he described as having seen on a clear summer night at Hutchinson, Minn. This he describes as "a solitary, brightly, luminous, cumulus cloud," which "shone with a uniform, steady, vivid, whitish light." He also adds: "I have been at some loss to account for the luminosity of the cloud. It could not have been due to reflected light coming from a city."

Could not the objects in the sky (the saucers) and the objects seen by Mr. Zeleny be one and the same thing? Could not these objects be moved by wind currents and perhaps, too, be magnetic fields? Could they not be tied in with the phenomena of ball lightning, occurring very rarely under conditions favorable to thunderstorm activity?

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The Use of Hydrofluoric Acid in Making Glass Microneedles[1]

THE following procedure provides a simple solution to the problem of making glass microdissection needles, such as those used in isolating yeast ascospores. The technique obviates the need for an expensive microforge (*1, 2*) by utilizing a 50% solution of hydrofluoric acid to produce a smooth, sharply pointed microneedle. Stepwise etching with acid provides control over formation of the point, whereas control is difficult to obtain with manual or mechanical pulling techniques.

Six-inch lengths of 2 or 3 mm soft glass rod provide the stock from which needles are made. One end of the rod is reduced in diameter to about 30 μ over a length of about 1 in. The small end of this filament is grasped firmly but gently with flat forceps. While a steady pull is exerted, this portion of the needle is moved slowly toward the flame of a microburner[2] until it heats rapidly and is pulled out into a hairlike *pointed* filament. The length and character of this portion of the needle are unimportant, provided only that the needle *tapers* to a point rather than ending in a fused bead.

All necessary bends are introduced before the point is etched, so as to avoid accidental heating and destruction of the delicate tip. Bending is best accomplished by bringing the needle near, but not into, the microburner flame *from the side* and guiding it with a metal dissecting needle as the glass softens. The exact bends required will depend on the type and dimensions of the moist-chamber type of micromanipulator clamp, and other apparatus used.

For the etching process, aqueous solutions of HF (50%) and sodium bicarbonate (saturated) are used. These solutions and two rinses of distilled water are placed in beakers large enough to minimize accidental contact with the walls during agitation of the needle in the solutions. The etching is carried out by immersing about 1 in. of the pointed end of the needle in HF for 5–20 sec, rinsing carefully and thoroughly, first in the bicarbonate solution, then twice in distilled water. Progress of the etching is followed under low power of a compound microscope. Etching is repeated until any hairlike tip is dissolved and the fine point of the needle is brought into the desired relationship to the heavier shank.

It should be emphasized that the HF must be neutralized completely by thorough rinsing in bicarbonate, otherwise pits and roughened areas will develop along the shank. These tend to retain HF from subsequent etchings and may in time result in weakening and breakage of the microneedle.

To a great extent this etching technique removes the uncertainty inherent in manual and mechanical needle-making procedures. Uniformly reproducible tools may be made with a minimum of previous experience. Stepwise etching with HF has been used successfully to produce flexible spatulate needles (*3*), and other applications are doubtless possible.

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[1] Abstracted from a dissertation submitted to the Graduate School of Yale University in partial fulfillment of the requirements for the Ph.D. degree.

[2] A serviceable microburner may be made from a 22-gauge hypodermic needle with the bevel removed.

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Book Reviews

The Theory of Relativity. C. Møller. New York: Oxford Univ. Press, 1952. 386 pp. Illus. $7.00.

This new addition to the "International Series of Monographs on Physics" is in many respects a remarkable one, which no teacher of relativity theory can afford to overlook. It contains many novel ideas, even for people familiar with relativity theory, and it will help answer students' questions that are not answered in other texts. Many references to original literature have been given in footnotes, but much of the material has never been published before.

About half the book deals with special relativity theory, beginning with a historical survey of the developments that made Einstein's hypothesis appear as a simplification of physics. After a thorough discussion of special relativistic kinematics, including the Thomas precession, there follows a chapter on special relativistic mechanics, in which Møller's proofs of the equivalence of energy and mass are unusually clear.

An introduction to tensor algebra is followed by discussions of successive infinitesimal Lorentz transformations, the motion of incoherent matter and its kinetic energy-momentum tensor, electrodynamics in vacuum, mechanics of general closed systems, definition of center of mass, mechanics of elastic continua and of perfect fluids, and a note on meson theory. Discussions of nonclosed systems, electrodynamics in matter, and special relativistic thermodynamics follow.

The second half of the book is devoted to general relativity. After an explanation of the principle of equivalence, Møller clarifies the transition from the special to the general theory by including an extensive discussion of rotating and of nonrotating accelerated rigid frames of reference. The discussion of the rotating disk gives a welcome example of a gravitational field that is "stationary" but not "static." The existence of Coriolis forces is a consequence of this fact. It also necessitates a distinction between a 3-dimensional metric tensor describing the non-Euclidean properties of the 3-dimensional space of physical observation, and the spacelike part of the more familiar 4-dimensional metric tensor. It is one of the merits of this text that the $(3+1)$-dimensional physical interpretation of the 4-dimensional fundamental equations of relativity is extensively discussed throughout the book. Thus, in the general theory, attention is not confined to finding "world lines" describing the motion of a particle in 4-space, but is directed toward finding how such a particle would describe a trajectory in the corresponding non-Euclidean physical 3-space. The 3-component gravitational force acting on such a particle is derived from the dynamic gravitational potentials, which are expressed in terms of the metric for 4-space. The discussion of the velocity-dependent forces—so important as the Coriolis force in the case of a rotating frame of reference—is postponed from this introduction on rotating disks, until Møller has discussed general tensor calculus, local systems of inertia, non-Euclidean differential geometry, and the momentum and mass of a particle in a general gravitational field. Discussions of the combined action of gravitational and other forces, mechanics of continuous systems, and general relativistic electrodynamics and optics in a vacuum follow.

The last two chapters of the book deal with the gravitational field equations and their solution for weak fields, for cases of spherical symmetry, and for a perfect fluid. Also covered are a variational principle for the gravitational equations in empty space, conservation of energy and momentum in gravitational fields, the gravitational mass of a system, the various effects by which general relativity theory can be verified experimentally, and cosmological models. The book closes with nine appendices that are mainly mathematical.

The book is offered as a text not only for students in theoretical but also for those in experimental physics, and the latter are advised to study mainly the first third of the volume. For the benefit of these students, many of the results of the special theory have been derived by using ordinary 3-dimensional vector notation only. This is very instructive, although it does not always simplify the proofs. The author gives explicit formulas in 3-dimensional notation for such fundamentals as the Lorentz transformations for coordinates, particle velocities, phase velocities, and Newtonian forces, as well as for the dragging of light, aberration, etc., for any magnitude and direction of the velocity of the medium or the observer with respect to the light ray. As experimental evidence of special relativity, the transverse Doppler effect is mentioned, as well as Champion's experiments on electron-electron scattering.

In general, Møller's presentation is almost exclusively algebraic, for he has attempted to avoid 4-dimensional geometric interpretation of the formulas of special relativity wherever possible. The reviewer regrets this, because visualization of the theory can help students find, by inspection, solutions of problems of relativity that otherwise require lengthy calculation. On the other hand, the few diagrams in Møller's book that do show a time axis are misleading. The source of this confusion lies in Møller's attempt to keep the special theory simple by treating Lorentz transformations as orthogonal transformations, using $x_4 = ict$. Of course, one cannot correctly draw an imaginary time axis. For correct visualization one must use $x^0 = ct$ as coordinate, which makes it necessary to present Lorentz transformations as oblique transformations in x,ct-space. This slight complication is just what Møller has tried to avoid. The real ct-variable he introduces later, when he comes to general relativity. From here on, x^4 denotes ct. (The notation x^0 is not used.) This and some other unusual or less fortunate notations, not to mention a few printing errors in formulas, should cause no serious trouble to careful readers.

It is a pity that the simple tensor transformations of the special theory were not introduced in the part of the book destined for students of general physics. Instead, the derivation of this equation of motion is given much later, wedged in between discussions of the Wiechert-Liénard potentials and a variational principle. Yet no elementary course in special relativity is complete without this equation, because of its practical importance. (Mentioning it without proof on p. 74 does not help.) Although the book is not entirely adequate for use as a text in a short introductory course in relativity, it is, nevertheless, a most valuable reference, even for beginning students, and still more so for advanced students and for the teacher. Møller's book thus deserves a wide circulation, and it will certainly become one of the recognized standard works on classical relativity theory. The reviewer considers the book of extreme importance because of its content and originality.

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Food Science: A Symposium on Quality and Preservation of Foods. E. C. Bate-Smith and T. N. Morris, Eds. New York: Cambridge Univ. Press, 1952. 319 pp. Illus. $8.00.

This volume is the outcome of an extended summer course in food science given under the Board of Extra-Mural Studies of Cambridge University in cooperation with the Low Temperature Research Station during 1948. A brief introduction by Franklin Kidd defines food science as the vast field which, beginning with photosynthesis, includes all processes involved in production, composition, storage, and preservation of foods and their utilization, and having fundamental significance for the welfare of mankind.

The editors have skillfully utilized the contributions of 26 British cooperating scientists in this compact and highly informative volume. Seven chapters of varying length supply condensed factual and statistical material of much interest and value. Of these, the first, by N. C. Wright, chief scientific adviser of the Ministry of Foods, presents briefly a concise and valuable summarization of the economics, supply, and distribution of foods in the United Kingdom during the period from 1934 to 1944, and the nutritional status of the population as of 1948.

The second chapter gives an extended survey of the composition, variation, nutritional values, and factors affecting internal changes in the principal foods. Meats, fish, eggs, fresh fruits, and vegetables, and the great group of cereals and milled products are each considered in detail. The book deals primarily with British foods, but its interest is not lessened for the American reader, although certain varieties of fish are unused here, or because some of the procedures described differ in detail from corresponding processes in this country. Chapter 3 discusses competently the basic constituents of foods under the headings proteins, mucopolysaccharides and mucoproteins, carbohydrates, and fats. This valuable chapter is followed by another dealing with "Some Aspects of Quality in Foods," in which the physical and chemical basis of quality, and the significance of the fine structure of biological tissues, both plant and animal, in nature are carefully treated. Chapter 5 deals briefly with "The Microorganisms"—the molds, yeasts, and bacteria—chiefly concerned with the processes of spoilage in foods. The treatment is largely from the physiological standpoint, and the data on the effects of environmental factors on growth are well but possibly too briefly presented. The subject of "Principles of the Control of Microbial Spoilage" especially would seem to warrant more expanded treatment than is given in this section, although the matter is skillfully presented. Chapter 6 devotes 40 pages to an intimate discussion of "Chemical Mechanisms of Spoilage" and covers a wide range of reactions. Rancidity in edible fats and fat-containing foods is treated very fully, its effects on odor, flavor, and appearance being discussed with some detail. The Maillard, or browning, reaction on dehydrated foods is also given careful attention.

The final chapter devotes over 60 pages to the principles of food preservation. Herein are treated the traditional methods of canning, preserving by concentration, refrigeration, and use of chemical preservatives. Much attention is given to refrigeration and quick-freezing and also to dehydration by modern methods; the subject of sugar preserves is likewise given detailed treatment. The recent developments in sterilization by radiation have come since the course was given and therefore are not discussed in detail. This does not impair the value of the chapter as a whole, although the process may have much future interest. An appendix describing "Organization of Research and Information Services in the United Kingdom" completes the volume.

The book is excellently printed, has many illustrations and graphs, and extensive bibliographies at the end of each section. Altogether, it is a book that all food chemists and technologists would find most useful and it should be a valued accession to every library that aims to carry on its shelves the most useful and authoritative volumes dealing with the great subject of food supply and food technology.

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Geometry and the Imagination. D. Hilbert and S. Cohn-Vossen; trans. by P. Nemenyi. New York: Chelsea Pub., 1952. 357 pp. $5.00.

David Hilbert (1862–1943) was a very great mathematician whose research extended into almost every field of mathematics. Furthermore, he was a great teacher and expositor, with a genius for presenting basic ideas uncluttered by details. His insight penetrated far beyond the obvious and brought to light relations previously unobserved. With a self-confidence supported by his pre-eminent position as a mathematician, he did not hesitate to devote attention to mathematics of the most elementary sort, such as arithmetic and plane geometry, and he was able to endow these humble topics with a dignity and depth unsuspected by more superficial observers.

"Intuitive Geometry" would have been a more accurate translation of Hilbert's *Anschauliche Geometrie*. The book, based upon lectures given by Hilbert in Göttingen in 1921, was first published by Springer in Berlin in 1932, and has become a mathematical classic. This translation by Nemenyi is precise and in excellent English. The Chelsea Publishing Company acknowledges indebtedness only to the attorney general of the United States.

There are six self-contained chapters in the book, each devoted to a separate type of geometry. The first chapter mainly concerns the conic sections and quadric surfaces, and until the concluding paragraph coordinates are not used. The purpose is to make the reader