the current state of model calculations. Such an account would very soon become out of date and would also be so complicated as to confuse most readers. The topics of rotation, mass loss and pulsation are briefly discussed, and then the final chapter considers the synthesis of the heavy elements.

The treatment throughout is suited to the needs of a competent physicist who lacks a specialist's knowledge. The author concentrates on the basic physics of stellar processes, and avoids excessive detail; the result is an admirably clear introduction to nuclear astrophysics and stellar evolution. The book was up to date at the time of writing, but inevitably there have since been important developments: The discovery of pulsars is the most obvious example. Despite this, I anticipate that the book will remain useful for a long time, and recommend it warmly as a textbook for students of stellar evolution.

* * *

The author is on the staff of the astronomy department at Manchester University, and is mainly concerned with problems in stellar rotation.

The case for space exploration

THE PROMISE OF SPACE. By Arthur C. Clarke. 325 pp. Harper and Row, New York, 1968. $8.95

by DONALD J. MONTGOMERY

"This foolish idea of shooting at the moon is an example of the absurd length to which vicious specialization will carry scientists working in thought-tight compartments." *British Association for the Advancement of Science (1926)*

"I believe this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the earth." *President Kennedy's Message to Congress (1961)*

"Tranquility Base here. The Eagle has landed." *First Message from Moon's Surface to Earth (1969)*

Do all of mankind's great adventures share this history of the space program: skepticism, commitment, achievement? If so, the space caravan is hardly the first one that has moved on despite the barking of the dogs, and our space advocates can eschew their defensiveness. Yet the space prophets must have origins more celestial than tellurian to refrain from saying "I told you so."

MGM

As a matter of fact, Arthur C. Clarke underplays his success in foreseeing such accomplishments as communications satellites and meteorological satellites—not to mention his 1959 forecast that man would land on the moon by June 1969. The purpose of *The Promise of Space* is not, however, to crow about the past; it is to stretch our imagination in speculating on the future. Clarke leads nontechnical readers through the physics of space flight without a single formula. He will surprise some technical readers about scientific material that they may not have given enough consideration. These portions are accurate and informative and show how Clarke has earned his reputation.

But what else does the book offer the technical reader? Beyond a valuable compilation of data, and the exposure of fallacies that somehow gained currency, the book offers an indictment of and an inspiration to unimaginative scientists who failed in earlier years to grasp the promise of space. For example, in 1957, the birth year of Sputnik I, what time span would have been ventured for commercial exploitation of satellites? The airplane took thirty years; yet in a mere seven years COMSAT stock was on the market.

"Beginnings—From Fantasy to Science," a mixture of entertaining history and informative physics, gets the reader over the threshhold. Then, in successive sections, we go around the earth, the moon and the universe. In each of these sections, history and physics are set forth, along with appropriate accomplishments and conjectures about the future. The book concludes with an eloquent exposition of the case for space exploration. Clarke's arguments are valid enough, but they serve more to reassure the faithful than to convert the nonbeliever; they are to a large extent esthetic if not downright emotional and are probably better phrased by editorial writers.

It is my deficiency that I am unromantic. I would base my case for support of the space program on more pedestrian arguments. The first argument answers scientific critics who are wont to complain that the money spent on the space program would be spent better on more pure research. This may be so, but a scientist—as well as any other citizen—needs to recall that most government programs are undertaken for their contribution not to his hobby but rather to a complex set of goals: security, in the form of military force or increased national prestige; health, through food production, environmental control; economic well being, through stabilization against depression and encouragement of growth; and enlightenment, with a concomitant intellectual satisfaction and a subsequent diminution of superstition and fear. In reference to space science, scientists would do well to ponder the viewpoint of Homer Newell, an educator and mathematician turned administrator of the National Aeronautics and Space Administration: "... It is the responsibility of Government to make it possible for the space program to contain the best science that the Nation is capable of, and a responsibility of the scientific community to see that such science is indeed carried out in all of our space vehicles."

The social critics remonstrate that money spent on the space program would be spent better in solving some of the pressing needs of our society. The easy answer is that the money would not be spent on these other programs anyway. This is true enough, but not very satisfying; the argument demands a more tedious reply, based on the perpetual problem of balancing consumption and investment. This point need not be labored, for throughout all history there were enough of the poor to have consumed all the resources invested in explora-

tions and expeditions, cathedrals and universities, roads and canals, books and instruments. Every society must make some investment for the future, and space exploration is certainly an exciting and promising item for investment. The difficulty in making allocations arises only because no man can foretell the future very accurately.

Nonetheless, in the desperate need to keep science and technology from alienating themselves from society, can one render some plausible connection between the potential of space science and our crying social needs? Here are two examples; the first was not anticipated, but currently attained, the second is the converse. ". . . Project Apollo developed techniques for directing the mass efforts of thousands of technical minds in a close-knit combination of government and industry. It may be possible to adapt these techniques to large social and environmental undertakings such as control of earth's complex ecological system." (*Fortune*, July 1969) The second example is "Space communications . . . may result in the disintegration of the cities and a great reduction in travel, as telecommunication and telecontrol will allow . . . men . . . to live wherever they please." (*The Promise of Space*, page 109)

The question then becomes "What portion of the nation's disposable income should be invested in the space program—civilian and military?" No man knows the proper balance point. But from Clarke's inventive mind has come this book that will entertain and inform the neutral inquirer, and that will render more difficult the task of the detractors of the space program.

* * *

The reviewer, a physicist and materials scientist at Michigan State University, spent some time in the space program.

Astronomical history

VISTAS IN ASTRONOMY, VOL. 9: NEW ASPECTS IN THE HISTORY AND PHILOSOPHY OF ASTRONOMY. (Conf. proc.) Arthur Beer, ed. (Univ. of Hamburg) 317 pp. Pergamon, New York, 1967. $22.00

VISTAS IN ASTRONOMY, VOL. 10. Arthur Beer, ed. 214 pp. Pergamon, New York, 1968. $16.00

by JOHN SUTTON

In this technological era, when historical studies are so often neglected, it is encouraging to find 1.5 books dealing with recent research into the history of astronomy.

Volume 9 of *Vistas in Astronomy* is devoted to the proceedings of a joint symposium of the International Astronomical Union and the Union Internationale d'Histoire et de Philosophie des Sciences held at Hamburg in 1964. It contains 32 contributions by scholars from 11 countries, and includes four in French and one in German. Many of the articles are concerned with the description and classification of manuscripts and astronomical devices such as sundials, astrolabes, armillary spheres and clocks. There are also studies of individual astronomers, observatories and astronomical movements in several countries, including Tibet.

The more interesting articles, particularly for the nonspecialist, are those that go beyond description and classification. For example, Owen Gingerich demonstrates with an electronic computer that Kepler's crucial calculations of the orbit of Mars would have required much less effort had he not been plagued by numerical errors.

This profusely illustrated volume is not an encyclopedia, but it does present an overall picture of research in the field, at least as it was several years ago. Although it is primarily a book for specialists, it does contain much of interest for other scientists.

The flow of history continues in volume 10. O. Neugebauer has produced a fascinating and devastating exposé of the mathematical methods of Copernicus. He shows that, contrary to popular belief, the Copernican theory of the solar system is as complicated mathematically as the Ptolemaic theory and produces no better planetary positions.

Herman Zanstra's defence of the occult world, based on his personal preferences and the poorly established phenomenon of mental telepathy, is unconvincing and rather unscientific. The republication of 24 pages of ancient star positions in Gerald Hawkins's article on astroarcheology is an unnecessary extravagance.

There is finally a return to conventional astronomy and the familiar format of this series. Of particular merit is Tibor Herczeg's thorough and systematic examination of theories of the origin of the planetary system.

Except for the objections mentioned, volume 10 is a worthwhile contribution to astronomy. Finally, radio astronomers will find it curious to note that *Vistas in Astronomy* has not contained an article on radio astronomy since volume one.

* * *

John Sutton is a research associate at the National Radio Astronomy Observatory.

Thermometry to date

PRECISION MEASUREMENT AND CALIBRATION, VOL. 2: SELECTED NBS PAPERS ON TEMPERATURE. NBS Special Publication 300. J. F. Swindells ed. 513 pp. National Bureau of Standards, Washington, DC, 1968. $4.75

by JAMES B. KELLEY

When completed this series will contain twelve volumes, of which the present one on temperature is the first despite its designation as volume 2.

It has reprints of articles on temperature measurements made at the National Bureau of Standards through June 1967. Plus, there is a bibliography of temperature-measurement articles drawn from all over the world from January 1953 to December 1965. Hence, the total impact of this volume is to put in one place the most complete reference work on temperature in the English language.

The book is divided into seven sections: expression of uncertainties, temperature scales, resistance thermometry, thermoelectric thermometry, liquid-in-glass thermometry, optical pyrometry and spectroscopic thermometry.

Without meaning to be prejudiced, I found the section in resistance thermometry the most interesting. Here, the introductory paper by H. F. Stimson is of such basic importance that it could easily be made the basis for several lectures in an undergraduate thermodynamics course. Following this paper there are "Notes to Supplement Resistance Thermometer Reports" that go into some of the details, including the calibration of a Mueller bridge.

There are also interesting papers on low-temperature resistance thermometers going down to 2.1 K. Altogether