From the limit of detectability presented above, one may conclude that $t/T_{1/2} \geqslant 23 \cdot 7$. Using the value[4] of $1 \cdot 7 \times 10^7$ yr. for $T_{1/2}$, we obtain $t \geqslant 0 \cdot 41 \times 10^9$ yr. I. Noddack and W. Noddack reported a value of $3 \cdot 5 \times 10^{-2}$ p.p.m. by weight of iodine in meteorites[5]. This value is considerably lower than that reported by Fellenberg. It is very doubtful whether the iodine content of meteorites is any lower than the value of $3 \cdot 5 \times 10^{-2}$ p.p.m. reported by the Noddacks. Using this lower value, we obtain $t/T_{1/2} \geqslant 17 \cdot 4$. It is clear that this calculation is very insensitive to such a change in the iodine abundance. The critical effect is, of course, that of xenon diffusion. H. C. Urey (personal communication) has pointed out that the iodine in stony meteorites may be bound on the surfaces of the mineral grains, and hence, the loss of xenon by diffusion might be greatly facilitated. This effect would cause the calculated lower limit for $t$ to be too large.

The $^{40}A$—$^{40}K$ age reported for the Beardsley meteorite is $4 \cdot 8 \pm 0 \cdot 2 \times 10^9$ yr.[1]; thus, a lower limit of $5 \cdot 0 \times 10^9$ yr. for the time since the formation of the elements is obtained.

If the assumptions mentioned above are valid, and if the Earth and the meteorites are cogenetic, all the radioactive elements with half-lives short compared to $4 \times 10^8$ yr. would have decayed in the time interval between nucleogenesis and the formation of the Earth and would, therefore, not contribute to the heating of the primeval Earth.

We thank Prof. M. G. Inghram and Prof. H. C. Urey for several stimulating discussions. This work was performed in part under the auspices of the U.S. Atomic Energy Commission.

G. J. Wasserburg

Institute of Nuclear Studies,
University of Chicago,
Chicago, Illinois.

R. J. Hayden

Argonne National Laboratory,
Lemont, Illinois.

Feb. 18.

[1] Wasserburg, G., and Hayden, R., *Phys. Rev.*, **97**, 86 (1955).
[2] Nier, A., *Phys. Rev.*, **79**, 450 (1950).
[3] Von Fellenberg, Th., *Biochemische Z.*, **187**, 4 (1927).
[4] Katcoff, S., Schaeffer, O., and Hastings, J., *Phys. Rev.*, **82**, 688 (1951).
[5] Noddack, I., and Noddack, W., *Svensk Kem. Tid.*, **46**, 173 (1934).

## Distribution-in-Speed of Fading of 150-kc./s. Waves

A considerable amount of work has been done on the 'speed of fading' of radio waves[1-3]. This quantity, often referred to as $v_\tau$, denotes the change in the amplitude in a certain time, $\tau$, expressed as a fraction of the root mean square amplitude of the wave. The first-order theory indicates that the distribution-in-speed should be a normal one representable by:

$$p(v_\tau) = \frac{\exp(-v_\tau^2/4\varepsilon)}{\sqrt{4\pi\varepsilon}}$$

It has, however, been pointed out[4,5] that, if the lag $\tau$ used for the computation of $v_\tau$ be large, the first-order theory breaks down and the distribution assumes a form:

$$p(v_\tau) = \frac{\exp(-v_\tau^2/4\varepsilon)}{\sqrt{4\pi\varepsilon}} \varphi(\varepsilon_1 v_\tau)$$

where $\varphi$ is a monotonically decreasing function of $v_\tau$, the rate of decrease depending on the parameter $\varepsilon$. This leads to a distribution narrower than normal, which we will denote as the modified Gaussian distribution.

The value of the lag $\tau$ for which the breakdown becomes appreciable is greater the smaller the frequency of the radio wave. Hence it can be expected that the deviation from the normal form of the distribution will be evident more readily at higher frequencies than at lower frequencies.

Workers at Cambridge[2,3], using short waves, found distributions significantly narrower than normal. An extension of the analysis to lower frequencies has been made by us at the Pennsylvania State University, using the fading of 150 kc./s. waves. The slow rate of fading of these waves made it necessary for us to use much larger time lags than those used by the Cambridge School. However, no significant deviation from normality has been found. Fig. 1 indicates a typical distribution-in-speed. We have superposed the corresponding normal and modified Gaussian distributions on the histogram. It will be seen how the histogram is statistically indistinguishable from the normal. Also, the expected theoretical deviation is so small that a statistical distinction would not be possible. This seems to bear out the previous prediction that the similarity to the normal distribution would be more pronounced with long waves than with short waves.

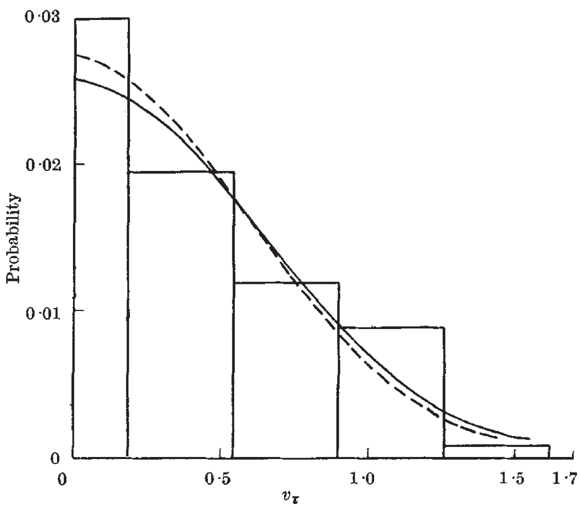


Fig. 1. Histogram for speed of fading with a lag of 20 sec. on March 8, 1952, at 0000. The normal distribution with $\varepsilon = 0 \cdot 19$ is shown superposed as a solid line. The dotted line shows the modified Gaussian distribution

This work was carried out with the support and sponsorship of the Geophysical Research Directorate of the Air Force Cambridge Research Center, Air Research and Development Command, under Contract *AF*19(122)-44.

R. B. Banerji

Ionosphere Research Laboratory,
Pennsylvania State University,
University Park, Pennsylvania.

Jan. 8.

[1] Ratcliffe, J. A., *Nature*, **162**, 9 (1947).
[2] Mitra, S. N., *Proc. Inst. Elect. Eng.*, **96**, III, 505 (1949).
[3] McNicol, R. W. E., *Proc. Inst. Elect. Eng.*, **96**, III, 366 (1949).
[4] Banerji, R. B., *Proc. Phys. Soc.*, B, **66**, 105 (1953).
[5] Banerji, R. B., Scientific Report No. 71, Ionosphere Research Laboratory, The Pennsylvania State University.