for the two counters measured 12 min. after the beginning of the irradiation for four capillary tubes corresponding to values of the time lag $\tau_2 - \tau_1$ between the counters stated in the first column.

The agreement between the experimental and calculated values for the ratio $G_1 : G_2$ is seen to be very good except for the fastest circulation, for which the calculated value depends mostly on the shorter period and on the short time-lag, the determinations of which are the least precise.

L. WERTENSTEIN.
Mirosław Kernbaum Radiological Laboratory,
Warsaw Society of Sciences,
At Turczynek, near Warsaw. Sept. 24.

[1] Hahn, O., and Strassmann, F., *Naturwiss.*, **27**, 163 (1939). Heyn F., Aten, A., and Bakker, C., NATURE, **143**, 516 and 679 (1939). Glasoe and Steigman, *Phys. Rev.*, **55**, 982 (1939).

Baade and Zwicky's Theory of Cosmic Rays, and the Helium Content of Beryls

PANETH and co-workers[1,2] have discussed the possibility that cosmic radiation may have produced the helium found in beryls by disintegration of beryllium nuclei, and they give experimental evidence that to do this the intensity would need to be at least sixty times greater. However, to reject cosmic radiation as a possible cause, on the experimental evidence, requires the assumption that, during the life-time of the beryls, the cosmic radiation has had its present intensity, whereas if the theory of Baade and Zwicky is true this is not so. These authors[3] have suggested that cosmic rays are produced at the flare-up of super-novæ. These, of which ten or so have been observed during recent years, rapidly reach a peak of brightness some 20,000 times that of the sun, lasting two or three days. During twenty-five days of maximum brightness they each emit, on the average, as much visible radiation as the sun does in 10^7 years, and after a life of a year or so they become faint stars[4]. They suggest that Tycho Brahe's nova of 1572 was a super-nova occurring in our Milky Way system. Zwicky estimates their frequency of occurrence as one per stellar system per 600 years[5]. They estimate that during its brief life a typical super-nova emits from 10^{53} to 10^{54} ergs, almost all in cosmic rays, and by averaging throughout the heavens they calculate a cosmic ray flux at the earth's surface of the same order of magnitude as the observed, namely, 3×10^{-3} ergs/cm.^{2} sec. However, they point out[3] that a super-nova occurring in the Milky Way 30,000 light years away would, for a short time, produce a cosmic ray flux at the earth some 10,000 times greater.

Evidently, if this theory is true, when considering the production of helium in beryls by cosmic rays, we must take not only the present cosmic ray flux into account, but also the average value due to one super-nova in the galaxy each 600 years. Let us assume that, in the past, super-novæ have occurred throughout the galaxy in proportion to the present density of visible stars. Then from Kapteyn's star distribution, as given by Jeans[6], I calculate the mean value of $1/D^2$, D being the distance from the earth to each super-nova, to be 4×10^{-8} (light years)$^{-2}$. An emission of 10^{54} ergs at the corresponding distance gives an energy at the earth's surface of 2×10^9 ergs/cm.^{2}, account being taken of the fact that a point on the earth can see only half the heavens. This equals the energy received in about 2×10^4 years at the present rate, so that, averaged over 600 years, the average rate of cosmic ray reception is about 35 times the present rate.

In view of the uncertainties of this type of calculation, it seems possible that the theory of Baade and Zwicky and the *experimental* data regarding the helium content of beryls are compatible. However, there is a theoretical difficulty which is pointed out by Fay, Glückauf, and Paneth[2]. The cross-section of the beryllium nucleus for disintegration by cosmic ray particles and quanta would need to be far greater than that predicted by the quantum theory either for photons or fast electrons, but as the quantum mechanics is inadequate to describe other qualities of cosmic radiation, perhaps this theoretical difficulty is not conclusive.

The suggestion that cosmic radiation has played any appreciable part in the production of biological effects, such as mutations, has also been discarded because of the small intensity. If Baade and Zwicky's theory is true, this conclusion also will need reconsideration.

JOHN READ.
Mount Vernon Hospital,
Northwood, Middlesex.

[1] Glückauf and Paneth, *Proc. Roy. Soc.*, A, **165**, 229 (1938).
[2] Fay, Glückauf, and Paneth, *Proc. Roy. Soc.*, A, **165**, 238 (1938).
[3] Baade and Zwicky, *Proc. Nat. Acad. Sci.*, **20**, 259 (1934).
[4] Baade and Zwicky, *Astrophys. J.*, **88**, 411 (1938).
[5] Zwicky, *Astrophys. J.*, **88**, 529 (1938).
[6] Jeans, "Astronomy and Cosmogony", 15 (1928 edition).

"The Relativity of Time"

PROF. H. DINGLE has put forward[1] the view that, while it is correct to deduce the "Fitzgerald contraction" of moving bodies from the Restricted Principle of Relativity, it is incorrect to deduce the slowing down of moving clocks. His main ground is that the second statement is meaningless, because a clock is not a well-defined measuring instrument. If, for example, it takes the form of a stream of equal grains of sand falling regularly in an hour-glass, the time elapsed may be measured equally well by the *number* of fallen grains, N_1, or by their total *mass*, N_2, or by their total *volume*, N_3. Since mass and volume have different transformation laws for moving axes, Prof. Dingle infers that N_1, N_2, and N_3 also have different transformation laws, some showing the retardation and others not.

If this argument is intended to show a real difference between kinds of clocks, it must mean that if two hour-glass clocks are synchronized and moving together, and if one contains a counting apparatus and the other an apparatus for finding the mass of the fallen sand, then although at any instant they show the same reading for an observer relatively at rest, they show different readings for a moving observer. This is clearly not true, if the distance between the clocks is negligible: if the two dials look the same, at any given instant, to one observer, they look the same to all, no matter what mechanism is behind them. What appears to have been overlooked is that the sand and the measuring apparatus both form part of the clock, and therefore move together: the mass involved is the rest mass, and its effect on the transformation law is *nil*. To obtain Prof. Dingle's transformation law the mass of the moving sand would have to be measured by the stationary observer, an arrangement which can scarcely be called a "clock".