

METEOROLOGICAL ASPECTS OF THE INTERNATIONAL BALLOON RACE OF 1920.

By C. G. ANDRUS, OBSERVER.

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SYNOPSIS.

Successful free-ballooning depends on meteorology, and especially on the study of free-air conditions. The International Balloon Race from Birmingham, Ala., October 23, 1920, was the first occasion of its kind in this country where meteorological upper air and surface reports were made available to the pilots and where assistance was provided to guide them in the interpretation and use of the telegraphic reports which the Weather Bureau supplied from the eastern and central United States. It is clear that more extensive free-air observations are necessary. Advices and up-to-the-minute data were of unusual value in this race, owing to the complex atmospheric conditions, which demanded a cautious nicety of control by the aeronauts. Conditions were not unfavorable at the surface, and were nearly normal in the free air. An analysis of the cyclonic conditions has been made in terms of the Bjerknes hypothesis of stream lines, and the application of this method explains the peculiarities encountered by the balloonists.

Explicit forecasts were made for the race. These were right, and the winning teams were those who followed closely the course mapped

among the most famous; the men attracted to partake in them are distinguished for daring and ability. In the last four years the study of upper-air conditions has taken such strides that to-day, without the intelligent use of the data thereby acquired, no pilot, however daring, lucky or enduring, can hope to remain in the front rank. He must take the guiding hand of meteorology for success and safety. The study of aerology will aid and protect him; it is an applied science.

The International Balloon Race for the Gordon-Bennett trophy was intended to be an annual event, but the war in Europe prevented the race since 1913. In that year, the winner was Mr. R. H. Upson, an American entry, thereby bringing the succeeding race to the United States in 1920. In this contest which was scheduled to start from Birmingham, Ala., October 23,

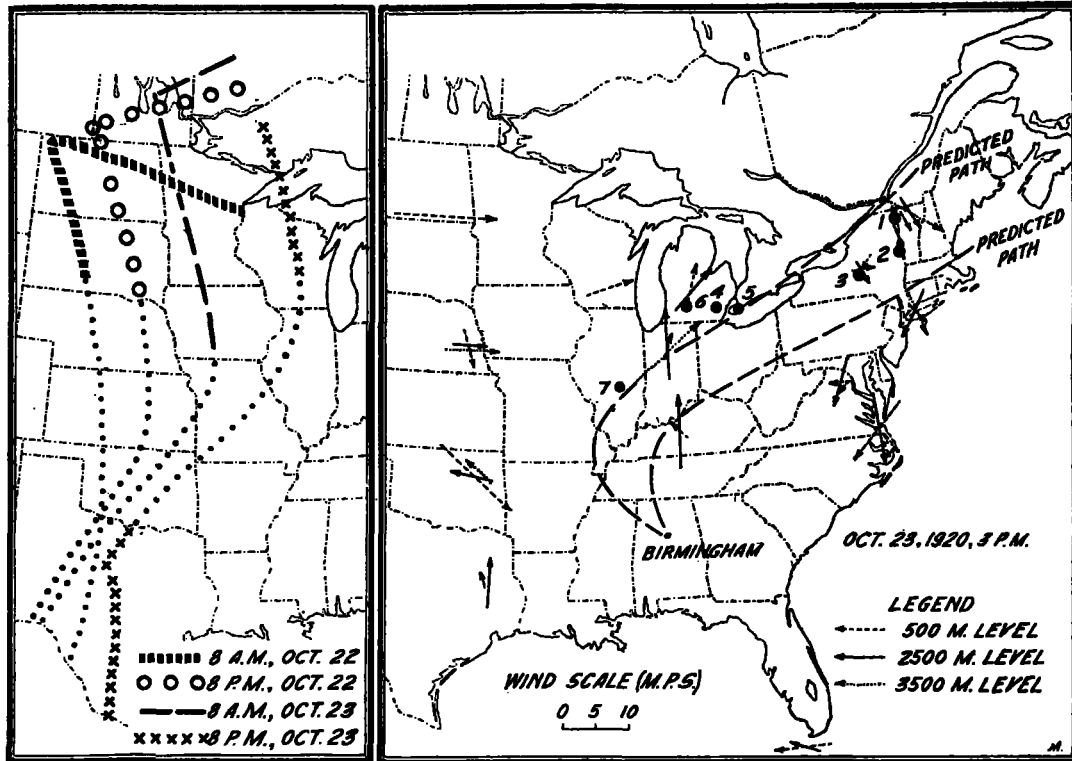


FIG. 1.—Positions of steering and squall-lines.

FIG. 2.—Predicted paths of balloons (see foot note 1), and upper winds Oct. 23, 1920, at 3 p. m. 75th mer. time.

out by the Weather Bureau. Not merely the horizontal currents of the atmosphere but also the thermal activity and the radiation, condensation and equilibrium values must be given due consideration in the modern aerial weather forecasts for free ballooning. Likewise, efficiency on the part of the aeronauts demands that they make the greatest use and allowance for the weather factor. Aerial transport of every character will do well to study this weather factor in order to promote greater efficiency.

Meteorology is the key to successful free-ballooning. To meteorology and its newest branch, aerology, the pilots of free-balloons must turn to solve the problems of the location and condition of their courses in the free air; the racing balloonist seeks the factors of greatest speed and longest fetch of the winds of the lower levels; the balloonist trying for a destination seeks the factors of direction; the reconnaissance balloonist seeks the elements of quiet and safety. Of the great sporting events of the world the International Balloon Races are

there were seven contestants; one Belgian, one French two Italian and three United States. As usual the race was to start regardless of weather conditions, and was a contest for the greatest straightaway distance from Birmingham to the landing place of the balloon. Landings at sea requiring assistance to land disqualify. The race is not an endurance contest, although it often happens that the old adage, "while you're in the air you're in the race" has a true ring and the longest run is often made by the men longest aloft. In the 1920 race the airmen descended in the vicinity of the Great Lakes (fig. 2), the winner, Lieut. De Muyter of Belgium, landing at North Hero Island, Vt., 1,100 miles from Birmingham.<sup>1</sup>

<sup>1</sup> Numbers beside landing points, in figure 2, indicate the following entries: 1. De Muyter, Belgium; 2. Honeywell, United States; 3. Valle, Italy; 4. Upson, United States; 5. Medori, Italy; 6. Thompson, United States; 7. Hirschauer, France.

It is worthy of note that Lieut. De Muyter is an enthusiastic student of aerology, and for a time was actively engaged in meteorological work in his country. It is notable also that the 1920 event has the distinction of being the first International Race where it was possible to provide a comprehensive survey of weather conditions aloft over the territory to be traversed by the aeronauts. This survey was provided by telegraphic reports of the upper air soundings at pilot-balloon stations of the Weather Bureau, the Army, and the Navy, in the eastern half of the country. This area was thus generally covered by reliable data, but large sections remained where no information could be had, owing to lack of stations equipped for the necessary observations. The need for a closer network of such stations is plain, when it is stated that the Mississippi River flows through the middle of a 400-mile-wide strip of territory from Iowa to the Gulf of Mexico devoid of a station equipped to furnish soundings of the upper air. On this particular occasion the balloons headed for this section when they left Birmingham and voyaged over it during the first 20 hours aloft.

Since this is the first race of a series to be furnished with upper-air as well as surface reports, these reports and the results of the race have been examined with a view to discovering the relationship between the two, and the dependence of the balloonist upon the whims of weather and wind.

Figure 2 shows the landing positions of the several balloons and the predicted path for the successful runs. This prediction was given the pilots and the press at the start of the race; its verification testifies to the reliability and the extent of the Weather Bureau's results in upper-air research. The balloonists took off from Birmingham just before sunset of the 23d, and floated north-northwestward the first night at elevations averaging 1 kilometer. During the following day they made only moderate speed, mostly toward the north, at various elevations. The following night was the crux: at that time those balloonists who had made the least distance westward had entered the freshening winds of the southeast quadrant of a low-pressure area and rapidly spread away from those pilots who had not gained this advantage. The flying during the last 20 hours was for the most part made in clouds and occasionally in rain, these conditions finally requiring the balloonists to descend. The results of the race are conclusive proof that only with the most effective and thorough aerological aid is it possible to win a modern race, even though physical endurance, technically perfect manipulation of the balloon, and a complete equipment may be provided by the pilot. Disregard or misinterpretation of the weather factor meant failure in this race and endurance was a negligible factor, as shown by the fact that the winner was also one of the first to land. Careful and comprehensive use of meteorological material was the factor that won the race.

During the two days the balloonists were flying, a barometric depression of decreasing depth moved from Manitoba northeastward to and beyond Hudson Bay; it carried an ill-defined pressure trough, at first stretching southward from the low's center but later lagging at its lower end, hence extending more toward the southwest. A narrow belt of foul weather, mostly of a showery and squally type, clung to the trough and its immediate rear, and cloudy conditions spread ahead over the greater portion of the East. A fine-weather, cool, high remained stationed along the Atlantic coast, but was undergoing a slow disintegration which allowed the invasion of

unsettled conditions on its northwestern quadrant during the second day of the race. This distribution of pressure gave assurance of the northward and then eastward drift of the balloons: An assurance that was greeted with great relief by the pilots since it precluded the hazards of a run over the Gulf of Mexico or the southern North Atlantic Ocean. Henceforth the trough of low pressure and the conditions attending it were the chief concerns of the pilots.

Generally, the upper air strata at high altitudes were moving at slow speed from the SW. and at lower altitudes more from the SE., yet of only moderate speed. The strong westerly component which often enters the currents at all elevations during the cold season had not yet appeared at even the highest levels sounded by pilot balloons, this being in close agreement with the precept<sup>2</sup> that the greater the north-south gradient of the surface isotherms the stronger the free-air winds at considerable heights. This condition of small west component persisted throughout the race.

Predicting the life history of a low-pressure trough from surface conditions alone is a very perplexing problem. The most serious failures in forecasting often result from misjudging the character and position of secondary centers of low pressure which often develop in troughs and assume sudden and marked severity. For the meteorologist as well as the balloonist it seems pertinent to make an analysis of the low-pressure trough conditions in the central States during the race. This study has been made in terms of the surface observations of the meteorological elements and the upper-air observations of wind flow, both of which are now regularly available to aeronauts in this country.

The Bjerknes hypothesis<sup>3</sup> of the structure of cyclones and squall lines has much to commend it for use in the present study, since the basic element considered in his solution of the structure of the moving cyclone is the same one which chiefly concerns the balloonist, namely, the wind. This element furnishes two configurations of flow at the surface and lowest levels of the atmosphere under the control of cyclonic formations: One configuration, the steering line, extending outward in front of the circulatory center of the cyclone, the other extending outward on the right-hand side of the center at an angle of from 60° to 120° from the steering line. This is called the squall line. At the surface, both of these lines are located along the convergence of wind streams, with contrasted heat and moisture content and define the surface limits of the warm and cold sides of the storm. Along either of these lines the balloonist finds rough navigating, discontinuous winds and precipitation. The upper-air conditions in the vicinity of these lines are important in their characteristics and in their indications concerning the storm's movement.

The positions of the steering and squall lines of the low which passed along the northern border during the race are shown in figures 1 and 3. It will be observed that the flights of the balloons came to a finish near the squall-line position; furthermore, it is clear that the first three were able to make such "eastings" during the first leg of the run that they kept ahead of the approaching squall-line as well as availed themselves of the fast-moving SW. to W. winds which are located in the southeast quadrant of all low-pressure areas, at low elevations.

Referring to the upper-air circulation over the general area covered by the balloonists, we find the following

<sup>2</sup> Gregg, W. R.: Note on high free-air wind velocities observed Dec. 16 and 17, 1910. *MO. WEATHER REV.*, Dec., 1910, 47: 853-854.

<sup>3</sup> Bjerknes, J.: The structure of moving cyclones, and Bjerknes, V.: Weather forecasting. *MO. WEATHER REV.*, Feb., 1919, 47: 90-99.

conditions prevailing on the evening of the 23d: (1) A well-defined circular wind system central over Pennsylvania and constant up to the 4-kilometer altitude, representative of the free-air circulation in a well-marked HIGH, especially of the type whose control of surface conditions wipes out the temperature gradients between the north and the south; (2) the absence of the typical squall-line characteristics of shelving and counterflow of the converging windstreams; (3) the low velocities above the 3-kilometer level, indicative of slight and varying west component in the wind flow at those levels; and the presence above the 2,500-meter level of a south component. During the next two days the anticyclonic whirl over the Atlantic coast moved off to sea, while in the upper air over the sector marked out between the steering and squall lines of the LOW the winds were typical of that location, composed of moderate to fresh velocities from the SW. or WSW. as far west as the situation of the forerunner of the squall line; in this case about 100 miles to the front of the surface squall line.

The nonexistence of a strong west component in the upper air was a disadvantage to the balloonists, inasmuch as it furnished no relief from the fickle winds of the lower altitudes just ahead of the squall line. One balloonist rose to a height of 6 kilometers seeking the oft-mentioned "prevailing westerlies" of the upper air. Incidentally, he was in the midst of a snowstorm from the 3-kilometer up to the 6-kilometer level—an indication of the location of the squall line aloft, since this occurred in eastern Michigan near noon of the 25th and considerably in the rear of the surface squall line at that time. It confirms the belief that the squall front reaches the ground layers first and the upper layers progressively later, along the upper side of the flat wedge of cold air.

The best distances should be found to have been made by those pilots who were able to stay the longest time in the outer currents of the HIGH during the first part of the race, and who were then able to pass from this anticyclonic control into the best winds of the cyclonic, viz, the WSW. winds of that part of the LOW's warm sector where those winds would be available the longest possible time before they would draw the airmen into the precipitation area or squall line of the LOW. This was the course followed by the winners. The others found themselves drawn onto the squall line far to the rear of the cyclone and, once within the control of this line, they were forced down by precipitation or the need of escaping the possibly violent turnover of the winds at that line. The squall line retains its reputation as a wave of air practically impossible to navigate at any level of the atmosphere within reach of the free-balloonist.

It may rightly be inquired whether it was possible to predict the conditions encountered and what was the best procedure in selecting the most favorable level to maintain at various stages of the run. The forecasts and advisory statements were verified closely, the best distances being made along the routes indicated by the forecasts, and conditions there agreed with those predicted. It was also possible to indicate to the pilots what many likely conditions would mean if encountered. It should be remembered that free-ballooning requires forecasts, which, unlike the usual weather forecasts, are designed to cover a moving area for the long period of at least 48 hours, in a specific statement devoid of mere probabilities or reservations. Forecasting for free-balloon runs is peculiarly exacting, since the balloonist must drift with and not across the wind to a possible position more favorable. The en-

tire prediction is therefore a series of forecasts successively dependent upon the successful fulfillment of each one previous. Such forecasts may have occasional alternative statements definitely covering two distinct weather processes either of which will be distinguishable for the pilot upon his flight. It must be taken into account that the pilot is unable to escape the warming and consequent expansion and increased lift of his gas bag in sunshine, and the cooling and consequent contraction and decreased lift in the shade. Air temperature and precipitation are also important considerations, since they, too, affect the weight and buoyancy of the balloon. What is true of the value of forecasts to free-balloons is largely true of their value to propelled airships, and likewise to airplanes. Free-balloon forecasts should cover the wind drifts at each flying level, the cloudiness, the sunshine, the precipitation (both amount and type of generation), the electrical activity, and the temperature.

It was impressed on the pilots in the present race by written forecasts and verbal consultation that the best procedure was to get as far north and east as possible the first 24 hours. Westward motion was advised against, and climbing advocated, if necessary, to keep away from the converging winds of the squall line, and to bring the balloons into the W. or SW. winds on the southeast side of the LOW on the second night of the race. The calm region near the forerunner of the squall line was described as a warning of the turnover squall to follow, and it was stated that the only possible relief, and then but a doubtful one, was to rise and endeavor to find a somewhat stronger westerly current at a higher level. It was advised, in the face of the usual practice and the generally sound policy of balloon pilots, that an expenditure of considerable ballast the first night would be true economy, since the upper winds at that time were directed more to the east than the lower, consequently peculiarly adapted to this race.

It is a natural conclusion that effective assistance can be rendered by an efficient consulting meteorologist to any aerial event of importance. He should be called upon not only to select the favorable flying levels in the next few hours, but also to analyze and describe the meteorological series of events which the flyer will encounter. He should also indicate to the flyer what changes will be likely in the structure of the atmosphere, and what will be the effect of deviation of the actual events encountered from those forecast, with special attention to the signs of approaching bad weather, applicable in the case. The forecasts should be intended to advise concerning the best flying procedure rather than merely warn concerning the worst.

The attitude of aeronauts toward guidance by a trained aerologist is not always one of amenability. Aviators, in balloons and in planes, are often of a type characteristically daring and aggressive; they enjoy to a degree the obstacles presented by difficult weather. Some airmen instinctively feel that meteorological advice deprives flying of some of its sporting chances and of its gameness, and consistently will not avail themselves of the assistance of the aerologist. But the really big aerial programs, transoceanic flights, and long-distance contests are carried out under the direction of capable advisers in aerology, and the time will shortly arrive when flights without aerological assistance will be relegated to the dubious sphere of stunt flying. The more efficiency is aimed at, in the operation of aerial transport, the more exacting will be the demand for upper air reports and predictions.