particularly for the view they provide of the criteria by which such books and the introductory courses are judged.

With a great deal of common ground shared by high-school and elementary-college physics, it is not unfair to group them in general discussions of the aims of such courses and the means to attain them.

If one starts with the premise that the aim of this type of physics course is to produce students who can apply neatly boxed equations to everyday life, and in this way calculate such quantities as the final temperature of a mixture of two liquids or the focal length of a lens, then the conventional texts will suffice. The usual excuse offered for this approach is that these are "useful" results, and are often assumed in more advanced studies.

Alternatively, one might start (as PSSC and some of the more enterprising college courses do) with different aims, without abjuring all of the older material. One might consider (as many do) that Ohm's law, Hooke's law, and others involve no great understanding, insight, nor appreciation of fundamental concepts before they can be applied, and this view is implicitly reinforced by the goodly market in cookbook-type collections of worked problems, some of which contain an appalling collection of gross errors in their statements. (One such book, so filled with errors that even a cursory reading will reveal the ignorance of its author, received a favourable review in this journal.)

With this second view, one considers it more important to stress the very basic concepts with a far deeper treatment than is customarily accorded them, and to build up a view of physics as a modern quantitative science which relies on experiment, deduction, analysis, and prediction. Given, in addition, a selection of those topics which are considered necessary and appropriate to the level being taught, the rest of the course is then easily filled with equally necessary preparation, and this will inevitably lead to the exclusion of many of the more familiar items of the physics menu. Some can be introduced through laboratory experiments, but most are of the type that even an average student can become familiar with by reading for himself.

It is precisely in this respect—the emphasis on important fundamentals and concepts rather than daily application—that the traditional approach and texts fall short, and in which PSSC excels; it is through a lack of comprehension of the relative importance of these areas that the PSSC-type advances are resisted. This is so clearly shown in recent new editions of older books, in which the attempts to bring the approach up to date stand isolated like Danish furniture in a Louis XV drawing room.

—M. W. F.

Telescopes. Gerard P. Kuiper and Barbara M. Middlehurst, eds. Vol. 1 of Stars and Stellar Systems, edited by G. P. Kuiper, and B. M. Middlehurst. 255 pp. U. of Chicago Press, Chicago, Ill., 1960. $8.50. *Reviewed by Otto Struve, National Radio Astronomy Observatory.*

IN his retiring address as vice president of the astronomy section of the American Association for the Advancement of Science, Ira S. Bowen stated, on December 29, 1960: "Most large telescopes in the past have required from 5 to 20 years for their design and

Newton's 2-inch reflecting telescope (shown in replica above) was the earliest ancestor of Mt. Palomar's 200-inch Hale telescope (below).

Mt. Wilson—Palomar Observatories photos

construction and have then had effective lives of a half-century or more. This means that telescopes now planned or in the design state will be used chiefly with photoelectric devices rather than with the direct-photography instrumentation typical of the last few decades. Any prediction of the properties of a device such as an image-intensifier tube that is still in the early development stage is very dangerous. However, if these telescopes now planned are to have maximum effectiveness, it behooves us to make the best guesses that we can as to these properties and as to the telescope design that will take full advantage of them." [Publ. Astron. Soc. of the Pacific **73**, 114 (1961).]

The time may be approaching when the interval consumed in building a very large ground-based optical or radio telescope, or space telescope, may exceed the active lifetime of a single experienced scientist or of a group of such scientists. Astronomers will have to realize that they are no longer living in the days of Sir W. Herschel, who built his telescope with his own hands, or even in the days of Joseph Fraunhofer who built some of the best refractors and heliometers for others, but who was able to profit from his own experiences and from those of his customers to make even better instruments. Instead, the astronomical community will have to train and develop a large group of engineers and scientists whose main interest will lie in studying all the necessary technological know-how in order to provide a later generation of astronomers with the kind of instruments they are most likely to require.

This is the first book in a series of nine entitled *Stars and Stellar Systems*. The editors describe the contents of this book as follows:

"Astronomical telescopes are of three kinds, according to their uses, and a fourth type is under rapid development. Reflectors and, to a lesser extent, refractors are used to record and analyze astronomical phenomena at optical wavelengths. Radio telescopes, of a wide variety of design and aperture, do the same at radio frequencies. Position-measuring devices obtain the basic data for a geometric and dynamic description of the universe. Each of these three classes is described in this volume in two or more chapters. Space telescopes have at present not yet attained the full development that would justify their inclusion in this reference work."

The first two chapters are devoted to the most important optical telescopes that are now in operation, the 200-inch Hale telescope, by I. S. Bowen, and the Lick Observatory's 120-inch telescope, by W. W. Baustian. The latter was probably written prior to the optical tests of the large mirror by N. U. Mayall and S. Vasilevskis [Astron. J. **65**, 304 (1960)] which gave values ranging between 0.10 and 0.17 for the Hartmann constant. The latter value is similar to that listed by Bowen for the 200-inch mirror.

A. B. Meinel's chapter on design of reflecting telescopes contains many interesting sections, such as those on mirror materials, and mirror-support systems. I. S. Bowen next discusses the use of Schmidt cameras, while R. R. McMath and O. C. Mohler deal with telescope-driving mechanisms. Problems of astrometric telescopes are treated by C. B. Watts ("The Transit Circle"), W. Markowitz ("The Photographic Zenith Tube and the Dual-Rate Moon-Position Camera"), and by A. Danjon ("The Impersonal Astrolabe"). Two chapters, by J. Stock and G. Keller, and by A. B. Meinel, are devoted to "Astronomical Seeing". J. G. Bolton wrote on radio telescopes, and F. D. Drake on radio-astronomy radiometers and their calibration. The volume concludes with a list of several hundred optical telescopes with apertures over 20 inches.

The reader will undoubtedly ask a number of pertinent questions to which the volume under review either gives no answers at all, or in some cases answers only by implication. He may, for example, wonder why Bolton was able to make a few reasonable predictions regarding the construction of future radio telescopes, while there are no such predictions in the case of ground-based optical telescopes.

Scientists who are not astronomers may ask whether there are not already enough optical telescopes with apertures in excess of 20 inches; and *if* there are too few *very* large reflectors, whether money and effort should be spent upon the construction of one telescope with an aperture of, say, 400 or 500 inches, or of several telescopes with apertures of 120 to 200 inches each.

In attempting to answer such questions, the reviewer believes that, at the present time, most of our knowledge of the universe rests upon results obtained with large ground-based optical and radio telescopes; also that the range of important problems that can be studied with such existing telescopes is enormous. Hence, it is reasonable to conclude that ground-based telescopes will continue to play an important role in astronomy for hundreds of years, and that their improvement must continue along with the development of the more spectacular types of space telescopes, or of telescopes that may some day be built on the moon.

It is much more difficult to make specific recommendations, and the reviewer is undoubtedly "sticking his neck out" in making the following proposals:

1. The construction of one very large reflector with an aperture of 400 or 500 inches can probably be justified, even now, in the light of existing technological knowledge and in the light of existing problems requiring solution.

2. The construction of special-purpose telescopes of appropriate size should be encouraged. The US Naval Observatory project for an astrometric reflector of fairly large size is a step in this direction. There should be other special-purpose telescopes, for example, one for the determination of accurate optical stellar radial velocities, one that will be treated as a precision measuring instrument devoid of many systematic and accidental errors that arise when one and the same telescope is used for many different types of observations.

Small Particle Statistics. An Account of Statistical Methods for the Investigation of Finely Divided Materials (2nd ed.). By G. Herdan, with a Guide to Experimental Design by M. L. Smith, W. H. Hardwick, and P. Connor. 418 pp. Academic Press Inc., New York, 1960. $14.50. *Reviewed by E. J. Öpik, University of Maryland.*

THE universe is built into a discontinuous assemblage of material particles, from atomic nuclei to stars. The size distribution of the nonquantized particles, or those above atomic dimensions, is a common ground for diverse disciplines, such as astronomy, geophysics, chemistry, biology, medicine, agriculture, technology of various materials, and above all physics, which encompasses all of them. Statistics provides the common instrument of representation and interpretation. Although the book does not mention meteors (which are small enough), or asteroids, planets, and stars (which, of course, are too big), and the names of only two astronomers appear in the author index of this monographic study, the reviewer finds himself here on familiar ground, with theoretical methods he has used himself, and with experimental data directly applicable to astrophysical problems. This may serve as a measure of the usefulness of the book to all those concerned with populations of particles (not necessarily small), whatever part of the universe they are interested in. Monographic literature on the subject is virtually nonexistent; Herdan's treatise thus fills an important gap and is an answer to urgent demand.

It is written with the utmost consideration for the unprepared reader, of whom little previous knowledge of mathematics is required. The formulae of statistics and their use are explained clearly and often in more detail than is necessary for workers in the exact branches of natural science. A considerable portion of the book is dedicated to giving an equivalent of an easy textbook on conventional statistics, theory of errors, and linear correlation. The mathematically, although not practically, more sophisticated notion of nonlinear correlation is, however, nowhere mentioned—a common though unfortunate practice since Pearson's time. Nature's correlations are nonlinear as a rule; the linear approximation usually works, but sometimes it may fail altogether.

Great care is also taken in describing and evaluating the absolute and relative methods of measuring and counting particle diameters: by direct microscopic measurements, by sedimentation, by permeability to liquid flow, and by optical extinction. However, in the treatment of the optical methods, the different processes of extinction by reflection, diffraction, and absorption are not considered; here the application of astrophysical theory could have helped to remove some basic uncertainties.

Consideration of meteor statistics could have enriched the subject by a new type of frequency function, without a maximum and with a monotonous increment of numbers for decreasing size, which can be schematized by a power law. This may be a more universal law of size distribution than the Gaussian or pseudo-Gaussian distributions analyzed in the book, with a diameter of maximum frequency, as is the case with terrestrial samples influenced by various natural selection factors.

The book is a unique and valuable contribution to the methodology of the study of particle sizes and their distributions and can be recommended as indispensable to all those concerned with the statistics and physical properties of particulate matter.

The Theory of Brillouin Zones and Electronic States in Crystals. By H. Jones. 268 pp. (North-Holland, Amsterdam) Interscience Publishers, Inc., New York, 1960. $9.50. *Reviewed by Nicholas Chako, Queens College.*

THIS is an extremely interesting and valuable book on the theory of electron energy states in crystals. The material is presented clearly and requires only a limited background in mathematics. It provides an account of the theory and methods which are of general validity rather than a detailed analysis of specific topics requiring long and complicated calculations. The subject matter is developed along the theory of Brillouin