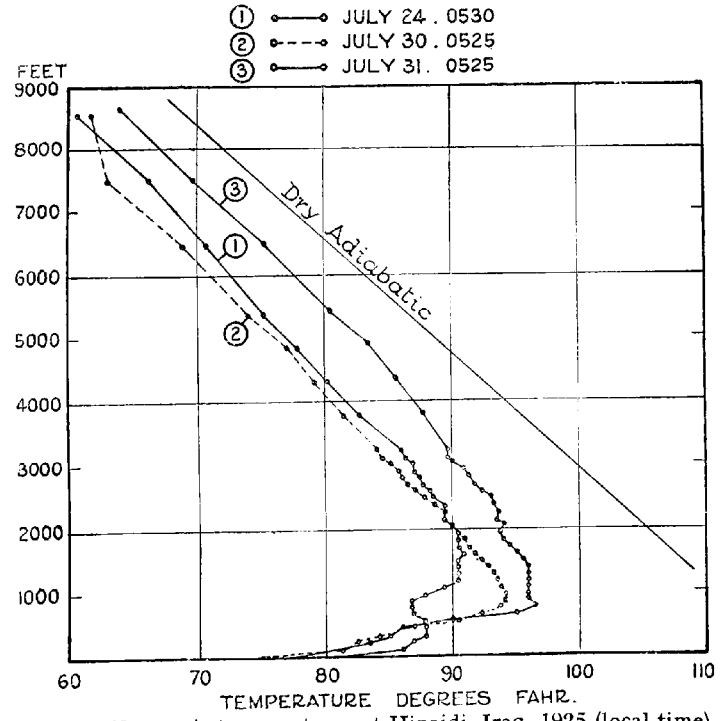

FIG. 2.—Upper air temperatures at Hinaidi, Iraq, 1925 (local time).

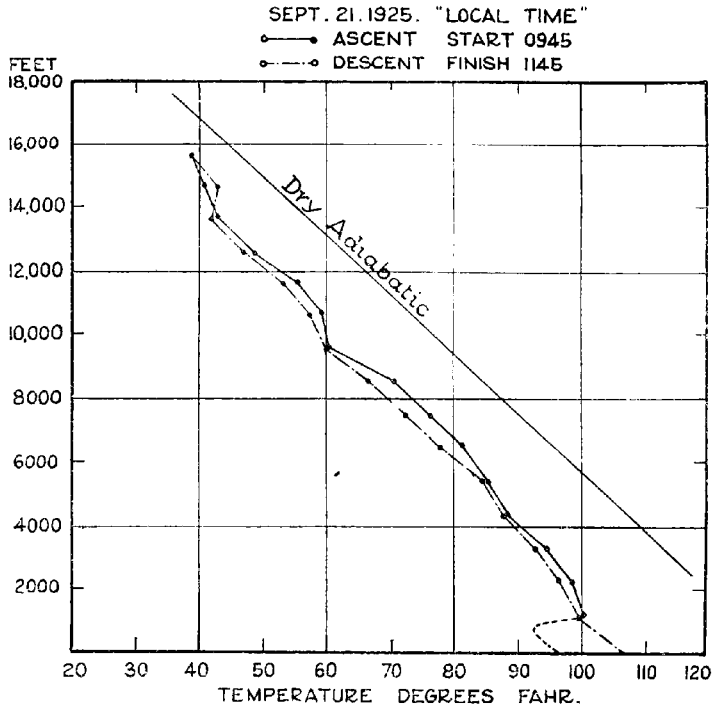

FIG. 3.—Upper air temperatures at Shaibah, Iraq.

TABLE IV.—SURFACE RELATIVE HUMIDITY.

Hinaidi.							Shaibah.	
	July.						Local time.	Sept. 21.
Local time.	9	10	13	24	30	31		
	Relative humidity %							Relative humidity %
1300	13	—	—	—	—	—	—	—
2000	21	—	—	—	—	—	0345	54
0300	—	30	22	37	27	18	0800	61
0800	—	21	14	28	24	21	1300	28

TABLE V.—MINIMUM TEMPERATURES IN THE SCREEN AT HINAIDI, 1925.

From 20h. of previous day to 8 h. (local time) :—

July	10	13	24	30	31
°F...	74	81	79	72	77

Each of the early-morning ascents shows a large surface inversion of the order of from 10° to 20° F. and almost entirely confined to the layer between the surface and 1,000 ft. Above this inversion the vertical temperature gradient up to the limit of the ascent is in each case practically the dry adiabatic. All these ascents were made at a time not very different from that of

TABLE VI.—UPPER WIND OBSERVATIONS.

(*a*) HINAIDI.

1925.	July 9.		July 10.				July 13.	
Local time.	1730.		0530.		0710.		0700.	
Ft.	°	m.p.h.	°	m.p.h.	°	m.p.h.	°	m.p.h.
Surface	NNW	21	NNW	10	NW'W	17	NW	21
500	338	27	359	27	311	19	340	23
1,500	335	30	352	34	354	32	344	38
3,000	335	30	341	31	338	31	338	21
6,000	—		—		337	40	332	17
10,000	—		—		—		326	15

1925.	July 24.		July 30.		July 31.	
Local time.	0700.		0700.		0710.	
Ft.	°	m.p.h.	°	m.p.h.	°	m.p.h.
Surface	NW'N	8	WNW	6	WNW	15
500	324	17	312	17	304	25
1,500	331	26	328	21	342	30
3,000	308	21	315	20	337	27
6,000	284	25	335	17	325	24
10,000	239	21	299	9	—	

(*b*) SHAIBAH.

	Sept. 21, 1925.			
Local time.	0315.		0710.	
Ft.	°	m.p.h.	°	m.p.h.
Surface	NW'W	7	W'S	5
500	342	23	342	14
1,500	349	29	343	19
3,000	339	28	344	17
6,000	—		311	23
10,000	—		313	8

minimum temperature at the surface, the night minima recorded in the Stevenson screen (Table V) being in all cases only a degree or two below the corresponding surface readings given in the tables and diagrams of this Note. These, therefore, show approximately the maximum intensity of the surface temperature inversion.

Referring to Table VI, it is seen that on all occasions of aeroplane ascents at Hinaidi in the early morning the wind speed at the surface at the times of commencement of the ascents was over 5 m.p.h., and in one case as much as 21 m.p.h., whilst the pilot-balloon ascents at about those times reveal speeds exceeding 15 m.p.h. at 500 ft. and 20 m.p.h. at 1,500 ft., and in one case reaching 38 m.p.h. at the latter height. Thus it appears that in spite of the turbulence associated with these moderately strong winds, marked inversions were able to persist up to heights between 800 and 1,600 ft. by virtue of the outward radiation from the earth, which would have been particularly effective in lowering the surface temperatures on account of the relative dryness of the surface air (Table IV), a characteristic doubtless existing up to a considerable height, and thus reducing any blanketing effect to a minimum.

In Fig. 6, the Hinaidi anemobiagraph record for July 30–31, 1925 is reproduced. This shows clearly the difference in type between the speed and direction traces of the daylight hours, when the vertical temperature gradient is practically the dry adiabatic right down to the surface, and those of the night hours when there is a strong surface inversion. With a mean wind speed of 20 m.p.h. there is, in the former case, much the greater gustiness with accompanying irregularities in direction, resulting from pronounced turbulence which is diminished after sunset as vertical convection ceases.

An inspection of the three curves in Fig. 2, which contain detailed information between the surface and 3,000 ft. (uncorrected altimeter height), reveals the existence in two out of the three cases of an isothermal layer of approximately 700 ft. vertical thickness representing a transitional layer between the surface inversion below and the almost adiabatic gradient above. In the third case the transition between these two conditions is almost abrupt. The irregularities to be seen on the curve for July 24, between the surface and 850 ft. (true height), appear to be due to a gradual rise in temperature of about 4° F. at the surface, which took place between 0400 and 0500 local time, causing, or being accompanied by, some increase of temperature up to 850 ft. (true height). The surface temperature then remained sensibly constant for about an hour and a half before recommencing to rise and thus continue the process of dissipation of the inversion.

Fig. 4. UPPER AIR TEMPERATURES IN 'IRAQ. 1922. *To face p. 10.*

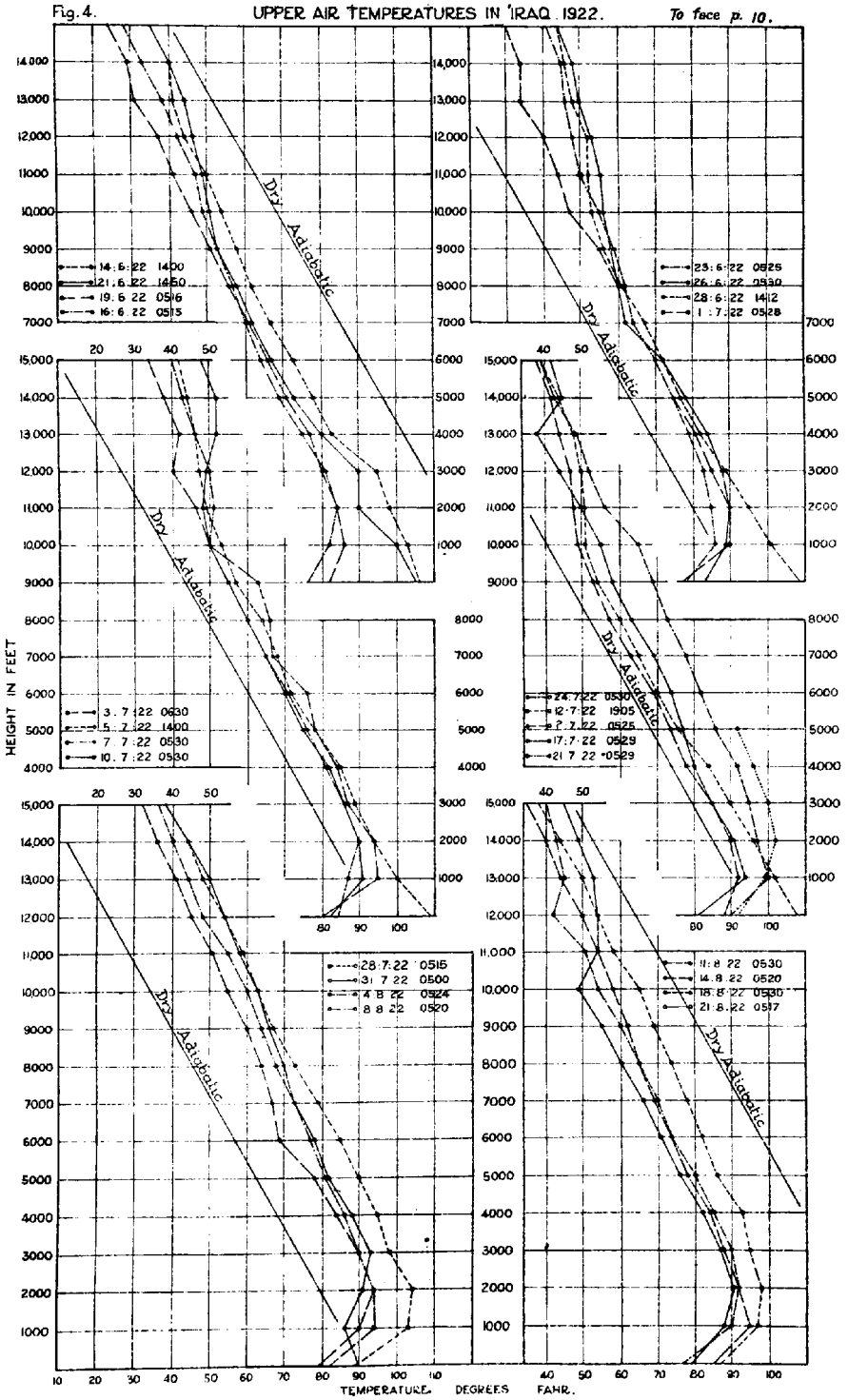

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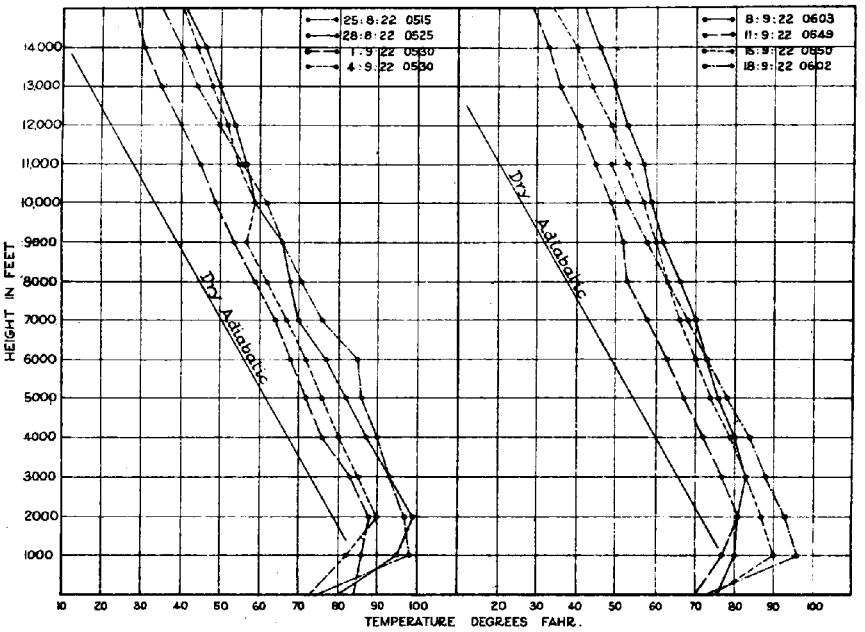
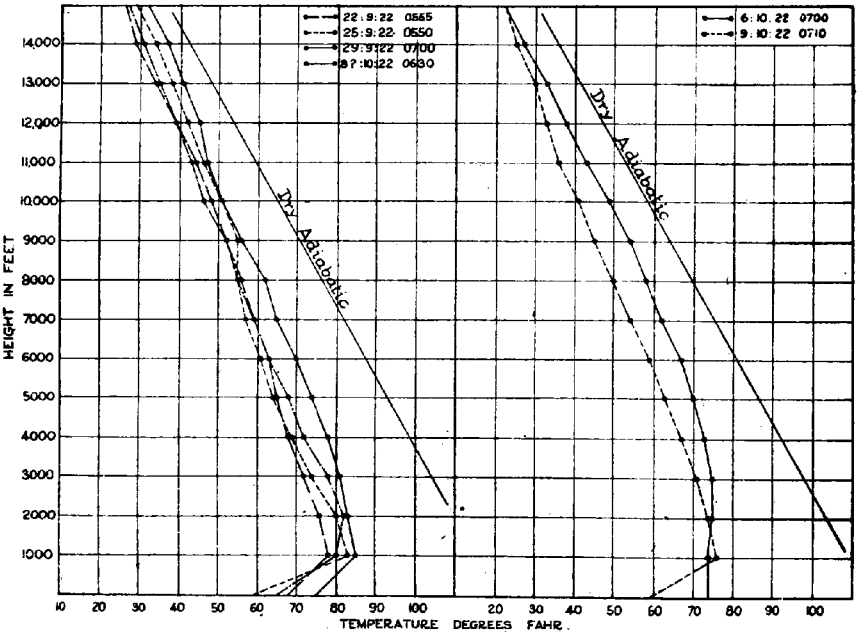
Fig. 5. UPPER AIR TEMPERATURES IN IRAQ
1922





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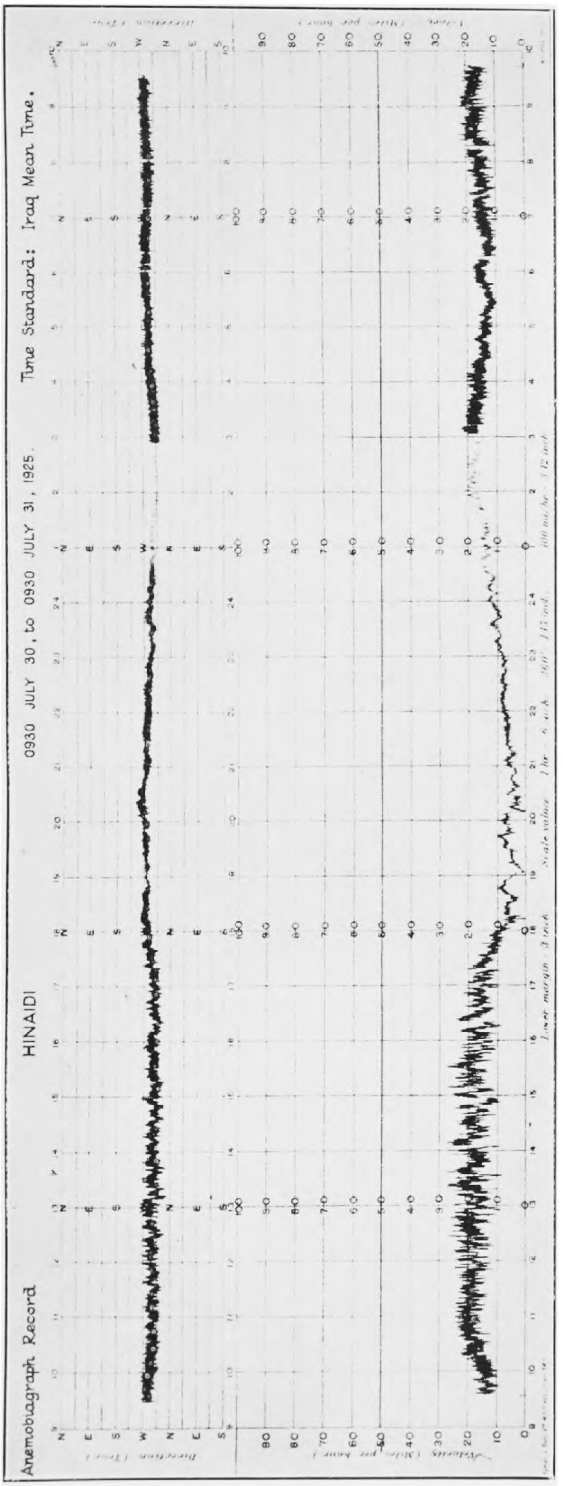

FIG. 6.

The ascent on July 9, which was made at 1750 local time, shows the steep lapse-rate extending right down to the surface. On this day the maximum screen temperature was 115° F. and the weather was described as " cloudless, squally, intermittent dust disturbances." Some gusts of gale force were observed.

(*b*) *Shaibah ascent.*—The observations at Shaibah depicted in Fig. 3 indicate the disappearance of the surface inversion between the time of commencement of the flight (0945 local time) and the time of landing (1145 local time). Lack of intermediate observations within the first 1,000 ft., however, makes it impossible to say what was actually the thickness of the inversion at 0945 ; the probable form of the graph has, however, been indicated by a dotted line, showing an adiabatic gradient next to the surface with a sharp inversion above, for by this time considerable surface heating had taken place as the screen minimum temperature of the preceding night was 69° F., and temperature had been rising steadily since 0545 local time. The differences in the readings at levels above 1,000 ft., on ascent and descent are doubtless in large measure due to lag in the thermometer, and the true value at any height would be approximately the mean of the ascent and descent readings at that height. The screen maximum temperature at Shaibah on this day was 108° F. and the weather was of a similar type to that during the July ascents at Hinaidi, with north-westerly winds, light to moderate by day, falling almost calm at night.

5. **Additional ascents.**—The curves in Figs. 4, 5, represent upper air temperatures obtained from 39 ascents made in Iraq from June to October (inclusive), 1922. No detailed information regarding the place at, or circumstances in which each ascent was made is available, but the object of including the diagram in this Note is to draw attention to the fact that the curves support those of Figs. 1–3 (which are for the same season of the year) in exhibiting the prominence of pronounced early-morning inversions, and the frequency of almost dry adiabatic lapse-rates up to considerable heights.

It would appear that the times given on this diagram are local times, and that the heights are uncorrected altimeter heights. The true heights would be of the order of 5 to 10 per cent greater than the altimeter heights.

A further series of observations of upper air temperature in Iraq is to be found in an article entitled " Some notes on temperature gradients in Iraq " by Flight-Lieut. E. J. D. Townesend.* These observations cover the period June 24, 1926 to June 28, 1927, and refer mostly either to the early morning or to the neighbourhood of midday.

* *London, J. R. Aeron. Soc.*, **32**, 1928, pp. 901–9.

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