Proceedings of the American Physical Society

1945 Annual Meeting at New York, January 24–26, 1946

THE 270th meeting of the American Physical Society, being the 1945 Annual Meeting, was held at Columbia University in New York City on Thursday, Friday, and Saturday, January 24–26, 1946, in conjunction with a meeting of the American Association of Physics Teachers. This was a meeting of unforeseen and unprecedented size, outranking by far in attendance the most populous of the Washington meetings of old. Of 1293 who registered, 911 gave themselves as members of the American Physical Society, and an undetermined fraction of the rest were members of both the Society and the Association. The halls of the scientific sessions were often overfilled and sometimes crowded to such an extent that many would-be listeners were excluded; one session was repeated in its entirety, also an event without precedent. All the available rooms of the capacious Mens' Faculty Club were bespoken for the dinner, yet a third of those who applied had to be turned away. This plethora of visitors, welcome sign as it is that the restrictions of the war are largely past, is a source of foreboding for the meetings of the future, and augurs a change in their character not altogether agreeable. The unexpected burdens were nobly borne by the Local Committee, composed of H. W. Farwell, W. W. Havens, J. E. Nafe, and B. A. Wooten, and ably assisted by Miss Margaret Griffin and other members of the staff of the American Institute of Physics.

President Harvey Fletcher gave his Retiring Presidential Address, and P. E. Klopsteg delivered the fifth Richtmyer Memorial Lecture of the AAPT. H. A. Bethe and A. H. Compton were joined by James T. Shotwell of the Carnegie Endowment for International Peace in a symposium "Nuclear Energy", ranging from the scientific to the national and international aspects of this timely topic. M. H. Trytten and E. U. Condon spoke on "Physics in National Affairs" under the auspices of the AAPT. Invited papers were given by Gleb Wataghin and by Marcel Schein, G. S. Klaiber, A. J. Hartzler, and D. C. Baldwin, the last four composing the group under the title "Nuclear Transformations Produced by High Energy X-Rays" which, describing as it did a break-through into a new field of experimental physics, was justly honored by an encore to accommodate the many people who could not force their way into the largest hall of the Pupin Laboratories. The Division of Electron and Ion Optics had ten invited papers, the Division of High Polymer Physics had twenty-six. The titles of all these speeches will be found below. Fifty-two ten-minute papers were contributed; the abstracts follow.

At the Business Meeting of the Society, the election of the following officers was disclosed by the report of the tellers: President, E. U. Condon; Vice President, L. A. DuBridge; Secretary, K. K. Darrow; Treasurer, G. B. Pegram; Councillors, J. A. Bearden and G. E. Uhlenbeck (term 1946–1949); Members of the Board of Editors, E. C. Konopinski, H. H. Nielsen, E. C. Pollard (term 1946–1948). J. T. Tate has resumed the Editorship after leave of absence for war work. J. W. Buchta, to whose able management of its journals during the war years the Society has great reason to be thankful, becomes Assistant Editor. L. P. Smith becomes Chairman of the Division of Electron and Ion Optics, J. B. Fisk succeeds him as Vice-Chairman. J. R. Pierce is re-elected as Secretary-Treasurer, A. J. Dempster remains on the Executive Committee and A. O. Nier enters upon it. H. A. Robinson becomes Chairman and S. L. Gerhard Vice-Chairman of the Division of High Polymer Physics; W. J. Lyons continues as Secretary and L. A. Wood as Treasurer; R. B. Barnes, W. F. Busse, and J. H. Dillon remain on the Executive Committee.

The dinner of the Society and of the Association was held on the Friday evening at the Mens' Faculty Club, and those whose places were in the main dining room heard short addresses by Harvey Fletcher, E. U. Condon, and R. C. Gibbs before the early adjournment customary at the New York dinners.

The Council, meeting on January 24, elected four candidates to Fellowship and one hundred and seventy-eight to Membership; their names are appended.

Elected to Fellowship:

H. L. Andrews, Louis Goldstein, E. J. Schremp, and Samuel Silver.

Elected to Membership:

Turner Alfrey, Jr., Harold V. Argo, William A. Arnold, Martin J. Arvin, Sidney Austin, Peter Axel, Hans George Baerwald, Paul H. Baldwin, Ralph B. Baldwin, Ferdinand P. Beer, Persa Raymond Bell, Jr., Floyd Mitchell Bennett, Jr., Paula Berger, Bernard Berkowitz, Seymour Bernstein, Howard W. Boehmer, Robert W. Bogle, Lowell M. Bollinger, Ralph Bown, Henry G. Brewer, Jr., Wesley E. Brittin, Bernard B. Brody, Harold Brown, Cornelius P. Browne, Walter V. Burg, Elias Burnstein, Blendin L. Burton, L. W. Butler, Kenneth M. Case, Geoffrey F. Chew, S. M. Christian, Melville Clark, Jr., J. Reid Clement, Solly G. Cohen, Norman Clark Colby, Eugene F. Coleman, Paul Dare Coleman, John W. Cook, L. E. Copeland, Clifton Bernard Cosby, Prescott D. Crout, Westley Farnsworth Curtis, Perry W. Davison, William Dashifsky, David B. Davis, W. Bruce Dayton, P. J. G. deVos, Laura Diehl, Robert E. Dillon, Carl E. Drumheller, Murray Ellis, B. G. Farley, William C. Farmer, Daniel B. Feer, Frederick W. Fenning, Lester M. Field, Francis George Firth, Robert C. Fletcher, Samuel N. Foner, Earl W. Ford, Victor Hugo Fraenckel, George K. Fraenkel, Katherine L. Franck, Sherman Frankel, Wolfgang Franzen, George D. Freier, David L. Fry, Chester R. Fultz, F. J. Gaffney, Irving G. Geib, Kenneth D. George, David Gilbarg, Norman Goldstein, Serge Golian, William Edwin Gordon, Elizabeth R. Graves, Richard F. Greene, Wm. G. Griffin, Jr., James E. Hacke, Raymond M. Hainer, Jay M. Hansen, Walter J. Haring, Charles W. Harris, Hiram E. Hart, John C. Hart, Paul L. Hartman, Donald E. Hartvigsen, Emmi Hauser, Fred Brown Haynes, H. M. Herreman, Erna M. J. Herrey, Claude Richard Hocott, Herman W. Hoerlin, G. Robert Hoke, Jean E. Hoopes, John J. Hopkins, Maynard H. Hunt, Irvien B. Irving, Herman Jarrell, Wilbur Kaye, Chris P. Keim, Walter H. Kohl, Walter S. Koski, Ernst Henry Krause, Norman M. Kroll, Thomas Samuel Kuhn, Dhirendra Nath Kundu, Jack Hershel Lepoff, Werner Leszynski, Seymour A. Lippmann, John A. Lockwood, Lawrence W. Lockwood, John F. Marshall, Lucien Martelli, Albert E. Martin, Jr., Harry Mason, R. L. McCarthy, Robert A. McConnell, James S. McCorkle, Walter C. McCrone, John Joseph Gerald McCue, Brunson S. McCutchen, John McElhinney, John C. Mead, Alfred W. Meyer, John A. Miskel, Joseph Frederick Mullaney, Harold Peter Myers, Joseph Alfred Neuendorffer, Leonard William Niedrach, H. Nordsieck, William C. Parkinson, Robert Erle Payne, George D. M. Peeler, Frederick T. Peirce, Robert T. Phelps, Eric Pickup, John L. Powell, Rene J. Prestwood, George T. Rado, John Rehner, Jr., T. Doman Roberts, Charles Vernon Robinson, J. Robert Rogers, Herbert Ruderfer, Donovan J. Salley, Fred H. Schmidt, Roderic M. Scott, Elwood F. Seasholtz, Montford W. Smith, Louis D. Smullin, Wilmer H. Souder, Robert Franz Stamm, Rudolph Max Sternheimer, John Willard Stout Jr., Martin Jay Swetnick, Benjamin Tannenbaum, John Torrence Tate, Jr., Robert H. Thayer, Hsue-shen Tsien, Anne Axon Unger, B. H. Van Horne, Thomas B. Van Poole, Jr., John J. Wagner, Robert Lee Walker, William Edward Waller, John Bernard Warren, Wallace Waterfall, Nelson Wax, Robert T. Webber, J. Weber, David V. P. Williams, R. B. Windsor, Jules I. Wittebort, Paul F. Yergin, Elmer L. Younker, James Henry Young, and Luke Chia-Liu Yuan.

Reports reaching the office of the Society indicate that we have lost through death since the previous meeting the following Fellows and Members: Harry Bateman (F, California Institute of Technology); A. A. Bacon (retired); A. E. Flowers (deLaval Company); Walker Kincaid (Georgia Institute of Technology); H. N. McCoy (F, retired); L. M. Potts, (F, retired).

KARL K. DARROW, *Secretary*
American Physical Society
Columbia University
New York 27, New York

Retiring Presidential Address of the American Physical Society

"The Pitch, Loudness and Quality of Musical Tones." (Demonstration Lecture introducing the new Tone-Synthesizer.) HARVEY FLETCHER, *Bell Telephone Laboratories.*

Fifth Richtmyer Memorial Lecture of the American Association of Physics Teachers

"Technological Research in the University." P. E. KLOPSTEG, *Northwestern University Technological Institute.*

Nuclear Energy

Scientific Aspects. H. A. BETHE, *Cornell University.* (30 min.)

Social Implications. A. H. COMPTON, *Washington University.* (30 min.)

International Implications. JAMES T. SHOTWELL, *Carnegie Endowment for International Peace.*

Invited paper

Statistical Mechanics at High Temperatures and Showers of Penetrating Particles. GLEB WATAGHIN, *University of São Paulo.*

Nuclear Transformations Produced by High Energy X-Rays

Artificial Production of Mesons by X-Rays from a 100-Mev Induction Accelerator. MARCEL SCHEIN, *General Electric Company and University of Chicago.*

Ionization-Chamber and Cloud-Chamber Studies of Nuclear Processes Induced by High Energy X-Rays. G. S. KLAIBER, *General Electric Company.*

Cloud-Chamber Studies of Artificially-Produced Particles of Intermediate Mass. A. J. HARTZLER, *General Electric Company.*

New Types of Photo-Nuclear Reaction. D. C. BALDWIN, *General Electric Company.*

Division of Electron and Ion Optics

Symposium on Oxide Coated Cathodes

Recent Published Work on Oxide Coated Cathodes. J. P. BLEWETT, *General Electric Company.*

The Experimental Basis for Present Theories of the Oxide Coated Cathode. G. E. MOORE, *Bell Telephone Laboratories.*

Some Chemical Studies of Oxide Coated Cathodes. L. A. WOOTEN, *Bell Telephone Laboratories.*

The Pulsed Properties of Oxide Coated Cathodes. E. A. COOMES, *University of Notre Dame.*

Studies of the Interface of Oxide Coated Cathodes. A. FINEMAN, *Radiation Laboratory, Massachusetts Institute of Technology.*

The Study of Oxide Coated Cathodes by X-Ray Diffraction Methods. A. S. EISENSTEIN, *Radiation Laboratory, Massachusetts Institute of Technology.*

Effect of Composition of Coating of Oxide Coated Cathodes. E. G. WIDELL, *Radio Corporation of America.*

Poisoning Troubles and Their Cures in Vacuum Tubes. B. R. CORSON, *Hytron Corporation.*

Cataphoretic Coating of Emissive Material. J. CARDELL, *Raytheon Manufacturing Company.*

Sparking of Oxide Coated Cathodes in Inert Gases. J. W. MCNALL, *Westinghouse Electric Corporation.*

Division of High-Polymer Physics

Thermal Diffusion of Polymers. P. DEBYE, *Cornell University.*

X-Ray Diffraction by Potassium Laurate Solutions (A Contribution to the Mechanism of Emulsion Polymerization). E. W. HUGHES, *Shell Development Company.*

The Use of Color and Fluorescence Indicators for Studying the Constitution of Glasses. W. A. WEYL, *Glass Science, Inc., State College, Pennsylvania.*

The Mechanical Properties of Fibers. HENRY EYRING AND GEORGE HALSEY, *Textile Research Institute Laboratories, Princeton, New Jersey.*

Stress-Relaxation of Compressed Cork. S. L. DART AND EUGENE GUTH, *University of Notre Dame.*

The Formation of Ionized Water Films on Dielectrics under Conditions of High Humidity. ROBERT W. FIELD, *General Radio Company.*

The Molecular Structure of Some Polyuronides as Revealed by X-Ray Diffraction Studies. K. J. PALMER, *Western Regional Research Laboratory.*

Statistics of Cross Linked Polymers. WALTER H. STOCKMAYER, *Massachusetts Institute of Technology.*

Thermal Polymerization of Drying Oils. H. E. ADAMS AND P. O. POWERS, *Armstrong Cork Company.*

Some Thermodynamic Properties of Slightly Cross-Linked Gels. R. F. BOYER AND R. S. SPENCER, *The Dow Chemical Company.*

The Determination of Polymer-Liquid Interaction by Swelling Measurements. PAUL DOTY AND HELEN S. ZABLE, *Polytechnic Institute of Brooklyn.*

Electrostatic and Tensile Properties of Rubber and GR-S at Elevated Temperatures. R. S. HAVENHILL, H. C. O'BRIEN AND J. J. RANKIN, *St. Joseph Lead Company.*

Significance of the Stress-Temperature Relationships for Rubber. PAUL E. WACK, R. L. ANTHONY AND EUGENE GUTH, *University of Notre Dame.*

The Theory of Permanent Set at Elevated Temperatures in Natural and Synthetic Rubber Vulcanizates. R. D. ANDREWS, E. E. HANSON AND A. V. TOBOLSKY, *Princeton University and Firestone Tire and Rubber Company.*

The Crystallization of Unvulcanized Rubber at Different Temperatures. LAWRENCE A. WOOD AND NORMAN BEKKEDAHL, *National Bureau of Standards.*

Tackiness of GR-S and Other Elastomers. W. F. BUSSE, J. M. LAMBERT, AND R. B. VERDERY, *General Aniline and Film Corporation.*

Stress-Time-Temperature Relations in Polysulfide Rubbers. M. D. STERN AND A. V. TOBOLSKY, *Princeton University.*

Application of Infra-Red Methods in the Structural Examination of Synthetic Rubber. J. E. FIELD, D. E. WOODFORD, AND S. D. GEHMAN, *The Goodyear Tire and Rubber Company.*

Viscometric Investigation of Dimethyl Siloxane Polymers. ARTHUR J. BARRY, *Dow-Corning Corporation.*

Some Fundamental Relationships between Intrinsic Viscosity, Diffusion and Sedimentation Constants, and Thermodynamic Properties of High Polymer Solutions. ROBERT SIMHA, *National Bureau of Standards.*

Thin Section Methods for the Electron Microscopic Examination of Cured Polymers. H. C. O'BRIEN, *St. Joseph Lead Company.*

Attachment for Obtaining Angular Distribution of Scattered Light from Measurements with a Ninety-Degree Turbidimeter. J. N. WILSON, *Shell Development Company.*

A Photoelectric Light Scattering Instrument and a Differential Refractometer for Measuring Molecular Weights. P. P. DEBYE, *General Aniline and Film Corporation.*

Thermal Expansion and Second-Order Transition Effects in High Polymers. III. Time Effects. R. S. SPENCER AND R. F. BOYER, *The Dow Chemical Company.*

A New Approach to the Theory of Relaxing Polymeric Media. M. S. GREEN AND A. V. TOBOLSKY, *Princeton University.*

Application of Molecular Distribution Methods to the Statistical Mechanisms of High Polymer Solutions. BRUNO H. ZIMM, *Polytechnic Institute of Brooklyn.*

Symposium of the AAPT

Physics and the Nation

Physicists in National Affairs. M. H. TRYTTEN, *Office of Scientific Personnel.*
Federal Support of Science. E. U. CONDON, *National Bureau of Standards.*

ABSTRACTS OF CONTRIBUTED PAPERS

A1. A Solution of the Equation for the Propagation of Waves of Finite Amplitude in One Dimension. JOHN M. RICHARDSON AND WILLIAM SHOCKLEY, *Bell Telephone Laboratories, Inc.*—The one-dimensional motion of a volume of gas initially at a uniform pressure p_0 and density ρ_0 is given by

$$\frac{\partial^2 x}{\partial t^2}-\frac{\gamma p_0}{\rho_0}\left(\frac{\partial x}{\partial x_0}\right)^{-\gamma-1}\frac{\partial^2 x}{\partial x_0{}^2}=0,$$

when vanishing thermal conductivity and the adiabatic law $p=p_0(\rho/\rho_0)^\gamma$ are assumed and x, p, and ρ are at time t the position, pressure, and density, respectively, of an element of gas initially at x_0. In case the initial conditions possess no characteristic length, one can show that the solution must be of the form $x=tf(x_0/t)$. With this form of the solution the equation of motion splits into two factors, one giving a non-trivial solution, and the other, a trivial solution corresponding to gas of uniform dilatation moving with constant velocity. These solutions can be fitted together to satisfy the initial and boundary conditions occurring in several situations, among which are the special cases of (1), an initially uniform gas expanding into a vacuum, and (2), an initially uniform gas expanding into another initially uniform gas of lower pressure.

A2. Diabatic, Rotational Flow in Two Dimensions. BRUCE L. HICKS, *Aircraft Engine Research Laboratory.*—The equations recently developed for three-dimensional diabatic flow[1] have been studied in the case of uniplanar flow. If the (variable) limiting velocity is V_t and the velocity field is represented by $\bar{w}=\bar{V}/V_t$, potential, stream, and vorticity functions can be introduced through the equations $(1-w^2)^{1/\gamma-1}\bar{\omega}=\nabla\varphi+\nabla\times\bar{k}\psi$ and $\omega=|\nabla\times\bar{w}|=L_1(\varphi)+L_2(\psi)$ where L_1 and L_2 are quasi-linear partial differential operators of the second order. Then $\partial\psi/\partial s=\partial\varphi/\partial n$ where $\partial/\partial s$ and $\partial/\partial n$ denote spatial differentiation parallel and perpendicular to the streamlines. If the heat source function is Q, then the equation of continuity requires that $\nabla^2\varphi=qf(w)$ where $q=Q/V_t{}^3$. The equation of motion reduces to a relation between w,ω,q and their s and n derivatives. If $q=0$, Crocco's equation[2] $(\partial/\partial s)(\omega/p)=0$ is obtained. If $\omega=0$, $(\partial/\partial n)(Q/V_tT)=0$. For $w\ll1$ (the case of "incompressible" flow), the symmetrical equations $\nabla^2\varphi=q$, $\nabla^2\psi=-\omega$, $2\omega q+w((\partial\omega/\partial s)-(\partial q/\partial n))=0$ are found. The third of these equations restricts considerably the variation of ω and q. Thus where $((\partial\omega/\partial s)-(\partial q/\partial n))$ is finite and continuous in the flow, (ωq) is of the same order as w.

[1] B. Hicks, Pasadena meeting of the American Physical Society, Jan. 12, 1946.
[2] L. Crocco, Z. a. M. M. 17, 1 (1937).

A3. Elastic Waves in Bars. J. HOWARD MCMILLEN,* *Princeton University.*—A method for measuring the velocity and propagation of elastic waves in bars was found. A bar, partially immersed in water, was struck and the waves within the bar were conveyed to the water as acoustic waves. These were recorded by means of spark shadowgrams. A fast and a slow wave was observed. Their velocities relative to the velocity of sound in water were measured by making use of the angle between the water wave and the bar. The fast wave was a dilation wave traveling with a velocity characteristic of a longitudinal wave in an infinite medium; this velocity is larger than the one associated with the stationary vibrations within the bar. The dilation wave velocities in cold rolled steel and yellow brass were 5994 ± 34 and 4252 meters per second, respectively. These velocities agreed within 2.5 percent and 4 percent with the calculated velocities when R. W. Vose's values for the elastic constants were used. The slow wave velocities were 2959 ± 79 and 1978 meters per second, respectively. These velocities were 8 percent and 11 percent lower than the calculated transverse wave velocity and 4.5 percent and 6 percent lower than the calculated Raleigh wave velocity. Dilation waves in Tennessee marble were also observed; they had a velocity of 6345 meters per second.

* Work done under contract with the Office of Scientific Research and Development.

A4. Measured Values of Ultrasonic Absorption and Velocity in Liquid Mixtures. F. H. WILLIS, *Bell Telephone Laboratories.*—G. W. Willard[1] reported an absorption peak at an intermediate concentration of a mixture of acetone and water, measured at a single frequency of about 10 mc. Professor K. F. Herzfeld[2] showed on theoretical grounds that this increased absorption could hardly be attributed to the unmixing effect of the acoustic wave—the observed increase in α/ν^2 was enormously greater. The writer has measured this mixture and others at four frequencies in the range 3.8 to 19.2 mc, using the Debye-Sears-Lucas-Biquard optical method with a differential photoelectric cell indicator. In the mixtures investigated α/ν^2 was found to be independent of frequency within the accuracy of the method, and there was no measurable dispersion of acoustic velocity. An absorption peak at intermediate concentrations not shifting with frequency was found in mixtures of acetone and water, and of ethyl alcohol and water, but not in mixtures of acetone and ethyl alcohol and of glycerol and water. The observed absorptions, except in the case of glycerol, were considerably greater than can be accounted for classically by viscosity and heat conduction alone. The absorption peaks await theoretical explanation. The work was done at New York University.

[1] G. W. Willard, J. Acous. Soc. Am. 12, 438 (1941).
[2] K. F. Herzfeld, J. Chem. Phys. 9, 513 (1941).

A5. Studies in Friction I. "Solid" *versus* "Polar" Boundary Films. M. EUGENE MERCHANT, *The Cincinnati Milling Machine Company.*—A study has been made of frictional phenomena under boundary lubrication conditions employing a type of apparatus which is designed to promote pronounced "stick-slip" sliding motion, of the type described by Bowden and Leben.[1] It has been found that the effect produced by adding a non-polar but chemically "active" organic compound, such as carbon tetrachloride, to a purified mineral oil is strikingly different from

that produced by adding a strongly polar compound such as oleic acid. The true kinetic friction value obtained with the pure mineral oil when applied to iron surfaces is unchanged by the addition of carbon tetrachloride, while the static friction value decreases linearly with increasing mole fraction of carbon tetrachloride. On the other hand, when oleic acid is added to the pure mineral oil both the kinetic and the static friction coefficients drop precipitously with minor additions, then much more slowly as concentration is increased. The durability of the boundary films produced by these two types of lubricant is also very different. The above behavior can be explained by a consideration of the method of formation and nature of the surface films produced by these two different classes of materials.

[1] F. P. Bowden and L. Leben, Proc. Roy. Soc. A169, 371–391 (1939).

A6. A Rapidly Acting Vacuum Valve. D. D'EUSTACHIO, *Bliley Electric Company.*—A cam operated vacuum valve is described. Construction details are given. It has been designed for use in small dynamic vacuum systems and has the following characteristics. The volume added to the side of the system that is periodically exposed to atmospheric pressure is reduced to a few cubic centimeters. The area of rubber exposed to the vacuum system is small. When the valve is open it acts as a baffle for the diffusion pumps, thus eliminating the need for additional baffles. The impedance is no greater than that of a good baffle. The valve is extremely rapid in action, requiring but a fraction of a second from the fully closed to the fully open position. The valve was designed for operation on a small system capable of going from atmospheric pressure to less than 10^{-4} mm in 30 seconds, and has been successfully used on such a system.

A7. Optical Analysis of the Structure of Supersonic Inhomogeneous Air-Jets.* J. WINCKLER, C. C. VAN VOORHIS, AND R. LADENBURG, *Princeton University.*—The air stream expanding from a reservoir under high pressure through an orifice into the atmosphere flows at supersonic speed and forms various shock configurations. Studies of such air-jets at various pressures in the reservoir have been made by interferometric technique supplemented by shadowgrams (see the following paper). The measured densities and derived values of shock strength, etc., are in satisfactory agreement with those calculated from the conventional theory. The structure of the jets is revealed by computing the streamlines and Mach lines. Some anomalous phenomena occurring when a needle was inserted into the shock region have been studied.

* This work was done in whole under Contract No. OEMsr-260 between Princeton University and the Office of Scientific Research and Development, which assumes no responsibility for the accuracy of the statements contained herein.

A8. Interferometric Study of Gas Flow around Various Objects in a Free Supersonic Homogenous Air-Jet.* R. LADENBURG, C. C. VAN VOORHIS, AND J. WINCKLER, *Princeton University.*—The gas flow in a free homogenous air-jet escaping with supersonic speed from a high pressure tank through a conventional Laval nozzle has been studied with the help of a Mach interferometer. The density (2.20 mg/cm^3) and Mach number (1.70) in the jet, computed from the observed shift of the interference fringes with respect to their position without the jet were constant over a region large enough to study the airflow about various objects inserted into the jet. Cones of 10°, 30°, and 45° semi-apex angle and a sphere of $\frac{9}{32}''$ diameter have been examined. Since the jet is axially symmetric and the light passes perpendicularly through the axis of the jet, the radial density distribution can be obtained from the fringe shifts by the use of the Abel integral equation. From the density distribution one can compute easily the pressure, temperature, and velocity everywhere, including the discontinuous change of pressure, etc., in a shock front. The agreement of the results with the conventional theory of compressible fluids, especially with the theory of Taylor-Maccoll of the gas flow around conical objects, is satisfactory.

* The work was done in Palmer Physical Laboratory under the sponsorship of the Navy Department, Bureau of Ordnance.

A9. An Electromagnet for Non-Magnetic Substances. WILLIAM VAIL LOVELL, *Sanford, Florida.*—The alternating current electromagnet described is effective on armatures of non-magnetic conducting substances, being able to attract objects from an appreciable distance. In addition to attracting magnetic material, the device attracts and holds diverse objects such as: a silver coin, an aluminum cup, a roll of copper wire, etc. The operation depends on well-known phenomena of attraction and repulsion between conductors carrying current. In the simplest form an alternating flux field induces currents of substantially like phase in a fixed member (called the attractor) and in a conducting object adjacent to the attractor. The zone of attraction is roughly a cone having its base in the surface of the structure and its apex in the axis extended. A non-magnetic conducting object situated so that the principal induced currents lie within this zone is attracted, otherwise it is repelled. In one form characterized by relatively short coils and conductive, rather than inductive, energization of the attractor element, there is a region of attraction between inner and outer zones of repulsion. Curves are given showing how the boundaries of the zones are determined.

A10. Further Observations on the Helical Movement of Matter in Sunlight. FELIX EHRENHAFT, *New York City.*—Photomicrographs in sunlight show that droplets of liquids and particles of light reflecting and heat conducting substances as Ag, Cu, Au, and light absorbing matter as *C* move in helical paths with regularly spaced turns towards the source of light—light negative—or away from it—light positive, simultaneously in the same portion of the beam (longitudinal photophoresis).[1] Further, a movement of matter normal to the beam already noted by the author and Whytlaw-Gray (transversal photophoresis), is seen from the photographs to follow helical paths with regularly spaced turns. In one example a particle 2 to 3×10^{-5} cm radius makes about 56 turns per second each with a diameter of about 3×10^{-3} cm. It is thus seen that light can

exert not only repulsion, but also attraction and torsion on matter free to move with six degrees of freedom. Forces heretofore postulated cannot account for these movements, nor do these movements violate the principle of entropy. Bartoli and Boltzmann suggested the hypothesis of light pressure in discussing the perpetuum mobile of the second kind envisioned by Eddi. Boltzmann attributed to his calculations a provisional character only, and stated that a contradiction to the second law of thermodynamics could be avoided by another hypothesis in agreement with Bartoli.[2] Droplets of an aqueous solution of chlorophyll are all attracted by the sunlight (attractive force about 10^{-7} dyne, gravitational force about 10^{-10} dyne). Droplets of distilled water under the same conditions relatively unaffected by the light. Other examples of organic solutions will be cited.

[1] F. Ehrenhaft, Ann. d. Physik 56, 103 (1918); Ann. de physique 13, 171 (1940); J. Frank. Inst. 233, 235 (1942); Science 101, 676 (1945).
[2] D. A. Goldhammer, Arch. Neerl. de Sci. [2] 5, 468 (1900).

A11. Motion of Electrolytes in Magnetic Field. C. E. SWARTZ AND W. VAN DER GRINTEN, *University of Rochester.*—Further investigations have been made of the motion of electrolytes in contact with metal in a magnetic field. It was shown a year ago[1] that the motion was due to current flow in the solution caused by potential differences which could be measured. The source of these potential differences is now proved to be simply voltaic cells set up at different parts of the same piece of metal. The phenomenon is only an unusual variation of those already discovered in the investigation of electro-chemical corrosion. Application of a "ferroxyl indicator"[2] shows regions of anodes and cathodes which confirm the readings taken with probes and potentiometer and also predict the observed liquid movement in the magnetic field.

[1] C. E. Swartz, Phys. Rev. 67, 201 (March, 1945).
[2] Walker, Cederholm, and Bent, J. Am. Chem. Soc. 29, 1256 (1907)

A12. An X-Ray Method for Measuring the Thickness of Thin Crystalline Films. A. EISENSTEIN, *Massachusetts Institute of Technology.**—When x-rays are scattered from a thin crystalline surface film overlying a crystalline base material, diffraction lines are observed from both components.[1,2] Equations are developed for the general case of (1) a flat sample, and (2) a cylindrical sample expressing the ratio of line intensities from the two materials as a function of film thickness. A usable range of 10^{-6} cm to 5×10^{-2} cm is indicated. Experimental confirmation is found in the range 10^{-4} cm to 6×10^{-3} cm.

* This paper is based on work done for the Office of Scientific Research and Development under Contract OEMsr-262. It is separated from similar contributed papers at the author's wish to avoid coincidence in time with the Division of Electron and Ion Optics.
[1] G. L. Clark, G. Pish, and L. E. Weeg, J. App. Phys. 15, 193 (1944).
[2] R. B. Gray, Bull. Am. Phys. Soc. 20, No. 5 (1945).

B1. On the Inelastic Photo-Effect of the Deuteron. J. M. JAUCH, *Princeton University.*—An experiment is proposed which would allow a decision between the two competing meson theories of nuclear forces, the weak[1] and the strong[2] coupling theories. The strong coupling variety predicts the existence of excited states of the nucleons with different spin and charge values. According to the latest calculations the first excited state of the nucleon would have an excitation energy of approximately $\epsilon=45$ Mev.[3] For γ-rays with an energy larger than $\epsilon+2.17$ Mev an inelastic photo-effect of the deuteron is possible where one of the ejected particles is in the lowest excited state. An order of magnitude calculation with perturbation theory neglecting the tensor force shows that the ratio of the inelastic to the elastic cross section goes through a maximum value near 90 Mev where it reaches about 0.07. This seems therefore to be an effect which could be observed with the experimental methods now available. In the weak coupling case no such states exist and an experimental distinction between the two theories could thus be reached.

[1] W. Pauli, Phys. Rev. 64, 332 (1943).
[2] G. Wentzel, Helv. Phys. Acta 13, 269 (1940); J. R. Oppenheimer and J. Schwinger, Phys. Rev. 60, 150 (1941).
[3] G. Wentzel, Helv. Phys. Acta 18, 430 (1945).

B2. High Energy Neutron-Proton Scattering and the Meson Theory of Nuclear Forces with a Strong Coupling. J. LEITE LOPES, *Princeton University.*—We investigated the anisotropy of the scattering of 14-Mev neutrons by protons in the symmetrical Møller-Rosenfeld theory with a strong coupling. In the second Born's approximation, the virtual excited states (isobars) of the nucleons decrease the ratio R of the differential cross sections in the backward and perpendicular directions (in the center of mass system), and R decreases with the isobar energy. However, R is still larger than 1 and our results suggest the possibility that the combined effects of the virtual isobars and the tensor force might give a forward scattering in agreement with Amaldi's experiments.[1] We also evaluated the cross section of the inelastic scattering of 100–200-Mev neutrons by protons with production of isobars, in the Møller-Rosenfeld, pseudoscalar and Schwinger theories (in first Born's approximation). The total cross section is $\sim10^{-26}$ cm^2 and its ratio to the elastic cross section ~0.03, for 100-Mev neutrons; the isobar energy assumed was 45 Mev. An experiment to detect the isobars would be crucial for a decision between the assumptions of the weak coupling and the strong coupling theories.

[1] G. Wentzel, Helv. Phys. Acta 18, 430 (1945).

B3. The Energy Distribution and Number of Cosmic-Ray Neutrons in the Free Atmosphere. S. A. KORFF AND B. HAMERMESH, *New York University.*—A balloon flight to determine the energy distribution and the number of neutrons produced by the cosmic radiation in the free atmosphere was carried. It was found that, in agreement with theoretical prediction,[1] there are practically no thermal neutrons in the free atmosphere, in contrast to the fact that near the surface of the ground, most of the neutrons are known to be thermal. The number, and the rate of production of the neutrons, increases rapidly with elevation, in good agreement with previous measurements.

[1] H. A. Bethe, S. A. Korff, and G. Placzek, Phys. Rev. 57, 573 (1940).

B4. The Transition Effect for Large Cosmic-Ray Bursts in Iron. R. E. LAPP, *The University of Chicago.*—Integral size-frequency distribution curves for cosmic-ray bursts larger than 100 particles were obtained with a spherical ionization chamber shielded by 1.25, 12, and 35 cm of iron. All three curves conform to the same inverse exponential power law having an exponent $=2.0\pm.2$. With the aid of G-M counter coincidence sets, the simultaneous occurrence of bursts and extensive atmospheric showers was determined for the three thicknesses of iron. For 1.25 cm of iron, it was found that 85 percent of the bursts were coincident with extensive atmospheric showers, while for 12 cm of iron 20 percent were coincident, and for 35 cm only 5 percent of the total bursts were observed to be simultaneous with atmospheric showers. Consideration of these results definitely indicates that at the maximum in the transition curve (about 12 cm of iron) 45 percent of the bursts are produced by narrow air showers or extremely high energy single electrons and 35 percent originate from mesotronic interactions (bremsstrahlung and knock-on processes). Based on these results, a discussion is given about the origin of large bursts under various thicknesses of material at higher altitudes.

B5. Absorption of Slow Mesotrons in Lead, Iron, Aluminium, and Water. H. P. KOENIG, *Laval University* (Introduced by F. Rasetti).—The absorption of slow mesotrons in lead, iron, aluminium, and water was measured by means of counters arranged in anticoincidence. The statistical error in the percentage of mesotrons stopped by the absorbing layers was less than 3 percent in all cases. This accuracy was made possible by the high efficiency (about 99 percent) of the anticoincidence group of counters. The values obtained for the relative absorptions in the different substances were compared with those calculated from the theory of energy losses by collision. As is well known, the theory predicts a lesser absorption in heavier elements for a given superficial mass. The uncorrected experimental values, however, gave an apparent discrepancy with the theory, especially in the case of lead. By taking into account the effect of scattering, which is of particular importance in heavy elements, the experimental data were brought into excellent agreement with the theory for lead, iron, and aluminium. For water, no reliable theoretical value could be calculated.

B6. Correction of G-M Counter Data II. J. D. KURBATOV AND G. K. GROETZINGER, *The Ohio State University.*—An expression has been derived for the correction of experimentally obtained G-M counter data which allows one to determine the number of counts lost due to the finite recovery time of the counter.[1] Experiments with a counter using a Neher-Harper circuit were performed to develop an experimental method for determining the correction of G-M data. Thin samples of P^{32} as Na_2HPO_4 of identical geometry and known relative intensity of electron emission were prepared which allowed us to vary in steps between 10 and 50,000 per second the number of electrons entering the counter and producing at least one ion pair. A curve will be shown which gives the correction directly up to a certain intensity after which the counting rate becomes independent of the intensity of the source. Comparison of these results with the theoretical correction[1] allows a determination of the recovery time as a function of the counting rate. For one arrangement the recovery time decreased from 7.4 to 5.0×10^{-4} second as the number of electrons entering the counter increased from 400 to 2500 per second.

[1] J. D. Kurbatov and H. B. Mann, Phys. Rev. 68, 40 (1945).

B7. Upper Limit of the Number of Low Energy Neutrons from a Ra-α-Be Source. A. A. YALOW,* R. S. YALOW,* AND M. GOLDHABER, *University of Illinois.*—A method has been developed to ascertain the upper limit for the fraction of the neutrons from a given source which are below a given energy, for which a comparison source exists. The relative number of neutrons from a Ra-α-Be and from a Ra-γ-Be source which are slowed to thermal energies by transmission through or reflection from thin layers of paraffin was determined as a function of the paraffin thickness. The neutrons were detected in a boron-lined proportional counter, shielded by cadmium from all C neutrons except those produced in the paraffin. The number of these neutrons was determined from the difference in counting rate which resulted when cadmium was interposed between the paraffin layer and the counter. When reduced to the same number of incident fast neutrons, the initial slope of the growth curves of the C neutrons is at least 10 times larger for Ra-γ-Be neutrons than for Ra-α-Be neutrons. It is therefore concluded that not more than 10 percent of the neutrons from the latter source have an energy as low as the mean energy of the photo-neutrons from the Ra-γ-Be source.

* Now at Federal Telecommunications Laboratories, New York.

B8. Radioactive Isotopes of Mo and Ma. J. E. EDWARDS AND M. L. POOL, *Ohio State University.*—A $4.2\pm.1$-day masurium activity has been produced by bombardment of Mo with deuterons or protons and by bombardment of Cb with alpha-particles. The production of this activity by proton bombardment of Mo has been reported.[1] The activity can now be definitely assigned to Ma^{96} by the reactions Cb(α, n), Mo(p, n), and Mo(d, n). The isotope emits a 0.92-Mev γ-ray and also Mo x-rays as identified with a curved crystal spectrograph showing decay by K-capture. The 67-hour Mo activity, produced previously by Mo bombardment,[2] has been produced by the reaction Zr(α, n) which assigns this β-emitter to Mo^{99}. Spectrograph photographs show Ma x-rays associated with this activity confirming earlier identification of the radiation.[2] X-ray photographs of a long period (64 days) Ma activity resulting from deuteron bombardment of Mo show x-rays characteristic of Mo and Ma of about the same intensity. A photograph taken 110 days after bombardment shows the Mo $K\alpha$ line to be slightly stronger than the Ma $K\alpha$ line. A later photograph shows a decrease in the relative intensity of the Mo $K\alpha$ line.

[1] D. Ewing, T. Perry, and R. McCreary, Phys. Rev. 55, 1136 (1939).
[2] G. T. Seaborg and E. Segrè, Phys. Rev. 55, 808 (1939).

B9. Low Energy Alpha-Ray Spectra and Mechanism of Alpha-Decay. W. Y. CHANG, *Princeton University.*—The same method as used for studying the low energy groups of alpha-particles from Po* was employed to investigate the alpha-particles from radium. A line at 4.615 Mev identifiable with Rosenblum's and five previously unknown lines in a region 0.5 to 0.9 Mev below the main line were found; their intensities are respectively about 2500, and between 110 and 60, if the intensity of the main line is set as 100,000. As in the Po case, if the particle groups do actually come from the nucleus as all performed experiments have indicated so, the ordinary alpha-decay theory is also in the present case in serious disagreement with the experiments, for the theoretical intensity varies with energy much more rapidly than the observed one. A mechanism other than a simple penetration through the statical potential barrier may therefore be needed. It may be reasonable to assume tentatively that the out-coming particle, while about completely leaving the nucleus, may interact strongly with the rest of the nucleus and consequently impart a certain portion of its kinetic energy to the latter, which may then become the energy of oscillation of the residual nucleus. Hence, at a given emission probability, the observed kinetic energy should be smaller than would be expected from the theory. In other words, the intensity would then appear greater for the observed energy, as can be seen from the Geiger-Nuttall curves. This may generally explain the experimental facts.

* W. Y. Chang, Phys. Rev. **67**, 267 (1945); details to be published soon.

B10. A Slow Neutron Velocity Spectrometer. L. J. HAWORTH[1] AND F. N. GILLETTE,[2] *University of Illinois.*—This apparatus, designed and constructed in 1941, employs a "time of flight" method for the study of those neutrons of a continuous distribution which have energies lying in particular small intervals. Ten such intervals may be covered simultaneously. The deflection modulated deuteron beam of the Illinois linear accelerator,[3] falling briefly on a target of heavy water ice, produces a short burst of fast neutrons. Paraffin around the target slows the neutrons almost to thermal equilibrium before escape. The neutrons are subsequently detected by a BF_3 chamber placed either 1.25 or 2.5 meters from the source. The resulting pulses are registered on one of ten counters which are made sensitive in consecutive time intervals of arbitrary length. The time interval covered by the entire group can be shifted at will with respect to the beam modulated pulse. Strength of the source limited the study to neutrons of energy between .004 and 1.0 electron volt. Certain experimental results obtained with the apparatus are described in the following paper.

[1] Now at Massachusetts Institute of Technology, Radiation Laboratory, Cambridge, Massachusetts.
[2] Now at General Precision Laboratory, New York.
[3] Manley, Haworth, and Luebke, Rev. Sci. Inst. **12**, 587 (1941).

B11. Experiments with a Slow Neutron Velocity Spectrometer.[1] J. H. MANLEY, F. B. BERGER,[2] AND F. N. GILLETTE,[2] *University of Illinois.*—Using the apparatus described in the previous abstract the relative numbers of thermal neutrons arriving at the detector in consecutive time intervals from paraffin sources at 300°K, 200°K, and at 135°K were measured. The colder the source the greater is the relative abundance of the slower neutrons. The velocity distribution curve for 300°K was obtained by analyzing the data taking into account the resolution of the apparatus and the strength of the source as a function of time and velocity. The best maxwellian fit is that for 400°K. By determining the time distribution of neutrons at the detector with and without an absorber in the beam, the total cross section of mercury and of manganese as a function of the neutron velocity was measured. For neutrons in the energy range from 0.004 electron volt to 1 ev the capture cross section for both these elements varies inversely as the neutron velocity. For mercury, $\sigma=(1180/v)\times10^{-24}$ cm^2, where v is in km/sec. For manganese the constant is 24.7.

[1] This work was done in 1941 and early 1942.
[2] Now at General Precision Laboratory, New York.

C1. On an Inequality of Quantum Hydrodynamics. F. LONDON, *Duke University.*—It can be shown that the commutation rules of the components of the hydrodynamical mass current density operators $\mathbf{j}(R)$ and $\mathbf{j}(S)$ at the points R and S[1]

$$[\mathbf{j}(R)\times\mathbf{j}(S)]+[\mathbf{j}(S)\times\mathbf{j}(R)]=-\frac{h}{2\pi i}\delta(R-S)\left(\operatorname{curl}\mathbf{j}(R)+2\mathbf{n}(R)\frac{e}{c}H(R)\right)$$

(n=particle density, H=magnetic field strength) correspond to an inequality for the *total* kinetic energy

$$U_{\text{total}}\geq\frac{h}{4\pi m}\left|\operatorname{curl} j+\frac{ne}{c}H\right|.$$

On the other hand available data about low temperature transfer processes (superconductivity and liquid helium II) indicate that these processes might be restricted by an inequality for the *hydrodynamical* kinetic energy

$$U_{\text{hydrodynamic}}<\frac{h}{4\pi m}|\operatorname{curl} j|.$$

[1] F. London, Rev. Mod. Phys. **17**, 310 (1945).

C2. Statistical Hypotheses in Stellar Dynamics. HERBERT JEHLE, *Université de Bruxelles and Harvard University.*—A stellar system like our galaxy is composed of a variety of different statistically independent elements (stars, multiple stars, clusters). Their motion is mainly determined by the smooth field of force produced by the smoothed-out stellar system. In order to discuss micro-aspects of the streaming field of the elements, and to find out what additional forces arise from encounters between neighboring elements, we have first of all to introduce a statistical hypothesis about the density of elements in the six dimensional Boltzmann phase space: we assume that statistically independent elements cannot be crowded into phase space more closely than with an expected value of one element per volume σ^3, σ being a constant characteristic for the system. This is plausible because too great densities in position space, without large mean square deviations of velocities, give cause to aggregation of formerly inde-

pendent clusters or stars into larger units. Given local values of mean square deviation of velocity Δv_x, our assumption indicates a minimum probable distance between elements. As we cannot expect a stellar system to be flattened into a disk narrower than this minimum distance, we get a minimum relation $\Delta x_3 \Delta v_3 \geqq \sigma/4\pi$.

C3. Relativistic Transformation of Current and Charge Densities. BORIS PODOLSKY, *University of Cincinnati.*—The components of $\rho \mathbf{v}/c$ and $i\rho$ must transform as components of a four-vector, so that if measured in one coordinate system they are known in all coordinate systems. On the other hand any operational definition of $\rho(\mathbf{r}, t)$ must take account of the positions of particles, that of sth particle being $\mathbf{r}_s(t)$, at the same time t. Upon performing the Lorentz transformation these will be $\mathbf{r}_s'(t_s')$ and t_s', since the transformed time will be different for each particle. Another observer, in measuring ρ', would use $\mathbf{r}_s'(t')$ and t', t' being the same for all particles. As particles are in motion $\mathbf{r}_s'(t_s') \neq \mathbf{r}_s'(t')$, and there appears to be no necessary relation between $\rho(\mathbf{r}, t)$ and $\rho'(\mathbf{r}', t')$, operationally defined in each coordinate system. It turns out, however, that if in each coordinate system the charge density is defined by $\rho(\mathbf{r}, t) = \Sigma e_s \delta(\mathbf{r} - \mathbf{r}_s(t))$, then relativistic equations of transformation hold.

C4. A Generalization of Nyquist's Thermal Noise Theorem. E. J. SCHREMP, *Massachusetts Institute of Technology.*—Nyquist's thermal noise theorem[1] may be stated in the following form: If $y(\nu) = g(\nu) + jb(\nu)$ is the admittance, at the frequency ν, of any 2-terminal linear passive network in thermal equilibrium at an absolute temperature T, then there exists in parallel with $y(\nu)$ a constant current generator of thermal noise, whose mean square in the frequency interval $d\nu$ at the frequency ν is given by[2]

$$\langle i(\nu) i(-\nu) \rangle_{Av} d\nu = 2kTg(\nu) d\nu, \tag{1}$$

where k is Boltzmann's constant. The present generalization of Nyquist's theorem yields, for any M-terminal linear passive network in thermal equilibrium, infinitely many equivalent representations in the sense of the companion theorem.[3] Thus, it is shown that in every such representation the internodal thermal noise currents $i_{mn}(r, a; \nu)$ are mutually incoherent and satisfy the invariant relations

$$\langle i_{mn}(r, a; \nu) i_{mn}(r, a; -\nu) \rangle_{Av} d\nu = 2kTg_{mn}(r, a; \nu) d\nu, \tag{2}$$

provided the generating parameter a obeys the constraint

$$a(-\nu)[a(\nu) - 1] y_{rr}(\nu) + a(\nu)[a(-\nu) - 1] y_{rr}(-\nu) = 0. \tag{3}$$

This theorem is similarly expressible on the loop basis.

[1] H. Nyquist, Phys. Rev. 32, 110 (1928).
[2] In this formula the factor $2kT$ may be replaced by the more usual factor $4kT$, if the noise contributions at the frequencies $+\nu$ and $-\nu$ are combined.
[3] Cf. abstract number SP1.

C5. Normal Modes in the Theory of Wave Guides. GLENN M. ROE, *University of Minnesota.*—In the usual development of the theory of electromagnetic wave guides[1, 2] it is assumed that the field can be expressed in terms of an infinite set of normal modes, each of which satisfies the wave equation and the proper boundary conditions. This assumption is valid for perfectly conducting boundaries, or for boundaries characterized by an impedance, but not for actual bounding media having zero or finite conductivities. In the latter case there can exist at most a finite number of modes satisfying both the continuity conditions at the interfaces and the boundary conditions at infinity. Furthermore, such modes are not orthogonal. The exact solution, in which the Green's function is given by a contour integral, can be manipulated to yield residues having the form of normal modes and an additional correction term given by loop integrals about one or more branch points. This correction term is important only for conductivities approaching zero.

[1] Carson, Mead, and Schelkunoff, Bell Sys. Tech. J. (April, 1936).
[2] J. A. Stratton, *Electromagnetic Theory* (McGraw-Hill Book Company, Inc., New York, 1941).

C6. On the Design of a Cavity of a Linear Electron Accelerator. E. S. AKELEY, *Purdue University.*—Consider a resonating cavity formed by planes $x = 0$, $x = \pi$ and surface of revolution $y(x)$ connecting planes. Assume electromagnetic field expressible as sum of finite number of TM_{01} modes, each characterized by its phase velocity v on axis. Only mode imparting energy to electron is $v = c$. Differential equation for $y(x)$ is $E_x dx + E_y dy = 0$. The analytic character of $y(x)$ in neighborhood of $x = 0$ is easily determined. This point is a singular point of the differential equation and may be a nodal point. The types of possible $y(x)$ are discussed in terms of the roots E_x and E_y and their common roots which are the singular points of the differential equation. The following cases have been or are being investigated: (1) modes $v = c$ and $v = c/2n+1$. The case $n = 1$ appears most favorable as regards energy dissipation. (2) modes c, $c/3$, $c/5$. A perturbation computation indicates a lower dissipation of energy with weak $c/5$ than with other two modes only. (3) c, $c/2$, $c/3$. (4) c, $2c$. Cases (3) and (4) give unsymmetrical and alternating cavities which may produce a more favorable separation of modes for the whole accelerator than is obtained in cases (1) and (2).

C7. Propagation of Radiation in a Medium with Random Inhomogeneities. PETER G. BERGMANN, *Columbia University.*—When radiative energy is propagated through a material medium over any considerable distance, it is frequently found that the signal picked up at some fixed point is subject to random fluctuations. This effect is present even when reflections from bounding surfaces are eliminated. The fluctuation is, therefore, believed to be caused, at least in part, by the random inhomogeneities of the medium itself. A theory has been developed which, on the basis of ray optics, leads to quantitative relations between the statistical fluctuations of the index of refraction of the medium and the fluctuations of the radiative field, provided the latter do not become too large. It is found that the r.m.s. fluctuation of the optical path length between two fixed points increases with the square root of the distance, while the r.m.s. intensity fluctuation for a fixed path of transmission increases with the $\frac{3}{2}$th power.

Similarly, relations can be derived for the deviation of a transmission path from a straight line and for the correlation of field intensities at two distant points.

C8. The Mean Free Paths of Cesium Atoms in Helium, Nitrogen, and Cesium Vapor. I. ESTERMANN, S. N. FONER, AND O. STERN, *Carnegie Institute of Technology.*—The mean free paths of cesium atoms in helium, nitrogen, and cesium vapor were measured with a molecular beam apparatus permitting the measurement of scattering deflections of about 5 seconds of arc. Using the free fall of the beam atoms, the variation of the mean free path with the velocity of the beam atoms could be determined directly. This variation was found to be in agreement with the equations calculated on the basis of classical theory treating the atoms as elastic spheres. The sums of the effective atomic radii found are 12.0×10^{-8} cm for Cs-He, 17.2×10^{-8} cm for Cs-N_2, and 27.3×10^{-8} cm for Cs-Cs collisions. These values correspond to mean free paths of 2.1 meters in He 2.2 meters in N_2, and 1.36 meters in Cs-vapor of 10^{-6} mm Hg pressure for cesium atoms corresponding to the maximum intensity of the gravity deflection curve.

C9. Maximum Rate of Multiplication of Unicellular Organisms. ALLEN L. KING, *Dartmouth College.*—When spherical unicellular organisms multiply by the fission process, the rate depends upon several physical factors. A kinetic treatment of the problem yields a maximum rate of $1.735\alpha\bar{c}V_0N^2/a$, where $\bar{c}$ represents the average speed of certain molecules, such as those of oxygen or a vitamin, which limit the multiplication process, and α represents that fraction of such molecules striking the cell surface which become part of the cell. V_0 represents the volume and a the radius of a single daughter cell immediately after fission and N represents the number of cells per unit volume when the rate of multiplication is a maximum.

R1. Ambiguities in X-Ray and Electron Diffraction Analysis. A. L. PATTERSON, *Bryn Mawr College.*—In a previous report[1] it has been shown that, in many cases, there are two or more non-congruent arrangements of atom positions in a crystal lattice which have the same vector distance set, i.e., which give the same x-ray diffraction pattern. This result is now extended to include non-congruent finite arrangements of points which have the same vector distance set even when all distances are distinct. A discussion is also given of the many finite arrangements of points which have the same scalar distance set and a comment is made on the effect of this result on the interpretation of electron diffraction data. It is pointed out with the aid of examples that weighting of atomic positions and of related distances does not necessarily remove the ambiguity, and that consequently the method used by Robertson and others for the investigation of isomorphous series will not always resolve an ambiguity.

[1] A. L. Patterson, Phys. Rev. 65, 195 (1944).

R2. The Orientation of Single Crystals by the Use of Two Simultaneous Bragg Reflections. I. FANKUCHEN, *Polytechnic Institute of Brooklyn.*—In connection with the problem of orienting quartz crystals for cutting into piezoelectric elements, a simple and accurate method was devised which depends on setting up a crystal so that two strong Bragg reflections of one incident beam occur simultaneously. The method was suggested by some experiments designed to observe Renninger's[1] forbidden reflections. In Renninger's experiments, one of the two planes in a position to reflect has zero intensity while for orienting purposes, it is convenient to use two strong reflections. The crystal is adjusted so that one of the planes is perpendicular to an axis of rotation and the x-ray beam is set to make the Bragg angle with this set of planes. Rotation, therefore, does not change the constancy of this reflection when the crystal is properly adjusted. Many other reflections occur during a complete rotation and by properly choosing a second reflection, the crystal is not only fixed in orientation but for quartz the "sense of cut" is also determined at the same time.

[1] Renninger, Zeits. f. Krist. 97, 107 (1937).

R3. The Breaking up of Single Crystals of Quartz. D. D'EUSTACHIO AND S. B. BRODY, *Bliley Electric Company.*—Quartz wafers prepared by etching from wafers 75 to 100 microns thick, are found no longer to be single crystals when they become thinner than 25 microns. The break-up is shown by a series of Laue photographs of progressively thinner crystals taken in the following way. A suitably prepared crystal is set in and nearly parallel to a well-collimated x-ray beam. The "spots" from thick crystals are broad, uniformly illuminated areas. As the crystal becomes thinner the intensity distribution becomes less uniform. The pictures of the thinnest crystals show many sharp dark lines against a faint general background. These dark lines become broader and the background increases in intensity when the crystal is bent. The entire crystal appears to be changed. The authors believe that the change from single crystal to the polycrystalline state is initiated by the formation of surface layers in the manner previously described.[1] If this is so, the effect should be time dependent. No method for preparing thin wafers that is fast enough to permit this to be verified has yet been found.

[1] D. D'Eustachio and S. B. Brody, J. Opt. Soc. Am. 35, 544 (1945).

R4. X-Ray Microradiographic Study of Strains in Crystals. C. M. LUCHT, M. MANN, AND R. SMOLUCHOWSKI, *General Electric Company.*—In previous x-ray microradiographic study of compounds and diffraction effects in various metals and alloys* a selective transmission within single grains was observed. Certain grains appear as having a "mottled" pattern which depends upon orientation of the grain. This phenomenon was further studied and interpreted as due to a diffraction effect in imperfect grains. By using filtered radiation and improving the experimental technique, many additional features were brought out which confirm this interpretation and provide a tool for the study of strains within single grains. This

method permits a study of strain distribution and temperature influence during annealing and cold working. Strain discontinuities at twin and grain boundaries can be observed.

* Hurd, Lucht, and Smoluchowski, Phys. Rev. 68, 100 (1945).

R5. Forced Vibrations of Piezoelectric Crystals. H. EKSTEIN, *Armour Research Foundation.*—The vibrations of anisotropic bodies under the influence of sinusoidally variable volume forces and boundary stresses are investigated. The displacement components are represented as sums of a system "zero order" solutions which solve approximately the free-vibration problem. By using Betti's theorem, the problem is reduced to a system of inhomogeneous linear equations which, for the free-body case, reduces to the homogeneous system derived in an earlier paper.[1] If the external forces are piezoelectric, the forces are no longer given explicitly because the electrical field distribution is known only if Maxwell's equations are solved simultaneously. However, if the pertinent piezoelectric constants are small, the field can be calculated approximately as if the crystal were not vibrating. The solutions can then be obtained by the above method. The electric reaction of the crystal upon the driving system can then be determined. As an example, forced vibrations of thin quartz plates between parallel electrodes are discussed.

[1] H. Ekstein, Phys. Rev. 66, 108 (1944).

R6. Deuteron Bombardments of Organic Compounds. RICHARD E. HONIG, *Massachusetts Institute of Technology.*—In order to study the chemical effects of heavy charged particles, a number of organic compounds—gases, liquids, and solids—have been bombarded with deuterons from the Massachusetts Institute of Technology cyclotron. This work, carried out under American Petroleum Institute Project 43c, included paraffins, organic acids, salts, and some complex mixtures. Gas bombardments were made at approximately atmospheric pressure in a water-cooled gas chamber (volume: 2.54 liters) provided with a two-mil copper window for the entry of the external deuteron beam. A thermocouple and a Bourdon gauge connected to a Microtorque potentiometer allowed the gas temperature and pressure to be recorded electrically at the control bench during the bombardment. Fixed volume runs as well as flow runs have been made. For the bombardment of liquids and solids, water-cooled target-holders provided with two-mil copper windows were mounted inside the gas chamber which served to collect the product gases. To prevent chemical reactions of the compounds with the metal parts, chamber and target-holders were goldplated. The efficiency of deuterons in producing particular chemical reactions has been computed in terms of the mean energy dissipated per primary molecule decomposed ("dissociation expenditure" $\Delta E/\Delta M$).

R7. Study of Metastable Ions with the Mass Spectrometer. J. A. HIPPLE, R. E. FOX AND E. U. CONDON,* *Westinghouse Research Laboratories.*—In the mass spectra of hydrocarbons there are peaks occurring at non-integral masses when the spectra are obtained with a mass spectrometer employing simply a magnetic analyzer. These have recently[1] been attributed to ions which dissociate spontaneously after being accelerated from the ion source into the analyzer. On the basis of this explanation the energy of each ionic fragment formed from a metastable parent may be predicted. Using an energy filter on the exit end of a mass spectrometer, a study has been made of *n*-butane, 1,3-butadiene, and ethane. In each case the energy measurements agreed with the values predicted confirming the earlier interpretation of the phenomenon. As a variation of the pressure does not affect the relative abundance of the metastable fragments as compared with the rest of the spectrum, the possibility of the phenomenon being caused by ion-molecule collisions is eliminated. Other evidence that the dissociation is spontaneous is obtained by varying the small voltage accelerating the ions out of the ion source into the ion gun. As this voltage is increased, the metastable ions reach the analyzer earlier in their lifetime and hence the peaks arising from their dissociation increase rapidly. Metastable ions have been observed in many hydrocarbons and some of these will be discussed.

* Present address National Bureau of Standards, Washington, D. C.
[1] J. A. Hipple and E. U. Condon, Phys. Rev. 68, 54 (1945).

R8. Mechanism of the Luminescence of Solids. FERD E. WILLIAMS, *RCA Laboratories* AND HENRY EYRING, *Princeton University.*—Equations calculated from a simple energy *versus* configuration coordinate diagram for the normal and excited states of the activator atom reproduce the complete temperature-dependence curves of luminescent efficiency of many phosphors. The configuration contours are drawn so as to provide an activated step with a small heat of activation for the luminescent process and an activated step with a large heat of activation for the radiationless recombination of the excited electron and the activator atom. This model, confirming experimental results, indicates that excitation with short wave ultraviolet light produces increased luminescent efficiency at low temperatures while excitation with long wave ultraviolet produces decreased efficiency compared to room temperature efficiency. On removal of the excitation some of the electrons exist in an excited state from which transitions to the normal state are forbidden, and some electrons have surmounted the potential hump and exist in an excited state from which transitions to the normal state are allowed. The latter electrons spontaneously drop to the normal level by a monomolecular temperature-independent process, while the former slowly surmount the barrier by strongly temperature-dependent kinetics. Such two stage decay is observed. The height of the barrier is confirmed by glow curve data.

R9. The Infra-Red Absorption of Methane as Influenced by Foreign Gases. NORMAN D. COGGESHALL AND ELEANOR L. SAIER, *Gulf Research & Development Company.*—The influence of foreign gases on the intensity of the infra-red

absorption of some of the light gases has been known for some time. A number of light gases among which are: CO, CO_2, SO_2, CH_4, etc. do not obey Beer's law of absorption in the infra-red either in a pure form or when contaminated by foreign gases. For example, when a non-absorbing gas such as hydrogen is added to a certain amount of an absorbing gas such as methane the absorption due to the latter is considerably increased. Dennison[1] has theoretically examined the shape and intensity of infra-red absorption lines and found that they are affected by the effective diameters of the molecules. Cross and Daniels[2] have studied the effect of several different gases on the absorption due to nitrous oxide and for each determined an "optical" collision diameter. The present work is an application of the same type of study to the case of methane. The shape and intensity of the absorption bands of methane have been studied as depending upon the type and partial pressure of foreign gas. Data will be shown and discussed which show large differences in the effects of different foreign gases. The data are also of practical interest in that they indicate what types of gas mixtures may be analyzed by infra-red absorption means.

[1] D. M. Dennison, Phys. Rev. 31, 503 (1928).
[2] P. C. Cross and F. Daniels, J. Chem. Phys. 2, 6 (1934).

R10. A Method of Preparing Absorbing Surfaces for the Infra-Red. L. N. HADLEY AND D. M. DENNISON, *University of Michigan.*—Surfaces which absorb practically 100 percent of the radiation falling within a small wavelength range have been used extensively for short radio waves. Solution of Maxwell's equations requires a perfect reflector covered with a dielectric layer of thickness $\lambda/4n$, where n is the index of refraction. Upon the dielectric layer lies a thin semiconducting layer whose resistance is 377 ohms/square. We have constructed surfaces of this type for the infra-red, using evaporated films. The mirrors are made of aluminum on glass, the dielectric films of lithium fluoride, and the semiconducting films of chromium. The fundamental frequency for which the surfaces are prepared is blacked out as are all odd multiples of the fundamental. A surface with fundamental at 13.9μ shows seven bands in the visible, corresponding to the odd overtones 21 through 33. A surface with fundamental at 3.25μ shows two bands in the visible: the fifth and seventh overtones. Theoretical and experimental curves of reflectivity *versus* wave-length have been obtained. We propose to use the surfaces in infra-red spectroscopy in the manner of reststrahlen plates to eliminate the use of a foreprism, and perhaps also in the detecting system. It is also possible through reflection at oblique incidence to obtain polarized infra-red radiation.

S1. Electrical Properties of Germanium Alloys. I. Electrical Conductivity and Hall Effect. K. LARK-HOROVITZ, A. E. MIDDLETON, E. P. MILLER, AND I. WALERSTEIN, *Purdue University.*—Germanium samples purified by high vacuum treatment have been alloyed by adding from 0.001 percent to 1.0 percent of metallic impurities. The electrical conductivity and transverse Hall effect of these samples have been investigated over temperatures ranging from -180°C to 650°C. Plotting log ρ (resistivity) and log R. (Hall constant) against $1/T$ shows that the resistivity at low temperatures decreases with increasing temperature, increases around room temperature and then drops sharply with a slope identical for the various samples. The Hall curves indicate electron (N type) or hole (P type) conduction, depending upon the type of impurity. P type samples show reversal of Hall effect, and the slope at high temperatures is identical for all samples, P and N alike, indicating that germanium behaves at low temperatures as an impurity semiconductor, but is at high temperatures an intrinsic semiconductor with energy level separation of about 0.76 volt. Hall values show that the number of current carriers ranges from about 10^{15} up to 10^{19} per cc. The temperature behavior of mobility, determined by R/ρ, cannot be explained as due to lattice scattering alone, but indicates the existence of another scattering mechanism, especially at low temperatures.

S2. Theory of Impurity Scattering in Semiconductors. E. CONWELL AND V. F. WEISSKOPF, *University of Rochester.*—Recent experiments on Hall effect and resistivity of germanium semiconductors have shown that the simple theory of lattice scattering alone cannot explain the temperature dependence of mobilities. Another obvious source of resistance is scattering by impurity centers, such as Rutherford scattering of electrons (or holes) by a random distribution of impurity ions. Because of the large wavelength of these thermal electrons their movement can be considered as free and their scattering by the impurity ions is given by the classical expression, assuming perfectly elastic collisions and effectively infinite mass for scattering centers. Scattering of an electron by one ion is treated as approximately independent of all other ions. The resistivity due to such impurity scattering is (in ohm–cm)

$$\rho=\frac{9\times10^{11}\pi^{3/2}e^2m^{1/2}}{2^{7/2}\kappa^2(kT)^{3/2}}\ln\left(1+\frac{36\kappa^2k^2T^2d^2}{e^4}\right),$$

where d is half the average distance between impurity ions and κ the dielectric constant of the semiconductor.

S3. Theory of Resistivity in Germanium Alloys. K. LARK-HOROVITZ AND V. A. JOHNSON, *Purdue University.*—The temperature dependence of resistivity of germanium alloys is considered in three ranges: (1) the impurity range of low temperatures with conduction due to impurity electrons or holes, (2) the transition range with contributions from both impurity and intrinsic electrons and holes, and (3) the intrinsic range of temperatures so high that the numbers of electrons and holes are equal. Resistivity in the impurity range is the sum of resistivity due to lattice scattering (proportional to $T^{\frac{3}{2}}$) and resistivity due to impurity scattering. Mean-free-path calculations indicate that the impurity mean-free-path increases and the lattice mean-free-path decreases with rising temperature. At a given temperature the lattice mean-free-path is the same for all germanium samples, but the impurity mean-free-path varies widely with impurity content. In the transition and intrinsic ranges conductivity is the sum of conductivities due to electrons and holes; their values are based upon

Hall constant values. Combination of these two methods allows complete synthesis of the experimental results throughout the entire temperature range.

S4. Electrical Properties of Germanium Alloys. II. Thermoelectric Power. K. LARK-HOROVITZ, A. E. MIDDLETON, E. P. MILLER, W. W. SCANLON, AND I. WALERSTEIN, *Purdue University.*—The thermoelectric power, Q of Germanium alloyed with various metallic impurities has been studied as a function of temperature from -180°C to 650°C. For this purpose thermocouples have been imbedded into the body of the semiconductors and temperature gradients of .5 to 30°C/cm have been used depending on the temperature range and the size of the sample. The thermoelectric behavior parallels R, the Hall effect. R and Q are positive for P type samples at low temperatures, reversing sign at high temperatures. The thermoelectric power, Q becomes zero at a temperature near but not identical with the temperature where R becomes zero. In most cases Q as a function of temperature rises in the low temperature range, passes through a maximum and decreases again near room temperature. The position and height of the maximum depends on the amount and type of impurity used. The temperature dependency of Q for samples containing the same type of impurity in varying amounts are represented by a family of similar curves: with increasing impurity content the position of the maximum shifts to higher temperatures and lower values.

S5. Theory of Thermoelectric Power in Germanium. V. A. JOHNSON AND K. LARK-HOROVITZ, *Purdue University.*—Thermoelectric power Q in semiconductors has been calculated under conditions of simultaneous conduction by positive and negative conductors. The low temperature form (impurity conduction only) becomes

$$Q=(\ln RT^{\frac{3}{2}}-5.32)k/e+\Delta Q,$$

where R is the Hall constant in cm³/coulomb and ΔQ is a term to compensate for the dependence of mean free path on velocity. In general

$$Q=-\frac{k}{e}\left[38.121\frac{n_1c-n_2}{n_1c+n_2}-0.659\frac{n_2}{n_1c+n_2}-\frac{n_1c}{n_1c+n_2}\ln\left(\frac{n_1}{T^{\frac{3}{2}}}\right)+\frac{n_2}{n_1c+n_2}\ln\left(\frac{n_2}{T^{\frac{3}{2}}}\right)\right].$$

where n_1 and n_2 are the number of electrons and holes per cc determined from conductivity and c is the ratio of electrons and hole mobility in the intrinsic range, identical for all germanimum samples. The thermoelectric power thus calculated is in agreement with experiment throughout the temperature range.

S6. On the Flow of Binary Gas Mixtures through a Long Capillary when the Mean Free Path is Comparable to the Capillary Diameter. A. J. DEBETHUNE AND R. D. PRESENT, *SAM Laboratories, New York, New York.*—The separation of a gas mixture by diffusion through a capillary of radius r depends on the fact that the molecules have different masses m_i and mean velocities $\bar{v}_i$. When the inlet pressure is so low that the mean free path λ is much greater than r, the flow is diffusive and the separation factor (at zero outlet pressure) has its maximum value $(m_2/m_1)^{\frac{1}{2}}$. At high pressures ($\lambda \ll r$) no separation occurs. We have treated the intermediate case ($\lambda \approx r$) where the transfer of forward momentum from light to heavy molecules in unlike collisions equalizes the transport velocities and decreases the separation factor. As the inlet pressure rises, this effect makes the flow non-separative before it becomes viscous. Flow equations are derived by equating the momentum acquired by each component from the pressure gradient to the momentum lost to the wall plus that transferred to the other component. The viscous effects are treated as a small additive perturbation on the flow. The integrated flow equations express the separation factor as a function of the inlet and outlet pressures. The same results have been derived by another method and extended to porous media by Bosanquet, Pollard, and Present. The theory has been quantitatively verified in many experiments on the flow and separation of several gas mixtures through various porous media.

S7. Separation of Gas-Mixtures Flowing through Porous Media. W. A. NIERENBERG, *SAM Laboratories, New York, N. Y.*—An experiment was performed measuring the separation of O_2-N_2 mixtures flowing through porous plates made of etched alloys as a function of high side pressure. The low side pressure is 1 percent of the high side pressure and the data are extrapolated to zero low side pressure. The porous plate forms one side of a 0.015" channel down which the high pressure gas flows viscously (~50 cm Hg) and the exit flow is 0.7 percent of the entrance flow. This technique is termed the "high-cut" method and it implies the continuous increase in heavy molecular concentration in the high pressure fraction by selectively removing the lighter molecules through the plate. This proceeds logarithmically (Rayleigh's law) with the undiffused fraction of the gas. The achieved magnification factor five is an extreme apparatus limit. The plate is tapered in the direction of flow to maintain the gas velocity and minimize back diffusion. Appropriate corrections are made for diffusion losses. The mixture is 50 percent O_2 and 50 percent N_2 to afford the maximum change in mole fraction. The analysis and comparison of samples is performed by a micro-absorption unit of novel design which handles 0.6 cc to 0.04 percent accuracy. The averaged forepressure curve of separation agreed with the theory of the previous paper to 0.6 percent compared to 0.43 percent average scatter from the best-fitting curve over a range of separation from 100 percent to 15 percent of the maximum theoretical value. The agreement is considered excellent.

SP1. Theorem on Equivalent Representations of an Arbitrary Linear Network. E. J. SCHREMP, *Massachusetts Institute of Technology.**—For any M-terminal linear network, active or passive, this theorem yields infinitely many equivalent representations, including one M-node representation, together with others having $N>M$ nodes, of which $(N-M)$ are internal and generally fictitious nodes.

Thus, with each internal node r the theorem associates a continuous group of equivalent representations generated by the transformation

$$i_m(r, a)=i_m-a(y_{mr}/y_{rr})i_r \qquad (m, n=1, 2, \cdots, N), \quad (1a)$$

$$y_{mn}(r, a)=y_{mn}-a(y_{mr}/y_{rr})y_{rn} \qquad (r=M+1, M+2, \cdots, N), \quad (1b)$$

where, in a given N-node representation, i_m is the net current injected at node m, e_m is the voltage of node m, and $y_{mn}=\partial i_m/\partial e_n$; and where $i_m(r, a)$, e_m, and $y_{mn}(r, a)=\partial i_m(r, a)/\partial e_n$ are the corresponding quantities for any value of the generating parameter a. For all values of a, the nodal equations

$$i_m(r, a)-\Sigma_n y_{mn}(r, a)e_n=\Sigma_n y_{mn}(r, a)=\Sigma_n y_{nm}(r, a)=0 \quad (2)$$

are satisfied. By successive application to different internal nodes r, s, $\cdots$, the transformation (1) and its inverse will generate all equivalent representations of the given network. This theorem is similarly expressible on the loop basis.

* To be given after paper C9 if time permits.

SP2. Transformation Theory of Hydrodynamical Equations. HERBERT JEHLE, *Université de Bruxelles and Harvard University.**—Stellar dynamics has still to overcome mathematical difficulties involved in solving hydrodynamical equations, particularly selfconsistent fields. Hydrodynamical equations can be simplified by writing them over into a wave equation for $|\psi|\exp(iS/\bar{\sigma})$ (time dependent Schroedinger type) which can be split into two real equations:

$$0=-\Sigma\nabla_\nu\langle(|\psi|^2\nabla_\nu S)\rangle+(\partial/\partial t)\langle|\psi|^2\rangle=\Sigma\nabla_\nu(\rho\bar{v}_\nu)+(\partial/\partial t)\rho,$$

$$0=-(\partial/\partial t)\langle(|\psi|^2\nabla_\mu S)\rangle+\langle|\psi|^2\rangle\nabla_\mu\bar{U}+\langle|\psi|^2\nabla_\mu(\delta U)\rangle$$
$$+\Sigma\nabla_\nu\langle\{-\tfrac{1}{2}\bar{\sigma}^2|\psi|^2\nabla_\mu\nabla_\nu\log|\psi|^2+|\psi|^2(\nabla_\mu S)(\nabla_\nu S)\}$$
$$=(\partial/\partial t)(\rho\bar{v}_\mu)+\rho\nabla_\mu\bar{U}-\int\int\int v_\mu\nabla(f)dv_1dv_2dv_3$$
$$+\Sigma\nabla_\nu(\rho\langle v_\mu v_\nu\rangle).$$

Poissons equation determines gravitation potential $\bar{U}+\delta U$ from $|\psi|^2$; bars or $\langle\rangle$ denote averages over position space volumes containing many elements; ($\bar{\sigma}$ stands for $\sigma/2\pi$). We assume that the distribution (numbers and intensities) of excited ψ_{nlm} states (n is about 10^5) corresponds statistically to the distribution (in numbers and masses) of statistically independent elements of a stellar system. This replaces the assumption about maximum phase space density and makes it impossible to observe discreteness of stationary states.

* To be given after paper C9 if time permits.

T1. The Constant Magnetic Current and Heinrich Hertz.* FELIX EHRENHAFT, *New York City.*—Heinrich Hertz[1] stated that with respect to unipolar induction we have to speak of the constant magnetic current with the same right as of the constant electric current, and that magnetic poles which form a continuous line and are mechanically moved in the direction of the line have an electrostatic action in the surrounding space. This action and the existence of single magnetic poles (charges) the author[2] has demonstrated in many experiments and has given photomicrographic evidence. The helical path of an iron particle with the mobility B with the axis of the helix parallel to an external homogeneous magnetic field H of 50 gauss has been described.[3] It can be calculated that, neglecting the velocity due to the constant longitudinal magnetic field in the beam of light, the constant horizontal velocity w due to the external field of 50 gauss is about 1×10^{-2} cm per second. Since the magnetic charge q equals w/BH, it follows that q is about 5×10^{-12} m.s.u. That the electrostatic charge e is about 4×10^{-10} e.s.u. can be calculated, since mv^2/R equals evH. Here an electrostatically charged particle rotates around H with a velocity of around 10^{-1} cm per second, a speed clearly not sufficient to create its own magnetic field. The mass m, the magnetic charge q, and the electrostatic charge e of the above particle have been determined by experiment, whereas in the theory of cathodic rays, beta-particles, etc. it was assumed that the particles carry only an electric charge, overlooking the possibility of their simultaneously carrying a magnetic charge. Thus the relationship e/m is open to question.

* Read by title only.
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