

horizon lasted until 7:30 p. m., when it was gradually replaced by yellow. The latter color was bright on the horizon until 7:40 p. m., and was barely visible at 7:50 p. m.—1 hour and 20 minutes after sunset. On some nights the twilight glow was visible for fully an hour and a half after sunset.

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RECENT BALLOON EXPERIMENTS.¹

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Notwithstanding the satisfactory state of the theory of solar constant measurements by the method of Langley, depending upon spectro-bolometric observations at high and low sun combined with measurements by the pyrheliometer, and notwithstanding the close agreement between results obtained by this method for many years at stations of differing altitude from sea level to 4,420 meters elevation, there still exists the possibility that if we could, indeed, go outside the atmosphere altogether, we should obtain values differing materially from those given above. So long as we observe at the earth's surface, no matter how high the mountain top on which we stand, the atmosphere remains above us, and some estimate must be made of its transmission before the solar constant can be determined. Different persons will differ in the degree of confidence which they will ascribe to measurements of the atmospheric transmission such as have been considered, and there are still some who totally disbelieve in the accuracy of the results thus far obtained, even though they be confirmed by observations at such differing altitudes. Accordingly it has seemed highly desirable to check the results by a method of direct observation by the pyrheliometer, attaching the instrument for this purpose to a balloon and sending it to the very highest possible altitudes. By a cooperation between the Smithsonian Institution and the United States Weather Bureau, experiments for this purpose were made in July and August of the year 1913.

¹[Extracted from "The solar constant of radiation." Journal of the Washington Academy of Sciences, Washington, Mar. 4, 1914, v. 4, No. 5.]

The instruments were modified in form from the silver disk pyrheliometer, which has been described above. As the apparatus could not be pointed at the sun, the disk was placed horizontally, and the thermometer was contrived to record its temperature by photography upon a moving drum. The receiving disk was alternately exposed to the sun and shaded by the intervention of a shutter, operated intermittently by the clockwork which rotated the drum under the stem of the thermometer. Five instruments of this kind were sent up on successive days. While it was well known that the temperature of the higher air would go as low as $-55^{\circ}\text{C}.$, it was believed that a blackened disk, exposed half the time to the direct sun rays, would certainly remain above the temperature of -40° , which is the freezing point of mercury. This expectation was disappointed. Accordingly, owing to the freezing of the mercury in the thermometer, the highest solar radiation records obtained during the expedition were at the altitude of 13,000 meters, although the balloons in some instances reached the altitude of 33,000 meters.

The results obtained, while they have not the same degree of accuracy as those obtained by direct reading of the silver disk pyrheliometer, are yet of considerable weight. All the measurements unite in indicating values of the solar radiation at altitudes of 10,000 meters and higher, which fall below the value of the solar constant of radiation as obtained by other methods, and above the value of the radiation at the summit of Mount Whitney as obtained by different observers with pyrheliometers. It is expected in the coming year to repeat the observations with balloons under much improved circumstances. By aid of electrical heating apparatus it is expected to keep the surroundings of the disks at approximately the freezing temperature, even though exposed to the air at temperatures as low as $-55^{\circ}\text{C}.$ In this way it is hoped to obtain good pyrheliometer measurements as high as it is possible for sounding balloons to go, and possibly to an altitude of 40,000 meters. As the atmospheric pressure at such altitudes is less than 1 per cent of that prevailing at sea level, the experiments, if successful, may be expected to remove reasonable doubt of the value of the solar constant of radiation.