hydroballistics, with emphasis on current and recent techniques.

Two articles, "Statistical hydrodynamics in porous media," by Adrian E. Scheidegger, and "Hydraulics of wells," by Mahdi S. Hantush, are concerned with the flow of fluids through porous media. These articles are not descriptive, elementary texts but advanced treatises and decidedly mathematical expositions. Their highly mathematical flavor makes these chapters difficult to understand, but they provide valuable insight into the intricacies of groundwater flow.

It is difficult to deduce Darcy's law from the fundamental laws of hydrodynamics, such as the Navier-Stokes equations, because it is impossible to give a complete description of the geometry of the pore system of a porous medium. Scheidegger's article is concerned with an approach that faces the difficulties head on by treating various phenomena only on a statistical basis.

Hantush, in a most important contribution to the field of hydraulics of water wells, covers basic principles and fundamental equations pertaining to the steady- and unsteady-state flow of water in aquifers. Definitions and useful approximations for several functions that are commonly encountered in well problems and in other groundwater flow problems are given. Drawdown and yield formulas are presented for steady- or constant-discharge nonflowing and flowing wells and collector wells in various aquifer systems.

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## Problems in Space Science

**Unusual Environments and Human Behavior.** Physiological and psychological problems of man in space. Neal M. Burns, Randall M. Chambers, and Edwin Hendler, Eds. Free Press (Macmillan), New York, 1963. x + 438 pp. Illus. $9.95.

This introductory text, which attempts to present a concise review of current knowledge about the physiological and psychological problems that man will encounter in the space environment, is divided into two sections, (i) Overviews, and (ii) Specific Problem Areas. In the first, the authors discuss general concepts of human reactions to stress and attempt to derive objective standards of measurement. Relevant experience gained from nonspace stress situations is then presented. In the second part, the environmental stresses anticipated in space flight are treated individually. The chapters, written by 16 specialists in the field, are entitled: "The physiological effects of unusual environments"; "Psychological and psychophysiological indices of stress"; "Computer simulation of man-machine systems"; "Psychological problems of prolonged marine submergence"; "Psychophysiology of high-altitude experience"; "Isolation and sensory deprivation"; "Operator performance in acceleration environments"; "Temperature effects on operator performance"; "Weightlessness"; "Vibration"; "The effects of radiation on integrated behavior"; and "The decade ahead."

The chapter on the effects of acceleration stress on performance is of particular interest in that Chambers discusses observations on Project Mercury astronauts and others who underwent similar stress conditions in high-altitude planes and the human centrifuge. The final chapter, written by the three editors, shows balance and insight in its evaluation of needed research in the field and of the changing concepts in scientific experimentation that are reflected, or even incurred, by a program where "the comfortable cushion of scientific information that traditionally separated the scientist from the engineer" (p. 422) is not available.

The great gaps in our knowledge of the effects of stress on man are perhaps the most important single fact in any treatment of the subject. Not only are we ignorant of many of the varied responses and cumulative effects of single stresses, but also, as Hendler points out in the conclusion of his chapter, "Questions regarding the combined effects of many stresses on physical tolerance and performance capability remain largely unanswered at this time" (p. 349). Although these deficiencies are clearly drawn in the final chapter, they are not stressed in the body of the volume. Understandably, the known rather than the unknown is emphasized. However, there is an assurance, a definiteness, in the presentation of data which could mislead the unwary reader into assuming that a great deal more is known than is, in fact, the case, and which could cause him to accept as proven hypotheses that which further research may undo. The statement, in the last chapter, that "the editors and contributors view our current level of knowledge as meager when compared with all that remains to be known" (p. 419), is certainly an honest view of the situation at the present time. One might wish that this had been the first chapter.

In view of the complexity of the subject discussed, it is obviously not possible to explore all of its aspects in depth in this small volume. It seems fair to state that the authors have reviewed the topics which, with respect to the national space program, appear to be significant to manned space flight. The data that are presented are accurate and current. Extensive and excellent references at the end of each chapter will guide the reader to more detailed studies. The book should be useful, particularly to engineers and designers, as an introduction to an understanding of the techniques and findings of research on the effects of extreme environments on man and the known limits of man's tolerances.

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## Airborne Particles

**Particulate Clouds: Dusts, Smoke, and Mists.** Their physics and physical chemistry and industrial and environmental aspects. H. L. Green and W. R. Lane. Van Nostrand, Princeton, N.J., ed. 2, 1964. xxii + 471 pp. Illus. Plates. $13.50.

In our daily life we are continually in intimate contact with many forms of airborne particulate matter. The suspended particles may be smoke from industrial plants, microorganisms, dust from volcanoes or outer space, salt particles from the sea, or ice crystals. The sun that shines into our rooms shows us that we are living in a cloud of particulate matter. The bluish trails of smoke behind automobiles are nothing but a suspension of very small droplets of oil in air.

What ties together these various phenomena is the character of the particulates. They are aggregates larger than molecules, but still so small that they fall very slowly. The authors have limited themselves to particles that fall with a terminal velocity less than that of a 100-$\mu$ water droplet. Within this

range are the relatively unstable dusts at one end of the scale and suspensions of ions and nuclei at the other.

The book has not been changed radically from the first edition (1957). Some 80 pages have been added to deal with recent advances. The theoretical treatment of suspensions of particulate matter is given in the first two-thirds of the book, which is devoted to the production of particulate clouds, their optical behavior, and their coagulation, deposition, and filtration. Considerable attention is given to the movement of particles away from the sources and the physical laws that govern diffusion and turbulence.

In part 2 the reader is acquainted with some of the practical consequences of the presence of aerosols. As a rule these are rather undesirable, and our present standards of living demand that smokes, dusts, and fumes be held to a minimum. The principles of various corrective engineering methods are discussed. Brief mention of health hazards, illustrated with some well-chosen examples, completes a balanced review of the practical side of the study of particulate matter.

The authors have had theoretical and practical experience in this field, and they have imparted an enjoyable personal touch to the book.

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## History of Science

**Archimedes in the Middle Ages.** vol. 1, *The Arabo-Latin Tradition.* Marshall Clagett. University of Wisconsin Press, Madison, 1964. xxxii + 720 pp. Illus. $12.

It is mostly senseless and futile, although it is quite a common practice, to attempt to decide who was the greatest representative of some science in a given period. However, whether one considers content, technique, style, or subsequent influence, one must describe Archimedes' contribution to mathematics and mechanics in superlatives. Fortunately, the modern reader has easy access to Archimedes' extant works. The English version by Sir Thomas Heath, who not only translated the Greek text but who also rendered the cumbersome Greek technical terminology into modern mathematical symbols, is readily available at a modest price in the laudable series of Dover reprints, and a word-true translation into French by Paul Ver Eecke is once again in print. Both are based on the definitive edition of the Greek text by J. L. Heiberg. He who wishes to consult the original Greek should use the second edition, published between 1910 and 1915, for it takes advantage of Heiberg's spectacular discovery of a Byzantine manuscript, a palimpsest that contained, among much else that was valuable for establishing a good Archimedes text, most of a hitherto unknown and highly important work by Archimedes called *The Method* (it was the only Byzantine manuscript of Archimedean works to survive into modern times; unfortunately its recent fate is unknown).

From any of these editions one may grow acquainted with Archimedes' results and techniques, and even from Heath's condensed rendition one cannot help receiving a strong impression of his elegant and dramatic style. For a penetrating analysis of all aspects of the Archimedean corpus one can further turn to E. J. Dijksterhuis' *Archimedes.*

But to get an impression of Archimedes' influence on later times one must go elsewhere. His impact on the 16th and 17th centuries is reasonably well known, but not until the appearance of Marshall Clagett's book could one really begin an evaluation of the Archimedes tradition in the Middle Ages, without recourse to manuscript material. (I might mention, though, that Clagett's *The Science of Mechanics in the Middle Ages* gave a foretaste of what was to come as far as the mechanical works were concerned.) The present volume, *The Arabo-Latin Tradition,* the first of two, is a critical edition and translation of Latin texts, dating from the 12th to the 15th century, which are derived from Arabic versions of certain of Archimedes' works, principally his *On the Measurement of the Circle* and *On the Sphere and Cylinder.* The second volume will mainly be devoted to William of Moerbecke's Latin translation, of 1269, from the Greek, of the greater part of Archimedes' extant works and related texts.

Clagett gives here the result of a Herculean labor. It involved first an exhaustive search through European libraries for Archimedean manuscripts, followed by a careful classification of them into families (there are, for example, 12 distinct types of treatises on *The Measurement of the Circle* printed in the present volume). He then constructed a critical edition representative of each family, collating the Latin text with its Arabic prototype, wherever possible; and finally he translated each version into English. The Latin and English texts are printed on facing pages, with introductory passages and accompanied by a critical apparatus and full indexes.

I cannot begin to do justice in a short review to the wealth of information contained, explicitly as well as implicitly, in this volume, but I wish it to be clear that its magnitude makes my few objections and corrections dwindle in comparison.

First, there are, of necessity, some errors like the one where the title of Al-Bīrūni's treatise is given as *On Finding Sines in Circles* where one should read *Chords* for *Sines* (p. 7), as Bīrūni's Arabic and Suter's German has it; here *Chords* does not even refer to the trigonometrical chord function.

Second, on occasion the English translations look a bit awkward to a mathematical eye; thus *multiplicatio* is translated by *multiplication* where *product* would be the proper term.

Finally, I cannot quite agree with Clagett when he writes that the Arabs had "mastered the techniques that mark Archimedes' work, and in such a way as to show that they had made them their own," or when he makes similar statements about the Arabs' Western successors. I find, after an admittedly cursory investigation, that the Arab and Latin additions to Archimedes' text, far from showing a mastery of his deeply original and powerful techniques, rather fall in the tradition of the commentators such as Theon and Pappus, who, with Euclidean tools, endlessly belabored rather trivial points while nicely avoiding the real difficulties. But such a judgment may well be premature, and much good work, in the nature of a mathematical rather than a text-critical analysis, can be expected to grow out of this volume; anyone seriously interested in the history of science owes Clagett a debt of gratitude for making such work possible.

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