throughout, even if it is not always possible to agree with the author. The text is enlivened by numerous clever cartoon drawings, many involving little demons doing various humorous things in the name of the principles of quantum mechanics.

* * *

The reviewer is Hazard Professor of Physics at Brown University and is interested in the philosophy of physics.

Kinetics of liquids

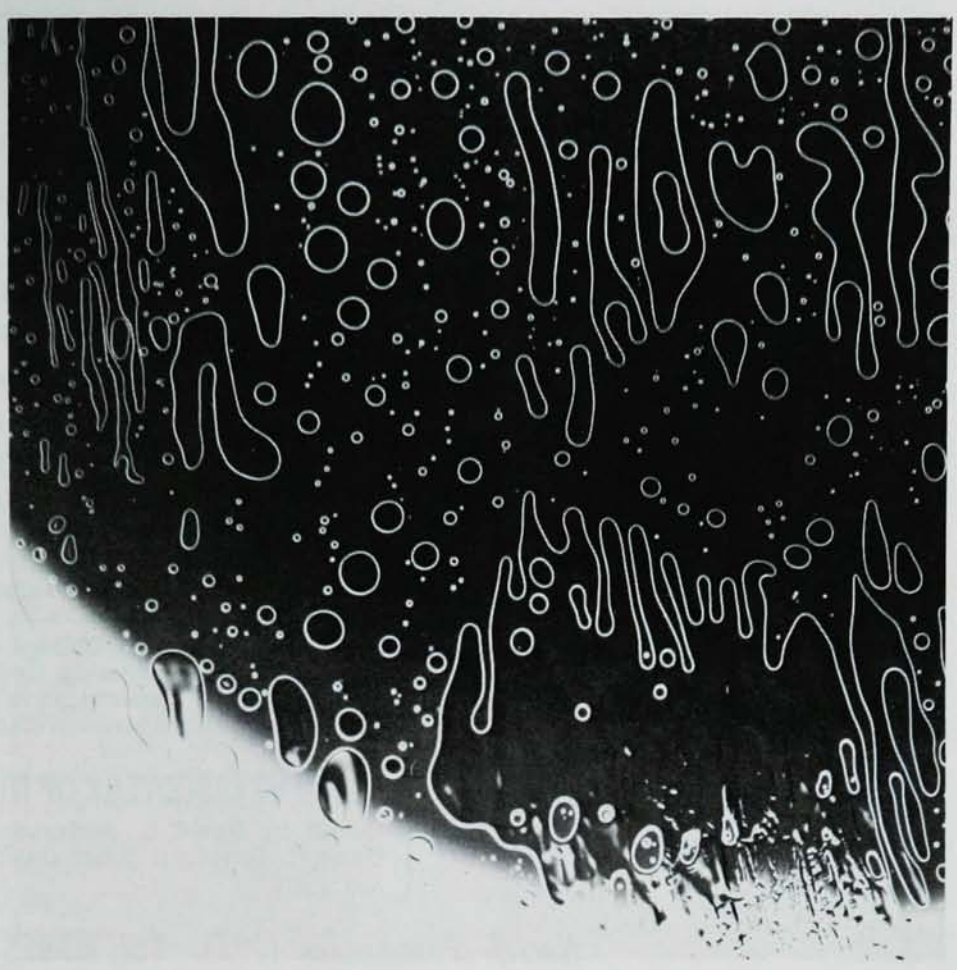
THE PHENOMENA OF FLUID MOTIONS. By Robert S. Brodkey. 737 pp. Addison-Wesley, Reading, Mass., 1967. $22.50

by LAWRENCE TALBOT

Texts on fluid mechanics make their appearance on the publishers' lists with almost predictable regularity. Authors of such texts are generally aware, sometimes to the point of self-consciousness, of their roles in the proliferation of material on the subject. They will often explain in a preface the rationale behind their entry into the lists: a new approach to the standard material, a new selection or arrangement of the material, a new projected audience and so on. Frequently such explanations are far from convincing. However, the present instance is a happy exception. The author's aim is to provide a first-year graduate text on fluid mechanics for chemical engineers, and to this end he has brought together many topics of technical importance to the chemical engineer that are not found in fluid mechanics textbooks.

The book is divided into three main sections. The first is intended to give a theoretical background to fluid flow, starting with some vector and tensor preliminaries. It then introduces the equations of change and the various flux vectors of transport theory and culminates in the derivation of the Navier–Stokes equations.

The second part of the book is devoted to the standard applications of the flow equations such as are found in most texts: inviscid flows, exact and boundary-layer solutions of the laminar-flow equations, integral methods, dimensonal analysis and one-dimensional compressible flow. These topics are treated generally in a selective and introductory fashion. Each by itself could form the subject of a complete volume (as indeed they have).



FORMATION AND MOTION of drops and bubbles. (An artist's impression reproduced on the jacket of *The Phenomena of Fluid Motions* by Robert S. Brodkey.)

The third part of the book really justifies its being. This portion, which accounts for two thirds of the volume, covers phenomenological and statistical theories of turbulence, non-Newtonian phenomena and multiphase flow. The approach is very well balanced. Theory is given where it exists, and comparisons with experiments are made. But important technical problems are not avoided simply because they are messy and not amenable to neat analysis. If the only approach is an empirical one, that approach is presented and argued through on its physical basis.

The bibliography is exhaustive and up to date. I know of no other book in which the subjects of non-Newtonian and multiphase flow are treated in as organized, clear and complete fashion as they are here. For this reason, this book will surely be of value not only for what it was intended, a graduate text for chemical engineers, but also as a source book for all engineers concerned with real-life fluid flow problems.

* * *

The reviewer is a professor of aeronautical sciences at the University of California, Berkeley.

A quasar guide

QUASI-STELLAR OBJECTS. By Geoffrey and Margaret Burbidge. 235 pp. W. H. Freeman, San Francisco, 1967. $7.50

by HONG-YEE CHIU

Eight years have passed since the discovery of quasars, but the origin and nature of these incredibly bright and bizarre objects remain a mystery. Theory after theory has been compounded to explain their existence, only to be abandoned when the next set of data came in.

In this well written book, Goeffrey

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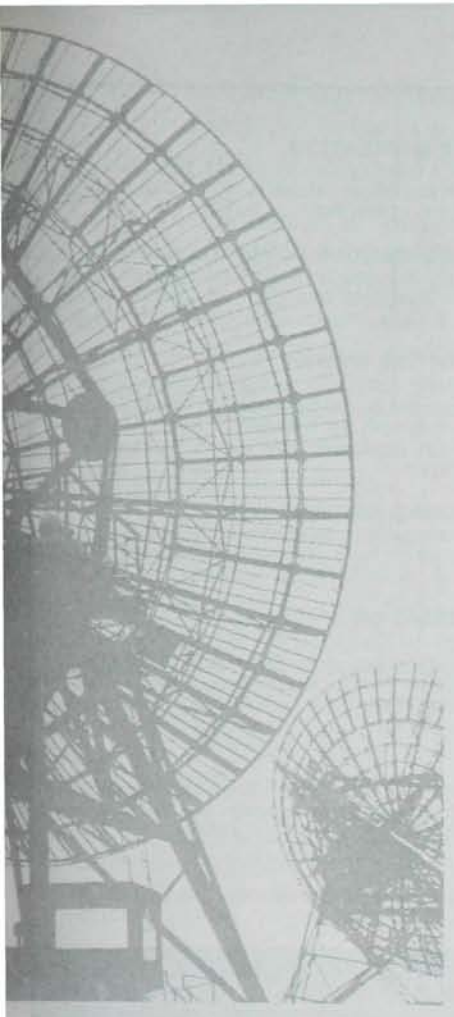

RADIO TELESCOPE at Cambridge, where Sir Martin Ryle and his colleagues catalog radio sources.

and Margaret Burbidge present a systematically classified and beautifully compiled account of the observational properties of quasars; their book could well become a classic in its field. Although one of the authors is a strong proponent of a speculation known as the "local theory of quasars," admirably those chapters devoted to observational facts contain only traces of favoritism.

The discovery of quasars came in 1961 almost by accident. The radio astronomy group at Cambridge University, under the direction of Martin Ryle, had been engaged in the cataloging of radio sources since the middle 1950's. Their aim was to provide precise locations of radio sources with the hope that they might ultimately be identified with objects visible on photographic plates made with large optical telescopes. In the 3C catalog there were a number of isolated radio sources whose positions did not coincide with any of the known supernova remnants or galaxies.

In a fruitful collaboration, radio astronomers provided their optical counterparts with the precise locations of several of those isolated radio sources that were then identified with starlike objects on plates made at the Mt Wilson and Palomar Observatories.

At first the images were thought to be stars, but, as data volleyed back and forth between England and southern California, further study showed that they were not stars, but objects of a kind hitherto unknown.

The spectra of these starlike images showed sets of emission lines that could be interpreted as highly red-shifted lines of common elements such as hydrogen, magnesium and oxygen. To date, the largest red shift found is 2.223 (PKS 0237-23) and the smallest, 0.16 (3C273).

Certain quasars also show absence of radio emission, but many quasars also show absorption as well as emission lines. Generally the red shift of the absorption lines is different from those of emission lines, and a large number of absorption-line red shifts are clustered at 1.95, for objects with emission-line red shifts ranging from 1.95 to 2.22. One quasar, PKS 0237, shows two sets of red-shift lines of 1.95 and 2.20 whereas the emission-line red shift is 2.223. Another quasar, PKS 0019-04, shows an absorption-line red shift of 1.965 although that of the emission line is only 1.955. This implies that the matter that produces these absorption lines is falling into the quasar. No explanation has been offered for this and other related peculiar phenomena.

The Burbidges present further analysis on the energy distribution from quasars, which cannot be explained in terms of any simple radiation mechanism such as black body or synchrotron. Their variability appears to be quite random and provides no insight, and their distribution in space is isotropic. These data, valuable as they are, offer little clue to the nature of quasars.

About one third of the book is devoted to theories. The authors are correct in dismissing present theories of quasars as inadequate or inapplicable. A valid question, however, still remains: Does the red shift of quasars indicate their distance or their state of motion? Those propounding cosmological distances for quasars are faced with the energy problem (and many others); those propounding local origin for quasars are faced with even more serious problems in addition to those already existing in the other case. (Caution: As the evolutionary path of physics has shown, one theory does not merit acceptance over another simply because it has fewer fundamental difficulties.)

In conclusion, I feel that the Burbidges did an excellent job. As new data piles in, this book will not only survive but will also serve as a guide for further presentations. I would compare this book with *The Realm of Nebulae*, which was also written when new data on cosmological observations were arriving at an astonishing rate. 30 years after it was published, students are still profiting by it. The basic method of research in cosmological observation has not changed, although many telescopes up to twice the size used by Edwin Hubble, in making the initial discovery, have since been built. Another 30 years from now, we can expect a student still to be profiting by reading the Burbidges' presentation of observational data on quasars in the golden 1960's.

* * *

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Beams at work

NARROW ANGLE ELECTRON GUNS AND CATHODE RAY TUBES. By Hilary Moss. 224 pp. Academic Press, New York, 1968. $11.00

by J. AROL SIMPSON

From time to time a determined worker succeeds in clearing a small patch in the thicket that grows rank on the border between science and technology. Once this area is cleared it presents no hazards for later settlers.

Hilary Moss has accomplished this task for his chosen subject by dint of almost 30 years of diligent and productive work.

The area of his clearing contains only electron guns of low total-current efficiency and convergence angles so low that lens aberrations and the small angular deflections of the beams play no role. But within this limited scope, which includes a large portion of the electron guns in current use, little now remains to be done, and we can stop worrying about this area. Moss's book is essential to anyone who needs to design a gun of these characteristics.

The book has no pretensions of