

BOOK REVIEWS

GUIDANCE FOR APOLLO

Space Navigation, Guidance and Control

Edited by J. E. Miller. (The Advisory Group for Aerospace Research and Development of the N. Atlantic Treaty Organization. AGARDograph No. 105.) Pp. x+373. (Maidenhead: Technivision, Ltd., 1966.) \$15.50.

IN June 1965 a series of lectures on space vehicle control and guidance systems was given in Europe by members of the Massachusetts Institute of Technology, under the sponsorship of the Advisory Group for Aerospace Research and Development. This book is based on the material assembled for these lectures; the authors have all been actively engaged on the Apollo programme, and the problems of navigation, guidance and control are discussed with particular reference to this mission.

A manned lunar landing within the next few years may or may not be a laudable objective; but none can doubt the monumental nature of the task, the dimensions of which are vividly brought out in this account of the evolution of the Apollo guidance and control concepts as they now exist. The various phases of the operation—the initial injection into a near-Earth orbit, the Earth-Moon flight, the transfer to lunar orbit, the descent to the Moon's surface of the two-man "excursion module", its ascent and rendezvous with the command module which remains in lunar orbit, the return flight to Earth and re-entry through the atmosphere—present a very wide range of interacting navigational and control problems, all of which are thoroughly explored in a lucid and convincing manner.

The book follows the pattern of the lectures and is divided into seven parts. The fundamental principles of guidance and navigation are elucidated in the first part, which also discusses in some detail the characteristics of inertial instruments such as gyroscopes and accelerometers. The second part sets out the various tasks of the Apollo mission, in which the judgment and adaptability of the astronaut—in particular, his ability to recognize and evaluate patterns, and his decision-making capability in the face of the unexpected—are used to supplement, and sometimes to override, the automatic operation of the machine. Because, it is argued, men have to be carried to fulfil the mission, they should be active crew members rather than passengers.

The third part contains a simplified discussion of the numerous theoretical techniques which have been developed or proposed to ensure that the trajectories are in some sense optimal, while the following two parts of the book give a detailed account of the inertial and optical navigation sensors of the Apollo guidance and control system. On-board digital computers are treated in the sixth part, which includes a chapter on the Apollo guidance computer and a reminder that, in terms of data storage, "in to-day's guidance computer we are realizing an overall density thousands of times greater than in the computers of 15 years ago". The final part deals with the control of spacecraft attitude and of flight path during powered flight, coasting and atmospheric re-entry, again with reference to the Apollo mission.

The subject matter is of necessity drawn from a variety of disciplines in the engineering and scientific fields, and editor and authors are to be congratulated on the way in which they have managed to integrate these many topics into a readable and informative whole. The book

will be widely read, not only by guidance and control specialists, but also by those who wish to gain a deeper appreciation of the formidable yet fascinating problems involved in placing a man on the Moon with a valid return ticket to Earth.
E. G. C. BURT

LUNAR POINT OF VIEW

Kepler's Somnium

The Dream, or Posthumous Work on Lunar Astronomy. Translated with a Commentary by Edward Rosen. Pp. xxiii+255. (Madison, Milwaukee, and London: The University of Wisconsin Press, 1967.) \$8.75; 66s.

KEPLER'S *Dream* on lunar astronomy is a significant document in the development of cosmological thought. It has been overshadowed by Galileo's *Sidereal Messenger* and by Kepler's own work on planetary theory. This English translation, amounting to an impeccable critical edition, should help to redress the balance.

For Kepler himself, the imaginary voyage to the Moon was a life-long, but ill-fated voyage. The details of the journey thither came close to witchcraft, and the popular identification of the mother Fiolxhulde (the name chosen for its Icelandic barbarity) with Kepler's own mother, was an important factor in her subsequent prosecution for witchcraft. The piece itself was composed around 1609, but derived from speculations which had occupied him since 1593. These were an outline of astronomy as it would be developed by an observer on the Moon; their purpose was doubtless to be an indirect support for the Copernican theory. Some ideas on the voyage, and on biological and social aspects of lunar life, were already worked out when Kepler discovered the writing of Plutarch on the same topic. By 1609, he was well convinced of the Moon being an Earth-like planet, possessing mountains and inhabitants as well. The *Dream* itself has the unfortunate account of the voyage, an extended discussion of lunar astronomy, and a sketch of patterns of living there—all before Galileo turned his telescope to the Moon.

The "Notes" and "Geographical Appendix" (also with notes) were composed much later; and in the latter, detailed features of lunar topography are used as evidence for the presence of reason and of social organization on the moon. Galileo prudently abstained from such speculations.

This edition gives translations of the various texts (which were published together in 1634); there are copious notes and appendices on biographical and bibliographical topics. Professor Rosen's massive and meticulous scholarship will make this a standard source for many years to come. Historians of science will have their appetites whetted for closer studies of the influence of this work and of its reputation; and non-specialist readers would welcome an analysis of Kepler's lunar topography in the light of modern knowledge. But as a product of a sort of historical scholarship which is still not sufficiently developed in this field, this edition of the *Dream* deserves praise, study and emulation.
J. R. RAVETZ

GRAPHICALLY DESCRIBED

Connectivity in Graphs

By W. T. Tutte. (Mathematical Expositions, No. 15.) Pp. ix+145. (Toronto: University of Toronto Press; London: Oxford University Press, 1966.) 42s. net.

THE mathematical theory of graphs has become so extensive that an exposition in some depth of a part of the subject is welcome. Professor Tutte's book is such an exposition.

The twelve chapters in this volume (which is intended as the first of a set of three) are on topics which the author regards as related to connectivity. The choice of