now is a single entity more than it ever was before, perhaps more so than the casual reader will realize from von Laue's book. The reader who may wish to ponder on the interrelation of the various disciplines would derive much assistance from a chronological listing of the most important landmarks in the history of our science.

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ELECTRON-TUBE CIRCUITS. By Samuel Seely. 529 pp. McGraw-Hill Book Company, New York, 1950. $6.00.

A MANUAL OF ELECTRICAL MEASUREMENTS. By Robert Quinly Gregg, Harry Emmons Hammond, and Robert Hartwig Frost. Addison-Wesley Press, Inc., Cambridge, Massachusetts, 1950. $2.50.

Journal notes

Polarization

The ionosphere is a region of charged particles above the earth which owes its existence to ionization of atmospheric gases by ultraviolet radiation from the sun. Knowledge of the structure and characteristics of the ionosphere is necessary for predicting its effect on radiowave propagation. Much information can be obtained by observing the echo reflected from the region when a strong pulse of radio frequency energy is directed toward it from the ground. Because the earth's magnetic field renders the medium doubly refracting to radio waves, the reflected wave usually is elliptically polarized. An instrument has been developed capable of measuring precisely the orientation and dimensions of the polarization ellipse.

The 1.5 megawatt transmitter with which the polarimeter is used emits a 150 microsecond pulse of radio frequency energy every 0.64 second on a carrier frequency of 150 kilocycles per second. The downcoming elliptical echo is resolved into two quadrature components by crossed loop antennas. The components are amplified with equal gains and phase shifts by two identical, broadband, superheterodyne receivers, and then connected to an oscilloscope which displays the original ellipse. The direction of rotation of the ellipse is determined by shifting the phase of one receiver output 90 degrees, and using this signal to turn off the oscilloscope intensity on every half cycle. The resulting Lissajous figure reveals the direction of rotation.

The observations are recorded photographically at a rate of one every 3 to 5 seconds, and the film is scaled for the ratio of axes, the angle of tilt, and the direction of rotation.

Measurements on the electric vector indicate that the polarization is, in general, elliptical with the major axis of the ellipse tilted east of magnetic north, and that only left-handed polarization is present which corresponds to the ordinary ray in the Northern Hemisphere. These results check well with simple ray theory. H.J.N.

A Polarimeter for the Study of Low Frequency Echoes. By A. H. Benner and H. J. Nearhoof. *Rev. Sci. Inst. 21: 830, October, 1950.*

Conductivity of an Electron-Proton Gas

Previous detailed analyses of conductivity in gases, developed by Enskog, Chapman, and others usually involve the tacit assumption that each collision between two molecules involves a large change in their velocities, either in magnitude or direction. In a gas consisting entirely of protons and electrons this assumption is not realistic. The velocity of a single electron changes frequently by relatively small amounts, with each change produced by a relatively distant encounter with another electron or with a proton. The cumulative effect of these small velocity changes gradually produces large changes in the velocity of an electron. Thus the position of an electron in velocity space changes in the same way that the physical position of a particle changes in Brownian motion, where the cumulative effect of many small displacements is also relevant. The differential equations developed to describe the effect of Brownian motion on the spatial distribution of a set of particles may be applied directly to describe the effect of collisions on the velocity distribution function of the electrons.

Use of this approach yields an integro-differential equation for the velocity distribution function. A precise solution of this equation has been obtained numerically by rather involved methods, although one term which could not be evaluated was neglected in this first investigation. The results give a more realistic picture of the velocity distribution function than any obtained hitherto, though the final conductivity does not differ greatly from that found in earlier, more approximate work. L.S., JR.

The Electrical Conductivity of an Ionized Gas. By R. S. Cohen, L. Spitzer, Jr., and P. McR. Routly. *Phys. Rev. 80: 230, October 15, 1950.*

Binocular Visual Space

Helmholtz discovered that vertical threads which to an observer appear to lie in a frontal parallel plane lie actually in a curved surface. This important experiment shows that physical space is measurably different from the subjective or visual space. Similarly, Hillebrand's alley experiment, in which vertical threads are arranged to give the impression of an alley formed by parallel walls, shows that the visual sensation differs from its physical counterpart. In recent years, Ames of Hanover, N. H. devised numerous ingenious experiments which show strikingly the lack of close correspondence generally assumed to exist between the physical and the visual spaces.

Theoretically the question was, "Is it possible to find the general relation between the physical space and the visual space? Is it possible to find the measuring rod, so to speak, which would determine the geometric characteristics of an individual's visual space?"

A distinguished attempt to establish this "metric" is presented in Luneburg's paper. He finds that the geometry of the visual space is non-Euclidean and shows this theory to be in agreement with the observations of Helmholtz, Hillebrand, and Ames.

Luneburg's metric involves two individual constant elements for the determination of which he outlines experimental procedures. If shown to be significantly correlated, these constant elements should reveal the differences existing in the size and distance judgment of different individuals and possibly have predictive value regarding success and failure in certain special tasks.

Luneburg's paper has been published posthumously by the Knapp Memorial Laboratory where these possibilities are being explored experimentally. PAUL BOEDER

The Metric of Binocular Visual Space. By R. K. Luneburg. *J. Opt. Soc. Am. 40: 627, October, 1950.*

Scattering Theory

Because high energy electrons have become available fairly recently, the scattering theory of the Dirac equation has been only slightly developed. For the most part the theory already developed for the nonrelativistic Schroedinger equation can be carried over. One important difference was noted: the Born approximation did not yield correct results in the scattering from heavy nuclei even at very high energies.

The difference between the relativistic and nonrelativistic theories may be understood quite simply in the following way. In the nonrelativistic case, as the energy increases, the speed also increases and the particle spends less time near the scatterer. Thus, for very high energies, the wave function is almost that of a free particle and the Born approximation is valid. In the relativistic case, increasing the energy cannot increase the speed beyond the speed of light, and the time spent near the scatterer does not become increasingly smaller. Thus, if the potential is sufficiently strong, the wave function may differ appreciably from that of a free particle even at high energies.

In this paper the validity of the Born approximation is analyzed through the behaviour of the phase shifts at high energies. It is found that the phase shifts do not approach zero at high energies but approach a definite value for which a simple formula is given. The Born approximation does not yield the correct asymptotic form of the phase shifts for strong potentials. This allows us to establish a criterion as to when a potential may be considered weak.

The remainder of the paper is devoted to a number of approximate formulae for calculating phase shifts. G.P.

The Scattering Theory of the Dirac Equation. By G. Parzen. *Phys. Rev. 80: 261, October 15, 1950.*

Sound Scattering

The nonspecular or scattered reflection of sound by certain surfaces composed of planar distributions of either semicylindrical or hemispherical bosses small compared to wavelength ("scattering reflectors") is treated by extending the exact eigenfunction solutions obtained for the problem of the single boss on an infinite plane and a plane wave at an arbitrary angle of incidence. The acoustic intensities for the various scattering reflectors (which possess some features characteristic of either striated or rough surfaces) exhibit nothing like the simple behaviour predicted by Lambert's law for "diffuse reflectors". This supports the contention that diffuse reflection, long considered the antithesis of specular reflection, is but the end result of *specular* reflections occurring at the surfaces of the irregularities; a situation essentially corresponding to a geometrical or ray rather than to a diffraction phenomenon. The results predict the occurrence of an extremum at the specular angle of reflection which furthermore may be *either* a maximum or a minimum. It is significant that such minima had been observed previously by E. Skudrzyk with rough surfaces whose irregularities were about the size of the wavelength, and also that an approximate Lambert's law behaviour was observed only for surfaces whose irregularities were 10 to 15 times larger than the wavelength.

Some ramifications of the results are also indicated and it is concluded that with a suitable sound source a characteristic space-time acoustical pattern for an arbitrary surface could be created—a problem closely related to the more general problems of the acoustical unitary mental construct and guidance devices for the blind. The motivation for the analysis hinges on this and its relation to previous work done by the writer with W. Etkin of the Guidance Device Project, City College of New York.

Further analysis, such as the extension to absorbent surfaces and to the electromagnetic case as well as the derivation of more accurate results to take into account multiple scattering phenomena, has been and is being done by the writer at the Mathematics Research Group, New York University under the sponsorship of the Geophysical Research Directorate of the Air Force, Cambridge. V.T.

On the Non-Specular Reflection of Plane Waves of Sound. By Victor Twersky. *J. Acous. Soc. Am. 22: 539, September, 1950.*