istic of the stars which was observed, the brightness, merited only a brief paragraph in the text-books. Attention was directed almost entirely to problems of spherical astronomy and dynamics. In contrast the great majority of modern books and papers deal with problems in astrophysics, stellar statistics or stellar dynamics. The newer topics receive this attention because they promise more rapid progress and the application of many new branches of knowledge. The older problems of position astronomy are no less important to-day than formerly. In fact, they are even more important, since through them are defined the fundamental reference systems used in many of the other analyses. As a result of this change of interest very few modern books on spherical astronomy are published and it is a pleasure to call attention to an excellent discussion of this field.

The second edition of Dr. W. M. Smart's text "Spherical Astronomy" is nearly identical with the first. In addition to the standard topics of spherical astronomy discussions are included of planetary motions, heliographic coordinates, star positions by photography, binary star orbits and occultations and eclipses. These additional chapters are of especial value, for the topics covered have seldom been discussed in texts or at best only partially considered. As in the first edition numerous clear illustrations are found throughout the book. A few errors in the text have been corrected, and three new appendices have been added. These treat the "Method of Dependences," "Stellar Magnitudes" and the "Coelostat." The first and third of these appendices are satisfactory, although some comment upon the relative accuracy of the "Method of Dependences," and the standard form of reduction could have been added with profit. The brief appendix on "Stellar Magnitudes" seems unnecessary in as much as magnitudes are not discussed anywhere in the text. It is unfortunate that the orbital elements of Pluto listed in Appendix C were not revised, for more precise orbits have been derived since 1931.

"Spherical Astronomy" deals only with the mathematical solutions of various problems. No attempt has been made to evaluate the relative advantages of the different solutions presented. Thus the author avoids controversy, but the reader is forced to rely upon some other source for aid in discrimination. This situation could have been partially remedied by more complete references to the original papers from which some of the analyses were drawn. The relations between the specific problems and the general problems of fundamental astronomy are not considered, and wisely so, for the book is designed as a text of working methods, not as an essay on problems in astronomy. For these reasons the book should be studied in the classroom or by students who have some general knowledge of the problems considered.

As a concise discussion of the solution of various problems in spherical astronomy Dr. Smart's book has no superior. It should be in the library of every serious student of astronomy, whether beginner or professor.

FLETCHER WATSON, JR.
HARVARD OBSERVATORY

SEISMOLOGY

Introduction to Theoretical Seismology, Part I, *Geodynamics.* By J. B. MACELWANE, S.J. New York. Wiley, 1936. x + 366 pages. $6.00.

SEISMOLOGY — the science of earthquakes — has grown out of its infancy in this country during the last decade or so. The graduation is fittingly marked by the publication of the first considerable text- and reference book on the subject in English.

The author has spared no pains to write a full and elementary account of the subjects treated. The classical theory of waves in an elastic solid is well presented in the first five chapters. Chapter VI, written by F. W. Sohon, S.J., treats the elements of the theory briefly by the methods of vector analysis. Chapter VII contains a beautifully written discussion of the methods of Zöppritz and Knott on the energy relations involved in the reflection and refraction of elastic waves.

The first part of Chapter VIII is not quite so clear. The effort to give an elementary account of the integral equation has involved the introduction of so much notation that the essentials of the theory are somewhat concealed, so that, for example, the equation of the Volterra type is spoken of as a Fredholm equation. The treatment is of course correct, nevertheless, although some improvement in detail could be effected, such as the abandonment of Simpson's rule in favor of better methods of quadrature. The later parts of this chapter present a summary of the important results on the interior of the earth which have been obtained in recent years by Macelwane and his co-workers. The schematic section of the earth as obtained by Dahm, pictured on page 227, is most interesting, and illustrates the rapid changes that are taking place in our conception of the interior of the earth.

The last three chapters treat the interpretation of seismograms, the determination of epicenters, and the problems of depth of focus. These chapters and the tables and curves will be very helpful to the practical seismologist, who still meets many puzzles in the task of unraveling the complex messages on his seismograms.

The theory of seismic waves is not an easy subject, and a very effective effort has been made to bring it within the reach of students who are unacquainted with mathematics beyond the calculus. But such students are not yet properly prepared to enter a subject like theoretical seismology. By presuming on a little more acquaintance with the powerful mathematical tools that are available the author could have greatly shortened and simplified the treatment of elastic waves. For example, the set of equations at the top of page 30 would be replaced by the shorter and easier statement that the matrix A is a diagonal transform of X by the orthogonal matrix l, and the reductions in Sections 68 and 69, which must appear very fortuitous to the student, would be presented as an application of a general theorem on the decomposition of a vector field into solenoidal and irrotational components. There would then be space for such topics as the work of Uller, Sezawa, and others on seismic waves, the method of Pekeris, a comparison of the travel-time curves of Jeffreys, Wadati, Gutenberg and Richter, and Macelwane, and a study of the earth's core, for which no satisfactory theory has yet been given. A discussion of these subjects written in as clear a style as the rest of the book would be most welcome to workers in seismology.

ARCHIE BLAKE

U. S. COAST AND GEODETIC SURVEY

THE NATIONAL ACADEMY OF SCIENCES

ABSTRACTS OF PAPERS[1]

Measurement of solar radiation from high altitude sounding balloons: BRIAN O'BRIEN, L. T. STEADMAN and H. S. STEWART, JR., introduced by Charles G. Abbot. Light received by a crushed quartz diffuser, with circular entrance aperture lying in horizontal plane when instrument is suspended at rest, reaches vacuum photocell mounted beneath diffuser with filter selecting desired spectral region. Identical area of photocell surface is illuminated irrespective of angle of incidence of solar beam. Photocurrent discharges condenser which on recharge causes radio transmitter to emit short dash. Frequency of dashes is proportional to light incident upon photocell. If instrument is suspended at rest with Sun at zenith angle z, the light intensity incident upon photocell is $I_h = k\ I_o \cos z$ where $I_o \equiv$ intensity of incident solar beam and $k \equiv$ instrument constant. An instrument suspended from a rising balloon swings as a conical pendulum of varying amplitude and ellipticity. For circular motion at half angle α the average intensity received by the photocell through one complete swing is $I = k\ I_o \cos z \cos \alpha$, the instantaneous values varying from $k\ I_o \cos (z-\alpha)$ to $k\ I_o \cos (z+\alpha)$. Since ten or more radio signals are transmitted during one complete swing and interval between any pair provides measure of intensity these yield directly the amplitude of swing and permit calculation of I_o from observed values of I.

Test flights made above 20 km exhibit good radio performance to 80 km distance. Instrument swing observed by telescope agrees with amplitude determined from radio signals. Complete unit weighs 1 kilogram including batteries for three hours operation. Laboratory tests indicate response is reproducible to one part in 200. Circuit is self-compensating for fluctuation in battery potential. It is hoped that a precision in radiation measurement of the order of 1 per cent. may be maintained on an absolute scale, but further refinements are needed before this can be assured.

Regulation of heat loss from the human body: JAMES D. HARDY and EUGENE F. DU BOIS. Experiments have been performed on two normal men to study the regulation of body heat loss when exposed nude to environments ranging from 22° C. (72° F.) to 35° C. (96° F.). In the temperature range from 30° C. (87° F.), to 32° C. (91° F.) the body eliminated a minimum amount of heat, and this was equal to the basal heat production. Beyond the range of this neutral zone, either in hotter or colder environments, the heat elimination from the body increased. In atmospheres of 32° C. or higher the skin temperature changed but slightly and regulation of body temperature was brought about by increased vasodilatation and sweating. The mechanism in this range is so sensitive that a 2° C. (3.6° F.) change in environmental temperature will increase the sweating about 50 per cent. and the peripheral blood flow about 20 per cent. The effect of forced air currents from an electric fan were studied. In the temperature range from 28° C. to 30° C. the increased convection caused considerable loss of heat and fall of skin temperature. At 32° C. (91° F.) the turning on of the fan caused an immediate but temporary slight fall in the skin temperature. The cooling effect of an electric fan at these summer-like temperatures lasts only a few minutes. Automatic regulation of body heat loss is effective down to 29° C., which is the low temperature portion of the neutral zone. At this point the thermal gradient, the difference between the skin and surroundings, is 4.7° C., and this is the maximum gradient at which the body can maintain its temperature. Thus as the environmental temperature is dropped the skin should cool in such a manner as to keep this gradient constant, if body heat is to be preserved. Actually the skin drops at only half the rate of the environmental temperature, and the heat from the body is not preserved. The question arises as to whether this cooling of the skin is the result of some physiological reaction of the body (even though incomplete) or of the fall in environmental temperature. As has been presented by Hardy, the conductance of the peripheral tissues in this range is constant, so that there is no evidence of significant physiological reaction. The drop in surface temperature is due to the fall in environmental temperature just as in the case of any warm inanimate object. The body cools until some mechanism, as yet undetermined, causes the onset of a chill. The muscular activity thus brought about causes a large rise

[1] Continued from the issue of SCIENCE for November 5.