BOOK REVIEWS

Physics. By the Physical Science Study Committee. 656 pp. $10.00. **PSSC Physics Teacher's Resource Book and Guide,** Part 1, ten chapters; Part 2, nine chapters; Part 3, seven chapters; part 4, eight chapters. $5.60. D. C. Heath & Co., Boston, Mass., 1960. *Reviewed by M. W. Friedlander, Washington University, St. Louis.*

As with so many things in our modern world, this book is the result of a committee effort. However, the result of *this* committee's labors is not just another compromise but a radical approach to their chosen topic—contemporary physics. Where most elementary texts daringly include a "Modern Physics" chapter at the end of an otherwise unexceptionably proper coverage of all the bric-a-brac of pre-20th century physics, here we find instead a treatment whose development follows a carefully laid-out pattern from the start. It has been customary for far too many years to start the instruction of physics with mechanics, and then to proceed on to the neatly parcelled divisions of heat, sound, light and optics, and magnetism and electricity, with perhaps a frosting of "modern physics." The relation between the various sections usually comes in a remarkable form; for instance, Joule's equivalent is presented as a revelation, and rarely as a particular example of the conservation of energy. In fact, its presentation follows the familiar pattern of the growth of physics, in which the separate areas grew independently, and the unity of the subject was but lately discovered. As each area grew, various "laws" were discovered, which permitted the calculation of the results of physical experiments with varying degıees of accuracy, and a great many fascinating natural phenomena were thus "explained". The real trouble starts with the more recent linking of these areas through a better understanding of more basic principles and the realization that these phenomena usually represent but special cases of a more interesting and profound generality. At this stage, and with never enough time in a physics course to cover everything, one is faced with the question of which topics to include, which to discuss in depth, and which to exclude. The conventional approach takes the easy way out: nothing is discussed in depth and everything is covered. The PSSC approach is the converse: selected topics are discussed in great detail, so that their foundations are exposed to a critical view and the assumptions and definitions clearly separated from the later logical development, with constant reference to experimental observation. The aim is the presentation of important modern topics, in the manner of modern physics (and this means not simply the mouthing of words like "proton" and "electron", but the demonstration of the close relation of many apparently unrelated phenomena, and the discussion of topics which are at the center of our present view of our universe: mechanics, wave motions, electricity, and atomic structure).

While the PSSC book is intended for high-school use, its clear superiority of approach over most freshman college and university texts will surely lead to wide use at this level too, although there are many parts of the material covered which a university course should present in greater detail. Thus it will probably not be satisfactory as the *sole* text at university level.

There may be points at which one might differ on the detail or mode of the presentation, but a book with this approach has been needed for so long that many of these arguments might appear to be quibbles. One will *not* find pictures of fighter aircraft, Great Lakes freighters, service-station attendants, and symphony orchestras, nor cut-away colored drawings of steam shovels, which so often enliven the pages of our conventional texts. One *will* find many diagrams and pictures, whose clarity of presentation and closeness of relation to the topic under discussion are admirable. (Even if this is not a book in which two colors are used throughout, it does not refrain from using colors where there is some point to it.) The emphasis at all times is on the essentials and an understanding of them.

Understanding and the logical extension of knowledge are the key aims, and in this the text succeeds. There are few sections which can be omitted without breaking into a carefully planned development. A remarkable feature of the book is the steady development in sophistication of approach and the subtlety with which it has been done. A teacher who was tempted to remove the section on light from between a general introduction (which includes kinematics) and the later dynamics, would then find himself in difficulties: physical ideas (for instance the use of models) are introduced and used implicitly later. With most books this is not the case; given the first section on mechanics and its introduction of various units, one can cheerfully shuffle the remaining sections and deal again. The distinction between science and technology is implicit —why should a physics course be the repository for information on the construction of high-fidelity systems or automobile gear boxes?

To turn now from general to more detailed comments, the book starts with a discussion of some very basic ideas: quantitative "explanation", reproducibility, interpolation and extrapolation, etc. This is followed by space and measurement, functions and scaling (the latter rather confused), kinematics, vectors, and then some sections on the structure of matter: elements, atoms, molecules, gases. The approach is good, but there are hidden pitfalls and also possibilities for greater clarity. Why mention non-Euclidean geometry (pp. 34, 43) without clarifying one's statements? Is it necessary to devote so much time to vectors (Chapter 6), considering how often they are later used? The idea of a physical model could be introduced with profit on p. 91, when mentioning complex motions and their analysis, and this idea could then be used with great effectiveness before its rather late introduction (p. 151). Also, it seems a pity to be content with merely a hint (p. 92) that Newtonian kinematics have limited applicability without discussing the simplest ideas of special relativity. The latter, after all, is one of the most important concepts of modern physics and is the subject of so many erroneous ideas that a simple presentation would be valuable.

Part 2 deals with optics and waves as the basis of our observations of physical effects. Perhaps its attitude towards the conventional is best illustrated by a footnote (p. 228): "We shall not give the proof of this 'lens maker's' formula here. Although no new physics is involved, the proof is a long-winded application of trigonometry and Snell's law." In all, this part of the book is splendid, but it seems a pity to interrupt the optics with a treatment of waves when many of the elementary ideas could be encompassed within the sections on kinematics. The treatment of the particle model of light seems unduly long, and its dismissal disproportionately brief.

In Part 3, there are sections on Newton's laws, gravitation, energy and momentum and their conservation, and heat and molecular motion. Again, the level is high and the penetration deep. There are some weak points: why not introduce the conservation of momentum for a single particle by $\Delta F = 0$ instead of through the use of collisions, which, although pedagogically fine, might seem strained to students? The extension of these ideas from two to three bodies is unconvincing (p. 379). It could be more strongly emphasized (p. 414) why the zero of potential energy is arbitrary.

The final Part (4), starts with electrical and magnetic topics, and proceeds to brief sections on the exploration of the atom, photons and waves, and quantum systems. Perhaps these latter sections could be expanded in a future edition? Again, a few points: Why (p. 496) should there be "no reason to assume two kinds of unit charge" (when talking of the Millikan experiment and electrolysis) when the masses of elementary particles display no such thoughtful regularity?

In a book in which the level of originality and integrity is far higher than one has come to expect at this stage, there are a few sections which must be specially mentioned as appealing to this reviewer even more than the others. Chapter 8 presents some basic ideas with great clarity. There is a good discussion in Chapter 10 of measurement and its limitations. The foundations of dynamics are laid with elegance through an operational approach which is in marked contrast to the conventionally dogmatic presentation of Newton's law. Section 22–6 (p. 352) is unusual and quite remarkable; the descriptions of Kepler and Ptolemy are both shown to be valid, but Kepler's is simpler and thus preferable, though at this stage both are descriptions and *not* explanations. The lessons which can be drawn from this brief section are legion. Finally, worth mentioning is the appropriately cavalier treatment of Ohm's law as a special case of the conduction of electricity instead of the conventional genuflection to it as one of the great truths of physics.

The PSSC course does not stop here. Reinforced with several films of great instructional value, and laboratory exercises which are pointed and do not merely result in the student appealing to a handbook for the "answer", the whole is an approach to physics teaching which is fresh and invigorating. The apparatus for the experiments, specially designed for PSSC and available commercially at very reasonable prices, is well conceived and a great asset. No more need the experimental side of introductory physics be a pointless drudgery which is often better not done. Clearly, the whole organization of the course has been thought out in minute detail, and the two manuals for teachers are mines of useful advice, besides having the problems already worked out.

The teaching schedule seems optimistically rapid, and, in practice, Part 1 seems to take longer than suggested, while in Parts 2 and 3 the schedule is easier to maintain. Perhaps Chapters 5 and 6, in particular, should be traversed rapidly, and referred to later when necessary. It seems that, in practice, these two chapters are responsible for much of the trouble.

Physics has always had the reputation for being hard. Almost certainly, the critics of the PSSC approach will point to the omission of conventional tidbits and decry the difficulty of various sections. There is no reason why physics should be easy, in the sense of presenting a set of easily memorized formulas (in boxes, in the text); there is no reason why the student should not have to put in some intellectual effort to follow a logical progression. Certainly in the initial years, when many teachers are unprepared for a course as critical as this, it will be easier to blame the course for the difficulties encountered by the students. What *can* be said with great pleasure after reviewing this offering, is that the students who are confronted with the PSSC course will at least be struggling with something of importance, and not with the outworn trivialities which can be so neatly boxed, underlined, and regurgitated. Why, in fact, should such a course be for the better students only (as has been suggested)? A course of this type might well be considered an essential basis for an understanding of the functioning of modern quantitative science.

Postscript:

Since this review was written, several others have appeared in which well-known college elementary-physics texts have been discussed. These reviews are interesting 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