increasing particle size. The size determinations (made with an optical microscope and a calibrated micrometer eyepiece) are accurate to $\pm$ 5 per cent at sizes above 5×10^{-4} cm. but below 10^{-4} cm. the error increases due to diffraction effects, and over-estimations are very probable. This may in part explain the apparent change in shape of the curves at sizes of about 10^{-4} cm. At even lower particle sizes changes in resistivity will occur and one would therefore predict changes in the shape of the curves at sizes of about 5×10^{-6} cm. The small but definite increase of the potential required for arc initiation with increase of particle size is partly to be attributed to distortion of the electric field as the particles on the cathode acquire an appreciable positive potential with respect to it.

Of special interest is the close proximity of the curves in Fig. 1 for a given powder, indicating virtually no dependence upon the metal involved (curves for tungsten cathode were similar to those shown in Fig. 1), and it therefore appears that arc initiation is dependent purely upon the electrical properties, probably the electrical strength, of poorly-conducting inclusions and surface dusts if these are present. However, the actual quantity of metal evaporated is dependent upon the thermal and electrical properties of the metal.

L. B. GRIFFITHS
P. C. L. PFEIL

Metallurgy Division,
Atomic Energy Research Establishment,
Harwell, Berkshire.
Aug. 13.

[1] Pfeil, P. C. L., and Griffiths, L. B., *Nature*, **183**, 1481 (1959).
[2] Pfeil, P. C. L., and Griffiths, L. B., *J. Nuclear Materials*, **1**, (3) (1959).

Stochastic Rectification of Non-linear Clocks

SIR JOHN CARROLL[1] has recently discussed the possibility of recovering an absolute scale of time from the observation of nuclear decay processes. The essence of the following remarks is that the owner of a non-linear clock can rectify it if he is allowed to observe the motion of a Brownian particle (in the sense of Norbert Wiener).

We define a *clock A* to be a deterministic mechanism which supplies at time t a pointer-reading $\alpha(t)$, called *apparent* time, where $\alpha(t)$ as a function of the real variable t is strictly monotonic increasing (it need not be continuous). The clock A will be called *linear* if $\alpha(t) = \lambda + \mu t$ for all t, where λ and μ are (perhaps unknown) constants. The determination of λ and μ for a linear clock is just a matter of the choice of origin and unit of time, and is not under discussion here. Now suppose that an observer possesses a clock A which, for all he knows, may be non-linear, and that he is allowed to employ it in recording the history of a particle which is known by the observer to be describing a one-dimensional Wiener motion. This is to say[2] that, if x_t is the co-ordinate of the particle at true time t, then $x_s - x_t$ (where $s > t$) has a Gaussian distribution with mean value zero and with standard deviation $\sqrt{(s-t)}$, and that the increments $x_s - x_t$, $x_u - x_v$, . . . are statistically independent whenever the corresponding intervals $(t, s]$, $(v, u]$, . . . are non-overlapping. Then the observer can construct (retrospectively) a perfect linear clock in the following way.

Let y_α be the value of x_t when $\alpha(t) = \alpha$ (if the value α falls within a 'jump' of the clock-function, then we take t to be the true time $\theta(\alpha)$ at which that jump took place, that is, we complete the 'graph' of the clock-function by drawing vertical lines at all the jumps). Suppose the observer wants to determine the interval T of true time corresponding to the apparent time-interval (0,1). He divides the apparent time-interval from $\alpha = 0$ to $\alpha = 1$ into 2^n equal sub-intervals of which the r th, say, is (α_{r-1}, α_r) $(r = 1,2, \ldots, 2^n = N)$, and observes for each r the position $x(r)$ of the particle (this will be the value of y_α when $\alpha = \alpha_r$); he then computes the sum:

$$S_n = \sum_{r=1}^{N} \left\{ x(r) - x(r-1) \right\}^2$$

Finally a theorem of P. Lévy[3] assures him that, with probability one, $S_n \to T$ when $n \to \infty$.

The proof is very simple; if $t_r = \theta(\alpha_r)$, then the points $t_1, t_2, \ldots$ must lie densely in the true time-interval $(0,T)$, and the theorem of Lévy then gives the result at once.

Any feeling that there is a paradox here can be dissipated as follows; a temporal uniformity is built into the Wiener motion, and it is the statistical independence of the successive increments of x_t which enables the observer to extract this uniformity from the history of a single particle. It would be interesting to characterize those stochastic processes which permit the reconstruction of the time-scale in this or some similar way.

DAVID G. KENDALL

Magdalen College,
Oxford.
Oct. 19.

[1] *Nature*, **184**, 260 (1959).
[2] See, for example, Paley, R. E. A. C., and Wiener, N., 'Fourier Transform in the Complex Domain' (New York, 1934), chapter 9. A distinction must of course be drawn between this mathematical construction and the path of an *actual* Brownian particle.
[3] Lévy, P., *Amer. J. Math.*, **62**, 487 (1940).

Structural Defects in Fused and Crystalline Silica

SAMPLES of fused silica (optical quality from General Electric Co.) in the form of disks about 4 cm. diameter and 0·64 cm. thick were treated with a modification of an etchant material previously used for various types of soda-lime-silica glasses[1]. In the modified solution the sodium ion was replaced by potassium. The composition of the etchant was 2·0 gm. potassium fluoride and 1·2 c.c. hydrochloric acid per 100 c.c. water. The flat surfaces of the disks were polished, and in initial etching treatments, it was observed that scratches and polishing defects were made visible. There was no evidence of flaw patterns on the polished surfaces characteristic of those found in soda-lime-silica glasses. In order to eliminate the effect of the polishing and surface treatments, the disks were split open and the fresh surfaces etched; the optimum time was about 24 hr.

The samples were broken by scratching with a diamond on one surface and tapping on the opposite side until the sample split open with a rapid break. The broken halves were placed immediately in the etchant.

A microscopic examination of these etched surfaces disclosed minute line patterns which in most cases matched exactly on the opposite fracture surfaces. Examples of typical etched surfaces on fused silica are shown in Fig. 1, A and B. The defects are the contrasting light lines extending through the fields. It may be seen that at their junction points they do not