is given it takes a little time to get accustomed to them. The notation, too, seems rather awkward and clumsy, especially as regards the use of subscripts. For example, expressions such as $z_{u_s u_{m+k}}$, used throughout the algebraic portion of the book, are rather frightening, especially since the three levels of type required are not always very well separated. Actuaries have a habit of festooning the four corners of a symbol with affixes and perhaps some such system could be adopted in this connexion. There are occasions where a little more practical guidance would be useful. For example, the discussion on repeated loops and degeneracy on p. 65 seems to imply that the examples of loops that have been quoted are likely occurrences, but this is not so, and for practical purposes such loops may be virtually ignored.

The book as a whole devotes rather more attention to linear programming than to the theory of games, the latter being represented by about a third of the book, and only the simpler forms of games are discussed. From the title of the book this is disappointing, and the reviewer feels that given the subject-matter included in the book the theory of games should have been put after linear programming both in the title and in the order of contents. This is, however, only a minor criticism of a very useful work which provides in a compact form some idea of the problems that can be tackled with the aid of the theory of linear programming.

P. G. M.

Statistical Method and Scientific Inference. By Sir RONALD A. FISHER, Sc.D., F.R.S.

[Pp. 175. London and Edinburgh: Oliver and Boyd, 1956. 16*s*.]

IN this book Sir Ronald Fisher sets out the basis of the reasoning underlying his two previous works—*Statistical Methods for Research Workers* and *Design of Experiments*. Many of the ideas contained in these books have been the subject of controversy, and a substantial portion of the present work is devoted to a refutation of criticisms. For a full appreciation of the book some acquaintance with past criticisms is desirable. Students beginning the study of statistics will, therefore, find the book unrewarding. On the other hand, it should prove of interest to a much wider circle of readers than professional statisticians. Indeed, any scientist who considers, at all seriously, the basic logical procedures involved in research work is likely to find it profitable to read this book.

The author starts with a description of the historical development of the study of scientific inference, with particular reference to the work of Bayes, Boole and Venn. Although the name of Laplace occurs fairly frequently in this discussion, the general impression is that the systematic study of the logic of scientific inference has been, for the most part, a British undertaking. Considerations of space may have contributed to this limitation of the historical treatment of the subject, but it is unfortunate, in view of the universal nature of the title, that the rather parochial tone thus set persists to some extent throughout the book. Within these limits, however, the book contains a most valuable discussion of statistical methods in relation to experimental work. This is, indeed, to be expected, since a considerable part of the present-day repertoire of statistical techniques derives from the author's work.

Coming to the discussion of modern ideas on scientific inference, the author soon introduces his concept of 'the fiducial argument'. This has been the subject

of much controversy, and it appears to the reviewer that Fisher's own presentation of the concept has undergone some development, possibly as a result of the controversy. However, this impression may arise from incomplete information on the premises from which Fisher has, in fact, been arguing. In the present work there occurs the sentence (on p. 44) 'In general, tests of significance are based on *hypothetical* probabilities calculated from their null hypotheses', and this does seem to provide a key to Fisher's mode of reasoning. In common with other parties to the discussion he regards probabilities as 'long-run frequencies', but there is disagreement on which 'hypothetical probabilities' should be calculated.

For example, if $\bar{x}$ and s be the mean and standard deviation in a random sample of size n from $N(\xi, \sigma)$ then (in the notation of Johnson and Tetley)

$$\sqrt{n}\,(\bar{x}-\xi)\,s^{-1} \sim t_{n-1}.$$

If this relationship be formally inverted we obtain

$$\xi \sim \bar{x}-(s/\sqrt{n})\,t_{n-1},$$

and if $\bar{x}$ and $s/\sqrt{n}$ be regarded as fixed this gives the 'fiducial distribution' of ξ. This distribution leads to probability statements about ξ which are identical with those obtained by direct probability arguments. However, Fisher would regard these probabilities as arising from a mixture of populations with σ varying according to its fiducial distribution (given s), i.e.

$$\sigma \sim \left(\frac{\sqrt{(n-1)}}{x_{n-1}}\right) s.$$

When the difference $(\xi_1-\xi_2)$ between the means of two normal populations $N(\xi_1, \sigma_1)$, $N(\xi_2, \sigma_2)$ is considered (the well-known Fisher–Behrens problem), the two modes of approach no longer lead to the same numerical answer, but, in Fisher's view, they involve no additional logical differences beyond those already implicit in the single-sample case. The only valid argument, within this framework, against Fisher would be to doubt the relevance of the particular hypothetical probabilities he chooses to calculate. Here we reach an impasse, for to many it is not clear that the hypothetical probabilities calculated by Fisher are more useful than those calculated on the assumption, for instance, that σ is constant (though we do not know its actual value).

Subsequent to the discussion of general principles, a number of specific examples of tests of significance are described. These include Student's t-test, simple regression analysis, and the Fisher–Behrens test already mentioned. The treatment of these topics is more polemic than expository in character, and is far removed from the average text-book development.

There are, finally, two chapters on Probability and Likelihood, and on the Principles of Estimation. These contain much familiar material, set out in a fresh and more concise form. The logical position here is, however, particularly confused, partly as a result of the use of concepts—in particular Consistency, Amount of Information, and Sufficiency—which have everyday meanings beyond what should be claimed for them. Nevertheless, the author makes his position as clear as could be desired; though the reader can disagree with his evident wish to put the method of maximum likelihood in a unique position.

This book will undoubtedly stimulate much discussion in statistical circles. Those who find it desirable or necessary to take part in such discussions must

certainly read this book; others cannot fail to be stimulated by it. Study of the material presented in the book will be misplaced only if the reader is so impressed by it that he imagines he has stumbled upon a universal way of thought which all should follow, though many do not, either through ignorance or blindness. This is a real danger, but one which must certainly be far from the author's intentions.

N.L.J.

Life Tables from Limited Data: A Demographic Approach. By GEORGE J. STOLNITZ.

[Pp. xii+164. Office of Population Research, Princeton University, Princeton, New Jersey, 1956. $4.00.]

THIS is one of a series of books sponsored by the Office of Population Research directed primarily to the demography of underdeveloped areas. This particular study is concerned with the methodology of mortality measurement when death registration is defective or non-existent.

The author first discusses what he calls the 'single census system', i.e. the derivation of survival factors from the relationship between successive age groups in the census (or survey) population when the births, of which these age groups are survivors, are known or can be estimated, and the population is closed, or nearly so. He then extends the study to circumstances of reality where the proportion of births surviving to specified ages is not known (otherwise the single census method would be superfluous) and have to be estimated from data relating to similar countries. The basic equation involves only ratios of proportions surviving to the same central ages at different points of time so that the error introduced is small. Nevertheless, a careful examination is made of the errors to be expected in varied situations. Ratios of births relevant to successive age groups are also involved in the basic equation, and these may be estimated from such fertility data as exist or by setting bounds to the ratio on certain assumptions, viz. (1) that it is below unity, (2) that the ratio of successive age groups in the population itself is a lower limit. The possibility of using a weighted mean of population and birth survival ratios is also considered. The author suggests several possible ways of dealing with the problem of emigration, e.g. by adding back emigrants, or deducting relevant births and restricting the life table to non-emigrants. Immigration is treated as the converse.

Throughout the book Prof. Stolnitz deals with practical data drawn from a wide range of countries and devotes much space to a careful appraisal of the potential magnitude of errors, and of various adjustments and internal checks that may be used to improve estimation. Not only is the method applied to the production of a large number of experimental tables for this purpose but in addition two original tables are produced, for the American native-white population of 1890 and the native population of Brazil in 1940. For students of demography the main interest in the book lies not so much in the methods of table construction, which are essentially simple, as in the demonstration of how useful information can be derived from inadequate demographic data by resourcefulness and skill, though in less skilled hands such data would be worthless.

B.B.