surfaces, it has a clean, fresh feel. Then again, in this area of northerly winds, as a rule, how clear the sky is!

In the summer this same condition is present, only, of course, greatly modified and masked by the great power of the sun. Here we have a clear sky and radiation from the sun supreme with every chance for high temperature, but the northerly winds keep the temperature down and but little rise occurs. Under the same conditions and southerly winds a "scorcher" would have been the result. * * *

As a rule * * * as long as the HIGH keeps its form and activity, there is a stationary or falling temperature within this area.—*Douglas F. Manning.*

DISCUSSION.

The "formation" of a HIGH and a big fall in temperature are coincident phenomena, since it is the arrival of an appreciable layer of cold dense air ousting warmer and therefore less dense air that makes the pressure rise so. When a HIGH appears without any change in temperature at the surface having occurred, a considerable body of cold air *must* have arrived aloft. For example, a fall of 5° C. at 500 meters altitude, 10° at 1,000 meters, and 10° at 1,500 meters would increase the density of this layer of air sufficiently to raise the surface pressure about 5 millibars (0.15 inch). Such a fall in temperature aloft would be possible without effect on the surface temperature if at first, as is commonly the case before cold waves in winter, the temperatures up to 1,500 meters were no lower than at the surface. Conversely, at the end of the cold wind, when a warm one sets in aloft, there may be no surface wind or other visible reason for a change, but the pressure will fall, and the air temperature at the surface may rise by the receipt of heat radiated from the warmer wind not far aloft.

Let us consider how the surface air temperature can fall so much faster than radiation, and transportation along the surface, could reduce it. After the temperature at 1 kilometer above the surface has fallen to 10° C. colder than that at the surface any further fall will be accompanied by a convectional interchange and an equal fall in temperature at the surface, the upper wind descending in a sudden gusts and routing upward the masses of warmer air near the surface. The temperature of the wind when it reaches the surface will be about 10° C. higher than when it started down from 1 kilometer. Nevertheless, its temperature will be lower than that which prevailed immediately before the gust arrived from aloft; otherwise it would not have come down. If the surface wind is 15 miles an hour that at 1 kilometer is likely to be 30 miles an hour, although its component from the direction of the surface wind may not be more than 25 miles an hour. This being the case, if the surface wind would in the course of the night lower the temperature at a place 5° C. merely by transportation along the surface, the fall to be expected would be nearly 5° more because of the wind aloft. Stronger winds and radiation from a snow surface into a clear sky at night would make extreme falls in temperature. Therefore, in forecasting the temperature change in a cold wave, the probable transportation of cold air at a moderate height is of more importance than that along the surface.—*Charles F. Brooks.*

BALLOON RACING — A GAME OF PRACTICAL METEOROLOGY.

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By RALPH H. UPSON, Consulting Aeronautical Engineer.

[22 E. 17th St., New York City, Feb. 25, 1921.]

Transportation has always been more or less influenced by the weather. During the last 50 years, this influence has been somewhat lessened by the increasing use of automotive vehicles. Now, however, the advent of commercial air navigation makes weather more of a factor than it has ever been before, so much so indeed that the success of aircraft for commercial use will almost depend on how far the design progress can be paralleled by developments in three-dimensional meteorology. Now the question is: How can we best study this very important factor of weather in its application to aeronautics? Meteorology is no more an exact science than medicine is. To be sure, there *are* laws and principles that can be implicitly relied upon, but the great bulk of our future development for some time to come must depend on the accumulation and coordination of plain *facts experience,* and *practice.* The performance of any aircraft (whether heavier- or lighter-than-air) is a resultant of two factors: (*a*) The power plant of the craft, and (*b*) the surrounding air, or broadly speaking—the weather. Quantitatively, the effect of the weather is usually unchanged by a difference of speed and maneuverability of the aircraft. For example, a 20-mile side wind blows an airplane or airship sideways at just 20 miles per hour regardless of its speed of advance.

As in other branches of science, the best way to study this important subject from a practical standpoint is to separate it as far as possible from outside influences which only disturb the observations and confuse the result. The free balloon is almost ideally suited to our present purpose for the following reasons;

1. Having no motor, its control is entirely dependent on coordination with existing weather conditions. The performance of a balloon is exactly like that of a free particle of air with the addition of altitude control.

2. The entire freedom from pitching, vibration, noise and wind, permits the most delicate observations to be made.

3. Its simplicity and safety of operation makes a balloon especially desirable for a great variety of experiments. A free balloon is so safe that it is *practically* fool proof. It would take considerably more than an *ordinary* fool to hurt himself in one.

The progress in other branches of aeronautics has if anything increased the value of the free balloon for training. During the war all our airship pilots and a large proportion of our kite-balloon observers received preliminary training by free balloon. For training in navigation and meteorology it has also been advocated for airplane pilots. But its greater and broader value lies in the general stimulus to meteorological knowledge to be gained by its development as a recognized sport. And it is in no disparagement of its scientific and practical importance to say that as a sport, ballooning is the finest that can be imagined. It is also very moderate in cost. Recent developments in fabric and gas generators put ballooning within reach, financially and otherwise, of any moderate-sized club.

The *safe* piloting of a free balloon is easily and quickly learned. There are only two controls, ballast and gas. To go up or stop coming down, throw out ballast. To come down or stop going up, let out gas. The control of altitude and with it the choice of the desired wind currents depends only on the proper expenditure of ballast and gas.

Ordinary flights usually last from one to twelve hours, the landing being planned for a time and place that will best suit the convenience of the passengers. But prearranged plans are seldom entirely fulfilled. To realize them the pilot must constantly match his wits and skill against the prevailing wind conditions, which are never twice the same. An interesting story, as well as a scientific treatise could be written about every balloon flight that was ever made.

The highest art of ballooning finds expression in the national and international races for distance which are held every year. These commonly run anywhere from 400 to 1,200 miles distance and 18 to 60 hours duration. Having been a loser myself in the last big race, I need not be at all bashful to say that one of these races will draw on almost every talent that a man has—knowledge of navigation and meteorology, experience in its application, ability to size up the actual conditions, good judgment in their interpretation, practical skill in handling the balloon, firmness in adhering to a good plan of action but always with eyes and mind open for a better one, courage or caution where necessary, and plenty of plain physical endurance without forgetting good sportsmanship: these are a few of the qualities one can use to advantage in a balloon race. Of the nine international races for the Gordon-Bennett cup since 1906, Belgium has been winner once, France once, Switzerland once, Germany twice, and the United States four times. This year the races will start from Belgium because of the Belgian lieutenant, de Muyter's, great victory last year.

Our most immediate concern now is to see that America is well represented in this year's race. We are allowed a total of three teams consisting of pilot and aid for the three different balloons, each nation being limited to the same number. The only way to organize is to organize for a purpose, the only purpose in this case being to bring back to this country the famous Gordon-Bennett trophy. The different component parts of the plan must include attention to the following:

1. *Financing the expedition* is outside the scope of the present article, but it may be remarked that America in the past years has never failed to have representatives in this race.

2. *Equipment* is relatively unimportant, the only real necessity being a fairly tight envelope and good instruments. A racing balloon it should be noted is a much cheaper proposition than either a racing yacht or an airplane. There are probably at least a dozen balloons in this country which would be satisfactory to use.

3. *Personnel* is the most important item of all. We have an unusually rich choice now, owing to the interest of the Army and Navy in free ballooning, with all the pilots who were trained during the war.

The history of balloon racing up to the present time shows conclusively that it is taking on more and more of a meteorological character. In the past, races have been occasionally won by mere practical skill in operation of the balloon, but the time when this is possible is rapidly passing, if indeed it has not already passed. In the future, meteorological knowledge instead of being a secondary factor in the assets of a team, will be absolutely the controlling factor.

The record of the race from Birmingham, Ala., last fall is a very interesting study in this connection. The winner was a trained meteorologist[1] besides being a good balloon pilot. His performance in that race sounds almost incredible, but the facts can not be avoided. He, the winner, among all those who really stayed in the race, landed the very earliest. All started from Birmingham, Ala., between 5:30 and 6 p. m., October 23. At 9:30 a. m. of October 25 the winner was landing in the State of Vermont, while most of the other balloons were floating gently over Indiana and Michigan. One of these (we need not mention names) had ballast in plenty for another 24 hours, but would have needed twice that length of time to reach the distance marked off by the winner. An altitude of up to more than 20,000 feet was tried without success, the experiment at that time only serving to exhaust the ballast supply. At 2 o'clock in the afternoon (of the third day) a landing was finally made near Detroit, at approximately the same spot where the winner had passed over about 16 hours before.

These are striking coincidences, it must be admitted, but there is plenty of other evidence at least as strong showing the great importance of meteorology in modern balloon racing. And the shoe fits both ways. Not only does balloon racing need meteorologists for its best development, but meteorologists need the experience and stimulus which free ballooning is best able to give.

Ballooning is by all odds the best practical training for anyone who would use weather knowledge. Then why not for professional meteorologists? To be perfectly frank, ballooning is no longer important for the making of structural experiments from an engineering standpoint. The more definitely practical types of aircraft, such as airships and kite balloons, have reached a point where they are no longer dependent on free balloon experience for their structural requirements. But the keen struggle of wits against weather and the wonderful spirit of adventure which is an intimate part of even the shortest balloon flight, will always keep alive this fine sport. It is not given to most of us in these modern days to make voyages of exploration to unknown parts of the globe, but this spirit of adventure and exploration is still alive in human hearts and it is to this that free ballooning makes its great appeal, thus increasing and extending the value of its scientific service.

The recent unintentional flight of a Navy balloon to Hudson Bay has furnished striking proof of how people will respond to anything that stirs this spirit. But there is one unfortunate thing about ballooning from a standpoint of the general public. It is hard for spectators to see anything more of a race than the start. Hence, there is more than the usual importance to be placed on consistent development and interpretation by those who are naturally the nearest to it. We must get away from false leads and put ballooning where it belongs, squarely on the basis of sport and meteorology.

To meteorologists in particular, I would say: "Take your child. It is yours to develop and to bring out its great possibilities. In your hands and with your guidance this wonderful sport will be preserved with added value for future generations, and there is nothing that will be of more real help to aeronautic development in general."

[1] A personal account of Lieut. De Muyter's experiences in this race is given in *L'Aérophile*, Dec. 1-15, 1920, pp. 366-367, under the title, "How I won the Gordon-Bennett cup."—EDITOR.

C. G. A. I.—Weather Conditions During International Balloon Race, October 23-25, 1920.

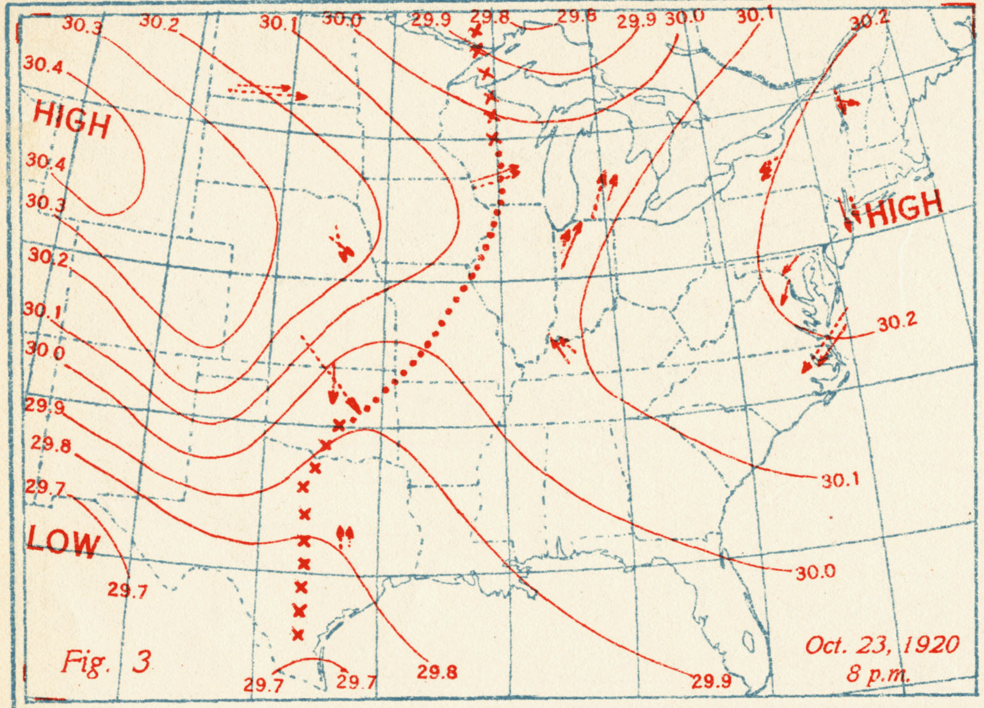

Fig. 3

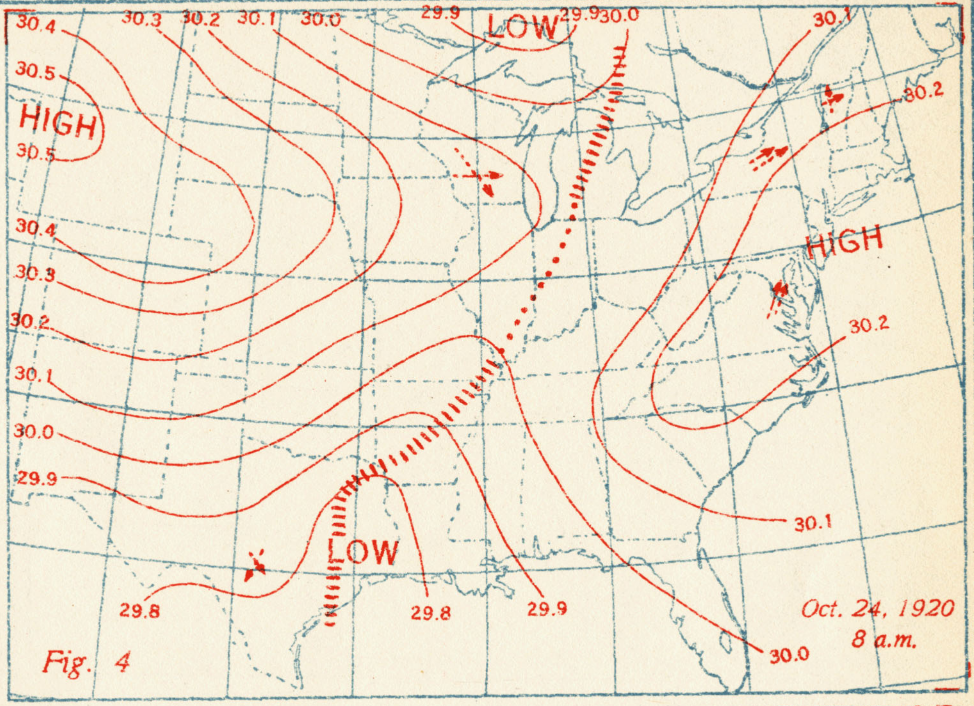

Fig. 4

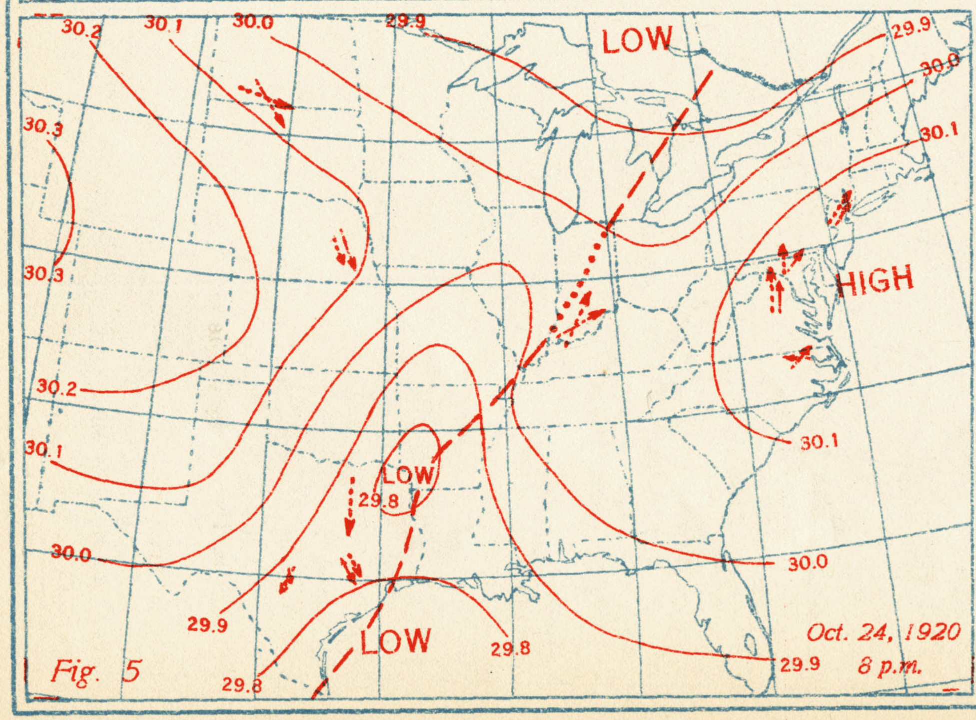

Fig. 5

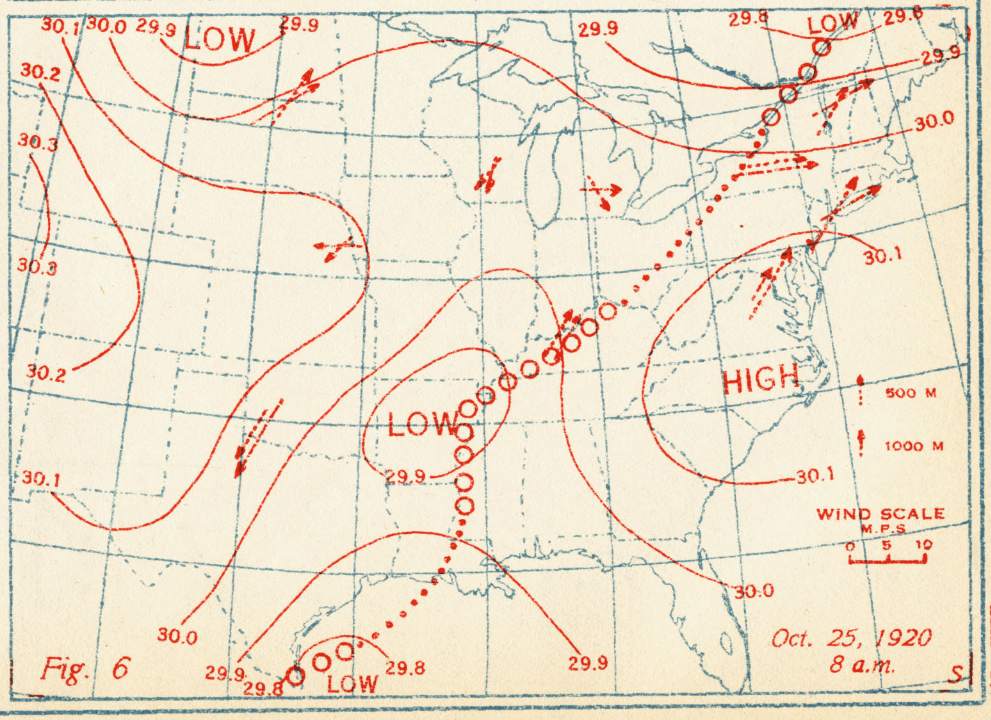

Fig. 6