Proceedings of the American Physical Society

MINUTES OF THE MEETING AT MINNEAPOLIS, MINNESOTA, NOVEMBER 29–30, 1946

THE 275th meeting of the American Physical Society was held at Minneapolis, in the Physics Building of the University of Minnesota, on Friday and Saturday, November 29 and 30, 1946. With about two hundred registrants, and some two hundred and seventy-five people in attendance at the most populous session, this meeting assumed the congenial character of those of the pre-war days: no simultaneous sessions and no overcrowding. There were three invited papers, by S. A. Goudsmit, H. D. Hagstrum, and D. W. Kerst, respectively; contributed papers numbered thirty-five. The arrangements for the meeting were very well handled by J. W. Buchta and Mrs. J. T. Tate.

The dinner was held in the Coffman Memorial Union on the Friday evening, with an attendance of 196. E. U. Condon gave an analysis of the various proposals for a National Science Foundation which came before Congress in 1946, and J. T. Tate received from Columbia University a medal signalizing his eminent contributions to the war effort. Impressive movies of the events at Bikini were exhibited.

The Council met on Saturday afternoon and evening. It elected to Fellowship the eight candidates and to Membership the one hundred and eighty-six candidates whose names appear below. The Council also nominated to the Governing Board of the American Institute of Physics J. T. Tate and E. U. Condon for three-year terms and A. J. Dempster for a two-year term. Including L. A. DuBridge and G. B. Pegram who continue in office, the Governing Board will after next February comprise five representatives of the American Physical Society.

The Society has lost through death the following Fellows and Members: J. R. Carr (Zurich), H. L. Cooke (F, Princeton), Dunham Jackson (F, Minnesota), Enoch Karrer (F, New Orleans), G. N. Lewis (F, University of California, Berkeley), P. K. McGall (Orange, N. J.), P. S. Turner (Washington, D. C.), J. E. Walter (Princeton), J. M. Willson (Rolla, Mo.).

Elected to Fellowship: C. R. Burrows, R. F. Christy, J. M. Davies, D. J. Hughes, Urner Liddel, J. A. Simpson, A. M. Weinberg, and G. J. Young.

Elected to Membership: N. Z. Alcock, Robert R. Allen, R. O. Anderson, George B. Arfken, Jr., Emerson D. Bailey, Carl Ernest Behrens, Felix M. Beiduk, Locklin Savage Bell, Philip Joseph Bendt, Verne Harrington Berry, Paul L. Betz, Karl W. Bewig, Garrett Birkhoff, John S. Blair, Ingram Bloch, Ralph Herbert Blumenthal, Lawrence A. Bornstein, Ralph Bray, Laurie Mark Brown, Gordon Lee Brownell, Donald C. Brunton, Anne Mary Buchy, Lawrence Whitney Burgess, Henry J. Butler, Julius H. Cahn, Hartman B. Canon, H. B. G. Casimir, Louis Chandler, Robert L. Chapman, Francis H. Clauser, Martin J. Cohen, Marius Cohn, Richard Louis Conklin, Thomas Coor, Jr., James Edward Corry, Jr., George Edward Crouch, Jr., Cassius W. Curtis, G. C. Dewey, Jean E. Dickey, Kenneth Edwin Dorcas, John J. Downing, Sidney David Drell, Ralph William Dressel, Stuart B. Dunham, William Walter Durding, Shirley L. Eberlin, Bengt Edlin, Daniel M. Ekstein, James Emmett Erickson, Gustave A. Essig, Harold Feeny, Fred G. Fender, John H. Fergus, Kenneth R. Ferguson, Bernard A. Fleishman, Sidney Frankel, Rachel G. Franklin, Hans Frauenfelder, Henry Charles Froula, Jr., Everett Gladding Fuller, Simeon V. Galginaitis, Richard Lawrence Geiger, Stanley Geschwind, Marvin L. Goldberger, Howard D. Goldgraber, James N. Grant, Victor Graziano, John H. Greig, John W. Gryder, Robert C. Gunton, Charles B. Haenny, Erwin Louis Hahn, Crockett Hall, Jr., Herbert J. Hall, Robert H. Hardoen, David Harker, Jack Heller, Donald L. Herr, Joseph Hirsch, Paul O. Hoffmann, John Hovorka, Horia Hulubei, Frank B. Isakson, Mary Caroline Jansen, Walter C. Johnson, Abraham Karen, Jesse R. Karp, David R. Kasanof, Robert H. Kasriel, Samuel C. Kelly, Charles T. Keniston, Madeline C. Kessler, Simon C. Kirsch, E. D. Klema, George Kolodny, Alexander Kossiakoff, Bernard Kramer, Henry Lawrence Kraybill, K. S. Krishnan, Charles B. Kunz, Louis Landweber, Jean Langevin, Elmer C. Larsen, Philip G. Law, Richard W. Lee, Lucille Leibowitz, Meyer Leifer, Alfred Leitner, Franklyn Kussel Levin, Leo Charles Levitt, George G. Libowitz, William A. Lindeke, Harry J. Lipkin, Stuart Phinney Lloyd, Idos W. Lohmann, Albert London, William Low, Franklin E. Lowance, James E. LuValle, Lloyd Godfrey Mann, Pierre Marmier, Marvin D. Martin, Joe T. Massey, Everett Lee McCleary, Robert E. McConnell, Harry Joseph McCready, Jr., William G. McMillan, Jr., Franz Metzger, John William Mihelich, Julian Malcolm Miller, Jatinder Nath Nanda, David B. Nicodemus, Sol Nudelman, Irving P. Orens, Jehuda Ovadia, Harry Palevsky, Robert G. Parr, Philip Parzen, T. P. Pepper, I. Perlman, Rolland Perry, Helen Peterson, Jack M. Peterson, James Alfred Phillips,

Herbert Priestley, Richard D. Radford, Robert Basil Randels, George Rappaport, Jerome M. Rehr, J. Gordon Retallack, Charles A. Reynolds, Joseph M. Reynolds, Richard Ayer Rhodes II, John E. Richardson, Kenneth Clay Ripley, Robert Sumner Rochlin, George Wayne Rodeback, Philip Rosen, Stanley Rowlands, James Reynolds Sagurton, Vance L. Sailor, Oscar Sala, Jacob Schroeder, Ernest Sharo, John R. Sites, Philip Bartlett Smith, Harold Stein, Jack Steinberger, Peter A. Stewart, William H. Sullivan, Karl Dale Swartzel, Ernest A. Taft, Paul Tamarkin, Stephen Tamor, William C. Taylor, D. Ter Haar, Frederick W. Van Name, Jr., Jerry M. Waite, Joseph Henry Wegstein, Leslie Swales Wilcoxson, John E. Willard, Bruce Donald Witwer, Joseph Laurence Wolfson, Donald Calhoun Worth, Marvin Eugene Wyman, and Marshall C. Yovits.

The names of the invited speakers and titles of their papers, and the abstracts of the contributed papers, are printed hereinafter.

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

Invited Papers

Why Germany had No Atomic Bomb. S. A. GOUDSMIT, *Northwestern University.*
Molecular Ionization and Dissociation Induced by Electron Impact. H. D. HAGSTRUM, *Bell Telephone Laboratories.*
The Design of the Large Illinois Betatron. D. W. KERST, *University of Illinois.*

ABSTRACTS OF CONTRIBUTED PAPERS

A1. Rotational Structure of InCl Bands at 2670A. J. G. WINANS AND H. M. FROSLIE, *University of Wisconsin.*—InCl bands near 2670 were photographed with dispersion 0.6 A/mm with absorption cells containing $InCl_3$ and excess of indium metal. The isotope effect showed carrier InCl not HgIn.[1] Observations and vibrational analysis of Miescher and Wehrli[2] were verified. System is probably $^1\Pi_1 \rightarrow {}^1\Sigma_0{}^+$. Bands with $v'=1$ show no rotational structure. Assuming dissociation products In $^2P_{1/2}$+Cl $^2P_{1/2}$ and predissociating limit In $^2P_{1/2}$+Cl $^2P_{3/2}$ fixes D_0'' between 4.62 and 4.65 volts. The 00 Q branch extends to $m>100$. For Q, $\nu = 37{,}410.599 - 0.00696\ m(m+1) - 1.39\times10^{-7}m^2\ (m+1)^2$. For P, $\nu = 37{,}410.599 + 0.214\ m - 0.00696m^2$. The unresolved R branch has head at 37,412.251 cm^{-1}. These give $B_0' = 0.1037$, $B_0'' = 0.1107$. Analysis of band 0–2 gives $B_0'' = 0.1032$, $B_2'' = 0.1093$ cm^{-1}. These give $r_0'' = 2.38$A.

[1] J. G. Winans, Francis Davis, and Victor Leitzke, Phys. Rev. **57**, 1079 (1940).
[2] E. Miescher and M. Wehrli, Helv. Phys. Acta **7**, 298 (1934).

A2. An Experimental Relation Between ω_e and Reduced Mass for Diatomic Molecules. R. L. PURBRICK, *University of Wisconsin.*—An equation of the form

$$\omega_e = a + c\mu^b$$

has been applied to the molecules of the first column of the periodic system. With constants $a=0$, $b=-0.734$, and $c=878.6$, the equation predicts ω_e for both molecules having identical nuclei and those formed from non-identical alkali atoms. The equation shows that the force constant, K, is approximately the same for these molecules. Indications are that similar equations may be developed for other columns of the periodic system, but with different constants.

A3. The Analysis of Molecular Spectra and the Calculation of Thermodynamic Quantities. ENOS E. WITMER, *Thermodynamics Research Laboratory, University of Pennsylvania.*—It is generally agreed that zero-pressure values of enthalpy, reduced entropy, and specific heat for gases can be calculated from spectroscopic data more accurately than they can be inferred from calorimetric measurements extrapolated to zero pressure. The University of Pennsylvania Thermodynamics Research Laboratory, operated under contract with the Navy Department, Bureau of Ships, has undertaken a comprehensive program of calculations aimed at obtaining definitive information regarding gases and gas mixtures of technical importance. In this connection it has been deemed advisable to improve existing machinery for the analysis of the spectra of polyatomic molecules. To that end, a very accurate and fine-grained table for computing quickly and accurately the energy levels of the asymmetric rotator is being prepared. The paper will discuss this table in relation to others previously published.

A4. Decay of Phosphorescence in Cu-Activated ZnS, HUBERT M. JAMES, *Purdue University, West Lafayette, Indiana.*—Phosphorescent fine-grained Cu-activated ZnS gives rapidly decaying flash radiation with intensity $I \cong I_0/(1+At)^2$, followed by more persistent radiation with intensity $I = C/(t+t_0)$ through a range of 10^5 in I. Here t is time elapsed after excitation and $t_0 \cong 2\times10^{-4}$ sec. These and other observations can be explained quantitatively if the trapping states in the crystal are surface states such as those discussed by Tamm. The conduction band is pictured as consisting of two parts, the main part corresponding to states in which the excited electrons move throughout the body of the crystal, and the lower to states in which they are trapped on the surface. The density of levels in the trap will be much smaller than that in the main band; both densities are assumed uniform. Thermal equilibrium is assumed between electrons in all these states. It is essential to apply the Fermi-Dirac statistics in discussing this equilibrium, since the trapping states may be almost filled. Only electrons in body states can reach holes and radiate; I is proportional to the product of this number and the number of holes. The theory satisfactorily describes the entire course of the intensity decay, and yields reasonable estimates of the characteristics of the trapping band.

A5. Minimum Sparking Potentials of Barium, Magnesium, and Aluminum in Argon. HAROLD JACOBS AND ARMAND P. LAROCQUE, *Sylvania Electric Products, Inc.*—Minimum sparking potentials of barium, magnesium, and aluminum in argon are found to be $93\pm\frac{1}{2}V$, $123\pm1V$, and $155\pm1V$, respectively. Utilizing the data in measuring the minimum sparking potentials, the ratios of electrons emitted from the cathode per bombarding positive ion (γ_m) are determined and found to be $0.149\pm.001$ for barium, $0.089\pm.033$ for magnesium, and $0.045\pm.002$ for aluminum. A relationship is found such that, at a given field per unit pressure, a lower work function indicates a lower sparking potential and a higher γ_m indicates a lower sparking potential, for the case of the three metals studied. A graphical method is proposed for predicting the minimum sparking potentials for metals, whose sparking potential values have not been determined, based upon the values of γ_m or the work function ϕ.

A6. Photoelectron Emission from Liquid Ammonia Solutions of the Alkali Metals. GORDON K. TEAL, *Bell Telephone Laboratories*.—The photoelectron emission of liquid ammonia solutions of sodium, potassium, and cesium was studied. Spectral sensitivity measurements on concentrated solutions of sodium and of cesium at -78°C reveal maximum responses at $\lambda=5200$A. Copper-colored (concentrated) and intensely blue (dilute) solutions of potassium both gave maxima at $\lambda=4800$A, the magnitude of the response being greater for the more concentrated solution. Sodium solutions are relatively insensitive in comparison to solutions of potassium and cesium. The long wavelength limits for all solutions studied are greater than 7000A and less than 9000A. The results are in agreement with the view that the valence electrons from the alkali metals are not closely associated with the alkali metal atoms but exist in energy states characteristic of the solvent and are bound with approximately the same energy for concentrated and moderately dilute solutions of all the alkali metals.

A7. A Measurement of the Self-Diffusion Coefficient of Uranium Hexafluoride.* EDWARD P. NEY AND FONTAINE C. ARMISTEAD,** *Rouss Physical Laboratory, University of Virginia*.—A method has been developed and successfully used for the measurement of ρD (ρ = density; D = diffusion-coefficient) for an isotopic mixture. The D thus measured should be a close approximation to the true self-diffusion coefficient. Two vessels were filled with UF_6 vapor of different isotopic concentrations but equal pressure. To start the experiment, the material in the two vessels was allowed to diffuse through a connecting pipe. The isotopic ratio in one vessel was measured as a function of the time with a mass spectrometer into which a very small sample was continuously being drawn. The isotopic ratio measured by the mass spectrometer is an exponential function of the time. The relaxation time together with the dimensions of the apparatus give the self-diffusion coefficient. Knowledge of the pressure allows calculation of ρD. The value of ρD at 30°C is 234 micro poise ±5 percent. Classically ρD is associated with the viscosity through the equation $\rho D=\epsilon\eta$, where ϵ is a pure number whose value is determined by the force law interaction of the molecules. Therefore, knowing the ratio of ρD to the viscosity, one can determine the force law interaction.

* This paper is based on work performed under Contract OEMsr-398 with the Office of Scientific Research and Development at the University of Virginia in 1942–1943.
** Now at Clinton Laboratories, Oak Ridge, Tennessee.

A8. Bridge Type Electrical Computers. WILLIAM KRASNY ERGEN, *Minneapolis-Honeywell Regulator Company, Minneapolis, Minnesota*.[1]—The prototype of the computers in question is a Wheatstone bridge, with the resistances in two opposite legs proportional to two magnitudes, a and b respectively, and the resistance in a third leg proportional to c. The fourth leg is adjusted to balance the bridge, either manually or by a servo mechanism. The resistance of the fourth leg is then proportional to ab/c. This bridge can be generalized by replacing the resistors in each leg by a series connection of resistors, each of which is proportional to a variable. Such a bridge solves quadratic equations, but only if the equation is of rank 4 and signature zero. By connecting several resistances in parallel into each leg of the bridge, one can solve higher order equations. A bridge used for the solution of a quartic equation will be shown. The equation was the equation of a straight line in bipolar coordinates and was used to guide an airplane on a straight line when the distances of the plane from two fixed ground stations were known by Shoran.

[1] Now at RCA Victor Division, Radio Corporation of America, Camden, New Jersey.

A9. Single Magnetic Poles and Cosmic Radiation. FELIX EHRENHAFT, *New York, New York*.—Photomicrographs will be shown of iron particles of light wave-length magnitude moving in helical paths in constant homogeneous magnetic fields (e.g., 3000 gauss), describing more than 40 regularly spaced equidistant turns per second (e.g., diameter 10^{-2} cm and pitch 2.5 times 10^{-3} cm) and bursts of clusters occurring in such fields each part of the cluster describing separately its own helical path after the burst. After many different experiments, movements of matter in homogeneous magnetic fields, reversal of movements with reversal of fields, and helical paths have been confirmed by Tauzin[1] and Rault who could find no other explanation[2] than single magnetic poles.[3] Single magnetic charges can be replaced neither by Ampere's circuit electric currents nor by spin of electrons. The admitted failure[4] in explaining the structure of elementary particles in cosmic radiation originates in the unfounded assumption that charged particles bear only electronic charges and in the non-recognition of magnetic charges. Electrically charged and uncharged particles can also bear magnetic charges. By taking into account that magnetism flows and penetrates matter the understanding of the phenomena of cosmic radiation will be facilitated.

[1] P. Tauzin; P. Tauzin and L. Rault, Soc. franc. de physique, Nov. 16 (1945); May 17 (1946); Comptes rendus **222**, 1037 (1946).
[2] A. Cotton, Ann. de physique **20**, 557 (1945).
[3] F. Ehrenhaft, J. Frank. Inst. **233**, 236 (1942); Science **101**, 676 (1945); Comptes rendus **222**, 1100, 1345 (1946).
[4] W. Heitler, Bull. Am. Phys. Soc. **21**, No. 5, 14 (September 19, 1946).

B1. The Electrical Charge on Precipitation at Various Altitudes and its Relation to Thunderstorms. Ross Gunn, *Army-Navy Atmospheric Electricity Project, Naval Research Laboratory, Washington, D. C.*—The free electrical charges on individual precipitation particles were measured at various altitudes up to 26,000 feet by an induction method that avoids touching them. In a weak cold front exhibiting no thunderstorm activity, and having the freezing level at 11,000 feet, positive charges averaging 0.033 e.s.u. were observed from 10,000 to 26,000 feet. Negative charges averaging 0.04 e.s.u. were measured from the surface up to 20,000 feet. Positive charges were not observed below 10,000 feet and negative ones were not detected above 20,000 feet. Between these levels a mixture existed. The free charge on a large number of the particles was so great that the electric field at their surface was an appreciable fraction of the breakdown field for air, showing that powerful electrifying agencies exist even under rather quiet frontal conditions. Electric field measurements on the airplane show that the particle charges are largely neutralized by nearby charges, presumably on the air or on the tiny cloud droplets. It is shown that the removal of this neutralizing charge will immediately produce thunderstorm electric fields and potentials. A time plot of the electric field on the surface of a flying airplane during the interval of a lightning strike is given.

B2. Biological Effects of Low Frequency Vibrations. H. B. Wahlin and B. R. Russell.—Vibrating string type generators operating in the range 1000 to 2500 cycles per second and at 60 cycles per second have been used for a series of preliminary studies. The string is a spring-brass or piano wire under tension held fast at two points a few centimeters apart; it is driven electromagnetically at the frequency of its own fundamental vibration, a magnetron type permanent magnet supplying the magnetic flux. A wire plunger fastened to the center of the vibrating section transmits the motion to a few cubic centimeters of liquid in a test tube. Experiments so far indicate rather slow breakdown of most biological cells; even the comparatively fragile red blood cells withstand ten minutes of vibration before 50 percent disappear; certain protozoa are 90 percent destroyed within two minutes, however. With the large amplitudes available at 60 c.p.s., such a vibrator serves as a tissue dispersing instrument which separates the cells without extensive rupture. Experiments on dispersion of liver and pituitary gland tissue and effects on sarcoma tissue and spermatozoa are in progress. Extension of the useful frequency range from 200 to 4000 c.p.s. is planned.

B3. The Ionization and Dissociation of Formic Acid Monomer by Electron Impact. Thomas Mariner* and Walker Bleakney, *Princeton University.*—In HCOOH vapor 65-volt electrons in a mass spectrometer produced $HCOOH^+$, one negative and twelve positive fragment ions. Unique reactions could not be found to account for the production of the negative ion and six of the positive ions. However, the first appearance potentials of $COOH^+$, CO_2^+, HCO^+, CO^+, H_2O^+, and H_2^+ require that they originate in reactions involving the least dissociation energy for the production of the corresponding radicals. CO_2^+ has a second appearance potential for which the responsible reaction is also deducible. Excess energy in all the assignable reactions is less than 1.0 volt. The low appearance potentials of $COOH^+$ and HCO^+ require that the trivalency of O^+ be utilized in the ionic structure, as was found for some of the ions produced from methyl and ethyl alcohol.[1] Ionization potentials at 11.0 ± 0.1 and 11.6 ± 0.2 volts were found for HCOOH. The upper one is consistent with the value of 11.29 volts reported in analyses of the band spectrum.[2] The possible explanation of the lower value in terms of a transform of HCOOH will be discussed.

* Now at the Stamford Research Laboratories, American Cyanamid Company, Stamford, Connecticut.

[1] Cummings and Bleakney, Phys. Rev. **58**, 787 (1940).

[2] Price and Evans, Proc. Roy. Soc. **A162**, 110 (1937).

B4. Peak Contour and Half-Life of Metastable Ions Appearing in Mass Spectra. J. A. Hipple, *Westinghouse Research Laboratories, East Pittsburgh, Pennsylvania.*—The diffuse peaks appearing in the mass spectra of hydrocarbons have recently been attributed to the spontaneous dissociation of metastable ions during transit through the instrument. Several workers in the field have objected to this interpretation on the basis that the appearance of diffuse peaks in the 180° instrument is unexplained—the peaks having roughly the same appearance as in the sectored-field instrument such as that employing a deflection of 90°. It will be shown that these peaks should be similar in both types of instrument. By varying the ion-draw-out voltage from 0.18 to 10.0 volts, and thus varying the time spent in the ion source, the half-life has been measured for the $C_4H_{10}^+$ ion in the metastable state responsible for the diffuse peak at the apparent mass 31.9 in *n*-butane. This dissociation process is $C_4H_{10}^+ \rightarrow C_3H_7^+ + [CH_3]$. The experimental points lie very closely to a straight line on a semi-log plot from 1.4 to 6×10^{-6} second. The half-life for this metastable state is 2×10^{-6} second.

C1. Reconstruction of a 400-kv d.c. High Potential Source. Samuel K. Allison, Leticia del Rosario, Joan Hinton, and Howard Wilcox, *Institute for Nuclear Studies, University of Chicago.*—The voltage quadrupling circuit, which was used before the war for studies in the transmutation of the light elements and as a *d-d* source during the war, is being largely reconstructed. The high resistance, of approximately 6.8×10^9 ohms, which was used to measure the high voltage, has been completely reassembled in a new helical structure which provides a separation of the individual resistors, good contacts, and corona prevention. The condensers in the voltage quadrupling circuit have been replaced by new ones of several times the previous capacity, and the new units have been distributed in rough agreement with a circuit analysis which minimizes the ripple and voltage lowering. The rectifiers used previously, which required continuous pumping, have been replaced with permanently evacuated units designed to operate under 250 kv inverse peak voltage. Surge resistors have been installed as structural elements in the high voltage circuit.

C2. Correction of G. M. Counter Data for High Counting Rates. III. DONALD N. GIDEON AND J. D. KURBATOV, *Ohio State University.*—The experimental work of correction of G. M. counter data has been extended to gamma radiation. The energies of the gamma sources used were mainly in the range 1–2 Mev. Similar to the studies of corrections for beta radiation, a series of samples of known true counting rates and identical geometry were prepared having up to 200,000 counts/minute. An arrangement of the large window G. M. tube with Neher-Harper and decade-counting circuits was used. The resolving time τ, calculated from the experimental data by means of an expression previously derived,* has been found to decrease for gamma- as well as for beta-rays with increasing density of radiations. Log τ for gamma-rays plotted against log of true counting rate is a straight line, with a smaller change in τ for gamma- than for beta-rays. A similar plot of τ for beta-rays is a curve which exhibits no simple relation between τ and true counting rate. The correction factor calculated for gamma-rays is smaller than that for beta-rays in the range below about 20,000 counts/min. for this counting arrangement and approaches similar values for higher counting rates.

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

C3. Radiations from Radioactive Lanthanum (140).[1] ALLAN C. G. MITCHELL, LAWRENCE M. LANGER, AND LEON J. BROWN, *Indiana University.*—Radioactive lanthanum, La^{140}, which occurs as a product in uranium fission, has been investigated. La^{140} grows from a Ba^{140} parent of 300-hour half-life. In order to measure the energy of the gamma-rays from a separated La^{140} source, the range of Compton electrons, ejected from an aluminum radiator, was measured by coincidence counters. The most energetic gamma-ray was thus found to have an energy of 2.0 ± 0.10 Mev. By placing the source between two gamma-ray counters, gamma-gamma coincidences were found. It is estimated that there are two gamma-ray quanta per disintegration. An absorption curve of the gamma-rays showed a gamma-ray of 2.0 Mev and one of approximately 300 kv. The beta-ray end-point was found to be 1.96 Mev. Beta-gamma coincidences were found. The number of beta-gamma coincidences per recorded beta-ray was independent of the energy of the beta-rays indicating a simple beta-ray spectrum. Experiments performed on a separated Ba^{140} source showed that the intensity of the gamma-rays grew from the barium with the expected period. In these experiments the barium source was placed in a coincidence apparatus set to measure Compton electrons from gamma-rays of energy greater than 500 kv. Both the coincidence rate and the singles rate grew in a manner to be expected if the La^{140} daughter emits the gamma-rays, and the Ba^{140} parent emits no high energy gamma-ray.

[1] Work done under auspices of Manhattan District.

C4. $d-H^3$ Reaction in Cb and Ag. D. N. KUNDU AND M. L. POOL, *Ohio State University.*—With heavy nuclei, $d-H^3$ reactions had been reported in Ag and Cu, but the possibility of spurious $n-2n$ reactions with neutrons from $d+d$ reactions, neutrons produced within the target material, chamber background neutrons was not completely ruled out. In the following, a number of thin foils of spectrochemically tested Cb of the same area and thickness, and shielded on all sides except the front, were bombarded with 10 Mev deuterons for various lengths of time. The foils were of such a thickness (0.005″) that the deuterons were completely stopped by the first foil; the other foils were subjected to neutron reactions only, if any. The Cb^{92} (10.1 D) activity was found, with and without chemistry, in good strength in the first foil; there was no measurable activity of this half-life in the other foils. The decay curves (10.1 D), β^- (1.38 Mev), γ (1.0 Mev), and ZrK_α x-rays (0.78A) decaying with 10.1 D checked well with Cb^{92}. With the deuteron energy used, the $d-(p, 2n)$ and $d-(d, n)$ reactions being less probable, the reaction is mostly $Cb^{93}(d, H^3)Cb^{92}$. With Ag target the same method gave Ag^{106} (24.5 min.) due to $d-H^3$ reaction.

C5. Yield of Photo-Neutrons from U^{235} Fission Products in Heavy Water. S. BERNSTEIN, W. M. PRESTON, G. WOLFE, R. E. SLATTERY, *Clinton Laboratories.*—The photo-disintegration of the deuteron has been used to study the hard gamma-rays emitted by fission products of U^{235}. The neutrons created in the process were used as the indicator of the presence of hard γ-rays. The fission products were placed at the center of a 10″ radius sphere of heavy water. Conclusions about the periods and yields of the hard γ-rays were made from the total number of photo-neutrons being captured in a large tank of oil surrounding the sphere of heavy water. Seven half-lives were found: 2.5 sec., 41 sec., 2.4 min., 7.7 min., 27 min., 1.6 hours, 4.4 hours, and 53 hours. The shortest one and longest one of these are least reliable. Eighty-five percent of the photo-neutrons appear in the two shortest half-lives, the 2.5-sec. component being three times as intense as the 30-sec. component. The total saturated activity of the photo-neutrons for an infinite amount of heavy water was calculated from the 10″ radius sphere measurements to be about 16.5 percent of the saturated delayed neutron activity. It is calculated that there must be of the order of one to two photons of energy above 2.2 Mev emitted per fission by fission products with half-lives greater than one second.

C6. The Total Scattering Cross Sections of Deuterium and Oxygen for Fast Neutrons. RICHARD G. NUCKOLLS,* CARL L. BAILEY, WILLIAM E. BENNETT,* THOR BERGSTRAHL,** HUGH T. RICHARDS,*** AND JOHN H. WILLIAMS, *University of Minnesota.*—The transmissions of H_2O and D_2O for neutrons of discrete energies between 0.35 and 6.0 Mev have been measured. These neutrons were produced by Li (p, n), C (d, n), and D (d, n) reactions with monoenergetic ions accelerated by the Minnesota pressure electrostatic generator. Previous experimental values**** of the (n, p) scattering cross section in the same energy region by the same technique were used to calculate $\sigma_s(D)$ and $\sigma_s(O)$ from the observed transmissions of H_2O and D_2O. $\sigma_s(D)$ is a monotonic function of neutron energy in this region. $\sigma_s(O)$ shows evidence for resonance phenomena.

* Now at Illinois Institute of Technology.
** Now at Naval Research Laboratory.
*** Now at University of Wisconsin.
**** Phys. Rev. (to be published).

C7. Resonance Scattering of Neutrons by Mn. N. H. BARBRE* AND M. GOLDHABER, *University of Illinois.*—It was previously shown that Mn has a neutron resonance level where resonance scattering predominates compared with resonance capture.[1] Continuing this work, we have measured the energy dependence of the scattering cross section of Mn in a "back scattering" arrangement. Detectors responding to resonance neutrons of different energy (25 to ~100 ev) have been used, and a gradual increase of the effective scattering cross section of Mn with increasing neutron energy of the detector has been found in this energy region. Absolute cross sections were obtained by comparison with carbon for which a scattering cross section of 4.8×10^{-24} cm^2 was assumed. The effective Mn scattering cross section is found to rise from 6×10^{-24} cm^2 at 25 ev to 120×10^{-24} at ~100 ev, while the scattering cross section of Ni, measured in a similar way, remains constant. Tentatively, and subject to a more final neutron energy scale, it is concluded that the resonance level of Mn has a resonance energy $E_0\sim100$ ev, a neutron width $\Gamma_n\sim10$ ev, and a radiation width $\Gamma_\gamma\sim0.1$ ev.

* Now at Western Kentucky State College.
[1] M. Goldhaber and A. A. Yalow, Phys. Rev. **69**, 47(A) (1946).

C8. Calculation of Angular Distributions in Resonance Reactions. G. BREIT AND B. T. DARLING, *University of Wisconsin.*—The treatment of angular distribution of disintegration products in nuclear resonance reactions can be shortened by applying the following two theorems: (I) A statistical mixture without correlation and with equal probabilities of states having definite projections of two uncoupled spins along an axis is[1] also a statistical mixture in the same sense of states corresponding to compounded spins with definite projections along the same axis. (II) When two angular momenta l, s are compounded to form a resultant j, the probability of the projection of l along an axis fixed in space having a certain value m, when summed over all states corresponding to the same j, is $(2j+1)/(2l+1)$. By means of these theorems and the symbolic ξ, η method, one can avoid much of the explicit calculation of normalized wave functions corresponding to the composition of angular momenta. The financial support of the ONR of the Navy Department is gratefully acknowledged.

[1] J. von Neumann, *Mathematische Grundlagen der Quantenmechanik* (1932), p. 183.

C9. Range Distribution of U^{235} Fission Fragments in Photographic Emulsion. H. T. RICHARDS* AND LYDA SPECK, *Los Alamos Laboratory.*—Eastman's fine grain emulsion 548–0 has been found suitable for recording fission fragments while remaining completely insensitive to alpha-particles. The high background grain count of this emulsion was removed by Liebermann and Barschall's technique[1] and the plates then impregnated with uranyl salts. One set of plates was used as a control and the other exposed to slow neutrons. The plates were then developed and examined under dark field illumination. No tracks were observed on the control plates. Four hundred tracks on the exposed plates were measured, and the range distribution is in agreement with ionization chamber measurements of total energy distribution reported by other workers. No large angle scatterings were observed for the portion of the range to which the emulsion is sensitive. No ternary fissions were observed. The measured range distribution showed a sharp maximum at 23 microns and extended from 11 to 33 microns.

* Now at the University of Wisconsin.
[1] L. N. Liebermann and H. H. Barschall, Rev. Sci. Inst. **14**, 89 (1943).

C10. The 93 kev-γ-Line of UX_1. H. L. BRADT* AND P. SCHERRER, *Federal Institute of Technology, Zürich.*—In the β-spectrum of UX_1 there occur L-, M-, and N-conversion lines of a 93 kev-γ-radiation. The fact that the wave-length as measured by Meitner is just the wave-length of the $K\alpha_2$ x-rays of the daughter product UX_2 suggested to Meitner that the observed β-lines are nothing but conversion lines of the $UX_2-K\alpha_2$ x-radiation. However, there seemed to be no acceptable reason for an excitation of this K-radiation. Our investigation of the β-spectrum and the γ-radiation of UX, using a magnetic spectrometer and counters of calibrated efficiencies, leads to the result that the lines occuring in the β-spectrum are, with high probability, like the similar RdTh lines (*Surugue* and *Tsien-San-Tsiang*[1]), conversion lines of a nuclear γ-radiation. The L_1-conversion coefficient of this 93 kev-γ-radiation has been determined from the intensity of the L_1-conversion line (0.05_1 electrons/β-decay) and the intensity of the unconverted γ-radiation (0.15 quanta/β-decay) as $N_e/N_q=0.34$, in agreement with the theoretical value for quadrupole radiation, calculated by Fisk. The upper limit of the UX_1-β-spectrum has been determined as (0.205 ± 0.01) Mev. 80 percent of all β-transitions lead to UX_2 in its normal state, while 20 percent lead to the excited 0.093 Mev level.

* Now at Purdue University.
[1] J. Surugue and Tsien-San-Tsiang, Comptes rendus **213**, 172 (1941)

D1. Ge—Ge Contacts.* S. BENZER, *Department of Physics, Purdue University.*—When contacted with each other, germanium crystals of various impurity content produce rectification and a rectification series** exists. Such a contact between two pieces of the same (homogeneous) crystal should produce a linear current-voltage characteristic, caused only by spreading resistance, if no appreciable surface layers exist. However, the characteristic observed for both polarities is more of the order of the back resistance observed when either piece of the crystal is contacted with a metal; in both directions, the negative resistance at high voltages appears, which is typical of the back characteristics of metal-Ge contacts using these alloys. Therefore, surface layers other than the natural blocking layer (caused by the contact potential difference between the two contacting elements, which should be zero in this experiment) must be taken into account for high voltage crystals and may help to explain their properties.

* This work has been carried out under contract No. W-36-039-sc-32020 between the Purdue Research Foundation and the Signal Corps.
** W. Brattain, Phys. Rev. **69**, 682(A) (1946).

D2. Photo- and Thermo-Effects in p-Type Germanium Rectifiers. RALPH BRAY AND K. LARK-HOROVITZ, *Physics Department, Purdue University.**—In contact rectifiers

(metal p-type germanium) the rectification efficiency depends on the metal and the resistivity and surface treatment of the germanium. Photo-conductive effects, *depending in magnitude on the particular germanium sample and the metal*, leave the "forward" resistance relatively unaffected, yet may so greatly reduce the "back" resistance as to apparently reverse the rectification. Photo-voltaic effects are observed usually in the back direction. Sometimes both polarities are observed indicating probably local changes in sign of contact potential. The photo-effects approach maximum sensitivity in the near infra-red (about 1.3μ). Quanta of this energy may lift electrons from the full band to the conducting band. The light affects only the immediate vicinity of the contact. At elevated temperatures, electrons are excited from the full to the conducting band and again apparent reversal of rectification occurs (as in the photo-effect above). The thermal effect however is independent of the metal. The lower the resistivity of the sample, the higher is the temperature required to produce the effect.

* This work has been carried out under Contract No. W-36-039-sc-32020, (Signal Corps) between the Purdue Research Foundation and the Signal Corps.

D3. Measurements of Hall Effect and Resistivity of Germanium and Silicon from 10° to 600°K. G. L. PEARSON AND W. SHOCKLEY, *Bell Telephone Laboratories*.—Hall effect and resistivity measurements of the type made at Purdue[1] have been extended over wider temperature and impurity range. Two samples of germanium, one P- and the other N-type at room temperature, were measured[2] from 600°K to 10°K. For the P-type germanium the log Hall coefficient is linear in $1/T$°K below 90°K, giving an activation energy 0.007 ev (a hydrogen-like wave function with a dielectric constant of 25 for which the binding energy is 0.02 ev predicts an activation energy of 0.01 ev). For the N-type sample a similar straight plot with approximately the same activation energy is obtained between 17 and 90°K. Silicon containing 0.03 atomic percent boron has essentially constant resistivity and Hall coefficient below 100°K. The interpretation of this result is that a free electron gas is formed by the overlapping impurity wave functions with a degeneracy temperature of about 275°K.

[1] K. Lark-Horovitz, A. E. Middleton, E. P. Miller, and I. Wallerstein, Phys. Rev. **69**, 258 (1946).
[2] We are indebted to Dr. E. U. Condon and members of the Low Temperature Laboratory at the Bureau of Standards whose cooperation made the low temperature measurements possible.

D4. Boltzmann's Superposition Principle and the Viscous Behavior of Grain Boundaries in Metals.* T'ING-SUI KÊ, *Institute for the Study of Metals, University of Chicago*.—The mechanical behavior of grain boundaries in metals has been a subject of constant controversy. The present research is designed to examine thoroughly the mechanical behavior of grain boundaries in metals in a quantitative manner. A simple torsional apparatus has been devised for measuring four types of anelastic effects at very low stress levels, namely: internal friction at low frequencies; variation of dynamic rigidity with temperature; creep under constant stress; and stress relaxation at constant strain. All four types of anelastic effects have been studied in 99.991 percent polycrystalline aluminum as well as in single crystal aluminum; the behavior in the two cases is very different. The four types of anelastic effects observed in polycrystalline aluminum satisfy the interrelations derived by Zener from Boltzmann's superposition principle within experimental error. These measurements corroborate quantitatively the concept that the grain boundaries behave as if they were viscous with a coefficient of viscosity decreasing with increasing temperature. The heat of activation associated with the viscous slip along the grain boundaries has been found to be 34,500 calories per mole, corresponding to a rapidly decreasing grain boundary viscosity with increasing temperature. Similar anelastic effects have been also observed in polycrystalline magnesium, indicating that the viscous behavior of grain boundaries is probably common to all metals.

* This research has been supported by ORI (Contract No. N6ori-20-IV) since May 1, 1946.

D5. Determination of the Lattice Spacing of Silver Bromide for Varying x-Ray Exposures. J. C. M. BRENTANO AND L. VAN CLIEF SPENCER, *Northwestern University*.—A recent theory of the latent photographic image by M. L. Huggins[1] postulates domains within the silver bromide crystal in which AgBr assumes a B3 structure. Experiments by B. Hess[2] indicate that with increasing exposure of photographic emulsions to x-rays, changes in the AgBr spacing of about 2×10^{-3}A occur. These could partly be interpreted in terms of this theory. Using an x-ray goniometer with high resolution and microdensitometric evaluation, we determined the lattice constant of pure AgBr crystals for increasing x-ray exposures. No change of spacing within the limits of error 2×10^{-4}A was observed. Our interpretation varies from that of Hess in that, for exposures to x-ray, the rising density range does not represent a gradual modification of the grains and that the transition from the range of increasing densities to that of solarization constitutes essentially a shift of statistical balance. We thus attach more significance to a comparison of spacing for maximum density with that for solarization than to a comparison of spacings within the rising density range of within the solarization range.

[1] M. L. Huggins, J. Chem. Phys. **11**, 412 (1943).
[2] B. Hess, Physik. Zeits. **44**, 245 (1944).

D6. Further Experiments on the Elastic Single Scattering of Electrons by Nuclei. W. W. BUECHNER, E. A. BURRILL, A. SPERDUTO, R. J. VAN DE GRAAFF, AND H. FESHBACH, *Massachusetts Institute of Technology*.—The apparatus used in making the observations previously reported[1] has been reassembled and the measurements extended to a lower atomic number by using beryllium as a scattering material. For angles up to 60° and for electron energies of 2.1, 2.2, and 2.3 Mev, the ratio of the observed scattering to that predicted by the Mott formula is 0.99 with a standard deviation of 0.04. Measurements have also been repeated on aluminum in this angular and energy range and the ratio of observed scattering to that predicted is found to be 1.00 with a standard deviation of 0.05. The earlier result for aluminum at 2.27 Mev which was reported

as anomalous and to be repeated has thus been found to be in error. Some preliminary measurements have also been made on carbon indicating agreement with theory. The present results, together with those reported earlier,[1] show that in this angular and energy range the elastic single scattering of electrons is in good agreement with theory for various nuclei ranging in atomic number from 4 to 79 (beryllium to gold).

[1] Van de Graaff, Buechner, and Feshbach, Phys. Rev. **69**, 452 (1946).

D7. The Relativistic Clock Paradox. E. L. HILL, *Department of Physics, University of Minnesota.*—A new solution has been obtained of the problem of relativity theory in which time intervals as measured by two relatively accelerated clocks are compared. This solution is based on the group of conformal transformations in four dimensions, which is known to express the kinematics of uniformly accelerated motions. It does not imply that the accelerations are produced by gravitational fields. The calculation has been carried only to second-order terms in the relative velocity and acceleration of the two clocks. It is found that there exists a doubly infinite family of solutions, the readings of the clocks being adjusted at first passage and their rates compared when they are at relative rest. For all solutions the readings are again the same when the clocks are in coincidence. The existence of multiple solutions shows that new conditions must be imposed to make the problem unique, but their physical meaning is not apparent.

D8. The Hydrodynamical Equations in Quantum Mechanics. M. DRESDEN, *University of Kansas.*—In the classical theory the hydrodynamical equations are obtained by an averaging process from the Boltzmann equation. The difficulty encountered in carrying over this program in the quantum theory is that it is quantum-mechanically impossible to define a probability density in phase space. Wigner,[1] however, has constructed a function—in terms of the wave function of the system—which is in a "certain sense" analogous to that probability density. Utilizing that function the quantum analog of the Boltzmann equation was found. It contains apart from the classical terms an infinite series of terms depending on h. The hydrodynamical equations which follow possess the same formal structure as the classical equations. The quantities occurring in them are, of course, different from those in the classical theory. They are defined—in terms of the distribution function—which in turn depends upon the wave function. One can prove that the quantum-mechanical analog of the hydrodynamical current density is actually equal to the quantum-mechanical mean value of the Landau operator[2] for that quantity.

[1] E. Wigner, Phys. Rev. **40**, 749 (1932).
[2] L. Landau, J. Phys. **5**, 71 (1941).

D9. The Abundance of He^3 in Helium. L. T. ALDRICH AND ALFRED O. NIER, *University of Minnesota.*—Alvarez and Cornog[1] have reported the existence of He^3 in atmospheric and well helium. The abundances given were 10^{-7} and 10^{-8} mole fractions respectively. With a high resolution 60° mass spectrometer a mass spectrum analysis of helium has been made. A spectroscopically pure sample obtained from the Air Reduction Sales Company through regular commercial channels indicated a small peak in the mass three position. This peak was proportional to the mass four peak for variations of pressure and electron energy. The peak was completely resolved from HD which was added to the sample in various concentrations to insure that the peak observed was not due to a hydrogen impurity. If, as seems likely, the peak is due to He^3, the concentration was approximately one part in 9×10^5. Other samples are being investigated.

[1] Phys. Rev. **56**, 613 (1939); **56**, 379 (1939).

T1. Note on a Discrepancy in Gyromagnetic Measurements and the Question of a Possible Variation of the Torsional Modulus of German Silver with Frequency. S. J. BARNETT AND D. S. WEBBER, *University of California and California Institute of Technology.*—A four or five percent deficit of the gyromagnetic ratios for certain ferromagnetic substances obtained some years ago by Sucksmith and Bates from the mean ratio obtained in much more elaborate investigations by one of us might be explained if the dynamic torsional modulus of German silver wire, Md, were smaller, and four or five percent smaller, than the static modulus, Ms. The calibrating operations of Sucksmith and Bates were carried out partly with rapid oscillations, partly with steady deflections, the two moduli being (implicitly) assumed equal. We have not worked with the true static modulus, but have determined the ratio of Md for frequencies ranging from 17 to 50 per second, comparable with those used by the authors mentioned, to Md for periods ranging from 4 seconds to 28 seconds—doubtless quite comparable with or greater than the times required for steady twists in the work referred to. We have detected no change within the high frequency range, or within the low frequency range; but the modulus has been found to diminish by about 1 percent from the low frequency range to the high frequency range—a diminuition interesting in itself, though sufficient to account for but little of the discrepancy mentioned.

T2. Electrophotophoresis and Electric Charges Smaller than the Electronic Charge. FELIX EHRENHAFT, *New York, New York.*—The phenomenon of electrophotophoresis as described long ago by the author[1] was recently confirmed by Tauzin.[2] Electrophotophoresis is a movement under the simultaneous action of light and homogeneous electric fields of particles proven to be otherwise electrically uncharged. The particles move in or against the direction of the field and reverse with its reversal. When irradiated by light, they carry an excess of positive or negative charge. Individual testbodies can lose or regain their electric charge suddenly or gradually, partly or entirely. Photomicrographs indicate that particles describe helical paths with regularly spaced turns in electric fields. Schedling calculated such electric charges e carried by single spherical bodies of Te of determined density and mobility B using their measured[3] electrophotophoretic velocity v in viscous medium in constant homogeneous fields E using the relationship $v=eEB$. Electric charges smaller than 10^{-10} e.s.u.

result thereby, and changes of charge take place seemingly continuously as described previously by the author in the case of radioactive testbodies of spherical shape and known density.[4] Here is a new proof of smaller than the electronic charge.[5]

[1] F. Ehrenhaft, J. Frank. Inst. **235**, 237 (1942).
[2] P. Tauzin, Revue scientifique (June–Dec. 1945), p. 276.
[3] P. Selner, Zeits. f. Physik **71**, 658 (1931).
[4] F. Ehrenhaft and D. Konstantinowsky, Ann. d. Physik **63**, 797 (1920); J. Frank. Inst. **230**, 384 (1940).
[5] F. Ehrenhaft, Physik. Zeits. **39**, 673 (1938); Phil. Sci. **8** (July, 1941).

T3. On Creep and Relaxation. B. GROSS, *National Institute of Technology, Rio de Janeiro, Brazil.*—When the principle of superposition is valid, the rate of creep $\varphi(t)$ and that of relaxation $\bar{\varphi}(t)$ are connected by $L[\bar{\varphi}]+L[\bar{\varphi}]L[\varphi]=L[\varphi]$, where L means the Laplace transform. φ and $\bar{\varphi}$ can be represented as Laplace transforms of primitive functions ρ (distribution function for creep) and $\bar{\rho}$ (distribution function for relaxation); thus $\varphi=L[\rho]$ and $\bar{\varphi}=L[\bar{\rho}]$. These expressions are substituted into the first equation, the iterated Laplace transforms giving Stieltje's integral equation; this is inverted by a formula due to Borel. There results a general relation, suitable for numerical computation, for the conversion of one distribution into another:

$$\bar{\rho}d\rho=\rho d\rho\Big/\left[1+\int_0^\infty\frac{\rho ds}{s-\rho}\right]^2+\pi^2\rho^2.$$

The integral is a principal value. The distribution function of relaxation times corresponding to a given rage of relaxation is given by

$$\pi\bar{\rho}=L[Im\bar{\varphi}(-t)],\quad\text{where}\quad\bar{\varphi}(-t)=\bar{\varphi}(t\exp.-i\pi),$$

provided $\bar{\varphi}$ satisfies certain conditions.

S1. Abnormal Isotope Abundances Produced by Neutron Absorption in Cadmium. A. J. DEMPSTER, *Argonne National Laboratory.**—Mass spectra of samples of cadmium will be shown that had been given a prolonged exposure to slow neutrons. The isotope at mass 113 is reduced to approximately one-eighth its normal abundance and the isotope at mass 114 is increased. The change is confined to the surface of the sample as the interior is completely shielded from the neutrons. No change in the abundances of the other isotopes could be detected. These mass spectra confirm the direct measurements reported by Moyer, Peters, and Schmidt[1] of neutron absorption by samples enriched in various isotopes, which indicated that the cadmium isotope at mass 113 is the main absorber of slow neutrons.

* To be called for after paper C9 if time permits.
[1] Phys. Rev. **69**, 666 (1946).

S2. Some Neutron Induced Activities in the Rare Earths. MARK G. INGHRAM AND RICHARD J. HAYDEN, *Argonne National Laboratory.**—Nitric acid solutions of samarium, europium, holmium, and ytterbium were subjected to neutron bombardment in the Argonne pile. Half-life and absorption data were obtained with standard counting equipment. Masses of certain activities were obtained by use of the mass spectrograph.[1] Using these techniques, the 46-hr. Sm activity was shown to result from an isotope of mass 153, the 9.2-hr Eu activity from an isotope of mass 152, and the 27-hr holmium previously given as 35 hr[2] from a mass of 166. The long-lived activity in europium was shown to result from two isotopes, the previously reported 154 and a new, long-lived 152 isomeric with the 9.2-hr europium. A new 99-hr activity found in ytterbium was found to be caused by an isotope of mass 175. Present evidence points to a mass of 177 for the short lived activity resulting from neutron bombardment of ytterbium.

* To be called for after paper C9 if time permits.
[1] R. J. Hayden and M. G. Inghram, Phys. Rev. **69**, 89 (1946).
[2] G. T. Seaborg, Rev. Mod. Phys. **16**, 1 (1944).

S3. A Nomogram to Facilitate the Determination of the Resolving Time of Counter Equipment. L. JACKSON LASLETT, *Iowa State College.**—The nature and the determination of the resolving-time parameters required for the coincidence correction of counter equipment has been discussed by Kohman.[1] In cases in which the counting rate is moderate, a simple, first-order correction may suffice. The resolving-time parameter, τ, may then be conveniently determined by counting two uncalibrated sources together (S counts/min.) and separately (C_1, C_2)—preferably in the order C_1, S, C_2. The value of τ may then be taken as given by $(S^2-C_1^2-C_2^2)\tau=D$, in which $D=(C_1+C_2)-(S+B)$, with B representing the background counting rate. A nomogram has been prepared to facilitate the solution of the above equation for τ. This nomogram may also be used, once τ has been determined, to obtain directly the correction which must be applied to any moderate, observed counting rate. It is believed that a nomogram can be particularly useful if determinations of resolving time and counter corrections are to be made as a matter of routine by technicians.

* To be called for after paper D9 if time permits.
[1] T. P. Kohman, Phys. Rev. **65**, 63 (A) (1944).

S4. The Escape Probability of Protons and Neutrons from Bombarded Bismuth. J. M. CORK, *University of Michigan.**—The bombardment of bismuth with deuterons has been extended to higher energies. In this bombardment the single bismuth isotope of mass 209 may be transformed into polonium^{210} (RaF) or bismuth^{210} (RaE) by d,n and d,p reactions, respectively. The latter is a beta-emitter of half-life 5 days which on decay converts into the alpha-emitting RaF. Thus, by noting the build-up of the alpha activity after bombardment, the yield of each product can be determined and hence the relative probability of the two competing d,p and d,n processes. Previous measurements up to 9 Mev indicated that the above ratio dropped from above 10 to a value of about 5, a result not unexpected in consideration of the Oppenheimer-Phillips process. At higher energies the d,n process might have been expected to become more probable, but up to 14.5 Mev the ratio d,p to d,n continues at about the same value as at 9 Mev.

* To be called for after paper D9 if time permits.