SCIENTIFIC WORK IN THE "CENTURY OF PROGRESS" STRATOSPHERE BALLOON

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On November 20, 1933, the balloon *Century of Progress* rose from Akron to an official altitude of 18,665 meters (barometer 49.5 mm.), and descended eight hours later near Bridgeton, New Jersey. During the flight experiments were carried on to determine: 1. The ionization by cosmic rays using an unshielded ionization chamber. 2. The ionization by cosmic rays in a chamber shielded by 7.5 cm. of lead shot, or the equivalent of 5 cm. of solid lead. 3. The number and directional distribution of cosmic rays with a double Geiger-Müller coincidence counter. 4. The photographic action of cosmic rays on x-ray films. 5. The transmission of the atmosphere for the solar spectrum, using a quartz spectrograph. 6. The state of polarization of the scattered light from the sky, using a crystal of calcite painted with uniformly spaced black bands, so as to compare visually the intensity of the ordinary and extraordinary rays. 7. The color of the sky, by comparison with color charts. 8. The composition of the air at high altitudes, by taking samples for subsequent laboratory analysis. 9. The viability of certain spores exposed to the low pressure and temperature of the stratosphere. 10. The intensity, range, and freedom from static of radio signals originating at high altitudes. 11. The photographic "visibility" of the earth, using ordinary and infra-red light. At the last moment it was not possible to include an experiment planned by A. D. Boyer of the University of Chicago for testing the action of cosmic rays on fruit flies, nor one by D. S. Hsiung of the University of Chicago for repeating the Bothe-Kohlhörster experiment with cosmic rays at high altitudes.

Both sets of apparatus for measuring the ionization by cosmic rays were self-recording, and gave satisfactory records. Due in part to an unexpected rapid rotation of the balloon, the program of directional experiments could not be completed, though valuable data on the number of rays were obtained. The rotation of the gondola also made it impossible to use the adjustable support for the quartz spectrograph, and attempts to secure spectrograms by holding the instrument in the hands gave unsatisfactory results.

The skylight at 90 degrees from the sun was completely polarized within an estimated limit of about 5 per cent. Close to the horizon the sky was white, due to haze and clouds. This shaded into a steel blue, and then into a saffron yellow, due apparently to light scattered from distant cirrus

clouds, and traversing a long path through the atmosphere. Above this highest layer of cloudy or hazy air, the color shaded rapidly through green to a deep blue. This blue showed no tinge of purple or violet hue. These observations were confirmed by the use of a hand spectroscope.

The radio signals were transmitted with surprising clarity on a wavelength of 19.7 meters. Immediately upon leaving the earth the oscillation frequency of the transmitter changed by about 30 per cent, due doubtless to change in capacity. Whereas close to the ground almost 100 per cent modulation was necessary to transmit satisfactory signals, at high altitudes 30 per cent modulation was sufficient. The signals were received directly at Chicago, New York and intermediate stations.

The rate of drift of the balloon while in the atmosphere was about 45 knots. This is considerably greater than occurred in previous stratosphere ascensions, though because of the different time of year is not surprising.

The temperature of the top of the balloon in the stratosphere rose to $-2°$C., though the air temperature was about $-55°$C. As the sun came close to the horizon the bag cooled rapidly, causing a descent which attained a speed of 18 meters per second. Of physiological interest is the fact that when the gondola was opened at an elevation of 8.1 kilometers (less than $^1/_3$ of an atmosphere pressure) none of the symptoms of dizziness, nausea, fatigue, etc., familiar at high altitudes were noticed, though both observers were engaged in heavy physical labor. Two explanations are apparent, first, the short period of exposure to the low pressure because of the rapid descent of the balloon, and, second, a possible high concentration of oxygen in the gondola before the ports were opened.

More detailed accounts of the results of the various experiments will be published by the individuals most directly responsible for them.

The balloon and gondola were built after the general design used by one of us in previous stratosphere flights, but with certain modifications demanded by the experiments and conveniences of navigation. The capacity of the balloon was somewhat greater, about 17,000 cubic meters, and the gondola, built of 95 per cent magnesium (Dowmetal), was somewhat lighter, 160 kilograms. The balloon was filled with 99.9 per cent hydrogen. The balloon, gondola, two men and essential equipment weighed a total of 1700 kilograms. In addition, 1800 kilograms of ballast, in the form of sand and lead dust, were carried at the start of the flight.

The barometer equipment consisted of two sealed aneroid barographs mounted outside the gondola, a double U-tube mercury in glass barometer inside the gondola, connected by rubber and copper tubing to the outer air, and two aneroid altimeters to determine the pressure within the gondola.

We wish to thank the Century of Progress Exposition for organizing the flight, the Chicago Daily News, the National Broadcasting Company, the Dow Chemical Company and the Union Carbon and Carbide Company for bearing the chief part of the cost of the flight. Of the many who have given valuable help in making the enterprise a success, we wish especially to thank the Goodyear-Zeppelin Corporation for their care in building the balloon, and the use of their personnel and their airship dock for handling the balloon previous to the flight; Admiral E. J. King, Chief of the Bureau of Aeronautics, U. S. N., for supplying essential navigating equipment; the Wm. Gaertner Scientific Corporation for supplying the quartz spectrograph; the U. S. Bureau of Standards for their assistance in connection with the barographs and other control instruments both before and after the flight; the U. S. Weather Bureau for their wholehearted assistance; the Navy Bureau of Construction and Repair for supplying submarine breathing equipment; the Hydrographic Office for navigational charts; the Bausch and Lomb Optical Company for loan of optical instruments, The Eastman Kodak Company for supplying some special photographic equipment, and Mr. T. J. O'Donnell, foreman of the Ryerson Laboratory shop, for his help in the final adjustments and tests of the gondola.

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