Comments on "The Secular Increase of the World-Wide Fine Particle Pollution"

G. F. SCHILLING

The RAND Corporation,[1] *Santa Monica, Calif.*

8 June 1964

In his recent paper, Gunn (1964) presents the results of important measurements of the electrical conductivity of the atmosphere over the Atlantic Ocean. His data appear ideally suited as a reference standard for 1962, and may well become one of the very few established benchmarks in this field.

From a comparison with corrected values of the *Carnegie* measurements of some four decades ago, Gunn (1964) infers that the average fine particle pollution of the atmosphere could have increased by only a relatively small amount between 1914 and 1962. He thus is able to show that Wait's (1946) forecast of the possibility of an alarming increase in world-wide air pollution has not come true—at least not yet.

In view of the special care with which these measurements were taken and analyzed by Gunn (1964), it may be of interest to point out that an additional inference can be made from his data about an important atmospheric problem, mentioned briefly by him. As discussed by Cobb and Phillips (1962), the presence of radioactive particulate matter produces two effects on the electrical conductivity of air: (1) the tendency to reduce the conductivity by providing surfaces for the diffusional loss of conducting ions, and (2) a counter tendency to increase the conductivity by increasing the rate of production of the conducting ions. Since the second effect outweighs the first, the net effect of radioactive airborne particles is to make the air more conducting. How the radioactive particles from an atomic cloud quantitatively affect the free air conductivity has been shown by Greenfield (1956) with regard to disintegration rates of bomb debris and the half-life of ions.

[1] Any views expressed in this paper are those of the author.

In principle, a comparison of atmospheric conductivity values can therefore be used to determine possible secular alterations in the radioactive contamination of the global air envelope near msl, caused by the explosion of nuclear and thermonuclear devices in the atmosphere. In practice, however, as exemplified by Gunn's (1964) study, a reliable comparison of absolute values obtained by different investigators with different instruments is exceedingly difficult. Hence the importance and significance of careful shipboard measurements. In addition to the ocean measurements given by Gunn (1964) in his Fig. 1, a few comparable data series are available for the years after 1950; they are listed in Table 1.

In contrast to the situation over land, one can expect the secular mean values of atmospheric conductivity over oceans to be influenced primarily by persistent air-borne contamination. In addition to fine particle pollution, the rate of residual fallout which reaches the lower atmospheric strata, sometimes delayed by months and years, should contribute to the absolute values measured. Published data (Glasstone, 1962) indicate that the stratospheric inventory of strontium-90 and cesium-137 decreased relatively rapidly after reaching maxima in 1954 and 1959. The surface burden of the fission and fusion products builds up as the stratospheric

TABLE 1. Recent shipboard series of measurements of the electrical conductivity of air over the oceans.

Dates	Ship and locations	Conductivity	Authors
Aug 1952	*American Chief*	2.32	Parkinson and Weller (1953)
Sep 1952	2–75°W, 40–53°N		
Oct 1952	R/V *Horizon*	2.69	Ruttenberg and Holzer (1955)
Nov 1952	108–195°W, 30°N–23°S	3.54	
Dec 1952		2.86	
Jan 1953		2.47	
Feb 1953		2.03	
Oct 1954	R/V *Baird and Horizon*	4.53	Holzer and Ruttenberg (1955)
Nov 1954	86–127°W, 3–27°N	3.68	
Dec 1954		3.21	
May 1962	*American Traveller*	1.96	Gunn (1964)
June 1962	North Atlantic	1.81	

Notes: Average total conductivity in e.s.u.$\times 10^{-4}$. High yield nuclear explosions of the IVY series took place on Eniwetok 31 October and 15 November 1952. The CASTLE series of explosions took place near Bikini and Eniwetok from March until May 1954. Both series contained tests of a thermonuclear device. A series of nuclear bomb explosions by the U.S.S.R. occurred reportedly (Glasstone, 1962) in September and October 1954.

fallout reaches the ground, and will have decreased substantially only since the cessation of atmospheric testing by the United States and the U.S.S.R. in 1962. Over the ocean, there is clearly no long-term effect to be expected from radioactive contamination of the surface layer of water. Shipboard measurements of atmospheric conductivity away from land should therefore be a valid indication of the magnitude of any persistent degree of radioactive contamination of the air itself.

There are some indications from long-time series of atmospheric electrical measurements at high mountain stations that the true air conductivity has returned to normal values at some time after each series of nuclear tests. This can be seen, for example, by comparison of measurements made in Hawaii in 1960–1961 (Cobb and Phillips, 1962) with comparable observations in 1951–1954 (Schilling and Childress, 1954, Schilling, 1955). However, it is obvious that series of ship observations are needed to establish such conclusions. Hence, we can reliably infer from Gunn's (1964) results that any radioactive contamination of the free air had indeed by May 1962 returned to such small values that it was not detectable as a secular increase in the electrical conductivity. We can only assume, of course, that this should have been the case again, following the last series of nuclear explosions in the atmosphere in 1962.

A further indication of the validity of this inference might be gained by comparing supplementary measurements of the nuclei density over oceans. As mentioned by Gunn (1964), his values are consistent with the *Carnegie* values, but, as expected, scatter badly. It is hoped, nevertheless, that Professor Gunn may in the future also publish these data and thus complete his account of the *American Traveller* measurements. It is needless to say that a repeat of his experiments in future years will be of great interest.

REFERENCES

Cobb, W. E., and B. B. Phillips, 1962: Atmospheric electric measurement results at Mauna Loa observatory. *Technical Paper No. 46*, Weather Bureau, U. S. Department of Commerce [available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.], 252 pp.

Glasstone, S. (ed.), 1962: *The effects of nuclear weapons.* U. S. Atomic Energy Commission [available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.], 730 pp.

Greenfield, S. M., 1956: Ionization of radioactive particles in the free air. *J. geophys. Res.*, **61**, 27–33.

Gunn, R., 1964: The secular increase of the world-wide fine particle pollution. *J. atmos. Sci.*, **21**, 168–181.

Holzer, R. E., and P. L. Ruttenberg, 1955: Summary of atmospheric electrical data at selected land and sea stations 1954. *Scientific Report No. 10*, Contract No. AF19(122)–254, Institute of Geophysics, University of California, Los Angeles [available from Air Force Cambridge Research Laboratories, Bedford, Mass.], 177 pp.

Parkinson, W. D., and R. I. Weller, 1953: Atmospheric electric elements over the ocean. *J. geophys. Res.*, **58**, 270–272.

Ruttenberg, S., and R. E. Holzer, 1955: Atmospheric electrical measurements in the Pacific Ocean. *Proc. Conf. on Atmospheric Electricity, Geophys. Research Papers*, No. 42, 101–108.

Schilling, G. F., 1955: On the variation of electrical conductivity of air with elevation. *Proc. Conf. on Atmospheric Electricity, Geophys. Research Papers*, No. 42, 53–58.

——, and P. L. Childress, 1954: Summary of atmospheric electric data at selected land and sea stations, 1951–1953. *Scientific Report No. 8*, Contract No. AF19(122)-254, Institute of Geophysics, University of California, Los Angeles [available from Geophysics Research Directorate, Air Force Cambridge Research Laboratory, Bedford, Mass.], 344 pp.

Wait, G. R., 1946: Some experiments relating to the electrical conductivity of the lower atmosphere. *J. Wash. Acad.*, **36**, 321–343.