can go wrong, it will. Resolutions to do better with respect to keeping written records are, unfortunately, both as common and as fragile as new year's resolutions.

The next four chapters, 7, "Classification, Sampling, and Measurement"; 8, "The Analysis of Experimental Data"; 9, "Errors of Measurement"; and 10, "Probability, Randomness, and Logic", contain, amid a wealth of related material such as operational definitions, curve fitting, quality control, and symbolic logic, a careful exposition of the statistical point of view as applied to scientific observation, analysis, and deduction, with emphasis on the Neyman-Pearson theory and the method of confidence intervals. Not only are modern statistical methods "based on very different fundamental views from those in vogue even a decade or two ago" but it would seem that some knotty difficulties remain to be reconciled in bringing scientific practice into consonance with them.

For example: the author repeatedly and quite properly stresses the importance of avoiding personal and subconscious bias (p. 23, "often elaborate strategems must be devised to enable the observer to get the true facts recorded in his notebook"; p. 44, "the honest and enlightened investigator devises the experiment so that his own prejudices cannot influence the result. Only the naïve or dishonest claim that their own objectivity is a sufficient safeguard."). These admonitions are certainly made more difficult to follow by the requirement of statistical theory that only previously stated hypotheses may be experimentally tested; by the suggestion (p. 169) that the "analysis [of experimental data] should be carried out as soon as possible, and particularly before it becomes impossible to carry out further experiments"; and, especially, by the requirement of sequential analysis that the data be continuously analysed as they are obtained.

As the text concedes (p. 294), the requirement that "hypotheses must be stated in advance of the observations is at variance with widely used practices and has some troublesome aspects". Does this stipulation of the Neyman-Pearson theory restrict the possibility of learning something new (i.e., not thought of beforehand) from experiments? How strongly was the photoelectric equation "established" by experiments performed *before* the hypothesis was proposed? In fact, almost everyone will agree with the statement (p. 360) that "good data can easily outlast many successive theories".

These "troublesome aspects" in the attempt to squeeze the whole structure of science based on experiment and observation into the mold of existing statistical theory are perhaps symptomatic of a need for further developments. Indeed, the author expresses regret that no generally acceptable theory of scientific inference has yet been put forward and feels that a great deal remains to be done "in reducing the highly technical separate languages employed by mathematicians, philosophers, statisticians, logicians, and natural scientists to some common ground so that these groups could understand one another better".

There follow Chapter 11, "Mathematical Work", and Chapter 12, "Numerical Computations", which include, for example, brief discussions of symmetry, approximations, mathematical induction, dimensional analysis, Buckingham's π theorem, model experiments, mental arithmetic, nomographs, large and small computing machines, interpolation, and numerical methods for differentiating, integrating, and solving equations.

The last chapter, 13, "Reporting the Results of Research", reviews in ten pages the principal features of a good research report or paper. It would be useful if this chapter, or the equivalent, were read by every student beginning a research problem, and reread whenever the resolve to keep a good notebook begins to flag!

Each chapter after the first two closes with a section on notes and references; the final index seems to be unusually complete and easy to use.

It is interesting to speculate on the applicability of the principles and procedures outlined in this book to research in other fields. The pure mathematician is more concerned with the creation of concepts and the logical interrelation of ideas and less with observation and experimental data. Thus the statistical paraphernalia fall away and the strength of ideas is somehow dependent on the way they fit into a larger structure. One cannot avoid the feeling that in physics also a very essential form of research has been the creation of concepts in terms of which new laws or relations can be formulated and that the strength of a new experimental result in physics often depends on the way in which it can ultimately be related to other physical ideas as much as on the confidence intervals assigned to the particular measurements. Therefore we teach our students theoretical physics; perhaps we should, in addition, teach more statistics.

In other fields based on observation the logically connected, commonly accepted conceptual structure to which new results could be related is certainly less ramified and less developed than it is in physics and chemistry—consider, for example, the sequence: biology, medicine, psychology, sociology, political science—the statistical interpretation of data assumes progressively greater importance. Let me hasten to add that no value judgment concerning these other fields is intended: they seem so fantastically complicated that it must be next to impossible to introduce meaningful concepts sufficiently sharp for mathematical use, say, in a minimum principle or a partial differential equation.

Nevertheless, a colleague in political science has asked to borrow my copy of Professor Wilson's excellent book.

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Creep of Metals. By L. A. Rotherham. 80 pp. Institute of Physics, London, England, 1951. 15s.

The (British) Institute of Physics which "concerns itself particularly with the application of physics in industry" is publishing a series of books and booklets under the general title *Physics in Industry*. The third one in this series deals with the phenomenon of creep in metals, a phenomenon which is very important for industry and quite elusive for solid state theory. Although the various attempts to describe it range from a purely empirical approach to more speculative treatments of mobility of dislocations and of vacancies, few of these efforts seem to have found much use among engineers who usually rely on questionable extrapolation of empirical data. The present small booklet describes the rudiments of the physics of creep in metals and the author succeeds admirably in putting some order into the maze of facts and theories of various degrees of reliability. Unfortunately some important facts, such as the Rehbinder effect and other surface phenomena, are not mentioned. The eight small chapters are on the characteristics of the creep curve, crystalline flow, metallographic features of creep, grain boundary creep, transient creep, steady-state creep, tertiary creep, and development of creep-resistant alloys. No need to say that most of the subjects are barely touched upon and, as suggested by the author, the numerous original references have to be extensively read to obtain a more complete picture. It is most refreshing to see a text primarily intended for engineers in which such "revolutionary" notions as dislocations and vacancies are freely discussed. Let us hope that this very readable booklet will do its share in bridging the still appalling gap between the science and the engineering of metals.

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The Expansion of the Universe. By Paul Couderc. 231 pp. The Macmillan Company, New York, 1952. $6.00.

In this book, Paul Couderc of the Paris Observatory brings together and summarizes the various theories and the observational evidence regarding the structure of the universe. He starts with a discussion of the astronomical methods of measurement of distances of remote objects, stars, and nebulae. He reviews the astronomers' evidence about the recession of the spiral nebulae. He then describes the various geometries and discusses how the observations fit each. He compares Einstein's and De Sitter's universes, the implications of Riemannian geometry and the cosmological problem. In conclusion he presents the various expanding models, depending on the value of the cosmological constant chosen, and the residual vestiges of a hyperdense state. Although he states that he personally favors the Lemaître solution, he devotes about the same amount of space to the other solutions as well.

This reviewer found the book interesting and readable. It gives an excellent account, in language that any physicist can understand, of the various points of view that have developed and of the interesting work that has been done in recent years in this field. With the new contributions made by the 200-inch telescope now beginning to emerge, the book provides an excellent background to enable one to fit the announcements into their proper place. The book will be of interest not only to students of astronomy but also to physicists and engineers who have some acquaintance with cosmology and who wish to keep up-to-date in their familiarity with this subject.

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Vision Through the Atmosphere. By W. E. K. Middleton. 250 pp. University of Toronto Press, Canada. 1952. $8.50.

The basic problem connected with seeing through the atmosphere is "to establish usable theoretical relationships between light, eye, target and atmosphere that will permit the calculation of the visual range at any time; and to provide means of measuring the necessary parameters quickly and accurately. . . ."

The initial chapters of the book deal with photometric theory, scattering and absorption of light, and the alteration of contrast by the atmosphere. The treatment is essentially from an engineering viewpoint: the usual, confusing photometric labels are introduced, and a series of relations are stated and manipulated. However, this is compensated by the rather extensive bibliography, the numerous tables and curves, and the comprehensive coverage of the experimental literature. The data on atmospheric constituents affecting the propagation of light and the section on observations of aerosols are particularly noteworthy.

The relevant properties of the eye, the visual range of objects and sources, the colors of distant objects, and the instruments for measuring the quantities of interest are treated in following chapters. Various curves of practical interest are included. The book ends with a discussion of the special problems of the meteorologist and a statement of the problems solved by the "new visual science", and of the problems still open. The final problem is "to insure the acceptance by the public of the remarkable techniques that are even now emerging. The public concerned is one that has been 'oversold' on such non-visual aids as radar and ground control, to the extent that they are likely to underrate the importance of actual seeing".

The present volume replaces the author's *Visibility in Meteorology*, which was initially published in 1935. The style is pleasantly discursive, and often colored by the author's extensive experience in the field. At the practical level, the book will be of direct interest to all concerned with seeing through the atmosphere, particularly as it affects transportation and military tactics. The theoretician may be stimulated to attempt rigorous treatments of certain of the problems posed by the book.

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Photoelectric Tubes

Photoelectric Tubes, by A. Sommer, a slim volume in the Methuen series of monographs on physical subjects, is the second and revised edition of the book published as *Photoelectric Cells* in 1946. The changed title indi-