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AIR MINISTRY.

METEOROLOGICAL OFFICE.

PROFESSIONAL NOTES NO. 20.

THE RELATION OF BUMPINESS

TO

LAPSE OF TEMPERATURE AT EL KHANKA, NEAR CAIRO

From July 27th to August 3rd, 1920.

Published by the Authority of the Meteorological Committee.

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THE RELATION OF BUMPINESS TO LAPSE OF TEMPERATURE AT EL KHANKA, NEAR CAIRO, FROM JULY 27TH TO AUGUST 3RD, 1920.

The following interesting description of bumpiness formed part of an official report received from Egypt. So far as is known this is the first investigation into the relation between bumpiness and the actual meteorological conditions in the upper atmosphere. Permission was therefore sought, and has been received, to publish the account as a Professional Note.

Extent and Duration of Bumps During the Summer Months.

The day can be divided into two periods :—

From 1800 to 0900 when there is no vertical motion in the air, and 0900 to 1800 when there are strong ascensional currents and generally disturbed conditions.

No definite information was available as to the maximum height to which these bumps extended, the general impression among pilots being that it varied greatly from day to day, the highest at which they had been encountered being at least 12,000 feet and the lowest at which they had been clear of them about 4,000 feet.

In order to determine, if possible, the cause of this variation from day to day, an aeroplane was fitted up with special strut thermometers and a total of 17 ascents to 10,000 feet made on seven consecutive days.

The results obtained are shewn in Figures 1 to 6, where temperature is plotted against height. The weather at the time of the observations appeared to be typical of the ordinary summer conditions.

A subsequent examination of the daily synoptic charts showed, however, that Lower Egypt was under the influence of a small secondary depression during the period in question. It is therefore considered that it would be advisable to carry out further tests to confirm the results obtained, but that in the meantime the following conclusions can be drawn :—

At sunrise the temperature gradient of the first few thousand feet is extremely small, in fact on July 30th the air was isothermal to a height of 4,000 feet.

Soon after sunrise the desert commences to heat up, and to warm the layer of air in contact with it. A point is soon reached when the air near the ground is less dense than that above it, with the result that it rises until it has cooled sufficiently by expansion to be again in equilibrium.

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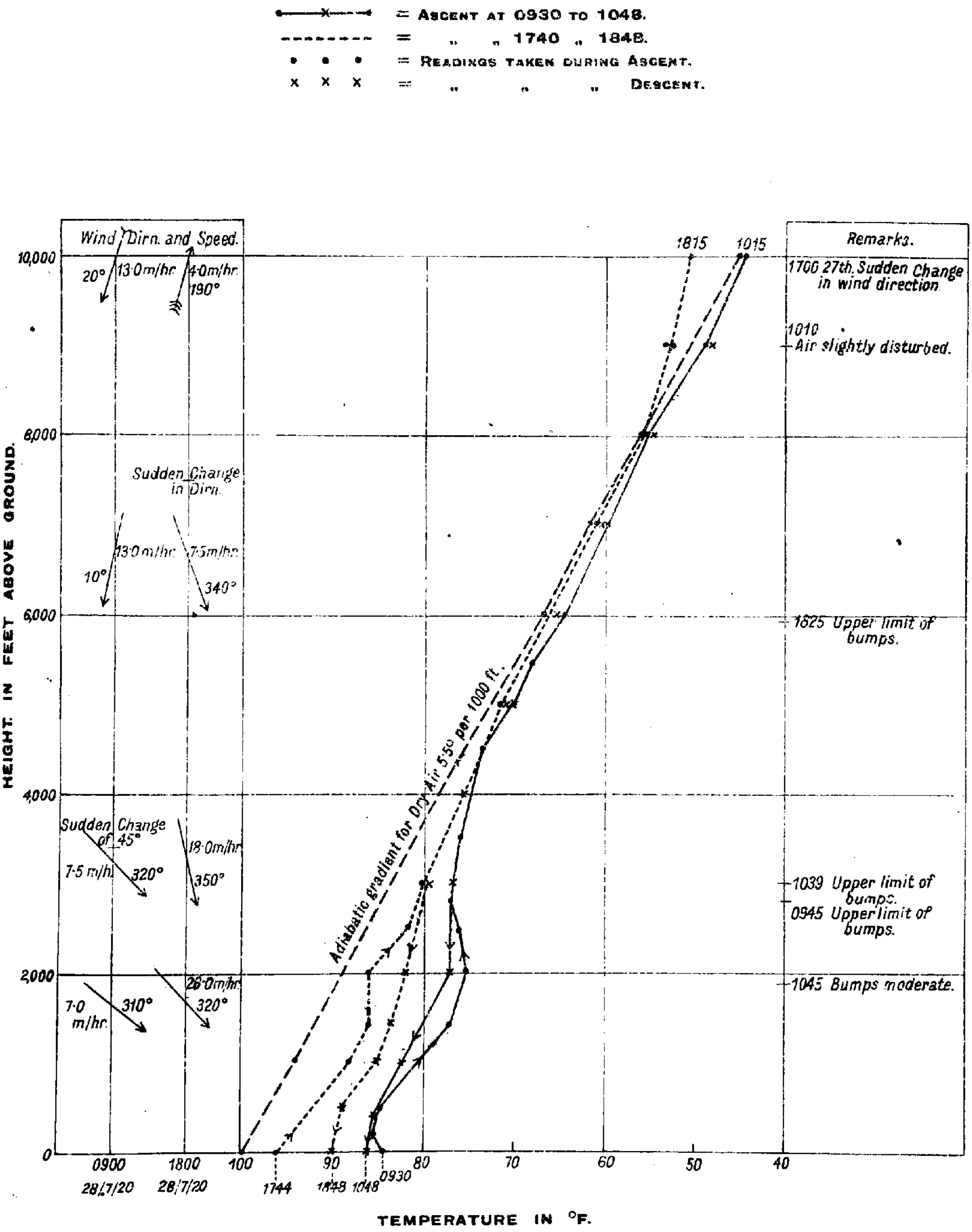
GRAPH SHOWING UPPER AIR TEMPERATURE AT HELIOPOLIS—EGYPT, 28/7/20.



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GRAPH SHOWING UPPER AIR TEMPERATURES AT HELIOPOLIS—EGYPT 29th JULY, 1920.

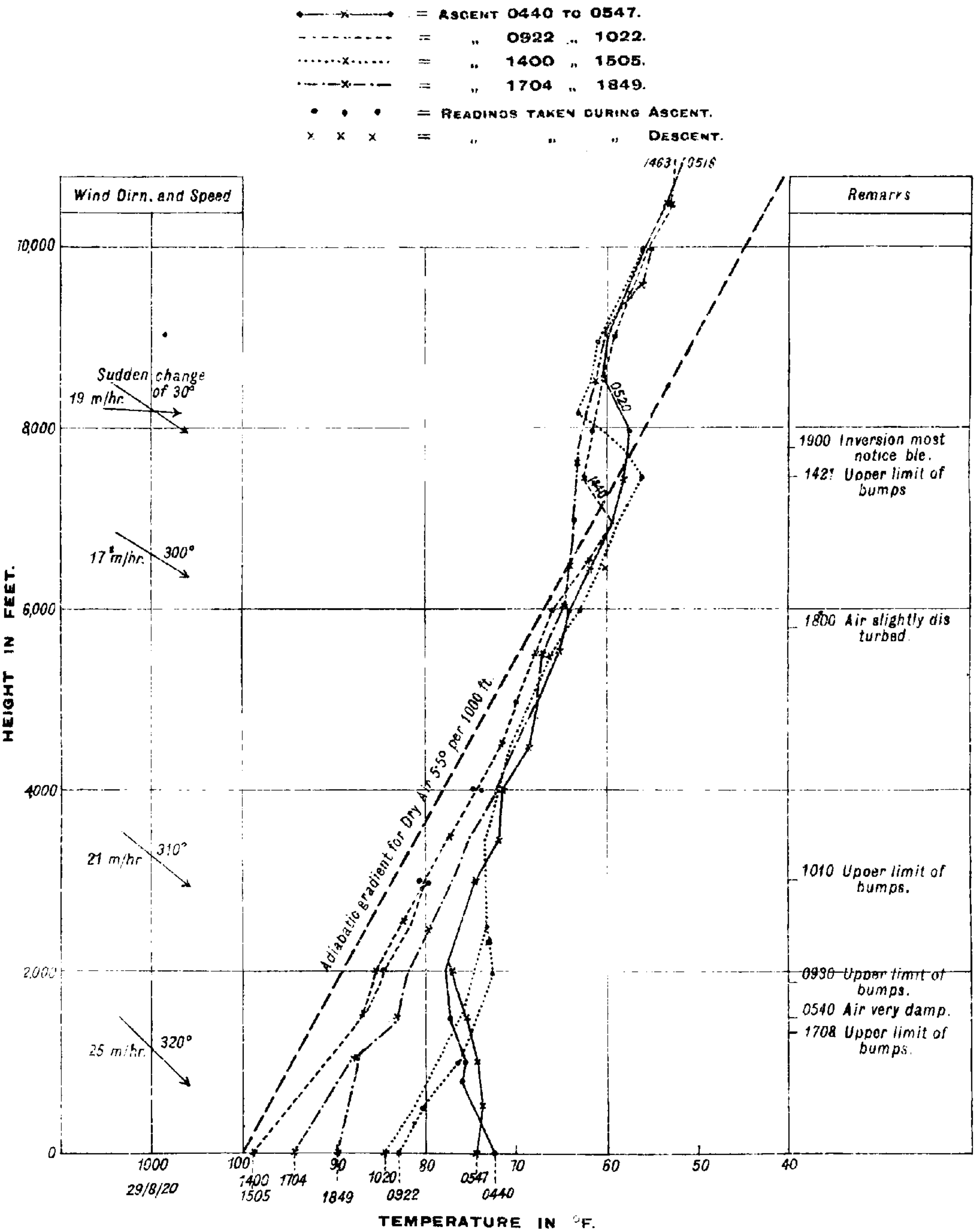
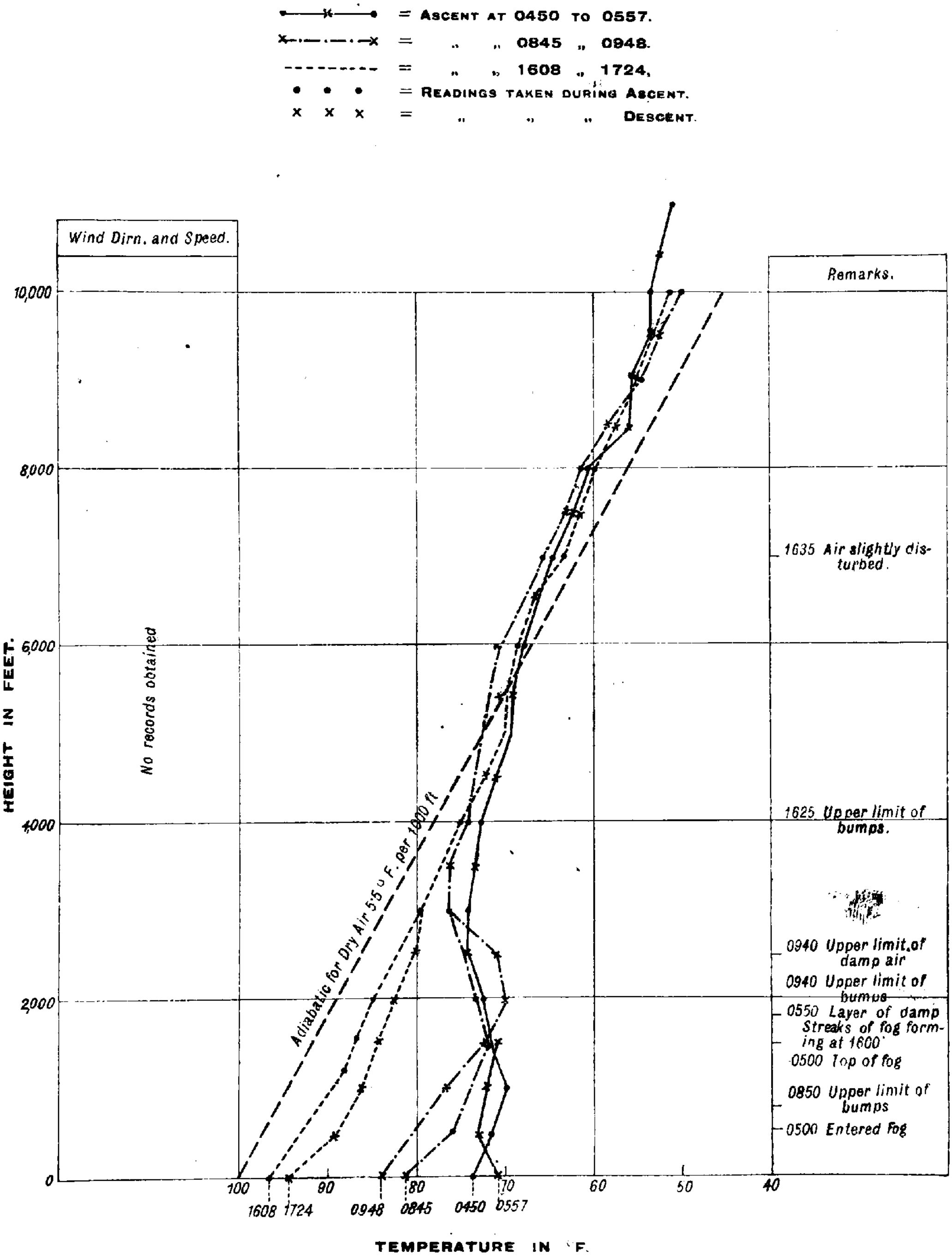


Figure 3.

GRAPH SHOWING UPPER AIR TEMPERATURES AT HELIOPOLIS—EGYPT, 30/7/20.



GRAPH SHOWING UPPER AIR TEMPERATURES AT HELIOPOLIS-EGYPT, 31/7/20.

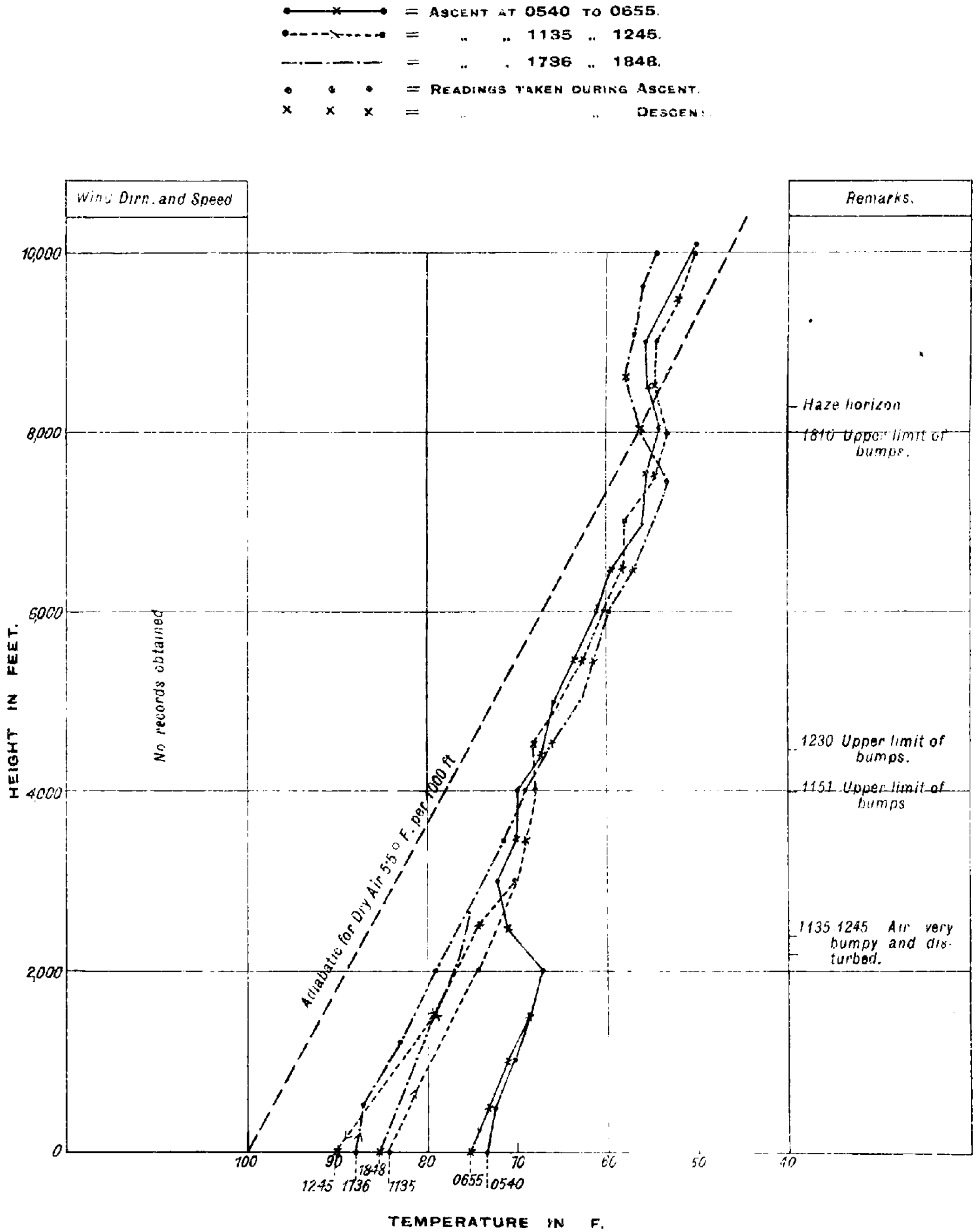


Figure 5.

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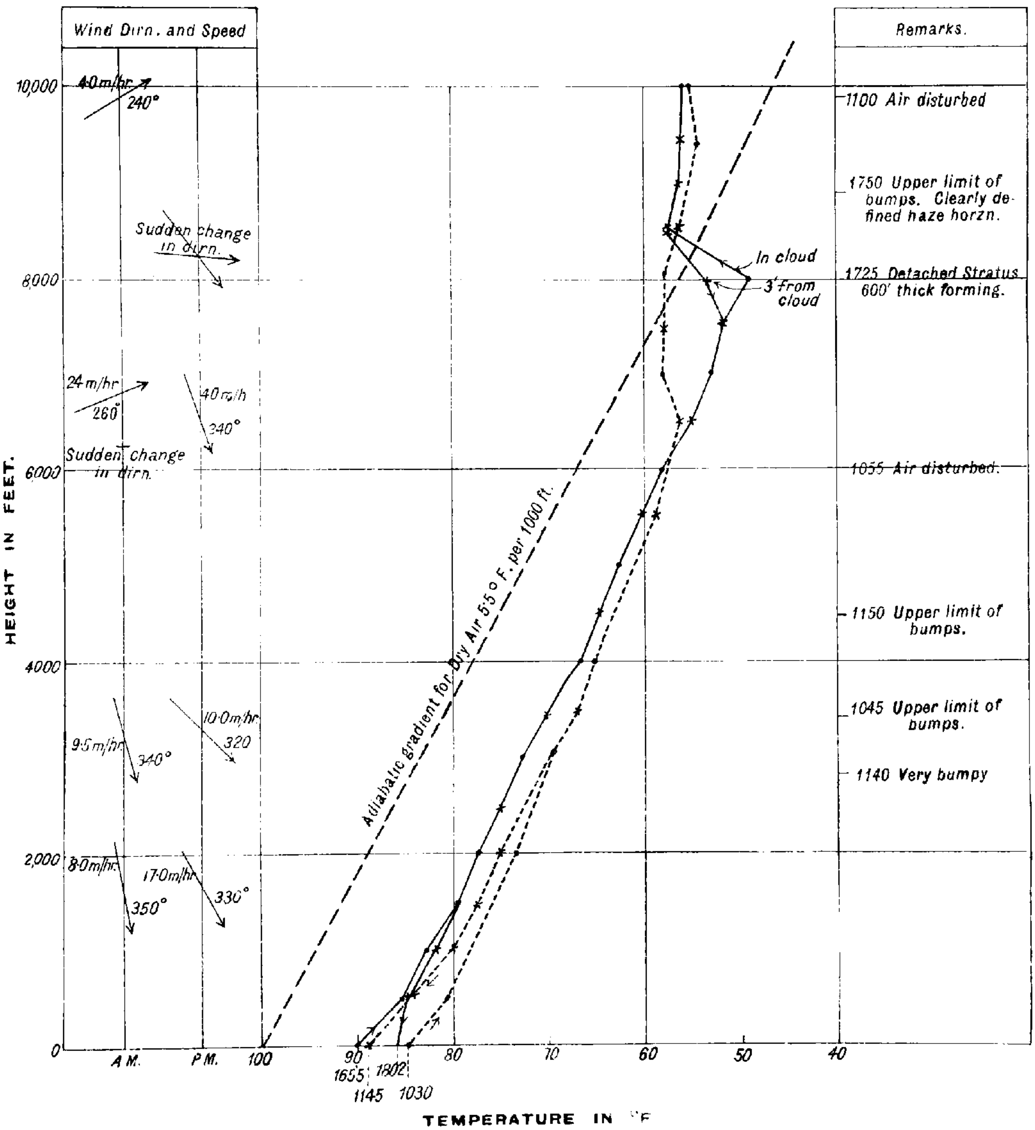
GRAPH SHOWING UPPER AIR TEMPERATURES AT HELIOPOLIS—EGYPT, 1/8/20.

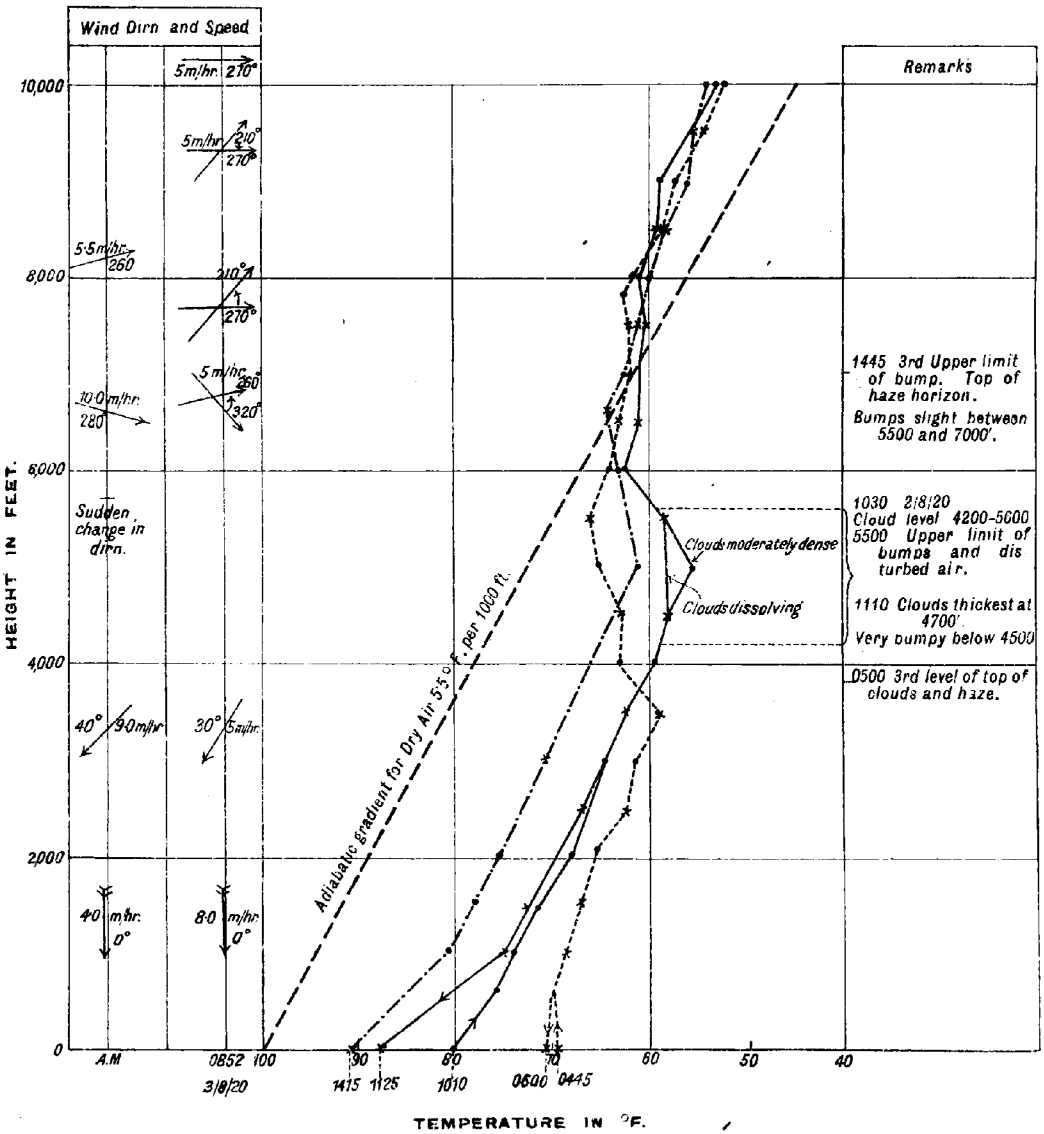
- - - - - - - - - - = ASCENT AT 1030 TO 1145.
•——×——• = " " 1655 " 1902.
• • • = READINGS TAKEN DURING ASCENT.
× × × = " " " DESCENT.



Professional Notes No. 20.

GRAPH SHOWING UPPER AIR TEMPERATURES AT HELIOPOLIS—EGYPT, 2/8/20 & 3/8/20.

- ●——×——● = Ascent at 1010 to 1125, 2/8/20.
- ●- - -×- - -● = " " 0455 " 0600, 3/8/20.
- —·—·—·— = " " 1418 " 1530, 3/8/20.
- ● ● ● = Readings taken during Ascent.
- × × × = " " " Descent.



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The temperature gradient up to this point, since the relative humidity is too low to cause condensation, becomes therefore the adiabatic for dry air.

As the surface temperature continues to increase towards the daily maximum, so will the height to which the surface air must rise to find equilibrium, and therefore the height to which the bumps are felt.

Thus on 29th the bumps had reached 2,000 feet by 0930 and 3,000 feet by 1010, and on 30th 800 feet by 0850 and 2,000 feet by 0940.

Towards the middle of the day the layer of air near the ground is receiving heat at such a rate that the gradient up to 1,000 feet frequently exceeds the adiabatic for dry air; the vertical currents are consequently of great intensity and may rise to great heights

On every occasion, however, it was found that at some height, which varied from day to day, an inversion of temperature occurred forming a limit to all vertical motion in the air.

It was quite possible to pass from very bumpy conditions to calm air by climbing 300 feet through this inversion.

Below this level, however, since the temperature gradient is adiabatic once convection has started, the bumps do not diminish greatly in intensity with height.

As a rule, therefore, nothing is to be gained by climbing to great heights, if the ship is unable to reach the level of the inversion.

This inversion of temperature was usually found at the junction between the Northerly and Westerly currents.

The junction of these two currents is not well defined, and varies greatly in height in summer. This would account for the great difference in the heights at which the bumps were felt on consecutive days.

Thus the maximum height to which the bumps extended during the hottest part of each day was found to be as follows :—

Date.	Height of bumps at about 1400	Maximum shade temperature.	Remarks on wind direction from pilot balloon ascents at Helwan.
	Ft.		
28th July ...	10,000 (estimated)	97·5°F.	Shift in wind occurred at 10,000 ft. on evening of 27th and at 7,500 ft. on evening of 28th.
29th July ...	7,500	97·5°F.	Shift in wind occurred at 8,200 ft. at 1000.
30th July ...	4,000	97·5°F	No record.
31st July ...	8,000	92·0°F.	From observation of drift of aeroplane change occurred at about 8,500 ft.
1st August ...	8,500	91·0°F.	Sudden change occurred at 8,500 ft. at 1600.
2nd August ...	5,500	86°F.	Sudden change in direction at 5,700 ft. at 1000.
3rd August ...	7,000	88°F	Sudden change in direction at 6,800 ft. at 0900.

The temperature gradient up to this point, since the relative humidity is too low to cause condensation, becomes therefore the adiabatic for dry air.

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It will be seen that the maximum shade temperature gives no indication of the height to which the bumps will extend; thus on the 30th with a temperature of 97·5°F. the bumps only extended to 4,000 feet, while on the 31st with a temperature of 92°F. they extended to 8,000 feet.

It appears, however, that if a *sudden* shift in wind direction is noticed from a pilot balloon ascent during the day, the bumps will not extend above that height.

It seems probable, however, that should the vertical currents subsequently obtain sufficient momentum to force their way through this junction, the friction caused will either damp out the sudden change in direction, or cause it to appear at a higher level.

Thus at 0900 on the 28th a sudden change in direction of 45° took place at 3,400 feet, which at 1039 was also the upper limit of the bumps. By 1800 this change in direction had risen to 7,500 feet, the temperature gradient to this height being adiabatic, showing that convection had been taking place.

It was also noticed during all ascents that there was a very clearly marked haze horizon at the point at which the inversion took place, and that this was also the upper limit of any small clouds that might have been forming.

Only in one case was any disturbance seen above this haze horizon, when at 1445 on the 3rd a body of air over the Mocattam Hills, about 500 yards across, broke through with great vertical velocity, rising to about 500 feet above the haze and then subsiding.

As a general rule, however, it appears that during the day the tops of any strati-form clouds, or the level of the haze horizon is also the upper limit of bumps.

This enables an estimate to be made of the height it will be necessary to climb in order to clear the bumps.

The ground temperature begins to fall between 1700 and 1800, the air immediately becoming stable and all bumps disappearing with great rapidity.

From this time until the morning the ground continues to cool at a fairly constant rate.

No measurements of temperature gradient were made at night, but from the early morning observations it is thought that no very large inversions of temperature are likely to occur within the first 500 feet of the ground during summer.

This is probably due to the evening breeze keeping the lower layers of air in motion, so that the morning inversion occurs at about 2,000 feet.

In winter, however, on account of the calmer nights, it is thought that the inversion may take place at a lower altitude.

In all cases ships leaving the ground in the early morning will have to be prepared for a sudden loss of lift on meeting the warmer layer of air.

Nature of Bumps.

There are three fairly distinct types of bumps which occur in the middle of the day.

1. Disturbed Air.—Air thoroughly churned up and disturbed does not, as a rule, extend more than 3,000 feet or 4,000 feet from the ground. It makes an aeroplane roll and pitch continuously, but would probably not have a great effect on a large airship.

2. Small Vertical Currents.—These are felt in an aeroplane as a sudden bump lasting from one to three seconds. They are caused by comparatively small bodies of air becoming superheated and rising quickly, and by corresponding bodies of colder air flowing down to replace them.

In many cases the bottoms of these rising currents can be detected by the presence of " dust devils " on the ground, or in the vicinity of a town by kites or hawks soaring.

The currents are not sufficiently powerful, except over hilly country, to cause a rigid to be carried up or down, but they would make her pitch badly.

Over hilly country the vertical speed is probably as much as 1,000 feet a minute, but considerably less over the cultivated land or flat desert.

3. Large Vertical Currents.—These are large bodies of air either ascending or descending. They have usually been noticed over the Nile Valley or near the edge of the cultivated land.

They can be detected when gliding, by carefully watching the aneroid, even in a heavy machine such as a D.H.9.a.

No exact figures for the rate of ascent or descent can be given, but 300 feet/min.—400 feet/min. is probably not excessive.

It is hoped to obtain more definite results from pilot balloon experiments which will be carried out shortly. These vertical currents appear to cover an area of at least $\frac{1}{2}$ to $\frac{3}{4}$ of a mile in diameter, and they would make it extremely difficult to land a rigid during the heat of the day owing to their effect on her when she reduced speed to approach the landing party.