were branches of learning of which he was not a master, or stimuli to which his mind did not respond. Asked by the King of Prussia, "What do you know?" he answered, "Everything, sire"; and to the further question, "How did you learn?", the reply was, "I taught myself". His contemporaries were duly impressed by the range of his knowledge, and if the solipsistic manner of which we are told suggests that he often knew that he was relying on a bluff which might easily be called, his portrait, which we can study for ourselves, suggests that he thoroughly enjoyed the sensation of carrying off the bluff.

An edition of Lambert's writings has now been planned on a generous scale; pure mathematics is to be followed by applied mathematics, geometrical drawing, astronomy, physics, philosophy, and logic, and the finest workmanship in Switzerland is being employed on the production. The first volume is a delight to handle and to read. It contains Fermey's *Éloge*, and papers on elementary trigonometry, on continued fractions, on the solution of equations, on rectification and quadrature, and on interpolation, introduced by Prof. Speiser in a brilliant critical commentary. The celebrated series for the power of a root of the equation $x^m + px = q$, which moved Euler to enthusiasm, is in the first paper. Lambert's first paper on the quadrature of the circle, which is well known from Rudio's reprint of 1892, is here, with its fallacies neatly exposed by the editor; the paper in which Lambert did establish the irrationality of π is to come in the next volume.

One complaint must be made. With one exception, the papers are reprinted from the collection prepared by Lambert himself (Berlin, 3 vols., 1765–72), and the references are to this edition, with no indication of the date of composition or first publication; the omission deprives us of any time-scale for the development of Lambert's ideas, and will be even more serious when we come to correlate his work in pure mathematics with his other investigations.

In conclusion, the directorate of the Schnyder von Wartensee Foundation and Dr. R. G. Bindschedler are to be applauded for meeting the costs of this undertaking. The time has perhaps gone when a wealthy patron could usefully build a telescope, or a charitable institution could found a chair, for if telescope or professorship is wanted a modern community is not slow to provide it from public funds. There are worse ways of buying a claim to be remembered in the republic of letters than the endowment of a worthy definitive edition; a bid in the grand manner has been made on behalf of the Schnyder von Wartensee Foundation, and we commend the example to puzzled decimillionaires.

E. H. NEVILLE

OSCILLATORY TIME-SERIES

Contributions to the Study of Oscillatory Time-Series

By Maurice G. Kendall. (National Institute of Economic and Social Research Occasional Papers, No. 9.) Pp. viii + 76. (Cambridge: At the University Press, 1946.) 7*s.* 6*d.* net.

THE classical approach to time-series was a search for hidden periodicities, observational error being considered the only obstacle to accurate prediction, and there is no doubt that it was the striking success of the associated methods in astronomy and tidal theory which led to the confident belief that they might be equally relevant to the study of social phenomena. Now, however, in this and many other fields one prefers to work with a quite different model, in which the time-series is generated by a linear operator supplied with a random input. (A pleasing example is the music made by a sea shell.) The resulting series, though in general oscillatory, will not be periodic, and the possibility of prediction will be severely limited by the continued occurrence of random changes in phase and amplitude.

Mr. Kendall's monograph discusses all existing methods of time-series analysis in relation to one of the simplest of these models, Yule's autoregressive scheme defined by

$$u_t + au_{t-1} + bu_{t-2} = \varepsilon_t.$$

Here u_t describes the time-series and ε_t the random input; a and b are constants and the linear operator can be found by solving the difference equation. The book contains much useful computational advice together with a new set of tables for harmonic analysis. The correlogram and periodogram analyses of four artificial series of great length supply the first empirical evidence about the relative value of these two methods, and this part of the work is sure to stimulate much further research. The labour involved in the work must have been very great, and the debt already owed to its author by the statistical world has been correspondingly increased.

Mr. Kendall's chief conclusion is that the periodogram analysis of autoregressive series is misleading and not worth the labour involved, but his case seems to me to be overstated. The greater share of condemnation really belongs not to the periodogram itself but to the classical (here inapplicable) method of interpretation. Recent work by the late Prof. P. J. Daniell[1] suggests that a *smoothed* periodogram might be of much diagnostic value, and one would like to see Mr. Kendall's sample periodograms compared with their expectation forms. Daniell also showed[1] that the *sample* periodogram and correlogram are algebraically equivalent, so that each contains exactly the same information; a very interesting consequence of his identity is that the smoothed periodogram depends mainly on the first few sample autocorrelations. Mr. Kendall's observations should also be compared with recent work by Prof. M. S. Bartlett[1] on sampling properties of the correlogram, which explains the failure to damp according to expectation when the series is of finite length.

The present debate about the best definition for the 'period' of an autoregressive series seems to me of doubtful value. What we need in practice is not a period of recurrence so much as an estimate of the time from the present boom to the next slump (and conversely). This might well be measured by the location of the principal negative minimum in the correlogram, and the ordinate there would indicate the degree to which the series was oscillatory. (Bartlett[2] has already pointed out the need for distinguishing between *oscillatory* series and those which are merely *fluctuating*—Kendall's series 2 is an example of the latter type.)

I am puzzled by equation (6·8) for the "m.d. (peaks)", because the latter expression has several possible meanings; 'mean number of peaks per unit length of series' appears to be the quantity actually determined, this being, of course, equal to the reciprocal of the given expression.

DAVID G. KENDALL

[1] Bartlett, M. S., *et al.*, *J. Roy. Statist. Soc.* (*Supp.*), **8**, 27 (1946).
[2] Kendall, M. G., *J. Roy. Statist. Soc.*, **108**, 93 (1945), especially p. 136.