formed by the regularity of the atomic arrangement." These comments sharpen the interest in Bragg's paper and underline the significance of the Stark citation.

The editors themselves are distinguished x-ray crystallographers who have made fundamental contributions in the field. Their own viewpoints would be immensely valuable to the student and of provocative interest to those who know their work. Why did these editors choose these particular papers and abstracts from so many?

Another omission in one sense more grave than the lack of commentary is the absence of any crystallographic background. To appreciate the development of x-ray diffraction theory in crystals the physicist should be aware of the work of A. Bravais and L. Sohncke, of A. Schoenflies and E. von Fedorov, and even more he should know how much knowledge or ignorance of their studies affected the early developments. The reader should be told the significance of P. Groth's presence in Munich and W. J. Pope's in Cambridge.

One of my colleagues has stated (and I agree with him) that for many physicists the solid state is cubic, the rare and atypical acknowledge the existence of hexagonal symmetry. The physicist, therefore, who reads this collection without a crystallographic introduction will be most deprived without being aware of his deprivation.

If we could have had Ewald's comments where appropriate as well as those of the editors, this collection would have been one of the most remarkable scientific treatises of our time.

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Sundials

By Frank W. Cousins
Pica Press, New York, 1970. $18.50

Managing Editor: What have you got there?

Book-Review Editor: It's a gorgeous book all about sundials.

ME: Sundials? Good grief, who needs 'em? They don't even keep good time, do they?

BRE: J. G. Porter says, in his Introduction here, that a properly made sundial, carefully set up, will give you the time accurate to the nearest minute. Is your watch as good as that? Apparently the eventual limit is set by the finite diameter of the sun's disc, which gives a slightly blurred edge to the shadow.

ME: OK, but what can there be to say about sundials that's worth 247 pages and $18.50?

BRE: Oh, there's something in here for everybody. Superb photographs of historic instruments. Quotations in prose and verse—from Ecclesiastes and Plato to T. S. Eliot and W. H. Auden. Geometrical theory of all kinds of sundials—did you know that there are horizontal dials, reclining dials, vertical dials, polar dials, equatorial and armillary dials, cross and star dials, analemmatic dials . . .

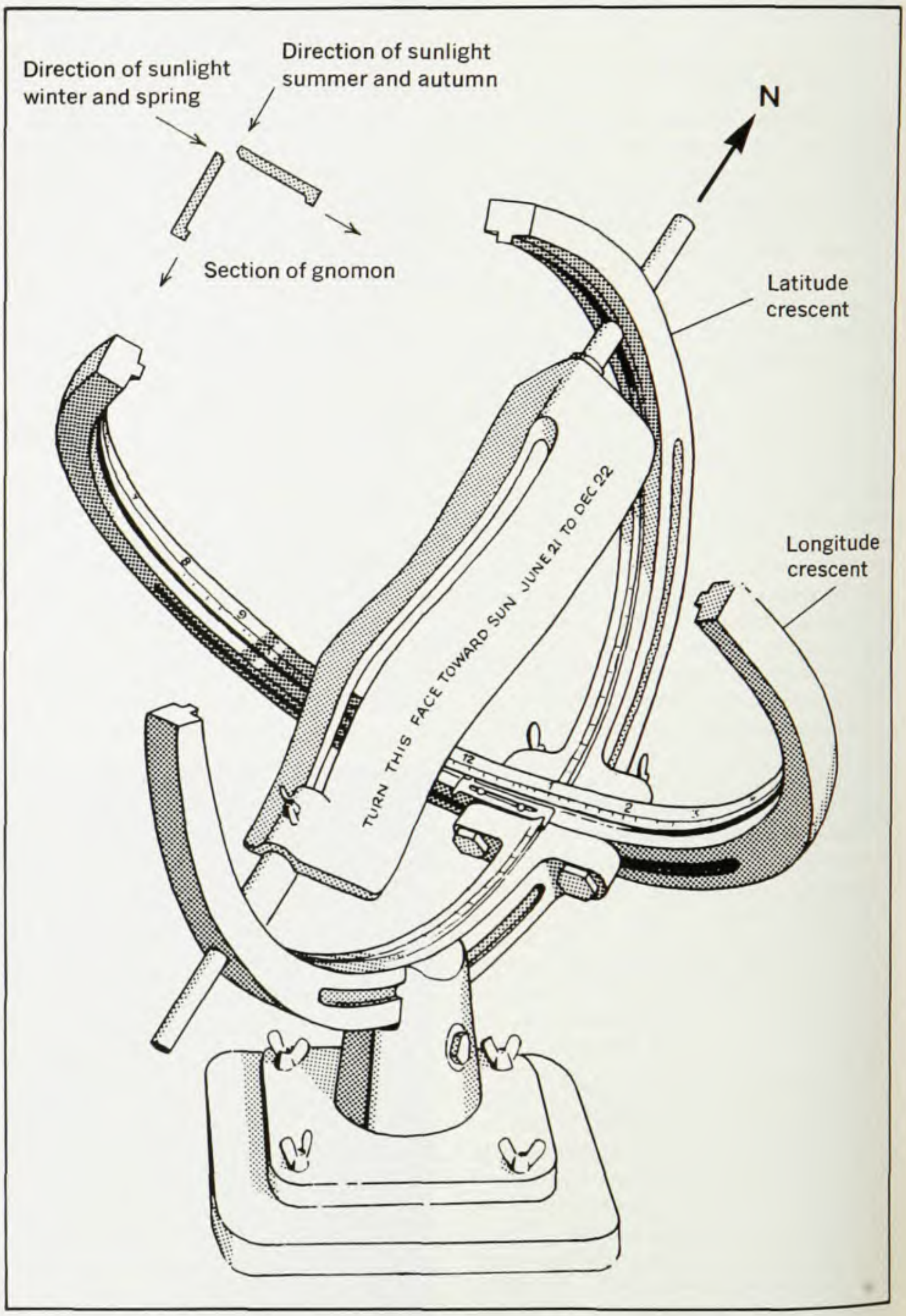
ME: Stop! Stop! But none of them are any good on a cloudy day!

BRE: He has two answers to that. One is poetic: "Horas non numero nisi serenas," which means, you unlettered scientist, "I count only the hours that are serene." Who wants to know the time on a grey day?

The other answer is more scientific. See, here is a very clever sundial invented by Sir Charles Wheatstone, which works by finding the plane of polarization of scattered sunlight. That one works even with an overcast sky.

ME: Yes, that's rather impressive. Is there nothing wrong with the book, then?

BRE: Well, Frank Cousin's writing style *is* rather rococo. It's fine for the descriptions of early instruments; many



Sundial, designed by R. L. Schmoyer in 1950. The time is read by turning gnomon for the minimum width of sunlight through the slot.

of them are rather rococo too. See here—do you know what a "potatory measure" is? I had to guess it from the context. But the style is not too clear for the geometrical and theoretical descriptive parts. Could you tell from this description, for example, how a polar dial works?

ME: (*Takes book*) Hmm. Well, I can see easily enough from the drawing, anyway. (*Browses*) These drawings are all good, aren't they? And I see there are tables of trigonometrical data you would need if you were designing a dial. And what's this fold-out chart... (*reads*) "Analemma for a horizontal dial..." I see, it's a detailed drawing of the layout of a dial that incorporates corrections for the time of year. You know, I could put a sundial like that in my backyard... (*exits, still reading*). —JTS

Universe, Earth, and Atom: The Story of Physics

By Alan E. Nourse
688 pp. Harper and Row, New York 1969. $10.00

Alan Nourse's stated aim in this book is to provide a comprehensible frame of reference for the nonscientist interested in the mysteries being probed today by physicists. In doing this he traces the line of thought that scientific thinking has followed and is still following. Therefore the frame of reference he chooses is historical, although the book never purports to be an historical treatise.

A curious but definitely nonmathematically minded person wanting to become acquainted with the things that get physicists excited can find here a book that is well written, contains almost no formulas, has several pictures and diagrams and does not condescend to the reader. Nourse has succeeded everywhere with the possible exception of conciseness. The nearly 700 pages almost overwhelm the reader who would like just to know something about why quasars quase, for example.

Even a dedicated reader will have difficulty jumping in at a given point of interest. Nourse has not been able to eliminate completely all the technical terms of physics, so his words need no further definition. What comes next definitely depends on what has preceded, so the discussion on the heart of physical matter is obtuse to the reader who has not gone through the previous 562 pages.

But these objections are minor in the light of the book's goals. Laymen of physics, if there still are any, can find the book informative and interesting.

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General Properties of Matter

By B. Brown
292 pp. Plenum, New York, 1969. $12.50

Despite some similarity in the end result, the educational process is strongly culturally dependent. B. Brown is a senior lecturer in physics at the University of Salford, Manchester, England, and his *General Properties of Matter* is intended as a concise introductory text for first-year university physics students. Even allowing for the difference in level (an entering student in Britain corresponds roughly to a midterm sophomore on a US campus), it is difficult to find any possible points of contact with an American college curriculum.

Title notwithstanding, the first half of the book constitutes a short, self-contained course on Newtonian mechanics (calculus through differential equations is assumed, but no mention is made of vectors until later). There follow chapters on surface tension (the next to longest chapter in the book), viscosity, hydrodynamics, osmosis and related phenomena, and finally the production and measurement of low pressures. Thermodynamics is not covered. The point of view is classical, mechanical and rigidly macroscopic with virtually no attempt to make contact with underlying molecular mechanisms nor to put the discussion in the larger context of "modern" physics.

Brown's clearly written exposition is enhanced by well illustrated discussion of a wide variety of classic experiments (for example, measurements of G by Boys, Heyl, von Jolly and Poynting, in addition to Cavendish) and techniques (no less than six distinct types of liquid viscometers are described). However, the physics program for which it was written is clearly quite different from the US norm, and, as a consequence, the book will appear rather stodgy and old-fashioned.

Michael Wortis
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Axiomatization of the Theory of Relativity

By Hans Reichenbach
208 pp. University of California Press, Berkeley, Calif., 1969. $7.95

This is the English translation of a curious museum piece, whose place in the history of thought may well deserve a detailed study. The foreword by Wesley C. Salmon is, alas, too apologetic. Salmon endorses Hans Reichenbach's positivism in general—philosophy can learn from physics but never teach it. And he defends Reichenbach's axiomatization: Weyl and Suppes have criticized it from the viewpoint of mathematical method, but it was written, he protests, from the viewpoint of physical method. This will not do. If positivism is correct then the present volume, as well as all that follows its wake, must be viewed as useless for physics.

In this volume Reichenbach tried to present, first, the topology of Minkowski's space occupied by light rays but no matter; second, the metrics of that space; third, the same metric when rods and clocks are introduced, and finally, general relativity. The mathematics is shoddy, and has been since somewhat improved upon. The physics is governed by various tendencies that need not always harmonize.

First, his extreme empiricism is expressed in the introduction: "The particular factual statements of the theory of relativity can be grasped by means of prerelativistic concepts; only their combinations within the conceptual system is new." This view is no longer held even by Reichenbach's colleagues and disciples. When he comes to assess the empirical basis (in the beginning of chapter 2), Reichenbach speaks of crucial experiments between the old view and the new, not of facts in isolation: These do not exist. Second, he formulates the axioms so that the intuitively acceptable and the intuitively unacceptable parts of special relativity stand out clearly: He wishes to shake those who object to relativity on intuitive grounds, especially when these are elevated to the status of philosophy—Reichenbach's pet aversion. Here he acts as a museum piece at his best.

Third, he smuggles in much general relativity to special relativity, presenting the ray of light's world line as a geodesic from the start. Although he has no refraction coefficient other than 1 in special relativity, he still calls the principle "Fermat's Axiom." This is rather laudable, because it forces a contrast between general and special relativity and shows the existence of divergence between the two. Here the accent, however, is on the claim of nondivergence in the small: The empirical basis of general relativity is not discussed at all, and, for instance, the fact that in general relativity but not in special relativity the speed of light *in vacuo* is variable is not mentioned. Fourth, Reichenbach stresses (in his final section) that a metaphysics of causality, including chiefly proper time sequence, is essential to the philosophy of space-time (hence the prominence of topology). So even the separateness of space from time in the four-manifold is stressed quite heroically and in the teeth of the whole literature on the subject. Again, one would like a contrast between this view and later works, such as Goedel's circular time cosmologies, not to mention the more recent theories