The average life of a center was found to be only about 3 months and a certain number appeared suddenly one month and could not be traced the next.

The movement as above indicated conforms rather closely with that of anticyclones that cross the north American Continent.

The paths of centers of deficit were found to be less regular than those of excess, North America being almost free from centers of deficit amounting to the limit set in the study. This agrees with the experience of the present writer, who is of opinion, that the explanation is to be found in the dispersion of cyclones which obtains in North America. Mr. Brooks notes that a number of centers originate in the neighborhood of Newfoundland and move in an easterly direction. This also is in conformity with experience on this side of the Atlantic; I may offer the suggestion, however, that the explanation of the origin in the location named, may be found in the very marked increase in energy of many cyclones that pass from the continent to the ocean over the Canadian Maritime Provinces. The pronounced contrast in air and water temperatures encountered in this region may be a factor in producing the sudden increase in energy and the associated low levels of pressure in cyclones that traverse that region.

Finally the author discusses the use of the paths of excess and deficit in their relation to forecasting the probable deviation from the normal of the monthly pressure one month in advance. He says:

The study of the tracks of centers of excess and centers of deficit suggests a possible method of forecasting the deviation of pressure from normal for one month from a consideration of the distribution during the preceding month by methods similar to those employed in daily forecasting. Since the life history of a monthly "center" does not occupy anything like so many months as there are days in the life history of an ordinary anticyclone or depression, and the monthly tracks, especially of centers of deficit, are even less regular than the day to day tracks of depressions, the process evidently requires a gread deal of care.

In order to estimate the chances of success in a forecast based only on the movements of centers of excess or deficit, Table 3 has been prepared, showing for each season for a number of areas the numbers of centers which (a) originated suddenly in the area or (b) moved into the area from some other region.

A center which moves into any region from outside, so long as it follows the normal track, would give a generally successful forecast; a center which appears in that region with no previous sign of its existence would give a failure. Hence as a preliminary test of the possibilities of forecasts deduced from the tracks, unaided by any other consideration, we may take (b) as successes and (a) as failures. This gives us the following frequency of successes and failures in Europe (Table 4):

TABLE 4.—*Probable result of monthly forecasts for Europe*

	Successes	Failures
December to February	6	5
March to May	15	1
June to August	5	4
September to November	5	2

From this table we should expect a reasonable amount of success in spring but doubtful results during other seasons. Evidently some improvement in the methods is required before long-range forecasting from the movements of centers of pressure deviation can promise success. Forecasts based on the movements of centers of excess in general offer greater chances of success than those based on the movements of centers of deficit.

PART 2 OF GREGG'S AEROLOGICAL SURVEY OF THE UNITED STATES

RESULTS OF OBSERVATIONS BY MEANS OF PILOT BALLOONS

By BURTON M. VARNEY

Like Part 1 of the Survey, Part 2 has been issued as a SUPPLEMENT to the MONTHLY WEATHER REVIEW, No. 26,[1] Part 1 having been SUPPLEMENT No. 20, dealing with "Results of Observations by Means of Kites."

The present SUPPLEMENT deals necessarily with free-air conditions over the country east of the Rockies only, sufficient data not having as yet been accumulated from the remainder. The main purpose of the paper being to supply data in a form that will be useful to aviation in such matters as the planning of flight schedules, Mr. Gregg presents extensive tables showing frequencies of different wind directions and speeds at flying levels, in addition to the abundant data now available for altitudes above those at which flying is commonly done. The information is classified under nine regional sections, an excellent arrangement which lends itself to the study of that portion of the country in which one may be interested. The free use of graphs and charts makes it possible for those less concerned with statistical details to form a satisfactory picture of the average free-air conditions over the United States.

Very briefly summarizing the salient points of the work, we have the following:

Average wind velocities in the free air.—At the surface these are highest as a rule in spring, while those of autumn are closely like the average annual velocities. For the country as a whole wind velocities approximately double from the surface to 500 m., which is about the level at which the gradient wind is reached. The increase is often much greater, especially at night and in winter, and it is least in the daytime and in summer. In the next thousand meters, little change of velocity, great irregularity, and often a decrease of velocity is the rule. Thence to the base of the stratosphere there is a gradual increase, except at southern stations in summer, where frequently there is almost no wind at any height within the range of observations.

Diurnal variation in wind velocities.—The author rightly takes pains to emphasize the fact of the reversal of phase which takes place between the ground and a short distance above it. The surface layer of air, characterized by the well-known afternoon maximum and early morning minimum of wind velocity, is exceedingly thin, only 50 to 100 meters, and above that the diurnal change of velocity is exactly reversed. At the surface the diurnal range is but 1 to 2 m. p. s.; at the level of the gradient wind it averages 2 to 4 m. p. s., but above that critical level it decreases to practical extinction at 1,500 to 2,000 meters.

Frequency of free-air winds of different velocities.—Experience has shown that it is the winds of 10 m. p. s. or more which must be reckoned with in planning workable flight schedules. It is therefore of interest to note that—

At the surface the frequency of winds of 10 m. p. s. or more is very small, averaging from 5 to 10 per cent, with a maximum as a rule in spring and winter. There is no very marked variation in different parts of the country.

A decided increase occurs immediately above the surface * * * At "ordinary flying levels"—i. e., 500 to 1,000 meters—winds

[1] This SUPPLEMENT is on sale by the Superintendent of Documents at 20 cents per copy.

of 10 m. p. s. or more occur from 20 to 25 per cent of the time in the Southern States and 40 to 45 in the Northern * * *. There is a fairly large seasonal range, from about 20 in summer to 45 in winter, the seasonal values as well as the annual being highest in the Northern States. Velocities of 20 m. p. s. or more occur in general at these levels less than 5 per cent of the time.

At greater heights the seasonal and latitudinal variations increase very decidedly, as well as the frequency of the higher velocities themselves. For example, at 4 and 6 kilometers, winds of 10 m. p. s. or more occur in the Northern States 45 per cent of the time in summer, 85 in winter * * *; in the Southern States except Florida the values are 35, 70 * * *, respectively.

Relation of velocities in the free air to directions at the surface.—After presenting the facts with regard to changes of wind direction with altitude (these are summarized later) it is pointed out that—

The different directions at the surface are associated with characteristic changes in velocity with altitude quite as definitely as with changes in direction * * *.

From the surface to about 500 meters there is a large increase with all directions; it is greatest with south to southwest winds and least with north-northeast to east winds.

At higher levels lowest velocities are still found above easterly surface winds, particularly east-northeast and east; highest velocities, however, occur above west to northwest winds at 2 kilometers and higher instead of above south to southwest * * *.

The seasonal and latitudinal variation, small at the surface, increases decidedly with altitude, the highest velocities and the nearest approach to a westerly direction occurring when and where the poleward temperature gradient, and therefore pressure gradient also, is strongest.

Frequency of free-air winds from different directions.—For the year as a whole there is in general at the surface comparatively little variation, although westerly winds are somewhat more frequent than are easterly, except during summer in Florida and southern Texas. There is also in all sections a seasonal swing from a slight preponderance of south component winds in summer to a similar preponderance of north component winds in winter, with the single exception of the Plains States, in which southerly winds are more frequent than northerly throughout the year. For the most part calms are observed only about 1 to 2 per cent of the time * * *.

There is in most parts of the country a pronounced swing above the surface to westerly directions as those of greatest frequency. This tendency is strongest in winter and increases with altitude in all seasons. For example, in the Northern States west component winds prevail at 4 kilometers 90 to 95 per cent of the time in winter, about 80 in summer, and 85 to 90 for the year as a whole. In the Southern States a west component is still strongly predominant in winter, but much less pronounced in summer. In the extreme south—i. e., Florida and southern Texas—an east component is more frequent than a west at all levels in summer. Generally speaking, a south component in the winds at upper levels occurs more frequently than a north component in the Southern States, whereas the opposite condition is found in the Northern States.

The turning of the winds aloft.—As a result of the thousands of observations which have been collected, it is now possible to set forth the extent to which free-air winds at various levels turn clockwise or counterclockwise from the direction of the wind at the earth's surface in detail commensurate with the importance of the subject to the aviator. Wind direction at the surface is intimately connected with both direction and velocity aloft. The degree of consistency of these relationships is considerable. From the extensive tables presented one may easily take out the facts relative to turning of the winds up to 6 kilometers for each of 16 surface directions and for calms by seasons and for the year. Similarity in these relations over large areas fortunately makes it possible to treat them under groups for Northern States and Southern States instead of the nine groups used in the rest of the work. It is impracticable here to quote the many summarizing statements made by the author, concise as they are, with regard to the frequencies and the amounts of the two classes of turning aloft. We may, however, quote the summary of summaries:

Taking a broad, general survey of the data presented * * * we find that those surface directions from which there is the largest deviation with altitude are in general also those which have the largest percentage frequency of turning, either to the right or to the left. Thus, considering annual values, southerly winds show at 4 kilometers a large deviation to the right and a very high frequency of clockwise turning; northerly winds, a large, though less decided, deviation to the left and a fairly high frequency of counterclockwise turning. Near the surface there is a similar consistency. In other words, to quote Doctor Meisinger, "The greatest average deviation occurs with the greatest reliability of turning; the least deviation occurs with the least reliability of turning."

Free-air resultant winds.—This final section of the paper is in some respects the most interesting of all. Here resultant velocities and directions for the country east of the Rockies are given on clear little maps, one series of which, particularly important because it deals with the usual flying levels, shows the facts for the surface, 500 m. and 1,000 m. for the four seasons and for the year. From these maps can be clearly recognized the west component in the winds at all seasons at all three levels in the Northern States, and for the same region a marked increase in resultant speed aloft as the westerly component becomes stronger, the winter season showing this most strikingly. In the highest level (1,000 m.) the variations of resultant speed with season and with latitude are most pronounced.

Of perhaps greater interest from the theoretical point of view is the series of maps portraying the summer, winter, and annual isobars and resultant wind directions and speeds at 500, 1,000, 2,000 and 4,000 m. above sea level. Among the more striking features of this series are the following:

In summer over the region between the Mississippi and the Rockies, the persistence of south-component winds up to at least 2,000 meters and the decided change to westerly and northwesterly up to 4,000 meters over the northern part of that region.

In summer over the eastern United States (except Florida), the rapid weakening of the south component with increasing altitude and latitude as the resultant wind swings north of west, this being already accomplished by the time 2,000 m. is reached.

In winter over the entire region (except Florida), the drift from westerly directions at all levels, with north component increasingly predominant the higher the latitude and altitude.

Florida stands in a class by itself, with its resultant southeasterly winds at all levels in summer, a tendency which in winter, however, persists through the lower levels only; between 500 and 1,000 m. in that season a shift to southwesterly has already taken place.

The supplement closes with a brief discussion of the relations between the facts set forth in this section and the seasonal shift of the terrestrial pressure system, with special reference to the migration of the horse-latitude belt of high pressure and its southward displacement aloft relative to its position at the surface. The results confirm theoretical conclusions reached by Shaw and others.