Magneto-Ionic Theory. In addition, it contains a good summary of the work of the pioneers of radio propagation such as Appleton, Hartree, Booker, and others. The basic equations governing radio propagation in the ionosphere are Maxwell's equations and the equation of motion of the electrons. The problem is completely defined upon specifying the propagation vector of the incident plane electromagnetic wave, the number densities and collision frequencies as a function of altitude, the earth's magnetic field, and the boundary conditions at the interfaces and at infinity. To simplify matters, Budden confines himself to the case of single reflections only.

The plan of the book is simple and logical. After describing the model of the ionosphere and giving the basic equations, Budden devotes entire chapters to propagation in a homogeneous, isotropic medium, properties of the Appleton-Hartree formula, definition of the reflection and transmission coefficients, reflection at a sharp boundary, slowly varying media (the WKB solutions), ray theory for vertical and oblique incidence when the earth's magnetic field is neglected and when it is included, the general problem of ray tracing, the Airy integral function and the Stokes phenomenon, various electron-density profiles when the earth's magnetic field is neglected, coupled wave-equations, the phase-integral method, full-wave solutions when the earth's magnetic field is included, and numerical methods of finding reflection coefficients and reciprocity.

On the whole, the presentation is lucid and to the point. There are numerous diagrams and graphs, and the book is remarkably free of misprints and errors. This reviewer would have been happier if less space had been devoted to the high-frequency case when the properties of the ionosphere vary slightly in one wavelength, and more space had been devoted to the low-frequency case (below 500 kc/sec) when the geometrical-optics approximation is invalid. As regards notation, Budden should have made a more strenuous effort to restrict himself to conventional and easy-to-write-and-say symbols. The Fraktur which he uses is particularly unsatisfactory from this point of view. Finally, the value of this book as a textbook would have been immeasurably greater if Budden had included problems.

The Rotation of the Earth. A Geophysical Discussion. By Walter H. Munk and Gordon J. F. Macdonald. 323 pp. Cambridge U. Press, New York, 1960. $13.50. *Reviewed by E. J. Öpik, University of Maryland.*

THE small variations in the elements of the Earth's rotation depend on the properties of the materials on our planet, their displacements and interaction with external agents, chiefly the tidal forces of the Sun and Moon. The study of these variations may serve as a clue to the hidden causes and unknown conditions: the elasticity, strength, and plasticity of the Earth's materials; the redistribution of matter over the Earth's surface due to meteorological, climatic, and tectonic agents; in particular, the problems of polar wandering and continental drift; all these are discussed in the book.

The monograph is principally concerned with these small, or slow variations in the position of the axis of rotation relative to a rotating coordinate system attached to the surface of the Earth, as well as with the changes in the rate of rotation depending on the moment of inertia and tidal friction. Except for the tides, these variations can be induced by purely internal forces.

On the other hand, with respect to an inertial frame of coordinates ("fixed" stars), the axis of rotation maintains a position unaffected by internal forces, although it may change its position relative to the solid surface of the Earth; its luni-solar precession and nutation are caused by external forces and, being well understood, are not considered in the book, which exclusively deals with the more problematic aspects of rotation. It describes the modern status of those problems which in most cases remain unsolved; it is thus a compendium of what has been done in the field, including research by the authors themselves, and may serve as stimulus and basis for further research. A few definite conclusions are reached, but most of the problems are left open.

A hard core of mathematical theory of wobble and rotation is followed by a detailed account of the various observational problems and their interpretations: short-term variations of latitude and the length of the day; the Chandler wobble of the Earth's axis; the long-term or "historical" variations in the length of the day, with an analysis of causes—the dissipation of tidal energy, the acceleration by atmospheric tides, a

Sun, moon, and stars—clues to the earth's rotational behavior. Woodcut by Hans Holbein, the younger.

possible participation of the Earth's core; the geological variations as supported or contradicted by paleomagnetic, paleontological or paleoclimatic evidence. A bibliography containing over 300 titles is appended.

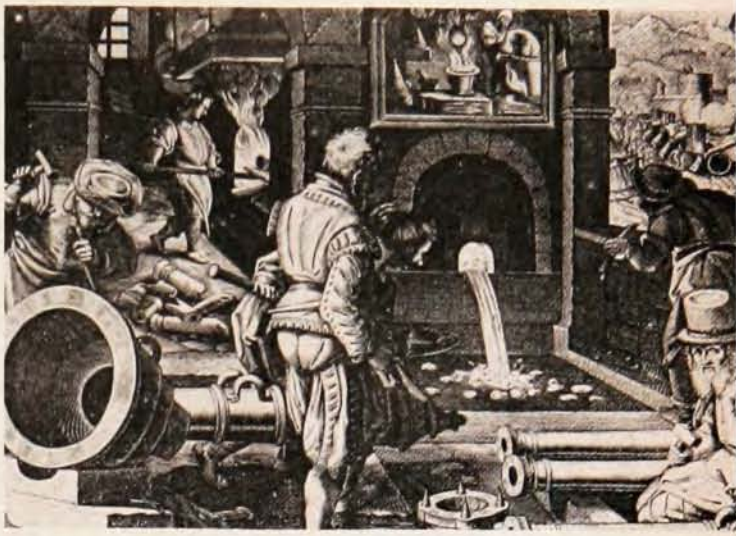
With all its valuable contents, the book is not an easy morsel to swallow. Little effort is made toward relieving the reader's task. The brevity of style and notations renders reading difficult and time-consuming, especially in the case of omissions [e.g., on p. 13, the author omits to say that equation (3.3.1) applies only to points on the axis of rotation]. The book is a manual for specialists, research workers in the same or adjacent fields, for whom a wealth of material and ideas is in store; it is less suited to the needs of the general scientific reader.

There are a few disturbing slips. Thus, on p. 5, in the first three lines of the text proper of the book, it is erroneously stated that "with a camera pointing vertically upward . . . the star trails appear as portions of concentric circles"; actually, except on the poles, the trails are portions of any non-concentric conical sections except circles. On p. 222, second line after equation (11.9.1), for σ twice the correct value is quoted; however, in the following equation, the energy contributed to the Earth's rotation by the solar atmospheric tide is evidently calculated with the correct value of σ.

The merits of the book greatly outweigh its shortcomings, as can be inferred also from its being the recipient of the Monograph Prize of the American Academy of Arts and Sciences for 1959 in the field of physical and biological sciences. It can be rated as an indispensable manual not only for those working in the very specialized field of the Earth's variable rotation, but also for the much wider circle of those concerned with its geophysical, geological, paleoclimatic, and cosmogonical implications.

A Short History of Technology: From the Earliest Times to A.D. 1900. By T. K. Derry and Trevor I. Williams. 782 pp. Oxford U. Press, New York, 1961. $8.50. *Reviewed by R. Bruce Lindsay, Brown University.*

ALTHOUGH scientists are at pains to point out that science and technology are two different things, and although this fact is worthy of emphasis, it remains true that the relations between these two disciplines have grown closer with the years and at the present time are of overwhelming importance for mankind. Hence, all who are interested in science will examine with pleasure the history of the development of technology in the volume under review. The authors explain in the preface that their book is a sequel to the monumental five-volume *History of Technology* by Charles Singer, E. J. Holmyard, A. R. Hall, and T. I. Williams (Clarendon Press, Oxford, 1954–58). It is, however, not just a digest or summary of the larger work but an entirely new approach, in which an effort has been made to relate the evolution of technological processes to the general historical background. On the whole this program has been carried out successfully, though the emphasis is still largely on the methodical description of inventions, the way they worked, and how they were applied.



History and technology in the making—a 16th century cannon foundry
The Bettmann Archive

The treatment is in part chronological, in part topical. Thus, Part 1 discusses developments from the earliest times to A.D. 1750, and Part 2 is devoted to the period from the industrial revolution to A.D. 1900. Each part is prefaced by a general historical survey of the period from the standpoint of relations between industry and technology and the general life of the times. This is followed by chapters describing particular branches of technology, such as, in Part 1, the production of food, the extraction and working of metals, transport, communication, chemical industry, etc., and in Part 2, the steam engine, building construction, textiles, the internal combustion engine, and the electrical industry.

The text is very readable and is profusely illustrated by 353 figures, most of them from contemporary sources. There are also 35 pages of chronological tables comparing technological developments in different regions and relating them to general history. There is a satisfactory bibliography, as well as excellent subject matter and name indexes, which make the book handy for ready reference.

The only adverse criticism a scientist might make is the relative paucity of reference to the relations between technology and science. It is recognized, however, that this is an enormous subject in itself and adequate treatment of it would have been difficult in a book of this compass. Moreover, the most striking illustrations of the mutual influence in question have, of course, come in the twentieth century, which is not covered by the present work. The challenge to cope with this whole question still remains.