NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS.

TECHNICAL MEMORANDUM NO. 194.

ATMOSPHERIC WAVES AND THEIR UTILIZATION IN SOARING FLIGHT.

By M. Albert Baldit.

Paper read at the Académie des Sciences, January 3, 1923, by M. J. Voille, and published in Comptes Rendus No. 2, January 8, 1923.

March, 1923.

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In soaring flight, ascending air currents are utilized and the interesting question is raised whether there are such currents which extend to any considerable distance and which can be utilized practically. If such currents exist, can they be discovered, measured, predicted? Would it be possible to draw up a weather map showing their course?

I may, first of all, point out that ordinary ascending currents, produced by abnormal heating of the lower layers, may sometimes extend to a considerable distance, for there may be a vertical motion of the heated lower layer combined with a vertical displacement of the upper, very cold layer. The air current will ascend as long as the hot air is drawn upwards. Such phenomena are not not unusual in hot weather.

Generally speaking, however, distinctly ascending currents occur in three cases:

a) Before barometric depressions;

b) In squalls and tempests;

c) In atmospheric waves, similar, in their broad lines, to waves in liquids.

If we observe that the abnormal movements of the air in squalls and tempests and, perhaps, those which occur before barometric depression all have a more or less undulatory character, we shall see that the last category comprises the greater part of the atmospheric movements bearing upon our subject.

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* A Paper read at the Academie des Sciences, January 3, 1923, by M. J. Violle, and published in Comptes Rendus No. 2, January 8, 1923, pp. 120-122.

It most frequently happens that these movements, represented be the special and very extensive class of undulatory clouds, are not of great amplitude and cannot be utilized for any practical purpose. Atmospheric waves with an amplitude of over a kilometer may, however, occur without our being aware of them, unless we happen to discover them accidentally, for we cannot perceive them, excepting by the use of special devices.

In studying the long series of soundings made during the war at Chalons-sur-Marne by the army weather bureau (soundings made with one or two theodolites and a captive balloon fitted with Rothé anemometers), I found a number of cases in which undulations of long period and great amplitude passed over the station without causing any particular visible phenomena. When the wave motion is much developed, it is easily rendered perceptible by frequent and regular soundings with the aid of a single theodolite, for the passage of the wave provokes a strong disturbance in the upward motion of the pilot balloon and this disturbance shows itself in an abnormal increase or decrease of the horizontal velocities. A comparison of these velocities with those found by the soundings taken before and after the passage of the wave and also with the velocities measured by an anemometer attached to the captive balloon enables us to calculate the vertical motion of the air with sufficient approximation.

On May 31, 1918, at Chalons-sur-Marne, the weather conditions were: clear sky all day; wind, northeast, from the ground up to an altitude of 9000 meters; average velocity of wind, 10 meters per second at all altitudes.

From a sounding taken at 3 p.m. we deduced the following vertical velocities in meters per second. Ascending velocities are marked plus (+); descending velocities, minue (-).

Altitude	Vertical velocity	Altitude	Vertical velocity
180 m	-1	1400 m	+1
240	-1	1520	+1
340	-3	1620	0
440	-2	1720	0
540	-2	1840	+1
640	-1	2000	+2
780	-1	2170	+2
860	-1	2360	+3
950	0	2520	+2
1050	0	2660	+1
1160	0	2790	+1
1280	+1	2990	0

The layer of air traversed may thus be divided into three parts: 1st, from the ground up to 1000 m the vertical current descends with a maximum velocity of 3 m/sec; 2nd, between 1000 and 3000 m there is no appreciable vertical current; 3rd, between 1800 and 3000 m an ascending movement with a maximum velocity of 3 m/sec.

By combining the vertical motion of the air with the horizontal motion of the balloon, we may reconstitute the real trajectory and we find that the pilot balloon has reached and gone beyond an atmospheric wave travelling more slowly than the balloon. The form and properties of this wave resemble those of a simple sinusoidal wave with an irrotational movement propagated in a liquid.

The propagation of this wave in an almost north to south direction is confirmed by the following fact. We had just observed the passage of this wave when we received a telephone message that

the captive balloons on the German front had been lowered to the ground and that the balloons on the French front had been subject to abnormal lifting stresses varying by over 400 kg. The aeronautical units concerned asked us for information as to the nature of this phenomenon. We were thus able to verify the propagation of the undulatory movement and to fix the distance of propagation at a minimum of at least 80 km. It is almost certain, however, that the real distance was much greater. We may add that there was nothing in the state of the sky to indicate the passage of this wave. The sky was almost clear and cloudless, except for a few cirro-cumulus clouds.

It is evident that these anomalies were due to the presence of an anticyclone or high-pressure area over the British Isles. This often occurs between the seasons, especially in May and September. Sometimes it is due to an advance of isotherms from the northern regions and constitutes a situation which is interesting in more than one respect. It may be that such undulatory movements are actually produced by the advance of a layer of cold air from high latitudes which causes a whole series of phenomena, such as tempests or squalls, of which the undulatory movement considered here is merely a particular instance. In some cases, this wave movement has some analogy with the phenomenon of the solitary wave in hydrodynamics.

For investigation purposes, captive balloons fitted with barographs and recording anemometers constitute a means of practical study. At the same time, several balloons at different levels

along two perpendicular lines enable us to determine the characteristic values of the wave motion.

Leaving out of account the rarity and irregularity of these phenomena, such ascending movements might be utilized in soaring flight by keeping within the region of the ascending currents. In this case, the horizontal displacement of the glider will be that of the wave.

Translated by Paris Office, N.A.C.A.