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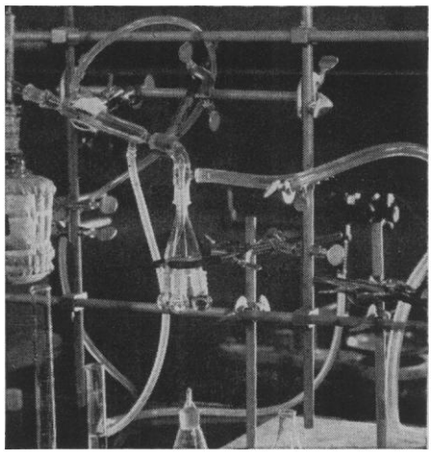

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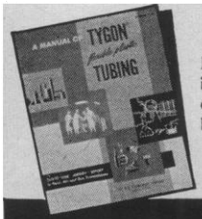

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Rainfall Singularities

This letter has been prompted by the appearance of a recent lead article in *Science* [**134**, 361 (11 Aug. 1961)]. Survey articles of this type, touching as they do on research problems which fire the public imagination, serve a useful purpose in presenting a comprehensive picture of the state of the art. It is unfortunate that Fletcher was not aware of the difficulties in the analysis of the rainfall data which he discussed, and their implications. There is now a good deal of evidence to suggest that there are no world-wide rainfall singularities. In the conclusion to his article Fletcher states, "If, however, as appears to be the case, the rainfall singularities are real, then the meteor hypothesis is the only one which has been advanced as yet which seems capable of explaining them." Logically, if the rainfall singularities are not real, then no hypothesis or speculation is necessary. Let us look at the observational evidence for the existence of rainfall or other geophysical singularities.

As Fletcher has noted, it is difficult to estimate statistically significant departures when a number of records have been arbitrarily lumped together. This is particularly true when there has been no effort to select observations that are independent of one another in time or space. Bowen's original work combined data from 300 stations for about 50 years ("15,000 station years"). The geographical distribution of stations is shown in Table 1.

Table 1. Geographical distribution of stations.

Area	Stations (number)
Argentina	10
Australia	50
Great Britain	100
Japan	32
Netherlands	5
New Zealand	58
Union of South Africa	10
United States	48

As is well known to meteorologists, the spatial correlation of rainfall over small regions (for example, Great Britain) is quite high. Not only does this spatial correlation decrease the number of the degrees of freedom of the resulting curve (see Fletcher's Fig. 6), but it introduces a bias into the estimation of what constitutes "world-wide" rainfall. Therefore the "15,000 station years" are equivalent to only a small fraction of this number of independent observations. This criticism is as valid now as it was when Bowen's work was first published.

However, Bowen's evidence seemed to be supported by the later work of Brier. Comparing two rainfall time series, independent of each other and of Bowen's original data, Brier stated that "these results [Brier's] lead to the conclusion that there has been a strong tendency for precipitation anomalies (both high and low) to occur on specific calendar days." Recently, R. Shapiro and N. J. Macdonald [*J. Meteorol.*, in press], using Brier's data, showed that the relationships between the rainfall series were due solely to a coincidence of days of average rainfall. This led to the conclusion that "Brier's results may be said to show a weak tendency for the association of nonanomalies of precipitation on specific calendar dates." Therefore, Brier's work cannot be considered evidence in support of the existence of rainfall singularities.

Fletcher indicates that Dmitriev and Chili also found rainfall peaks that corresponded to those in the Bowen data. Unfortunately, no reference is given.

Again, according to Fletcher, "Bowen found a correlation between his rainfall peaks and intense meteor showers occurring about 30 days previously, as shown in [Fletcher's] Table 1." Because of the number of showers, their duration, and the 28 to 32 days that Bowen actually allows for verification, the results shown could easily be obtained by chance, as a simple chi-square test will show.

As further support, Fletcher goes on to cite the cirrus-cloud study by E. K. Bigg [*J. Meteorol.* **14**, 524 (1957)]. Bigg claimed some association between the mean percentage of sky covered by cirrus and Bowen's 300-station rainfall curve. A simple calculation shows that the linear correlation coefficient between the two curves in Bigg's paper is only + 0.24. Even if the observations were completely independent of one another (which they are not), the correlation does not even approach the 5-percent significance level. It is not surprising, then, as Fletcher has also noted, that Braham failed to find any confirmation of Bigg's results.

It is quite apparent that the evidence for the existence of rainfall singularities will not stand careful scrutiny. It seems irrelevant, then, to speculate on physical explanations.

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The comments of Macdonald and Ward emphasize the fact that controversy still rages over almost all aspects of the meteor hypothesis. It is perhaps unfortunate that decisive physical tests of the theory are lacking and that most arguments concern the statistical significance of apparent correlations between various time series. It is a notorious fact that statistics can be made to support almost any proposition in a sufficiently complicated situation, and both the proponents and the opponents of the theory have often erred in drawing unwarrantedly strong conclusions from inadequate sets of data.

The criticism of the data upon which Bowen's world rainfall curve was based appears to have a certain validity. Ideally, some sort of weighting should be introduced to take account of the clustering of sets of stations, but any such doctoring of the raw data brings with it further possibilities of bias. It would, however, be most instructive to see the results of some such independent and impartial treatment of the same data.

It is impossible to comment on the criticism of Brier's conclusions until the paper referred to has been published. The reference to the Russian work was omitted as not being readily available to readers. It is as follows: A. A. Dmitriev and A. V. Chili, *Trudy Inst. Morskogo Gidrofizicheskogo* **12**, 181 (1955?).

As my original article was intended to imply, I do not believe that the existence of world-wide rainfall singularities has been either unequivocably demonstrated or finally discounted. The same must be said of the meteor hypothesis itself.

N. H. FLETCHER

Department of Physics,
University of New England,
Armidale, Australia

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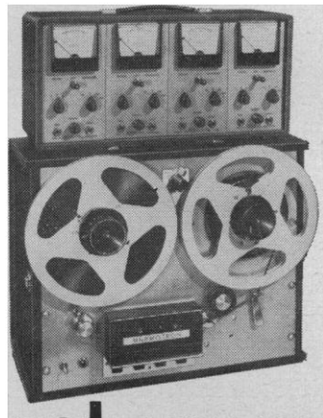

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