THE ATMOSPHERIC OCEAN

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The navigation of the air by balloons and aeroplanes has extended the interest in the nature of the atmospheric ocean, hitherto confined to meteorologists. It is a striking fact that whereas the winds above and the currents in the seas were long ago determined for the benefit of navigators, the upper air conditions have been investigated purely from a scientific standpoint and only systematically within the last twenty years. About 1890 scientific balloon ascents were begun in Germany, and two years later balloons equipped with automatic instruments attained great heights in France. In 1894, the first kites were employed at Blue Hill to lift self-recording instruments for the purpose of ascertaining the meteorological conditions prevailing in the free air at different heights above the ground. In order to utilize to the best advantage these various methods of exploring the air, there was formed at Paris in 1896 the International Commission for Scientific Aeronautics with headquarters in Strasburg. The scope of its work has gradually been increased, so that some thirty government and private stations in various parts of the world now make simultaneous observations with kites and balloons once a month. In addition, expeditions have been sent to both northern and southern latitudes, and the atmospheric conditions at high altitudes over the oceans and continents studied for a longer time. The observations are centralized and published monthly in Strasburg, and this material collected solely to increase our knowledge of the atmospheric circulation cannot fail to be useful also to aeronauts. The stations in America which co-operate in this work are the Mount Weather Observatory of the United States Weather Bureau on the Blue Ridge, in

This instrument, weighing two pounds, records barometric pressure, temperature, relative humidity, and wind velocity.

Fig. 1.—The meteorograph.

Fig. 2.—Method of protecting meteorograph from weather and rough usage.

Fig. 3.—Sending up a "sounding balloon" with meteorograph attached.

Virginia, and the writer's observatory on Blue Hill, near Boston, and the results at the latter will be chiefly quoted in this article.

First, we will consider some general characteristics of the atmosphere. At the outset it should be noted, that while only on mountains can continuous observations at a considerable and fixed height be conducted, yet such observations, even if made on mountain summits, do not represent the conditions at an equal height in the free air. Consequently, to obtain them, it is necessary for man to ascend into the atmosphere, or, as is generally done to-day, to send up instruments that attain heights double, or treble, those which he himself can reach. Fig. 5 represents a vertical section of the atmosphere which lies within twelve miles of the earth, and contains eleven-twelfths of the whole mass of air. Meteorologists are only concerned with this portion, because all the atmospheric disturbances occur well within it, and it is certain that aeronauts will never rise to its upper limits. In fact, the greatest height to which man has ascended in balloons is seen from the diagram to be but little over six miles, while on mountains he has climbed to a height of less than five miles. The reason for these limitations is the increasing rarefaction of the air, for it is also seen from the scales on the borders of the diagram, that the pressure is halved for about each three and a half miles of ascent, though this distance, owing to the decrease of temperature, diminishes with the altitude. Registration or sounding balloons have reached in America the height of twelve miles, and in Europe the extraordinary height of eighteen miles, where the atmospheric pressure is only a fraction of an inch of mercury, instead of thirty inches,

This shows, to the right, a kite ready for an ascent; to the left, the engine house and gear for winding in and out the kite wire; a theodolite; and a meteorograph ready to be attached to the kite.

Fig. 4.—Kite plant at Blue Hill Meteorological Observatory.

under which we breathe at sea-level. Kites can be employed to give detailed data up to four miles, while clouds and balloons furnish information about the air currents very much higher. The average height of the cirrus cloud is about six miles in our latitude, and it moves on the average about 80 miles an hour from a westerly direction, as does the whole upper atmosphere, except at the equator, where the drift is from the east.

Fig. 5 shows the distribution of temperature over the globe, so far as known. The line of freezing temperature, which touches the earth near latitude 60 deg., rises more than three miles above the equator. The temperature however continues to decrease with height, and ten miles above the equator is some 180 deg. F. lower than at the surface of the earth. In fact, this temperature of -100 deg. F. is lower than is found at any height in northern or southern latitudes, for the reason that over the equator the temperature ceases to decrease at a greater height than nearer the poles. So the line marking this change of condition is seen to rise above the equator, separating the low average temperatures indicated from the upper stratum of nearly constant temperature and variable winds, which extends to an unknown height, certainly exceeding eighteen miles. The cause of this isothermal stratum is not definitely known, nor has it any practical interest for the aeronaut, since this rare and intensely cold air will forever form an impassable barrier to all animate creatures.

We will describe next how the data are obtained at Blue Hill Observatory. Fig. 4 shows the kite-plant prepared for a flight with the registering instrument, or meteorograph, ready to be attached to the kite-wire. This instrument, seen uncovered in Fig. 1, though weighing only two pounds, records barometric pressure (from which the height is calculated), air temperature, relative humidity, and wind velocity; and these data being continuously inscribed on a revolving clock drum, can be correlated as regards time and altitude. Additional kites are clamped to the wire as the height and weight increase, and they are drawn in by a steam engine, which operates a windlass having devices for measuring the amount of wire out and the strain to which it is subjected. In this way data are quickly and surely obtained for hours at a time at a nearly constant height up to several miles above the station on the ground. An historical account of the work here and abroad appeared in the *SCIENTIFIC AMERICAN*, August 10th, 1907.

While attended by greater losses, both of time and material, the so-called sounding balloon must be used to obtain temperatures, and approximately the direction and speed of the air currents at great heights. One of these balloons being sent up from St. Louis, where the first experiments in America were made in 1904 by the Blue Hill staff, is shown in Fig. 3. A detailed description of their use may be found in the *SCIENTIFIC AMERICAN*, February 27th, 1909, and it will suffice to say that the balloon is made of sheet-rubber and closed after being filled with one hundred cubic feet of hydrogen gas. To a parachute covering the upper portion hangs below the balloon an instrument which records the barometric pressure and temperature. This apparatus is lighter than that carried by the kites, and to obviate freezing of the ink at the extremely low temperatures encountered, the record is made by a stylus on a smoked sheet of metal covering the clock cylinder. The balloon rises until the expansion of the contained gas bursts the rubber envelope, which, with the instrument supported by the parachute, sinks to the ground, often several hundred miles from its starting point. By means of a notice and a small reward to the finder the instrument, with the graphic record of temperature and height, protected from rough usage and exposure to the weather as shown in Fig. 5, was recovered in 72 out of 76 instances when dispatched from St. Louis. These balloons, and others without instruments, are followed with a surveyor's transit until lost to view, and in this way the direction and velocity of the wind up to ten or twelve miles may sometimes be ascertained in clear weather. At night, or in cloudy weather, the place where the sounding balloon fell, and the length of time it was in the air, as shown by the automatic record gives the resultant drift of the upper currents. Sounding balloons can also be used at sea provided two are coupled together, for when one bursts and drags its twin slowly down, the full balloon supports the instrument in the water, and floating at a considerable height serves as a beacon to guide the steamer to its recovery.

From the point of view of the aeronaut the wind is the most important element in the atmospheric ocean. First, as regards its velocity. At Blue Hill the mean velocity, which is 16 miles per hour, increases most just above the Hill owing to withdrawal of friction at the ground, but it continues to augment up to a great height. The following figures may be considered typical of wind conditions in the free air over most of the United States. At a third of a mile above sea

level, the velocity is 22 miles per hour, at a mile 29 miles, at two miles 34 miles an hour, at three miles 50 miles, and at six miles 81 miles per hour. The annual range increases fast with height, so that the velocity of the upper winds in winter is more than double their summer speed and may sometimes exceed 200 miles an hour. The wind velocity also increases nearly twice as fast at night as in the day time up to about a third of a mile, when the velocity decreases (except in winter) up to three-quarters of a mile. Since the highest velocity at low levels is in the afternoon, the conditions only a short distance above the ground are completely reversed. The winds in our latitudes change their velocity and direction with the movements of the areas of high and low barometer, but whatever the direction of the surface wind it tends to become westerly at a height of a couple of miles, the southerly winds at the surface generally turning to the right and the northerly winds to the left. In the tropics, the trade-winds blow steadily from the northeast north of the equator and from the southeast south of it. An expedition sent jointly in 1905-6 by M. Teisserenc de Bort and the writer to explore the atmosphere above the tropical Atlantic from a steam yacht, demonstrated that above the trades, as was to be expected, the wind generally changed direction, so that above the northeast trade it turned, either in a right or left-handed direction, to the southwest, and above the southeast trade it became northwest. The height of this reversal varied greatly, and near the equator the wind was east at all heights. Prof. Hergesell found the counter-trade in the Caribbean Sea as a very strong southwest wind three miles above the northeast trade-wind at the surface. The prevailing winds at different heights over the globe are indicated in Fig. 5.

The practical importance of these considerations to

Fig. 5.—Vertical section of the atmosphere.

aeronauts is obvious. Aerial craft, both heavier and lighter than air, cannot tack like ships, because they drift bodily with the current in which they are immersed, and to advance against it they must have a speed greater than that of the wind. Therefore, they should seek the level at which favorable currents are known to prevail. Near the ground the wind is more gusty, on account of the obstacles which it encounters, and during the daytime irregular ascending currents are felt, whenever there is little wind, up to the height of a mile, where the cumulus clouds are formed. Supposing a dirigible balloon to possess the speed of at least 20 miles an hour, it would be truly dirigible at low levels in the vicinity of Boston on one day in two during the winter half year and on five days in six during the summer season. If the average speed exceeded 30 miles an hour, it could be used almost every day in summer and be hindered one day in six in winter. The safety of aeroplanes would, however, be endangered by winds exceeding 20 miles an hour, especially if gusty. Certain high-level routes across the Atlantic appear advantageous, provided the air craft can remain several days in the air at a height of two or three miles. By utilizing the prevailing westerly wind at this height Europe might usually be reached in less than four days and the return made from northern Africa to the West Indies by the northeast trades in about the same time, even if no motive power were used. By ascending sufficiently high, the southwest counter trade would probably make possible the eastward passage between the West Indies and Teneriffe or Madeira.

Such information about the atmospheric ocean can be furnished the aeronaut by the aerologist—as the explorer of the air, who remains on the ground, is called—in the same way that the hydrographer has surveyed the seas for the benefit of the sailor.

New York's Annual Electrical Show.

An average of from fifteen to sixteen dollars per year per individual is spent in the United States for electricity, according to a conservative estimate of Mr. T. Commerford Martin. Of course, the vast majority of the population spends practically nothing for electrical service, except in the way of trolley fares, telephone tolls, and the like. Indeed, most of the \$1,500,000,000 representing the amount paid for electrical service may be accounted for in lighting and power industries, and telephone and telegraph service. Nevertheless, there is a large and growing use of electricity in the household, which is assuming such proportions that we may well call ours the electrical country. The annual exhibition of electrical appliances in this city has for its object to educate the public in the use of electricity, particularly in the home. For this reason, the present exhibition, running from October 10th to 20th, devoted nearly half of its floor space to domestic appliances of all sorts, taking in practically every class of work done in the domestic workshop and showing how much more neatly and expeditiously the labor may be performed by the use of the electric motor and electrically-heated utensils. Particularly noticeable in this connection was the large number of vacuum cleaning machines, ranging from the small portable ones, weighing but twelve pounds, to large permanent installations for heavy work. There were no less than eight exhibitors of vacuum cleaners out of the seventy-five odd in the entire exhibition, while there were as many more booths devoted to electrically-heated cooking utensils.

Here the housewife was shown how a spring chicken may be broiled for two and a half cents' worth of electricity; how creamed oysters can be prepared for one and three quarters cents; how a Welsh rarebit may be made for a cent and a half, and how the griddle may be kept hot and in working operation for an hour and a half at a cost of but two and a half cents. Not only light cooking, but elaborate meals may be prepared on the electrical stove at small cost, with no danger of overheating the house in summer time, and with practically no odor, because the majority of the utensils are operated on the fireless cooker principle, in which the vapors are largely confined during the cooking operation. For the worried housewife who is troubled with inefficient domestics, the electric motor was suggested. The applications of this little power device about the house are without number. All operations, from dish washing to silver polishing, from dough mixing to ice cream freezing, may be done by the electrical servant, and at a cost which is no doubt less than that of the human servant. Then there was the electric laundry, the electric water purifying apparatus, washed air ventilators and countless suggestions for beautifying the home with ornamental lamps, electroliers, fountains, etc.

The decoration of the hall was most pleasing. The entire Madison Square Garden was draped in Nile green and white cheese cloth, with gold decorations. The hall was flooded with light, there being over a hundred thousand electric lamps. The lamps were arranged in triple-banked octagonal electroliers, of which there are three down the center of the hall, and twenty-eight suspended about the oval arena. As one entered the show he was greeted by a representation of Father Knickerbocker juggling electrically lighted balls of different colors.

While the major part of the show appeared to be particularly adapted for those who are interested in the household use of electricity, there were many other valuable and instructive exhibits. A complete line of advertising specialties was shown, and a practical demonstration of the best methods of lighting stores and store windows was given by devoting nearly the entire south side of the arena platform to model store fronts artistically illuminated. Another point of interest in the exhibition was the display of testing apparatus, where not only electrical appliances were tested, but other devices and materials as well.

For the first time in the history of the Electrical Show, Thomas Edison took a booth, the object being to demonstrate his storage battery, of which we have heard so much for many years, and which has only recently been reduced to commercial practice. Here the spectator was shown how flake nickel is produced by nickel-plating copper, cutting up the plated metal into tiny snips and then dissolving the copper by means of acid. The various processes of forming the perforated tubes, which are filled with flake nickel and nickel oxide, were explained.

Owing to the fact that the Electrical Vehicles Association of America was holding its annual convention here at this time, the display of electrical trucks and pleasure vehicles was unusually complete. This, by the way, demonstrates another growing electrical industry, which central power stations find to their interest to promote. The Korn photo-telegraphic machine is one of the novelties of the exhibition. There was a noticeable absence of wireless apparatus. While the show contained nothing startlingly novel, it was a decided success, as a brilliant spectacle and from an educational point of view as well.