count of gravitational radiation, of the prototype black holes associated with the Schwarzschild and Kerr metrics, of the equilibrium, stability, and evolution of ordinary and super-massive stars, of relativistic star clusters, and of accretion processes in the vicinity of highly condensed objects.

Much of this material is not particularly relativistic, and when relativistic effects do come in they are usually treated as perturbations, although occasionally they are also qualitatively important. It is my impression that future developments in this subject will require a more mathematically sophisticated technique than is used by Zeldovich and Novikov. The truth of this has already been foreshadowed by the singularity theorems of Penrose and Hawking, and it seems to be substantiated in the recent work of Carter and Hawking on the final asymptotic state exterior to a collapsing system and on the efficiency with which rest-mass is converted into gravitational radiation when black holes combine. Thus although this book will remain valuable for some time to come for the physical insights it provides, the future research worker in relativistic astrophysics will probably need to supplement it with a more profound treatment of general relativity.

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Separation Technology

Synthetic Polymeric Membranes. Robert E. KESTING. McGraw-Hill, New York, 1971. xii, 308 pp., illus. $18.75.

In 1855, Adolf Fick reported the first experiments on osmosis and diffusion through artificial membranes. The membranes were cast collodion (nitrocellulose) films that separated pure water from a saturated solution of common salt. Fick observed the selectivity that is the basis of all membrane separation processes in noting that whereas appreciable osmotic transport of water occurred there was very little transport of salt. Fick's main purpose in performing this experiment was to check the theory that separation occurred by motion of the solution through fine pores —pores small enough that the salt concentration was very small within them. He concluded, on grounds that seem quite incorrect today, that this pore theory was untenable, both for these artificial and for natural membranes.

Strangely enough, the question of the existence and importance of pores in membrane transport processes is still unresolved and is one that excites violent emotions, a major reason for the controversy being that the detailed structure of membranes, both artificial and biological, is not well known by direct measurements. The past decade has seen a dramatic increase in the study of membrane transport and, most particularly, in the synthesis of new membranes for specific separatory processes. Indeed, more new types of membranes have been introduced in this time than in all of previous technology. For instance, the differential transport of salt and water studied by Fick is the basis of a process for making fresh water out of salt or brackish water. The process, reverse osmosis, is simply the forcing of salt water through a suitably selective membrane. A key technical event in its development was the discovery—by S. Loeb and S. Sourirajan—of a cellulose acetate membrane structure that gave both efficient separation and large flow. This discovery coupled with a far-reaching program of support by the Office of Saline Water of the U.S. Department of the Interior has led to an extremely broad search for new membranes and increased investigation of the relationship between structure and properties. The volume under review is the first to take full advantage of this increased effort. (A complementary encyclopedic and authoritative account of the present understanding of membrane transport is found in *Transport Phenomena in Membranes* by N. Lakshminarayanaiah, Academic Press, 1969.)

The emphasis of the present work is on the structural aspects of synthetic polymeric membranes as they relate to the properties and modes of fabrication. In order, the author treats dense membranes (films), porous membranes, phase inversion membranes, membranes formed in situ, and ion exchange membranes. The chapter on porous phase inversion membranes is the first extended account in English of this commercially important and complex technology. If the process is not rendered completely clear by this treatment, the reason lies in the fact that four volatile components concomitantly evaporate into a controlled atmosphere to leave the porous cellulose ester behind.

Another feature of the book is a large collection of scanning electron photomicrographs of various structures. Unfortunately, those that are original to the author are uniformly given with no indication of magnification.

A chapter that deals with the microscopic aspects of membrane processes is less successful than the rest of the book. Kesting emphasizes those studies that indicate a structuring of water at interfaces. Unfortunately, the collection of work cited is somewhat careless and the results are ill digested. For example, some early work by Schwan on the high-frequency dielectric properties of hemoglobin solutions is presented to demonstrate the existence and indicate the importance of bound or structured water but later work from Schwan's laboratory (*J. Phys. Chem.* **73**, 2600 [1969]) that significantly modifies his earlier conclusions is neglected. Indeed, the bound water is now thought to amount to less than a monolayer on the protein molecule.

With some reservations concerning the theoretical explanations of transport processes, this book can be recommended to those engaged in membrane research and development as well as those who wish to apply membranes with a better knowledge of their structure.

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American City Planning Since 1890. A History Commemorating the Fiftieth Anniversary of the American Institute of

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