TENNESSEE FIREBALL OF AUGUST 21, 1933

By STERLING BUNCH and CHARLES P. OLIVIER [1]

On August 21, 1933, at $7^h39^m39^s$ p.m. (C.S.T.), a splendid fireball appeared over Tennessee, moving almost north to south and ending over a point just north of Knoxville. By good fortune S. Bunch, regional director for the American Meteor Society in Tennessee and Kentucky, saw it and secured full observations. Two other experienced A.M.S. members, L. J. Wilson and P. S. Watson, also observed it. Requests for observations were at once published by Bunch in local papers. These notices brought in reports from other observers. We give below a table showing the stations, the names of observers, the color of the fireball, and the estimated durations of the fireball and of the train.

TABLE 1

Station	Observer	Color of fireball	Duration of fireball	Duration of train
1. Knoxville, Tenn.	S. Bunch	B-W	0s.8	3m15s.
2. Franklin, Ky.	L. J. Wilson		"Slow"	3m.
3. Pulaski, Va.	P. S. Watson	R-B	6s	3m±.
4. Jefferson City, Tenn.	F. Weed, Jr.			30s.
5. Newport, Tenn.	C. E. Parrott	Blue		30s.
6. Clarksville, Ga.	C. H. Fonde			1m±.
7. Boyds Creek, Tenn.	T. W. Stansbury		2s	
8. Near Jefferson City, Tenn.	W. A. Burkhart			2-3m.
9. Johnson City, Tenn.	H. Leonard			2m±.
10. Washburn, Tenn.	L. M. Cleveland			"Long."
11. Bearden, Tenn.	Mrs. Chas. Seiber			2m±.
12. Chattanooga, Tenn.	W. H. Wilson			
13. Coal Creek, Tenn.	Mrs. Earl Martin			4-5m.
14. Cleveland, Tenn.	R. G. Parks			50-70s.
15. Rockwood, Tenn.	J. E. Johnson	B		1m+.

The data were handled as follows: Bunch made a preliminary solution with partial data; he then sent all reports to Olivier, who made a complete solution; the reports were finally returned to Bunch, who independently made a complete solution. It is considered that the publication of the principal results thus deduced is of interest, for each author used his personal judgment in measuring the plots and weighting the calculated quantities. The close agreement of the results gives us added confidence in them.

TABLE 2

	By S. Bunch	By C. P. Olivier	Adopted
Height, beginning	171.8 km.	169.7 km.	170.8 km.
Height, ending	45.5 km.	44.7 km.	45.6 km.
Length of path	143.4 km.	144.5 km.	144.0 km.
Projected length of path	69.9 km.	72.3 km.	71.1 km.
Slope=h of radiant (uncorrected)	60°.5	60°	60°.2.
Azimuth=a of radiant (uncorrected)	187°	187°	187°.
Began over	83°45′	83°44′	
	+36°43′	+36°43′	
Ended over	83°51′	83°51′	
	+36°05′	+36°04′	
Earth point=E_1		83°52′	
		+35°50′.4	
Height of mid-point of train	81.4 km.	80.4 km.	80.9 km.
Velocity of train drift (minimum)	129 km/hr.	127 km/hr.	128 km/hr.
Local siderial time at E_1			270°57′.8.
Zenith correction (parabolic velocity assumed).			−0°55′.
Radiant (corrected)			α=278°.8. δ=+64°.7.

Bunch estimated the brilliancy of the fireball as greater than that of the full moon, its angular diameter approximately as great as the moon's, and its duration as 0.8 of a second. The train lasted 205 seconds, and he plotted it five times during this interval. Its change from a definitely outlined, irregular, sinuous train to an ill-defined roundish mass of light occurred within 20 seconds, as he saw it (very greatly fore-shortened, however, as he was almost in the line of motion of the fireball). Wilson (station 2) gives: Diameter equal to two thirds that of the moon; visibility of train, longer than 2 minutes; four drawings of train made. He was in such a position that the train was drifting almost directly away from him. Watson (station 3) gives: Head nearly equal to full moon; color, red and blue; speed, fairly fast; duration, 6 seconds; train seen for 3 minutes, drifting eastward. He plotted on a chart the final position of the train. According to this observation, just before disappearance, its lower end had a height of 57 km, its upper end, 108 km. The drift was almost directly toward him, and hence appeared slightly upward. All of the other observers confirm these general statements, but lack of space prevents us from quoting their reports here.

The observations of 6 observers could be used in determining the beginning point and of 8 observers for the end point. The beginning point is fixed with fair accuracy for this type of work, and the end point with great accuracy. It is evident from the few and widely divergent estimates of duration of visibility of the fireball itself that no reliable relative velocity can be deduced. As usual, therefore, parabolic velocity has been assumed and the zenith correction calculated. The radiant point was then found. In the von Niessl-Hoffmeister Catalog, fireball no. 377, seen October 1, 1893, shows striking similarities in description and radiant, making allowance for the expected shift in the 8-day interval.

This fireball was obviously a very fine one, of a distinctly blue color, and the case was favorable for the study of train drift. Train drifts being of fundamental value for the investigation of currents in the upper atmosphere, in fact, our only means of determining such currents, no pains were spared to secure the best results. We conclude that the train drifted almost horizontally in an easterly direction, that is on a west wind, with a minimum velocity of 128 kilometers per hour. If there was any deviation, it was slightly to the south of east, but by assuming east we could scarcely be 15° in error. If we do assume that direction of motion the velocity will be about 2 percent greater than the minimum given above. The fireball itself came so low in the atmosphere before bursting that it is not improbable that meteorites fell from its debris. The observations from station 1, since they were practically at right angles to the direction of drift, are the ones mainly used to derive the velocity.

TABLE 3.—*Wind velocities and directions from surface to 7.8 km as determined from pilot-balloon observation begun at 4:30 p.m. (C.S.T.)*

Altitude (km)	Direction	Velocity (km/hour)
Surface	Northeast	13.0
0.5	do	19.4
1.0	do	16.6
1.5	do	18.4
2.0	East	19.1
3.0	Northeast	15.8
4.0	do	17.3
5.0	North	19.4
6.0	Northeast	8.3
7.0	North	14.4
7.8	Northwest	9.4
Cirrus clouds	West	

6:45 p.m., C.S.T., barometer, 29.96 inches; temperature, 82°; weather, clear.

[1] I beg to call to the attention of all Weather Bureau observers their unexcelled opportunities for the collection of data on fireballs. If, when one is reported, they would put notices in local papers stating what data are needed, in most cases they would meet hearty response. The American Meteor Society will willingly undertake the reduction of all reports sent to headquarters, giving full credit to the observers.—C.P.O.

The wind velocities derived from this and other train drift studies are not incomparable in magnitude with velocities encountered nearer the surface. The conditions in the lower atmosphere near the time of the fireball is, therefore, of some interest. Table 3 is made up from data taken from the records of the Knoxville Weather Bureau office for that date.

This is the third velocity of the drift of a meteor train secured by the American Meteor Society within a year. It further illustrates most excellently what can be accomplished by cooperative effort.

For this paper, the initiative in observing and in securing the reports of others is due to S. Bunch; also an independent solution was made by him. C. P. Olivier has made a critical study of the data, computed the quantities given under his name, and exercised a general supervision, as is usual in the American Meteor Society work.

The highest wind velocity observed at Knoxville by the pilot-balloon method was at 1.5 km above surface, 201.6 km per hour, but this was in November. Summer velocities of near 100 km per hour have been observed.

AN 18-DEGREE HALO

By E. MONROE HARWOOD

[Blue Hill Meteorological Observatory, Milton, Mass., December 1933]

A lunar halo at Blue Hill Observatory, Milton, Mass. which began at 7:10 p.m. (E.S.T.) October 4, 1933, and continued until after 12:40 a.m., October 5, at first was mistaken for the common one of 22° radius but later seemed noticeably smaller; so measurements were made on it with an astronomical stick graduated in degrees and tenths. At 12:40 a.m., October 5, two such measurements both showed 18°12′ as the angle from the near edge of the practically full moon to the inner edge of the halo, horizontally, on the right-hand side of the moon. The halo was of marked brightness. No other halo was observed at the time, but there was a bright corona, of approximately 3° radius. The sky was completely covered with cirrostratus in a uniform sheet.

NOTE.—This halo is the 18°58′ halo (yellow light) listed in "Physics of the Air", 2d edition, page 517, produced by pyramidal faces inclined to each other 53°58′. Clearly, because red light, corresponding to the inner edge of the halo, gives a radius of 18°20′ which, when diminished by the radius of the moon, 15′, to correspond with the angular distance measured by Mr. Harwood, reduces to 18°5′, a value identical, to well within the observational errors, with that which he found, namely, 18°12′.—Editor.

A HALO OF UNUSUAL RADIUS

By ROBERT G. STONE and SALVATORE PAGLIUCA

[Mount Washington Observatory, Gorham, N. H., Oct. 7, 1933]

From 7:30 p.m. until sometime after 10 p.m., October 4, 1933 (75th meridian time) we saw from the Mount Washington Observatory, New Hampshire, 1,911 meters above mean sea level, a bright, complete, circular halo that, with a theodolite, repeatedly and consistently measured 23.5° from its inner edge to the proximal limb of the nearly full moon. The elevation of the moon above the horizon at 9 p.m. was about 37°.

The ring was of approximately equal brightness and width all around. No trace of the 22°-halo, or any other halo than the one measured, was seen. The sky was completely covered with a thick uniform veil of cirrostratus (species, *nebulosus*, in the 1932 International Atlas of Clouds) that appeared to be unusually low (the appearance of the sky is almost exactly reproduced on plate 43 of 1932 International Atlas of Clouds). The pressure had been falling slowly since morning after 2 days of high barometer and fair weather. Delicate cirrus prevailed during the day, giving way to cirrostratus about 6 p.m. The temperature at 8 p.m. was 30.6° F.; relative humidity, 71 percent; wind, ESE (all day) at 17 meters per second.

The halo was first measured several times with an astronomical stick which though giving only rough readings, indicated radii considerably greater than 22°. Suspicion and curiosity were thus aroused and readings then made with a Keuffel and Esser theodolite of modern design adapted to pilot balloon observations. These measurements were made in three ways, viz: (1) from the outer proximal limb of the moon *right* to the inner edge of the halo, (2) from the outer proximal limb of the moon *up* to the inner edge of the halo, and (3) from the inner edge of the left limb of the halo horizontally through the center of the moon to the inner edge of the right limb of the ring, and, as stated, repeated several times with always the same result.

At 8 p.m., the same evening, L. A. Wells at the Blue Hill Observatory, Milton, Mass., noted 0.8 Cirrus and Cirrostratus filosus, at an estimated altitude of 8 km., moving from SW. at a speed which earlier observations indicated to be approximately 25 meters per second. A solar halo, beginning at 8:04 a.m., exhibited right and left parhelia from 4:05 p.m. until after 4:10 p.m. A lunar halo began at 7:10 p.m. and continued until after 12:40 a.m., October 5, with an equally bright corona of approximately 3° radius also persistent. Finger measurements of the solar halo by E. M. Harwood indicated 22° approximately. Astronomical stick measurements of the lunar halo at 12:40 a.m. the 5th gave 18.2° as the radius in two readings taken from the apparent edge of the moon to the inner edge of the halo, horizontally, on the right-hand side of the moon. Observer Harwood noted even before making the measurements the small size of that halo and its marked brightness. No other halo was observed at the time; the sky was completely covered with Cirrostratus in a uniform sheet.

(All times given above are 75th meridian time (E.S.T.).)