Proceedings of the American Physical Society

MINUTES OF THE INDIANAPOLIS, INDIANA MEETING, DECEMBER 28–30, 1937

THE 39th Annual Meeting (the 218th regular meeting) of the American Physical Society was held at Indianapolis, Indiana on Tuesday, Wednesday and Thursday, December 28, 29 and 30, 1937 in affiliation with Section B—Physics—of the American Association for the Advancement of Science. The presiding officers were Professor H. M. Randall, president of the Society, Dr. Lyman J. Briggs, vice president, Professor G. Breit, Professor H. A. Erikson and Professor H. H. Marvin. There were about three hundred physicists in attendance at the meeting. All sessions were held at the Indianapolis Athletic Club.

The joint session with Section B of the A.A.A.S. and the American Association of Physics Teachers was held on Tuesday afternoon at two-thirty o'clock. Dr. Harvey Fletcher of the Bell Telephone Laboratories, Inc., vice president of Section B, presided. The retiring vice president of Section B, Dean George B. Pegram of Columbia University made an address. Professor H. M. Randall of the University of Michigan, president of the American Physical Society, delivered an address on "The Spectroscopy of the Infra-Red" and Professor G. Breit of the University of Wisconsin, spoke on "Some Recent Progress in the Understanding of Nuclei."

On Wednesday evening at seven o'clock in the Lantern Room the members and friends of the American Physical Society and the American Association of Physics Teachers convened for dinner. Two hundred and sixty-five were present. President Randall presided and called upon F. K. Richtmyer, president of the American Association of Physics Teachers to speak. Professor Richtmyer in turn called upon Professor D. L. Webster to make the annual award of the American Association of Physics Teachers to Professor Edwin H. Hall of Harvard University. Professor Hall responded with an outline of the early history of the development of laboratory apparatus in the United States. He also recited one of his own sonnets to the delight of all the guests. The Chairman then called upon Dr. Lyman J. Briggs of the National Bureau of Standards and Professor G. W. Stewart of the State University of Iowa for brief remarks.

Annual Business Meeting. The regular annual business meeting of the American Physical Society was held on Tuesday afternoon, December 29, 1937 at two o'clock, President Randall presiding. The President had appointed Messrs. Walker Bleakney and H. W. Webb to canvas the ballots for the officers of the Society. They reported the following elections:

President, LYMAN J. BRIGGS
Vice President, JOHN T. TATE
Secretary, W. L. SEVERINGHAUS
Treasurer, GEORGE B. PEGRAM
Managing Editor, JOHN T. TATE
Members of the Council, four year term, G. W. STEWART, RICHARD C. TOLMAN
Members of the Board of Editors, three year term, A. L. HUGHES, F. A. JENKINS, THOMAS H. JOHNSON.

The Secretary reported that during the year there were 241 who accepted election to membership and seventeen were reinstated to active membership. The deaths of twenty members were reported, fourteen members resigned and twenty-seven members were dropped. The membership as of December 24, 1937 was as follows: Honorary Member, 5; Fellows, 745; Members, 2363; total, 3113.

The Treasurer presented a summary of the financial condition of the society. It was impossible to present a final report for the year at the Annual Meeting because the fiscal year ends on December 31. The Treasurer's financial report will be audited, printed and distributed to members.

The Managing Editor made a brief report on the general status of the publications of the society and stated that a detailed, audited financial report for 1937 would be printed and distributed.

The Annual Business Meeting adjourned at two-twenty P.M.

Meeting of the Council. At the meeting of the Council held on Tuesday morning, December 28, 1937 one candidate was elected to fellowship, eight members were transferred from membership to fellowship and thirty-five candidates were elected to membership. *Elected to fellowship:* Hilario Magliano. *Transferred from membership to fellowship:* Charles S. Fazel, R. G. Herb, Herrick L. Johnson, Edward B. Jordan, R. C. Mason, Richard D. Present, F. Simon, and Dudley Williams. *Elected to membership:* J. M. Anderson, Clarence L. Babcock, Paul D. Bales, E. Irving Bergeson, Robert J. Bessey, Rolf Buchdahl, Harold E. Clark, Vincent Dillon, Joseph D. Elder, W. A. Fowler, Philip W. Froebes, David C. Grahame, Raymond Gustafson, Donald E. Hull, William P. Hurley, F. Joliot, F. London, Myron S. McCay, R. Naidu, Marcel K. Newman, Anna R. Oliver, Robert D. Park, Herbert Schimmel, W. M. Schwarz, Takeo Shimizu, Merle A. Starr, Louis G. Stier, James A. Van Allen, A. E. Vivell, John W. Walker, Ernest T. S. Walton, Yuzuru Watase, George Welch, Gifford E. White and John S. Wiggins.

The regular scientific program of the Society consisted of sixty-four contributed papers, number 25 having been withdrawn. Numbers 19, 36, 37, 49 and 59 were read by title. The abstracts of the contributed papers are given in the following pages. An Author Index will be found at the end.

W. L. SEVERINGHAUS, *Secretary*

ABSTRACTS

1. On the Hydrodynamical Theory of the Viscosity of Suspensions. EUGENE GUTH, *University of Notre Dame,* AND OTTO GOLD, *University of Vienna. (Introduced by George B. Collins.)*—Einstein, in his thesis, 1906, developed a theory of the viscosity of a suspension. He calculated the disturbance which a spherical particle causes in a laminar stream of a viscous fluid. From the energy dissipated, he derived an equation connecting the viscosity of the solvent, η, with the viscosity of the suspension, η_0, the total volume, v, of the suspended particles and the volume, V, of the suspension: $\eta=\eta_0(1-2.5v/V)$. This relationship holds only for small concentrations. For higher concentrations one must take into account the mutual disturbance caused by a pair of particles of a laminar stream. This has been done by a special adaptation of the method of reflections, first introduced by H. A. Lorentz for taking into account the influence of walls on Stokes's law. A lengthy calculation leads to the result: $\eta=\eta_0(1-2.5v/V-14.1v^2/V^2)$. This equation is applicable to all solutions of high molecular substances with spherical shape, such as rubber latex solutions, protein solutions, and the changing of the viscosity of lubricating oils by the addition of small quantities of higher molecular compounds. The equation was verified experimentally in the case of suspended glass spheres.

2. The Viscosity of Monolayers: Theory of the Surface Slit Viscosimeter. WILLIAM D. HARKINS AND JOHN G. KIRKWOOD, *University of Chicago.*—The surface viscosimeter which makes use of the flow of a film through a rectangular capillary slit possesses many advantages in comparison with other types. Perhaps the greatest of these is the fact that, since it has no moving parts, no motion is imparted to the substrate (usually aqueous) by the instrument. Since surface viscosimeters which utilize moving rings or disks impart such a motion, their theory is thus made much more complicated. If

$$\alpha=f_1-f_2/l$$
$$\eta=\alpha a^3/12A-a\eta_0/\pi,$$

where a is the diameter of the slit, f the surface pressure, A is the area flux, η the viscosity of the film, and η_0 of the water, and l the length of the slit. The viscosity of a film of arachidic acid, with 20 C atoms in a straight chain, is found, in work with Dr. R. J. Myers, to be 0.0017 surface poises. Expanded films, such as that of oleic acid, have exceedingly small viscosities. Several ring surface viscosimeters have also been developed in the laboratory, and these are suitable for work with plastic films.

3. Arrangement of Molecules in Unimolecular and Multimolecular Layers. L. H. GERMER AND K. H. STORKS, *Bell Telephone Laboratories, Inc., New York, N. Y.*—Our recent study[1] of the structure of films built from many molecular layers of stearic acid by the Langmuir-Blodgett technique has been extended to *unimolecular* layers of stearic acid, and to *unimolecular* and *multimolecular* layers of barium stearate. Electron diffraction patterns from barium stearate prove that films several molecules thick have hexagonal structures with c axes parallel to axes of the hydrocarbon chains and normal to the supporting surface. Details of the patterns vary with pH of the water, which controls the amount of barium in the film. In *single molecular layers* also barium stearate molecules are arranged with axes normal to the supporting surface, but in one layer there exists almost no regularity in lateral spacings. Single layers of stearic acid molecules have the same arrangement as barium stearate in single layers, although multi-layers of the acid have an entirely different struc-

ture.[1] We suggest that this difference is due to combination of the first layer of acid molecules with a metal surface. From multi-layers of stearic acid diffraction patterns differ widely; these represent different polymorphic forms.

[1] Proc. Nat. Acad. 23, 390 (1937).

4. Electric Moment of the Methyl and Ethyl Alcohol Molecules. J. D. STRANATHAN, *University of Kansas.*—The dielectric constant of methyl alcohol vapor has been determined at 14 temperatures between 25.0° and 206.0°C. At each temperature measurements have been made at an average of 23 different pressures ranging from zero up to near saturation. The polarization at any one temperature was obtained by a least square solution for the slope of the best straight line through observations at various pressures at that temperature. A least square solution for the best Debye line through the polarization data at different temperatures yields a preliminary value $(1.694\pm0.003)\times10^{-18}$ e.s.u. for the electric moment of the methyl alcohol molecule. The moment here found is in essential agreement with values reported by Miles and by Kubo. It is obtained, however, from more extensive data, and has associated with it a smaller probable error. Data on ethyl alcohol previously published by Knowles have been recalculated, using a least square treatment throughout, and making a minor correction to the value he used for the absolute zero of temperature. The resultant moment is $(1.690\pm0.005)\times10^{-18}$ e.s.u. Knowles, using largely a graphical determination of slopes, obtained 1.686×10^{-18}; no probable error was stated.

5. Permanent Electrets as a Function of the Method of Preparation. WILFRED M. GOOD, *University of Kansas. (Introduced by J. D. Stranathan.)*—Preliminary to a proposed study of the effect of the method of manufacture of electrets upon their subsequent behavior, it was deemed advisable to develop a procedure of manufacture which could be accurately controlled, and which would yield electrets with uniformly smooth surfaces and not subject to cracking. Electrets have been made in an oil bath whose temperature is automatically and continuously lowered from 90° to 30°C over a period of from 1 to 10 days. The conventional tin foil electrodes have been replaced by rigid electrodes of solid tin. The resulting electrets have exceptionally smooth and closely parallel surfaces, and show no tendency to crack provided the electric field is applied at the proper temperature (75°C). Application of the field at a higher temperature (90°C) has caused each of the 4 electrets so made to crack in a peculiar manner apparently associated with the fringing of the electric field. Preliminary measurements indicate that electrets made as described above show the same general behavior as those cooled more rapidly in air, though there is some indication that the time of aging is affected.

6. The Variation of Apparent Ionic Volumes with Concentration in Aqueous Solutions. G. W. STEWART, *State University of Iowa.*—The free ion theory of electrolytes leads to a linear relation between the apparent ionic mol volume of an electrolyte, Φ, and the square root of the concentration, c, at dilute solutions, and also to values of the rate of change of the former with the latter. While the theory is of distinct value, it is seriously inadequate. Of 208 strong electrolytes only 62 percent have the $\Phi-c^{\frac{1}{2}}$ linear variation, and with these the values of the rate of change of Φ with $c^{\frac{1}{2}}$ vary widely from the computed values, the divergence being from one-fifth to fifteen times. In 22 percent the linear relation is more nearly c than $c^{\frac{1}{2}}$. Assuming an approximately linear relation at dilute solutions the value of the exponent of c varies from a -0.5 to 2.0. The explanation of the limitation in the free ion theory is the absence of a consideration of liquid structure or of the forces that produce it.

7. The Existence of a Vitreous State in Gelatin Gels. BASILE J. LUYET, *St. Louis University.*—Gelatin gels of concentrations varying from 10 to 60 percent can take the vitreous state, that is, can be brought to temperatures at which their viscosity is of the order observed in solid bodies, but their structure is not crystalline. For that purpose, the gels are immersed in liquid air in thin layers; they then keep their transparency and isotropic properties, but are hard and breakable as glass; when they are warmed up slowly they devitrify, that is, they crystallize, at a temperature of more than 150 degrees above the temperature of ebullition of liquid air. To insure a sufficient cooling velocity during the immersion, the gel layers, when supported on glass plates 50 micra thick, can be as much as 0.5 mm thick, with a 50 percent gel, while they must not exceed a few microns with a 10 percent gel. The experimental demonstration of the fact that a high water content (90 percent) can stay unfrozen in an aqueous gel at some twenty degrees below zero requires a revision of the entire problem of "bound water."

8. Estimates of Age of the Planet from Isotope Ratios. ARTHUR BRAMLEY, *Washington, D. C.*—Recent opinion on radioactivity of potassium supports Muhloffs' value of 1.8×10^{9} years.[1] With this value for the half life, the ratio of the rate of formation of argon from potassium to that of calcium is $1/10^{3}$ whereas considerations based on the intensity of gamma-radiation require for this ratio the value 1/100.[2] The relative abundances of Ca^{40} and K^{40} on the earth's crust taken in conjunction with this value for mean life indicate that the nuclei of Ca^{40} and K^{40} have been in equilibrium for 2×10^{10} years. This is of the same order of magnitude as the age of the stars. If during part of this time the temperature of the earth's atmosphere was over 7000°, the argon formed in that period would have escaped into interstellar space.[3] The reaction rates as calculated from the relative abundance of argon and calcium and from gamma-ray intensity can be brought into harmony provided we assume that the earth's atmosphere was hotter than 7000°, 1×10^{10} years ago. An uncertainty in these calculations arises from difficulty in determining the argon content of the earth's crust.

[1] Klemperer, Proc. Roy. Soc. 148, 638 (1935).
[2] Bramley, Science 86, 424 (1937).
[3] Jeans, *Dynamical Theory of Gases*, chapter 15.

9. The Relation Between Stefan's Radiation Law and Nernst's Heat Theorem. ARTHUR E. HAAS AND EUGENE GUTH, *University of Notre Dame.*—Although Nernst's heat theorem represents an independent thermodynamic principle, the vanishing of the zero entropy may be derived from "classical" principles in the special case of the black-body radiation. We start with the energy equation of classical thermodynamics: $(\partial U/\partial V)_T = T(\partial P/\partial T)_V - P$, where U is the energy, V the volume, T the temperature, and P the pressure. In applying this general relation to the black-body radiation we make use of Stefan's law according to which the density of energy u is equal to aT^4, a being a constant. The integration of the resulting differential equation leads to the expression for the radiation pressure: $p = \frac{1}{3}aT^4 + bT$, b being another constant. The insertion of this result into thermodynamical formulas yields the following equation for the entropy: $S = \frac{4}{3}aT^3V + bV$. From Maxwell's electromagnetic theory we have: $p = u/3$. Comparing this with the above expression for the radiation pressure, and remembering that $u = aT^4$, we see that b must be zero. This, however, requires that S be zero when $T = 0$. The statistical interpretation of the entropy of the black-body radiation leads to the result that the number of photons emitted by a black body is proportional to T^3.

10. The Persistence of Molecular Vibration in Collisions. ROBERT J. DWYER, *R.C.A. Institutes, Inc., Chicago, Ill.*—The dispersion of sound, discovered by G. W. Pierce and theoretically interpreted by K. F. Herzfeld and F. O. Rice, indicates a slow transfer of energy between translational and vibrational molecular degrees of freedom. It seemed desirable to find a direct optical method of observing and measuring this effect. Apparatus has been developed in this laboratory for the purpose of investigating molecules present in very small concentration, like radicals, by their absorption spectra.[1] The lines of the rotational structure of any branch of a band indicate by their intensities the relative concentrations in different rotational levels. The relative concentrations of molecules responsible for two absorption spectra may therefore be determined merely by matching rotation lines. The shift of concentrations from lower to upper vibrational levels caused by the electrical discharge was observed in iodine vapor by comparing intensities of the absorption spectrum with those when the discharge was on. By varying the phase between an electric switch and optical shutter snapshots of the absorption spectrum could be taken at different intervals after the discharge was interrupted. Iodine molecules raised from the zero to the first vibrational level were able to persist in this level through several thousand collisions with other iodine molecules before losing their vibration.

[1] A. A. Frost and O. Oldenberg, J. Chem. Phys. **4**, 782 (1936). A. A. Frost, D. W. Mann and O. Oldenberg, J. Opt. Soc. Am. **27**, 147 (1937).

11. A Study of the Anisotropy of the Atomic Vibrations of a Zn-Cu Alloy. R. A. HOWARD, *Washington University, St. Louis, Mo.*—The atomic structure factors for an alloy of zinc and copper in the ϵ phase, containing approximately fifteen atomic percent of copper, have been measured. This alloy has an hexagonal lattice with an axial ratio of 1.56, which is less than the value of 1.633 for close-packed spheres. It has been shown for pure zinc[1] and pure cadmium,[2] which both have an axial ratio greater than 1.633, that the atomic vibrations are greater along the c axis than perpendicular to it. One might, therefore, be led to expect that in the case of a crystal in which the atoms are separated by less than the normal distance along the c axis, as is the case for the Zn-Cu alloy used here, the atomic vibrations would be less along the c axis than in a direction normal to it. The results show this effect very strikingly. The structure factor curve bears a remarkable similarity to that obtained by Wollan[3] for a Cd-Ag alloy, which also possesses a hexagonal lattice and an axial ratio of 1.56.

[1] G. W. Brindley, Phil. Mag. **21**, 790 (1936). G. E. M. Jauncey and W. A. Bruce, Phys. Rev. **50**, 408 (1936). E. O. Wollan and G. G. Harvey, Phys. Rev. **51**, 1054 (1937).
[2] G. W. Brindley, Proc. Leeds Phil. Soc. **3**, 200 (1936).
[3] E. O. Wollan, reported at Thanksgiving meeting (1937).

12. Calculation of Transition Energies of Polymorphous Molecular Crystals. M. BRUCH-WILLSTÄTTER AND H. SPONER, *University of Wisconsin and Duke University.*—A number of crystals show at low temperatures the phenomenon of a transition from an oscillatory motion of their molecules to a rotational one. In many cases the lattice type is preserved during the transition, which is usually not sharp but covers a range of temperature of several degrees. In other cases, however, the transition is connected with a change in crystal structure which sets in sharply at a definite temperature. Transition energies have been determined experimentally for a number of cases by several authors. Here a calculation of these transition energies has been carried out for N_2, CO, HCl and HI by using London's simple theory of van der Waals forces. The first three substances show transitions with a change in crystal structure while HI represents an example of the other type. The calculated values come out larger than the experimental ones, some by a factor 2, but no more can be expected from the approximative treatment. A more accurate calculation is rendered difficult because of lack of experimental data.

13. Segregation of Polonium in Bismuth Crystals. ALFRED B. FOCKE, *Brown University.*—The study of the distribution of polonium as an impurity in bismuth crystals reported some time ago[1] is continued, using improved methods of high speed counting of α-particles. Measurements on over twenty crystals confirm the results of the earlier paper showing that the polonium is segregated into small regions separated by distances of $(0.55 \pm 0.01)\mu$ and $(0.86 \pm 0.03)\mu$ in directions parallel to the [111] and [11$\bar{1}$] axes, respectively. It is also found that where twinning due to cold working occurs the spacing along the original [111] axis changes to that expected along the [11$\bar{1}$] axis, the distribution of impurity thus following the crystallographic change. This must indicate either a large scale migration of the polonium at relatively low temperatures

or that the twinning process is not atomic in nature but that relatively large regions of the crystal change their positions as entities.

[1] A. B. Focke, Phys. Rev. **46**, 623 (1934).

14. Radioactivity of Air, Water, Cave and Soil Gases. OSCAR G. FRYER, *Drury College. (Introduced by R. R. Ramsey.)*—An electroscope is described which has new features particularly suited for field work. Tests were made on caves and springs in Ozark, Wichita, and Arbuckle Mountains of Arkansas and Oklahoma. Also a series of tests covering a period of 8 months was made on caves, springs, air, and soil gases in the limestone belt of Indiana. Rainfall affects the radon content in some springs more than in others. Radioactivity is not proportional to rainfall, yet a continued dry period is marked by an appreciable decrease in activity of most springs. There is no correlation between atmospheric pressure and radon content of spring water in the vicinity of Indiana University. In the limestone belt it is thought that the source of activity is in the soil and not in the limestone below as no limestone caves there showed any activity while the soil above was very active. Radon content of soil gases increases with depth. Radioactivity of the soil decreases with continued rainfall but is not affected by barometric pressure. Radon content of soil gases here is much greater than in other countries, while the activity of the air is less.

15. Photographic Measurements of the Brownian Motion. CHAS. HIRE, *Murray State Teachers College. (Introduced by W. L. Severinghaus.)*—Gamboge particles of uniform size were suspended in water. Positions of the particles in a suitable sealed microscope slide were recorded instantaneously at intervals of 1/128 second by a photographic method using an electric spark as the light source. Particle diameters were determined from the rate of settling by applying Stokes' formula. In addition to the Brownian agitation, the photographs revealed field vibrations in which all particles moved in the same directions simultaneously. Simple corrections for the field vibrations gave the true Brownian Displacements. Calculations from the corrected data gave for Avogadro's Constant a value of 7×10^{23} molecules per mole, and calculations from the uncorrected data gave results comparable with those of Henri. The paper contains a brief discussion of corrections needed for the law of Stokes. Apparatus and data table are illustrated with lantern slides.

16. The Variation of Contrast with Wave-Length in Photographic Materials. W. R. KOCH, *Materiel Division, U. S. Army Air Corps, Wright Field.*—Contrast data obtained for different wave-lengths with various photographic materials were reported. Measurements extended through the visible and near ultraviolet regions and included the effect of varied development conditions. The relation of these results to the selection of suitable emulsions for photographic photometry was discussed. Applications of the data in the field of chemical analysis by spectrographic methods as well as in the field of color photography were noted.

17. Anodic Properties of the Aluminum Cell. W. B. PIETENPOL AND T. EDWIN DEVANEY, *University of Colorado.*—Further experiments substantiate the previously proposed theory that in the aluminum cell the active film is composed of colloidal aluminum hydroxide which partially traps anions but allows cations to pass. The generally accepted Gunther Schultze theory, which assumes that the high resistance is due to a thin gas film, predicts that the capacitance should decrease with drop in voltage and increase with drop in temperature. Experiments show that, in accord with the hydroxide layer theory, the capacitance remains nearly constant with drop in voltage and decreases slightly with drop in temperature. With ammonium hydroxide the electrolyte, aluminum hydroxide is formed and there is evidence that the high resistance is due to it. With oxalic acid, the electrolyte, the exposure of the anode to air for a time causes the current upon the anode's return to the solution to remain for some time below its former value. For this and similar effects, no explanation can be given by the Gunther Schultze theory. However all results are in accord with the proposed slow hydrolysis of aluminum oxide to aluminum hydroxide.

18. The Width of the Resonance Peaks in Disintegration of Boron by Protons. JAMES S. ALLEN, ROBERT O. HAXBY, JOHN H. WILLIAMS, *University of Minnesota.*—The width of the resonance peak occurring in the reaction $B^{11}+H^1\rightarrow Be^8+He^4+Q$ has been measured for targets of various thicknesses. For a pure Boron target of thickness sufficient to slow 160 kv protons by about 500 volts, the full width at half-maximum was approximately 10 kv. The peak occurred at 159 kv. The transformer kenetron set, ion source, and accelerating tube described by Williams, Wells, Tate and Hill[1] were used. A new voltmeter consisting of 250 10 meg. resistors was used for the voltage measurements. By tapping off a small fraction of the total voltage across the voltmeter, the amount of ripple in the voltage supply was measured with a cathode-ray oscillograph. At 170 kv the total ripple was 4500 volts, or 2.6 percent. The resonance occurring in the reaction $B^{11}+H^1\rightarrow C^{12}+\gamma$ has been studied for thick Boron targets. Using a G.M. tube, the number of γ-rays was determined as a function of the tube voltage. When differentiated the curve was similar to that for the above reaction and the peak occurred at approximately the same voltage.

[1] Williams, Wells, Tate, Hill, Phys. Rev. **51**, 434 (1937).

19. The Angular Distribution of Resonance Disintegration Products. R. D. MYERS, *Purdue University.*—An attempt is made to account by symmetry considerations for the anisotropy observed in the angular distribution of products of nuclear disintegrations. The Bethe-Placzek[1] method of averaging the cross section of a nuclear disintegration over the several spin orientations is adopted so as to be suitable for finding A_L, the average Lth coefficient of the expansion in spherical harmonics of the angular intensity. The dependence of A_L on L is found to occur only through certain coefficients whose variation with L

can be calculated. For resonance the formula simplifies and may even reduce to one term so that the variation with L is known and the slope of the curve for the angular distribution of the products is completely determined. The theory is applied to the disintegrations (1) $D^2+D^2 \rightarrow H^3+H^1$ and (2) $B^{11}+H^1 \rightarrow Be^8+He^4$. With certain assumptions as to the scheme by which the disintegration occurs the distributions of the protons and α-particles are found to agree with those observed experimentally by Neuert.[2]

[1] Bethe and Placzek, Phys. Rev. **51**, 450 (1937).
[2] Neuert, Physik. Zeits. **38**, 122 (1937).

20. Capture Cross Section for Thermal Neutrons. A. H. SPEES, W. F. COLBY AND S. GOUDSMIT, *University of Michigan.*—The density of thermal neutrons in a hydrogenous substance is proportional to their rate of production and inversely proportional to their rate of absorption, provided the density varies linearly around the position of the measurements. The addition of a small amount of cadmium salt does not change the production but increases the absorption. This provides a simple method to determine the capture cross section of various solutions and mixtures in terms of that of cadmium. The neutron density was measured by the activity of silver foils put horizontally at the center of a cylindrical vessel of 26 cm diameter and the same height which was placed near the Michigan cyclotron. The effect of the silver foil (0.067 g/cm^2) on the density was estimated by using a few thicknesses and extrapolating (about 7 percent) to zero thickness. It was verified that the reciprocal of the activity (corrected for nonthermal neutrons) is indeed a linear function of the cadmium concentration up to about 0.08 moles of Cd in 100 moles of H_2O when the cross section is increased by a factor five. For water the results gave $\sigma(H_2O)=.00020\sigma(Cd)$, for NaCl a preliminary measurement gives $\sigma(NaCl)=.014\sigma(Cd)$. With $\sigma(Cd)=2600\cdot10^{-24}$ cm^2 this yields $\sigma(H)=.26\pm.02\cdot10^{-24}$ cm^2 (neglecting $\sigma(O)$) and $\sigma(NaCl)=36\pm4\cdot10^{-24}$ cm^2.

21. Neutron Yields from Deuteron Reactions at High Energy. LUIS W. ALVAREZ, *University of California.*—The relative neutron yields from 15 elements bombarded with 7.6 Mev deuterons have been measured with ionization chambers, and in some cases checked with radioactive detectors. The thick target yield *vs.* Z curve is very nearly of the form $Y=ke^{-Z}$, and all 12 elements tried from Li to Sn gave points which lay very closely on a smooth curve. Background neutrons from the cyclotron prevented the curve from being carried to higher Z. Carbon has been most carefully investigated; excitation functions for the production of N^{13} and of neutrons have been compared, and the number of N^{13} atoms at saturation has been compared with the number of neutrons per second from Carbon (determined by standardization with a Ra+Be source). The relative neutron yields for C and Ni have been compared with their relative radioactive yields. All three of these comparisons indicate that the number of neutrons from C is larger than can be accounted for by the reaction leading to N^{13}. The most satisfactory explanation at present is that the following reaction is responsible for the excess: $C^{12}+d \rightarrow C^{12}+n+p$. This represents a capture followed by two Bohr evaporations.

22. Radioactivity Induced in the Rare Earth Elements by Fast Neutrons. M. L. POOL, *Ohio State University.*—With the exception of illinium, thulium and lutecium all the rare earth elements (fifteen in number) have been bombarded with slow and fast neutrons. The fast neutrons were obtained by the lithium plus deuteron reaction. Deuterons of 6.3 Mev were produced by the cyclotron in Professor Cork's laboratory at the University of Michigan. Most of the slow neutron periods have already been found by other observers. However, changes and additions have been necessary in some cases, probably because of the greater slow neutron equivalent of the cyclotron or the higher purity of the elements used. Several of the rare earths were spectroscopically pure. Since it is difficult to assign definitely to a nucleus a radioactive period based upon evidence from slow neutron activation alone, fast neutron activation is of great advantage. Deuteron activation was also used in a few cases. In all, twenty-six different radioactive periods have been observed. Of these, twenty have been placed with reasonable certainty. There are seven cases in which the radioactive body emits positrons. Evidence exists for three new stable rare earth nuclei on which radioactive nuclei terminate.

23. Radioactivities Induced by High Energy Protons. L. A. DUBRIDGE, S. W. BARNES, E. O. WIIG, J. H. BUCK AND C. V. STRAIN, *University of Rochester.*—Studies previously reported on proton induced radioactivities have been extended. It appears that for nearly all elements so far studied above O^{16}, which show induced radioactivity, the reactions must be of the p-n type. In the light elements this leads to a positron emitting isotope and the reactions have thresholds at 1.8 Mev plus the positron energy. For heavier elements electron emission is preferred and such isotopes can be formed at much lower energies (1.4 Mev). The following e^+ emitting isotopes have been formed: O^{15} (2.1 m); F^{18} (107 min.); Mn^{53} (40 m); Cu^{61} (3.2 hr.); Ga^{68} (68 m); Se^{75} (105 m); Ag^{106} (25 min.); Sn^{113} (14 m). The following e^- emitters have been found: Cu^{64} (12 hr.); Ga^{70} (18.2 m); Br^{80} (18 m, 4 hr.); Br^{82} (36 hr.); Ma^x (0.5 m, 31 m); Ag^{108} (2.4 min.). In most cases these periods check with previous observations. Yield curves for + and − emitting isotopes of the same element ($Ga^{68, 70}$) show pronounced differences, as do the curves for the two periods of Br^{80}. The excitation function for the O^{18} p-n reaction shows a peak at 3.6 Mev, the top of the potential barrier.

24. The Radioactive Isotopes of Zinc. R. L. THORNTON, *University of Michigan.*—The radioactive isotopes of zinc have been investigated through the bombardment of Zn and the neighboring elements Cu and Ga with high energy deuterons and with slow and fast (Li+D) neutrons. Chemical separations of the bombarded element were made and the observed half-periods in Zn are shown in the following table.

Bombarded Element	Projectile	Periods Observed in Zn
Zn	D	60 min., 14 hr. (4 d., 30 d.)
Zn	Slow neutrons	60 min., ~10 hr. (weak)
Zn	Fast neutrons	40 min., 14 hr.
Cu	D	65 min.
Ga	D	14 hr. (in addition to other periods)

These results, in combination with those of other workers, make possible a provisional assignment of the observed periods as follows: Zn^{63} 35 min., Zn^{65} 1 hr., Zn^{69} 14 hr. This is on the reasonable assumption that the 40 min. period observed from fast neutron bombardment of Zn is really due to a combination of the known 35 min. period of Zn^{63} with the 1 hr. period found from the other reactions. It would seem reasonable also to ascribe to Zn^{71} a period either of 4 d. or 30 d. These activities however are not strong and must be investigated further. The observation that radioactivity is produced in Zn through deuteron bombardment of copper would suggest either a (D, γ) reaction from Cu^{63} or a $(D, 2n)$ reaction from Cu^{65}, since the observed intensity makes Zn contamination of the Cu unlikely.

25. On the Thermoelastics and Structure of Rubber. F. E. DART AND EUGENE GUTH, *University of Notre Dame. (Introduced by George B. Collins.)*—In an exactly analogous manner as for gases, one can formulate for rubber a state equation for unilateral deformations by studying its thermoelastic behavior. From such a state equation important conclusions may be drawn toward a molecular theory of the rubber structure. Experimentally one can get information on the state equation of rubber (or any other material) by investigation of: (1) The stress-strain diagram at different temperatures; (2) The dependency of the stress on the temperature at constant length; (3) The dependency of the length on temperature at constant stress. (1) was handled by Ornstein and his co-workers, but only in the adiabatic case. (2) was handled by Meyer and E. Ferri. (3) was handled by M. L. Braun and also H. Bouasse. Meyer-Ferri and Braun investigated samples of almost the same composition and vulcanization but their results differ. Our general conclusion is, that there are samples of rubber for which a state equation of the van der Waals type holds. This is also in accordance with the new statistical theory of the elasticity of rubber.[1] Further experiments under well-defined conditions are still in progress at University of Notre Dame.

[1] E. Guth, "Statistical Theory of the Elasticity of Natural and Artificial Rubber and Similar Long Chain Compounds," Paper presented at the International Conference on Rubber, Paris, June 1937; "Revue general du Caoutchouc," in print.

26. Air Driven Tubular Vacuum Type Centrifuge. J. W. BEAMS AND C. SKARSTROM, *University of Virginia.*—The method[1] of spinning long tubes and rods in a vacuum has been improved and extended. By reducing the free air space directly beneath the driving turbine, much heavier rotors may be supported upon the air cushion by simply increasing the pressure of the air. Rotors weighing 75 lbs. have been supported and spun with ease. Rods 25 inches long and 2 inches in diameter have been spun with great stability. The maximum rotational speed in all cases is set only by the strength of the rotor. A multi-stage vacuum type centrifuge for vapors consisting of 19 "theoretical" centrifuges connected in series and mounted in an alloy steel tube 14 inches long and 4 inches in diameter has been constructed. The application of the tubular centrifuge to the separation of isotopes is discussed.

[1] Beams, Linke and Skarstrom, Science **86**, 293 (1937).

27. A Convenient Light Source for a Ten Inch Wilson Cloud Chamber. WILSON M. POWELL, *Kenyon College.*—The new Westinghouse coil-coil filament 60 watt clear lamp is arranged with the filament in a straight line. This type of filament will replace the usual type in all common bulbs in the future and can be purchased for 20 cents. It is possible to choose bulbs such that when the back surface is silvered on the outside the image from the mirror falls directly above and in the plane of the filament itself. Two plano-convex lenses six inches in diameter and nine inches in focal length are placed before the bulb with their convex surfaces together. They are adjusted so that an image of the double filament exactly fills the edge of the cloud chamber. A mirror on the far side of the chamber reflects the light back through again. By using four bulbs with their corresponding condensers and operating them on 220 volts d.c., good photographs of cosmic-ray tracks were obtained on "Super-X Panchromatic" film at f: 3.5. The lights were turned on automatically by counter control for about 1/15th of a second. No shutter was used on the camera. The bulbs were still in good condition after 100 flashes. This work was done at the Bartol Research Laboratory.

28. Effect of Valence Electrons on Intensities in Electron Scattering from Zinc Oxide. VIVIAN A. JOHNSON AND HUBERT M. JAMES, *Purdue University.*—A comparison of the intensities in electron and x-ray diffraction patterns from zinc oxide discloses systematic anomalies, if, as is usual, one employs formulas valid for a system of spherically symmetric atoms.[1] The qualitative character of the discrepancies indicates a polarization of the atoms parallel to the line between each zinc atom and the nearest neighboring oxygen. It has been shown that the anomalies cannot be due to polarization of the inner shells of the atoms by intracrystalline fields.[2] To determine whether they can be due to the asymmetrical distribution of the relatively few valence electrons, we have carried out computations with a simple model. Two of the valence electrons of each zinc-oxygen pair of nearest neighbors we have supposed to be in uniform distribution through the crystal, the other two in a uniform linear distribution between the neighboring nuclei. The form factor for this distribution was added to the Pauling-Sherman[3] expression for the symmetrical distribution of the other electrons, and the total used in computing corrected structure factors for the crystal. Within the limits of experimental error these cor-

rected structure factors agree with those obtained from measured electron diffraction intensities.

[1] H. J. Yearian and K. Lark-Horovitz, Phys. Rev. **42**, 905 (1932). K. Lark-Horovitz, H. J. Yearian and J. D. Howe, Phys. Rev. **47**, 331 (1935). H. J. Yearian, Phys. Rev. **48**, 631 (1935).
[2] V. A. Johnson and L. W. Nordheim, Phys. Rev. **51**, 1002 (1937).
[3] L. Pauling and J. Sherman, Zeits. f. Krist. **81**, 1 (1932).

29. Secondary Emission of Electrons from Sodium Films on Tantalum.* PAUL L. COPELAND. *The Research Foundation, Armour Institute of Technology.*—Sodium films condensed on tantalum plates in vacuum lacked luster, and, although the photoelectric work function was very low, secondary emission (as in work by Bruining and Boer[1]) was very low. Mild heat treatment increased luster and the secondary emission rose to maxima of about five secondaries per primary. When logarithms of secondary to primary ratios are plotted against primary energies, slopes just beyond the maxima are characteristic of sodium. For higher primary energies slopes are characteristic of tantalum. The primary energy corresponding to the inflection increases with film thickness. Measurement of films was made by microtitration of the sodium with dilute hydrochloric acid using phenolphthalein as indicator. Inflections at 2.5, 3.5, 3.8, 3.2 and 3.7 kilovolts correspond respectively to measurements of 2, 6, 7, 8, and 9 micrograms of sodium per square centimeter. Inconsistencies in this sequence indicate errors which may be as great as 25 percent. All the evidence, however, indicates that films of sodium 200 monatomic layers thick on tantalum yield secondary emission characteristic of the sodium up to primary energies of about 3 kilovolts; for higher energies the characteristics of the tantalum begin to influence the results.

* Preliminary report of work supported in part by a grant-in-aid from the National Research Council.
[1] Physica **4**, 473 (1937).

30. Design and Construction of an Electron Velocity Analyzer for Ionization Probability Measurements. M. E. BELL, E. A. COOMES, AND W. B. NOTTINGHAM, *Massachusetts Institute of Technology.*—A tube constructed by M. E. Bell used an indirectly heated "oxide" cathode electron source. The electrons were accelerated into a semi-circular "magnetic" analyzer with 0.4 mm entrance and exit slits. Electrons leaving the analyzer were accelerated into the ion chamber, also semi-circular, with slits defining a circle with 3 cm radius. An electron collector at the exit slit converted the chamber into a second velocity "spectrometer." Results obtained were in general agreement with E. O. Lawrence[1] except for an apparent yield of ions at less than 10.4 ev. To distinguish between electrons leaving the ion collector and ions arriving two grids surrounding the collector are needed. E. A. Coomes rebuilt the original tube with this modification but was unsuccessful because the cathode heating current disturbed the magnetic field. A third tube built by W. B. Nottingham used a thoriated filament heated by 300 cycle pulsating current as the electron source and such carefully constructed parts that the tube serves as a means of determining e/m for the electron. ($1.760 \pm .003 \times 10^7$ abs. e.m.u.) Since this is possible, an absolute scale of electron energies is thus available and the ionization probability curve may be accurately placed on the energy spectrum without making any assumptions as to contact difference in potential.

[1] E. O. Lawrence, Phys. Rev. **28**, 947 (1926).

31. Ionization of Mercury Atoms as a Function of the Bombarding Electron Energy. W. B. NOTTINGHAM, *Massachusetts Institute of Technology.*—The experimental tube described in the above abstract has been used to determine the ionization produced in mercury vapor as a function of the electron energy. The salient results obtained are the following: (1) Ionization commences at 10.38 volts with a sharply rising probability curve of small magnitude compared with that of the second mode of ionization. (2) Electrons with an energy of 10.9 electron-volts have about sixteen times higher probability of ionization than those with 10.4 electron-volts. (3) The probability curve has a maximum at this energy as was shown by the experiments of E. O. Lawrence, although he computed its value as 11.29 volts on the assumption that no contact difference in potential existed between the inside and the outside of the ion chamber. (4) The photoelectric emission produced by the radiation from the excited atoms is remarkably strong and shows many sharp maxima and minima which would, of necessity, be confused with "ultra-ionization" potentials unless special provision were made to eliminate this effect. This may very well account for the many critical potentials observed by P. T. Smith.[1]

[1] P. T. Smith, Phys. Rev. **37**, 808 (1931).

32. The Distribution of Energies Among the Incoming Cosmic-Ray Electrons. I. S. BOWEN, R. A. MILLIKAN AND H. V. NEHER, *California Institute of Technology.*—The distribution of energies has been studied by taking cosmic-ray ionization curves practically up to the top of the atmosphere at four different latitudes between 0° and 60° N magnetic. The maximum number of incoming electrons is found at about 5 billion e-volts. The numbers fall off to very small values above 30 billion e-volts and also below 3 billion e-volts. In other words, the incoming particle rays are largely limited to a definite band of energies either because of the mode of origin of the rays or because of this, plus possible blocking effects of celestial magnetic or electric fields.

33. The East-West Effect in Southern India. H. V. NEHER, *California Institute of Technology.*—In the month of November 1936 two sets of three large (37 cm×7 cm) Geiger-Müller counters were used to measure the East-West effect at Kodaikanal (geomagnetic latitude 0°, elevation 7800 ft.) in southern India. One set was used to measure the azimuthal effect while the other recorded the zenith angle effect. Comparison of one set of readings with the other shows that the data are self consistent. Somewhat larger relative values of the West excess are found than those reported by Johnson[1] in Peru. By using the data of Bowen, Millikan and Neher[2] and of Johnson[1] on the apparent absorption coefficient of the radiation due to charged particles, an empirical relationship is found

connecting μ and E. Further, an empirical formula is found from the balloon data of Bowen, Millikan and Neher[3] for the energy distribution of the particles incident on the top of the atmosphere. An application of these two relationships to the East-West effect explains satisfactorily the West excess at the equator. This indicates that the charged particles responsible for the West excess are of the same nature as those which give the latitude effect—namely, electrons. The analysis further indicates that of the total radiation at 7800 ft. elevation in southern India at least one-fourth is due to positrons.

[1] T. H. Johnson, Phys. Rev. **48**, 287 (1935).
[2] Phys. Rev. **52**, 80 (1937).
[3] Some data are used which will be published in the near future.

34. The Latitude Effect for Cosmic-Ray Showers. W. H. PICKERING AND H. V. NEHER, *California Institute of Technology.*—Two Geiger counter sets have been taken from San Francisco to India via Japan and return via Australia. Both the vertical intensity and the shower intensity were measured as a function of latitude. By using large counters in the Neher-Harper circuit,[1] quite reliable results were obtained. The latitude effect for the vertical rays was found to be 14.5 percent in the region of the East Indies and 10 percent in the Pacific Ocean. Both these results are in good agreement with those found with electroscopes in the same regions.[2] The showers show a much smaller latitude effect amounting to about 6 percent in the East Indies. There is also some evidence that the "plateau" of the curve giving the variation of the showers with latitude extends to lower latitudes than the corresponding "plateau" of the curve for the vertical rays. These results show that the latitude sensitive part of the radiation is relatively not as efficient at producing showers as the nonlatitude sensitive component.

[1] Neher and Harper, Phys. Rev. **49**, 940 (1936).
[2] Millikan and Neher, Phys. Rev. **47**, 205 (1935).

35. The Energy Flux of the Corpuscular Cosmic Radiation. C. G. MONTGOMERY AND D. D. MONTGOMERY, *Bartol Research Foundation of the Franklin Institute.*—Recent improvements in the measurement of very high energies in cloud expansion chambers make it possible to estimate what fraction of the total cosmic ray energy crossing a horizontal surface occurs in the form of kinetic energy of charged corpuscular rays. The total amount of the energy flux may be obtained by integrating the cosmic-ray ionization from the point considered to infinity, since all of the cosmic-ray energy is eventually dissipated in the ionization and excitation of atoms. The energy flux is conveniently expressed by the mean energy per corpuscular ray recorded in a counter telescope. This mean energy is computed for vertical rays from the data of various observers, and is found to increase continuously from a minimum value near the top of the atmosphere as the atmospheric depth increases. The value at sea level is 3.04×10^9 volts. The mean energy measured by P. M. S. Blackett in his expansion chamber is 3.11×10^9 volts. We therefore conclude that, at sea level, practically all of the cosmic-ray energy is carried by charged particles. This is not in accord with the theoretical behavior of a beam of electrons and their secondaries, since in that case half of the energy would be in the form of photons.

36. Cosmic Radiation and the Earth's Magnetism. THOMAS H. JOHNSON, *The Bartol Research Foundation of the Franklin Institute.*—Records during the April 1937 magnetic storm, reported by Forbush[1] and Hess and Demmelmair[2] have shown that a world wide decrease of cosmic ray intensity, j, occurred during the period of weakened horizontal field strength, H. The effect for three widely separated stations can be expressed by (1) $Hdj/jdH=10$. On the assumption that the effect was due to a change in the earth's magnetic moment, M, consistency with the latitude and asymmetry effects requires that (2) $Mdj/jdM=-0.2$. Combining (1) and (2), $dM/dH=50a^3$ which is fifty times the value of this coefficient if the effect were due to internal disturbances. If the disturbance were caused by a system of external circular currents distributed as $\cos\lambda$ over the surface of a sphere of radius a' then[3] $dM/dH=-(2a'^3-a^3)/3$ which reduces to $-a^3/3$ if the currents are in the outer atmosphere. It would be necessary to have $a'=4a$ if numerical agreement is to be realized, but this result is trivial since a system of currents at such a distance would weaken rather than strengthen the field in the space where the cosmic rays suffer most of their deflection. It is concluded that the storm effect is at least 150 times greater than can be accounted for by increased bending of the orbits in any field reconcilable with the magnetic variations.

[1] S. E. Forbush, Phys. Rev. **51**, 1108 (1937).
[2] V. F. Hess and A. Demmelmair, Nature **140**, 316 (1937).
[3] S. Chapman, Nature **140**, 423 (1937).

37. A New Analysis of Cosmic Radiation Including the Hard Component. L. W. NORDHEIM, *Duke University.*—A careful comparison of the high altitude cosmic-ray data at different latitudes[1] gives very strong support to the assumption of practically quantitative validity of the radiation theory up to energies of some 10^{10} ev. The analysis shows further the necessity of a separate "hard component" and allows an estimate of its intensity at high altitudes. These data together with the geomagnetic effect at sea level, the energy distribution near sea level[2] and the absorption curve at great depths below sea level[2] (all pertaining to the hard component) can be explained simultaneously by assuming that, in addition to normal ionization, the hard rays are absorbed by a discontinuous process (probably connected with shower production) the cross section of which decreases for increasing energy. A reasonably good quantitative representation of all the data mentioned is given by a primary distribution[3] proportional to E^{-n} (E=energy; $n\sim3$) for both electronic and hard rays with electrons being the more numerous and behaving according to theory, and the absorption coefficient for the hard rays being proportional to E^{-1} for $E>8\times10^9$ ev. A large number of other facts (especially about showers) gives a qualitative confirmation of this picture.

[1] Pfotzer, Zeits. f. Physik **102**, 41 (1936) (geomagnetic latitude 50°); Bowen, Millikan, Korff and Neher, Phys. Rev. **50**, 579 (1936) (38.5°); Bowen, Millikan and Neher, Phys. Rev. **52**, 80 (1937) (3°).
[2] Blackett, Proc. Roy. Soc. **A159**, 1 (1937).
[3] As already suggested by Heitler, Proc. Roy. Soc. **A161**, 1 (1937), and Nordheim, Phys. Rev. **51**, 1110 (1937).

38. Energy Losses of Pauli-Weisskopf Particles. J. F. CARLSON, *Purdue University.*—The work of Anderson and Neddermeyer[1] and of Street and Stevenson[2] lends plausibility to the idea of the existence of a corpuscular component in the cosmic rays that can be identified neither with particles of electronic nor of protonic mass. Street and Stevenson[3] offer evidence that this mass is in the neighborhood of 100 times the electronic mass. Since the information about these particles is as yet incomplete, it will be of some interest to compare the behavior to be expected if these particles possess a spin of $\frac{1}{2}$ unit, i.e., satisfy a Dirac wave equation, or if they should have zero spin and be described by a scalar wave function proposed by Pauli and Weisskopf.[4] The various methods of energy loss for particles satisfying the Pauli-Weisskopf scalar equation have been investigated and a comparison of these results with the results obtained for a particle possessing spin will be given.

[1] Neddermeyer and Anderson, Phys. Rev. **51**, 884 (1937).
[2] Street and Stevenson, Phys. Rev. **51**, 1005 (1937).
[3] Street and Stevenson, Phys. Rev. **52**, 1003 (1937).
[4] Pauli and Weisskopf, Helv. Phys. Acta **27**, 709 (1934).

39. Cosmic-Ray Observations in the Stratosphere. L. F. CURTISS, A. V. ASTIN, S. A. KORFF, L. L. STOCKMANN AND B. W. BROWN, *National Bureau of Standards and Department of Terrestrial Magnetism, Carnegie Institution.*—Using radio methods it has been found possible to record the response of a Geiger-Müller tube counter to cosmic rays at altitudes up to 116,000 feet. Records were made automatically by means of a recording receiver at a ground station. The averaged results from the 12 highest flights show a gradual rise in cosmic-ray intensity which is clearly evident at a pressure of about 500 millibars and then decreases slightly at a pressure of about 300 millibars after which the rise to maximum intensity at a pressure of about 100 millibars is very rapid. This maximum is about 150 times the count recorded near the ground level and is followed by a rapid decrease in counting rate at pressures below 100 millibars. At the highest altitude reached, approximately 116,000 feet, where the pressure is only 5 millibars, the counting rate falls to a value which is about the same as that observed at a pressure of 500 millibars. The general trend of these observations indicates that as the limit of the atmosphere is approached the counts continue to decrease, confirming the view which has been put forward by other observers that the greater part of cosmic-ray phenomena are due to secondary effects generated within our atmosphere.

40. The Infrared Absorption by the Selenium Hydrides. WILLIAM C. SEARS, DONALD M. CAMERON AND HARALD H. NIELSEN, *Ohio State University.*—The fundamental bands in the infrared absorption spectra of the molecules H_2Se, HDSe and D_2Se have been located and preliminary measurements on their rotational structures carried out. *H_2Se:* The centers of the fundamental bands for H_2Se, adopting Dennison's notation, are as follows: $\nu_1=2300$ cm^{-1}, $\nu_2=1110$ cm^{-1} and $\nu_3=2380$ cm^{-1}. Their identification rests on the fact that the bands at 2300 cm^{-1} and 1110 cm^{-1} appear to have similar structures while that at 2380 cm^{-1} is different, showing a gathered Q branch at the center. The rotational spacings in all three bands, which are quite regular except at the center, appear to be the same and equal to about 7.8 cm^{-1}. *HDSe:* For this molecule the frequencies are: $\nu_1=1610$ cm^{-1}, $\nu_2=910$ cm^{-1}, and $\nu_3=2385$ cm^{-1}. Here the rotational spacings are known only for ν_2 and ν_3 and these are equal to about 5.5 cm^{-1}. The frequency ν_1 shows a gathered Q branch while ν_2 and ν_3 do not. *D_2Se:* For this molecule only ν_2 and ν_3 have been identified. ν_2 occurs near 760 cm^{-1} while ν_3 is found to be at 1700 cm^{-1}. The spacings are known definitely only for ν_2 and are equal to about 4.0 cm^{-1} or approximately one-half of the spacings for the lines in the H_2Se bands.

41. The Zeeman Effect of Gold. H. N. MAXWELL, *Hood College,* AND J. B. GREEN, *Ohio State University.*—Several of the classifications of Au I by Symons and Daley[1] in the region of λλ5000–6000A have been verified by Zeeman effect measurements, and the g values determined. For the $5d^{10}6s$, $5d^{10}6p$, $5d^{10}7s$, $5d^{10}6d$, and $5d^{9}6s^{2}$ the g values are unperturbed; but those for the $5d^{9}6s6p$ and $5d^{9}6s6d$ are perturbed from the LS-coupling values. The spectrum of Au II has been investigated by McLennan and McLay,[2] by Rao[3] and by Mack and Fromer.[4] No classifications of Au II lines in the region λλ4760–5726 have been made. This region seems to be rich in lines, but the wavelengths found in the tables are in disagreement (sometimes as much as 1.5A) with our measurements. Several well-defined multiplets appear, which, if the above classifications are correct, indicate transitions between a previously unidentified configuration, $5d^{8}6s6p$, and $5d^{8}6s7s$ or $5d^{9}6d$.

[1] Proc. Phys. Soc. London **41**, 431 (1928).
[2] Proc. Roy. Soc. Canada **22**, 103 (1928).
[3] Proc. Roy. Soc. **A1** and **2**, 118 (1933).
[4] Phys. Rev. **48**, 357 (1935).

42. The Zeeman Effect of Selenium II. J. B. GREEN, *Ohio State University,* AND R. A. LORING, *University of Louisville.*—The Zeeman effect of selenium II has been studied in fields of about 37,500 gauss. The selenium was introduced in powdered form into a brass rod which served as an electromagnetic interrupter and the metal vaporized readily. To date, several of the strongest lines have been measured, principally those involved in transitions between $4s4p^{4}$ and $4s^{2}4p^{2}5s$ with $4s^{2}4p^{2}5p$. The g values are all perturbed from LS-coupling values, but the assignments of J values by Martin[1] are generally in agreement with the observed patterns; with the exception (so far) of 21° which has a J value of $\frac{3}{2}$ instead of 5/2 as assigned by Martin.

[1] Phys. Rev. **48**, 938 (1935).

43. Raman Spectra of Disubstituted Acetylenes. FORREST F. CLEVELAND AND M. J. MURRAY, *Lynchburg College, Lynchburg, Virginia.*—The Raman spectra of (a) $C_6H_5\cdot C\equiv C\cdot CH_2\cdot Cl$, (b) $C_6H_5\cdot C\equiv C\cdot CH_2\cdot CH_2\cdot Cl$, (c) $C_6H_5\cdot C\equiv C\cdot CH_2\cdot CH_2\cdot CH_2\cdot Cl$, (d) $C_6H_5\cdot C\equiv C\cdot CH_2\cdot OH$, (e) $C_6H_5\cdot C\equiv C\cdot CH_2\cdot CH_2\cdot OH$, (f) $C_6H_5\cdot C\equiv C\cdot CH_2\cdot Br$ have been measured by means of apparatus previously described.[1] Compounds b and e have also been measured by Faucounau[2] and compound d by Gredy.[3] No measurements on a, c, and f seem to have been reported. The characteristic

acetylenic frequency at 2200–2300 cm^{-1} is double in many disubstituted acetylenes.[4] Gredy has found that if one of the substituents is a phenyl group, the line of lesser intensity is of lower frequency. The present results verify this conclusion for compound *d*, but for compounds *a* and *f*, prepared from *d*, the weaker line has a *higher frequency*. The acetylenic frequency is double in *a*, *d*, and *f*, but is broad, intense, and apparently single in the remainder of the compounds. The sum of the widths (in hundredths of a mm) of the two lines in *a* is 32, the width of the single line in *b* is 27, and in *c* the width is 22. Since the line of comparable intensity at 1600 cm^{-1} has a width of only 16 and since the above widths decrease as additional CH_2 groups are inserted, it seems probable that the single broad line in *b*, and perhaps also in *c*, may be an unresolved doublet. Preliminary attempts to resolve it by use of a grating have proved unsuccessful. Experiments designed to determine qualitatively the depolarization factors of the acetylenic frequencies are now in progress.

[1] Cleveland and Murray, Am. Phys. Teacher **5**, 270 (1937).
[2] Louis Faucounau, Comptes rendus **199**, 605 (1934).
[3] Blanche Gredy, *Theses* (Paris, 1935).
[4] J. H. Hibben, Chem. Rev. **18**, 50–51 (1936).

44. Raman Spectra of Some Inorganic Compounds. J. Rud Nielsen, N. E. Ward and H. Dodson, *University of Oklahoma.*—The Raman spectra of aqueous solutions of sodium metaborate, borax and sodium aluminate and of crystalline sodium metaborate, borax, boric acid, halides of cadmium, zinc and mercury, and potassium cyanate have been investigated. With sodium metaborate solutions prolonged exposures yielded two faint and diffuse frequencies in addition to that already reported.[1] The latter frequency was found, practically unchanged, in crystalline metaborate. These facts show that the metaborate ion cannot be triatomic and linear, as previously assumed.[1] The crystal powders were observed with the technique developed by Ananthakrishnan.[2] New frequencies were found with most of the crystals already studied. Thus, with mercuric chloride two new low frequencies were observed, while with boric acid twice as many frequencies were found as observed by Ananthakrishnan.[3] Attempts are being made to correlate the Raman spectra with the crystal structures.

[1] J. Rud Nielsen and N. E. Ward, J. Chem. Phys. **5**, 201 (1937).
[2] R. Ananthakrishnan, Proc. Ind. Acad. Sci. **5**, 76 (1937).
[3] R. Ananthakrishnan, Proc. Ind. Acad. Sci. **5**, 200 (1937).

45. The Signs of the Nuclear Magnetic Moments of Li^6 and K^{41}. John E. Gorham, *Columbia University.*—Nonadiabatic transitions between magnetic quantum states of atoms in an atomic beam were used to show that the signs of the nuclear magnetic moments of Li^6 and K^{41} are positive.[1] A beam of atoms 230 cm in length was passed through a weak nonhomogeneous field 153 cm long, a selecting slit, a weak transition field whose direction changed rapidly with respect to the atoms, a strong field, and was detected on a hot tungsten wire.

[1] I. I. Rabi, Phys. Rev. **49**, 324 (1936).

46. Absolute Nuclear Moment of Indium 115. S. Millman, I. I. Rabi, *Columbia University*, and J. R. Zacharias, *Hunter College.*—The atomic beam method of zero moments has been applied to indium to measure the nuclear spin and the hfs $\Delta\nu$ of the normal $^2P_{1/2}$ state. The spin was found to be 9/2 and the $\Delta\nu=0.381$ cm^{-1} in agreement with spectroscopic results. The resolving power attained was sufficiently high to allow a measurement of the fine structure of the zero moment peaks. From the separation of the two $m=-3$ peaks of $\Delta H/H=0.0193$ we calculate the moment of indium to be 6.40 ± 0.20 percent nuclear magnetons. This value does not depend on any assumptions with regard to the nature of the interaction between the nuclear spin and the electron configuration. Zero moment peaks arising from the metastable $^2P_{3/2}$ state, lying 2212.6 wave numbers above the $^2P_{1/2}$, were found. The intensity of these peaks is in good agreement with what is expected from quantum statistics. Their exact location will permit an evaluation of the nuclear quadrupole moment.

47. On the Magnetic Moments of Neon and Argon. J. M. B. Kellogg and Norman F. Ramsey, *Columbia University.*—It is generally assumed that the nuclear spins of the isotopes having even atomic weights and even atomic numbers are zero. For elements of this type where the spin is not known from band spectra, the possibility remains that the spin is not zero but that the magnetic moment is very small. With an atomic beam apparatus capable of detecting a magnetic moment of the order of 0.05 nuclear magnetons which is half as large as the smallest nonzero nuclear moment hitherto reported, the elements neon and argon have been investigated for the presence of a magnetic moment. Deflection of the atoms was produced in an inhomogeneous magnetic field of length 48 cm and maximum gradient 110,000 gauss/cm. The diminution in intensity at the center of the undeflected beam was determined quantitatively with a Stern-Pirani detector. Helium, spin zero, showed no change in intensity. The weakening of the beam in the cases of neon and argon could be accounted for by the diamagnetic moments of these elements. Thus, if neon and argon have a magnetic moment, it is less than 0.05 nuclear magnetons.

48. *Tabulation and Study of the Energy Levels of the Asymmetrical Rotator.[1] Enos E. Witmer, *University of Pennsylvania.*—In a previous abstract[2] the author stated that there is a very close correspondence between the *doublet* energy levels of the asymmetrical rotator according to quantum mechanics and the energy levels according to the old quantum theory and gave the formulas which link the two theories. Therefore a usable formula for $\tau_c(s;\, n_2/J)$ is of value to the spectroscopists. The following formula for the epicycloidal motions, which is derived rigorously, is rapidly convergent over a very large part of the domain of τ_c. Let $y=(1-s)^{\frac{1}{2}}(1-n_2/J)$. Then

$$\tau_c\left(s;\frac{n_2}{J}\right)=2y-\frac{1}{2}\left(\frac{2-s}{1-s}\right)y^2 -\frac{1}{2^5}\left(\frac{s}{1-s}\right)^2\frac{y^3}{(1-y)^2}(4-3y) -\frac{1}{2^6}\left(\frac{s}{1-s}\right)^3\frac{y^4}{(1-y)^3}(5-3y)$$

$$-\frac{1}{2^{13}}\left(\frac{s}{1-s}\right)^4\frac{y^5}{(1-y)^6}[528-1264y$$
$$+984y^2-243y^3] \text{ etc.}$$

* To be read by title.

[1] With the support of a grant from the Penrose Fund of the American Philosophical Society.

[2] E. E. Witmer, Phys. Rev. **51**, 1001 (1937).

49. The Experimental Verification of the Quantum Mechanical Dispersion Theory by Reflections and Diffuse Scattering of X-Rays from Zinc. W. A. BRUCE AND G. E. M. JAUNCEY, *Washington University, St. Louis, Mo.*—Experimental values of Δf are obtained by correcting ΔF for thermal vibrations, since

$$\Delta f=(F_{\lambda=.71}-F_{\lambda=1.54})e^{M(K,\psi)}, \qquad K\equiv(\sin\phi/2)/\lambda$$

where $$M(K,\psi)=(a\cos^2\psi+b\sin^2\psi)K^2$$

and is determined from diffuse scattering experiments. $F_{\lambda=0.71}$ is taken from Miller,[1] while $F_{\lambda=1.54}$ is taken from Wollan and Harvey,[2] and Brindley.[3] The reflection experiments and the diffuse scattering experiments were all done at approximately the same temperature. The values of a and b as obtained from our diffuse experiments[4] are 2.27 and 0.64A^2. An average of Δf obtained by using Miller and Brindley's F values and values of a and b determined by diffuse scattering gives $\Delta f_{\text{ave}}=2.35$. Hönl,[5] in a quantum-mechanical treatment of the dispersion theory, gives a value of Δf (for $\lambda=.71$A and $\lambda=1.54$A) of 2.36. M may be obtained by other means. Δfs obtained with these other Ms are also averaged and compared.

[1] R. D. Miller, Phys. Rev. **51**, 959 (1937).
[2] E. O. Wollan, G. G. Harvey, Phys. Rev. **51**, 1054 (1937).
[3] G. W. Brindley, Phil. Mag. **21**, 790 (1936).
[4] G. E. M. Jauncey and W. A. Bruce, Phys. Rev. **51**, 1067 (1937).
[5] H. Hönl, Zeits. f. Physik **84**, 1 (1933).

50. Position of the Center of the Compton Modified Band. G. E. M. JAUNCEY, *Washington University, St. Louis, Missouri.*—Several experimenters[1] have found the center of the Compton modified band to be shifted slightly from its position as given by Compton's simple theory. Jauncey's theory[2] of the profile of the modified band is based on the assumption that the scattered photons which give rise to the band may be treated as having bounced off free electrons having the same distribution of speeds as the actual electrons in the scattering substance. Later, Jauncey[3] showed that to a first approximation, if the component velocity distribution function of the atomic electrons is $f(u)$, the profile of the Compton band is given by $f(Ax)$, where $A=c/\sin\frac{1}{2}\phi$, $x=(\lambda_C-\lambda')/\lambda_C$, and λ' and λ_C are respectively the wave-lengths of the actually scattered and the "Compton" scattered x-rays. To a higher degree of approximation it is now shown that the profile is given by $(1-2bx)\cdot f(Ax(1+bx))$, where $b=(1+\text{cosec}^2\frac{1}{2}\phi)/2$. This profile is not symmetrical about $x=0$ even though $f(u)$ is symmetrical about $u=0$. A Maxwell distribution with a most probable speed of 25 volts gives a shift of 0.23 X.U. for Mo $K\alpha$ rays at $\phi=180°$.

[1] Ross and Kirkpatrick, Phys. Rev. **46**, 668 (1934). Kirkpatrick, Ross and Ritland, Phys. Rev. **50**, 928 (1936). DuMond and Kirkpatrick, Phys. Rev. **52**, 419 (1937).
[2] Jauncey, Phil. Mag. **49**, 427 (1925); Phys. Rev. **25**, 314 and 723 (1925).
[3] Jauncey, Phys. Rev. **46**, 668 (1934).

51. A Theory of the X-Ray Absorption Edges and Their Fine Structure in Ionic Compounds. ROLF LANDSHOFF, *University of Minnesota.*—It is assumed that the act of absorption lifts the electron into the unoccupied outer shell of a nearby cation, to the nearest for the edge and to those farther away for the short wave satellites. The older theory pictured the electron as jumping into one of the traveling states. Its main disadvantage is, that the removal of an electron from the emitting ion gives rise to an electric field in the neighborhood of this ion, and therefore to a polarization energy which should be considered in the energy balance, but which spoils the good numerical agreement. The present theory restores this agreement. The occurrence of discrete localized levels below the continuum of traveling states has already been stated by Slater[1] and v. Hippel[2] in the theory of the ultraviolet absorption of ionic crystals. From the experiments of Brewington[3] this seems to be even more distinct in the case of the x-ray absorption with a more pronounced line structure near the edge.

[1] Slater and Shockley, Phys. Rev. **50**, 705 (1936).
[2] v. Hippel, Zeits. f. Physik **101**, 680 (1936).
[3] Brewington, Phys. Rev. **46**, 861 (1934).

52. The Use of Intensifying Screens in X-Ray Diffraction Work. CARL GAMERTSFELDER AND NEWELL S. GINGRICH, *University of Missouri.*—The photographic method of investigating x-ray diffraction by liquids has given reliable relative intensity measurements, but it has the disadvantage that long exposure times are required. A Fluorazure intensifying screen has been used in an attempt to decrease this exposure time, and an investigation is being made to determine the reliability of intensity measurements using a film in conjunction with an intensifying screen. Diffraction patterns of liquid potassium with Mo $K\alpha$ radiation have been obtained with and without an intensifying screen and microphotometer curves have been obtained from them. The relation between blackening and intensity for the film alone does not hold when an intensifying screen is used. In order to obtain the relation between x-ray intensity and blackening of the film, the Mo $K\alpha$ and Cu $K\alpha$ lines, reflected from a calcite crystal, have been recorded on films with and without intensifying screens, and through various filters of known materials and thicknesses. These experiments show that the intensifying factor, using Cu $K\alpha$, varies from about 1.2 at a film blackening of 0.12 to about 2 at 0.46, and the intensifying factor using Mo $K\alpha$ varies from about 5 at a film blackening of 0.14 to about 12 at 0.52. There is no indication of an increase in line width with the screen, and there has been no difficulty with afterglow.

53. The Determination of the Characteristic Temperature of MgO from X-Ray Measurements. H. S. RIBNER AND E. O. WOLLAN, *Washington University.*—The characteristic temperature Θ of a simple crystal can be determined from measurements of the ratio of the intensities of a regularly reflected x-ray line at two different temperatures, at various values of $\sin\theta/\lambda$. We have made such measurements for MgO at room temperature and at the

temperature of liquid air by a photographic method and have analyzed the results by a procedure which does not require a knowledge of the absolute ratio of the intensities at the two temperatures. The value of Θ which we obtain in this way is equal to $721°\pm21°$K. This corresponds to a root mean square amplitude of thermal vibration of the atoms of 0.069A at room temperature. The characteristic temperature has also been obtained by comparing the experimental scattering factor for MgO at room temperature with the theoretical scattering factor for the atom at rest and the result is found to show satisfactory agreement with the above mentioned value. A value for Θ can also be calculated from specific heat data, and the relation between the value so obtained and that obtained by x-ray measurements will be discussed.

54. The Effect of Lattice Enlargement upon Our Ideas of Order *versus* Disorder in Crystals, Including Mix-Crystals. F. C. BLAKE, *Ohio State University.*—In 1918 Professor Max von Laue, in discussing mix-crystals, stated the two alternative views of such crystals for certain ternary compounds: (a) random distribution of two of the three atoms involved; (b) a great enlargement of the unit cell with an ordered arrangement of the two atoms that normally would substitute for each other in (a). No one seems adequately to have studied the possibilities of view (b), since, in general, "superlattice" lines tend to appear due to the difference in scattering power of the two substitutional atoms for first and higher order reflections. By enlarging the lattice to a definite but finite size it is possible to determine an "ordered" arrangement that is the exact equivalent of the random distribution (a). Details of this arrangement for one type of cubic crystals will be given. This means, of course, that all superlattice lines are absent.

55. Electric Impedance of Single Arbacia Eggs. KENNETH S. COLE AND HOWARD J. CURTIS, *College of Physicians and Surgeons, Columbia University.*—The end of a two or three mm thin-walled glass tube is heated until it closes down to a capillary about 50μ in diameter and 200μ long. The capillary end of the tube is partially immersed in sea water, and when an egg, 75μ in diameter, is dropped in the upper open end, it settles to the top of the capillary. The water level in the tube is then raised until the egg is pushed into the middle of the capillary. Measurements are made between electrodes placed in the tube and in the outside solution. The low frequency resistance of a 48μ tube rose from 24,000 ohms when filled with sea water to 840,000 ohms with an unfertilized egg in place. This increase might be due to a membrane resistance of 13 ohms cm^2 but this value is no more than a lower limit since a layer of sea water 0.2μ thick between the egg and the glass would produce the same result. Assuming the membrane to be nonconducting, the observed low frequency capacities and the higher frequency data give average membrane capacities of 0.8μf/cm^2 for the unfertilized, and 2.8μf/cm^2 for the fertilized eggs. These results are in agreement with those obtained from suspensions, and the technique may be used for several problems which are not otherwise possible.

56. A Three-Component Accelerometer. J. E. SHRADER, *Drexel Institute of Technology.*—A type of accelerometer has been devised which measures the three components of acceleration simultaneously and records them on the same photographic film. The distinctive features of this accelerometer are: (1) The method of securing great sensitivity by large magnification of the motions of the pendulums. (2) The employment of special damping devices by means of which the pendulums become practically dead beat. (3) The disposition of the pendulums and the optical system whereby the records of all three components are recorded on the same photographic films. Proper damping which is a very important feature of an accelerometer is secured by the use of hollow discs or diaphragms by means of which energy of vibration is dissipated by forcing air into and out of the hollow chamber through a small opening. It is found that optimum damping is secured by a certain size opening which is determined by trial. By the use of air as a damping fluid the instrument can be operated in any position and damping does not vary markedly with temperature.

57. A Mechanical Harmonic Synthesizer-Analyzer. S. LEROY BROWN, *University of Texas.*—A machine is described which has thirty harmonic elements (fifteen sine components and fifteen cosine components) that operate simultaneously. The driving mechanism is a train of twenty intermeshing spur gears that are high grade but selected from commercial stock. These gears drive fifteen shafts with rotational ratios ranging from one to fifteen. A Scotch cross head is operated from each end of each shaft with the pin of each cross head set in quadrature with the pin of the cross head at the other end of the respective shaft. The sum of the thirty sinusoidal movements is communicated to a tracer point (pencil) by means of pulleys and a continuous fusee chronometer chain, and the curve is traced on a drawing board that is driven uniformly past the pencil point. Analysis is accomplished by setting the amplitudes of the thirty elements to correspond to the values of thirty of thirty-two equispaced ordinates from a wave-length of the curve to be analyzed. Thirty components (fifteen sine and fifteen cosine components) of the curve being analyzed are then determined from the values of thirty of thirty-two equispaced ordinates of a wave-length from a single trace produced by the machine.

58. *Photoelectric Geiger-Müller Counters with Caesium Cathodes. GORDON L. LOCHER, *Bartol Research Foundation of the Franklin Institute.*—Several photoelectric counters with cathodes of thin caesium hydride on silver and on hydrogen-soaked platinum have been made. The caesium surface is prepared by bombardment of caesium azide with H^+ ions or with electrons; the metal thus liberated is distilled on to the cathode and lightly bombarded with H^+ ions. Glass envelopes of Pyrex and Nonex are used. The counter gas is hydrogen at 2 to 6 cm pressure, purified by: passage through subliming magnesium and two cold traps, storage in a flask heavily lined with evaporated barium, and conduction to the counter through two cold traps and another barium flask. The counters have a narrower

"voltage plateau" than ordinary counters used with the same coupling resistance. At room temperature, the spontaneous rate, due to thermionic emission, is usually high. These tubes have thresholds (by filters) of about 8000A, and have sensitivities greatly exceeding those of any other photoelectric counters that the writer has produced. One type has a cathode that can be cooled with CO_2 ice or liquid air without refrigerating the entire tube. Work done so far shows that it is entirely feasible to use photoelectric surfaces with low work-functions in counters. The quantum efficiencies of the surfaces have not been determined, and can certainly be improved. Some stellar photometric measurements made with one of these tubes, by Dr. O. Mohler, of the Cook Observatory, indicate that the over-all sensitivity of the tube (used as a counter) is of the order of that of a good photo-cell and pliotron arrangement. The oldest caesium counters retained were made in June and in Sept. 1937.

* Read by title.

59. A New Geiger Counter. T. G. How and K. Larkhorovitz,[1] *Purdue University.*—Following the suggestion of Geiger of the possibility to use an inverted counter: tube inside, wire outside, different forms of counters have been investigated which allow the direct introduction of the sample into the counter. The final form adopted consists of three wires inside the cathode cylinder held at the usual potential difference in respect to the cylinder. Argon-air mixtures of pressure from 4 cm to 8 cm are being used. The sensitivity of the counter is comparable with that of an ordinary counter. The counters have been tested using potassium and rubidium salt crystals.[2]

[1] I am indebted to the American Academy of Arts and Sciences for funds supporting this work.
[2] The counters will be exhibited in operation at the Science exhibit of the A. A. A. S. during the meeting.

60. Effects of Fringing Flux in Large Magnets. J. D. Howe and I. Walerstein, *Purdue University.*—The magnet constructed for the Purdue cyclotron has tapered pole pieces shaped according to an equation suggested by Bethe to reduce the fringing flux in the space outside the pole gap. In this design the flux density at the pole face is the same as it is near the yoke, and the product of its value and the maximum radius of curvature of the accelerated particles is about 15 percent higher than it would be for cylindrical pole pieces. To minimize the loss due to fringing flux the energizing coils are placed some distance from the yoke. The ampere interaction of the current in the coils with the fringing flux is found to produce a force causing a repulsion of the coils away from the air gap. Complete mapping of the magnetic field in the neighborhood of the pole pieces shows that for an energizing current of 160 amperes in each coil the field in the air gap between the pole pieces is 16,050 gauss, and the horizontal component of the field in the neighborhood of the coils has an average value of 750 gauss. The resulting force tending to "float" the upper coil is 3.4 tons.

61. High Frequency Systems for the Cyclotron, J. R. Dunning and H. L. Anderson, *Columbia University.*—Improved methods have been developed for feeding high frequency energy to the accelerating electrodes of the cyclotron (or any electrodes having appreciable capacitance). By using, in place of the usual coil, a short-circuited section of a transmission line having approximately equal inductive reactance, the resonant circuit thus formed with the electrode capacitance may be made to have a much higher Q value than has been hitherto attained. Both parallel wire and concentric lines may be used, but in general any method employing parallel wire lines may be improved electrically and mechanically by using concentric lines. In the concentric line system adopted here the advantages are: (1) much higher accelerating voltages; (2) higher efficiency; (3) higher frequencies; (4) shielding; (5) elimination of insulators; (6) energy fed into the system at low potential; (7) ease of adjustment; (8) water lines introduced at ground potential. Power from the oscillator is fed capacitatively to a nonresonant low impedance coaxial line which in turn feeds the resonant loaded quarter-wave line electrode system. The oscillator is frequency stabilized by a high Q concentric line directly exciting the grids, and operates with an efficiency of about 50 percent at 20 mC. Virtually all of the power output is delivered to the electrodes. For the cyclotron this means a considerable increase in energy and intensity of the ion beam.

62. Some Observations of Magnetic Viscosity in Iron. C. W. Heaps, *Rice Institute.*—Measurements of magnetic viscosity in iron wires have been made, using a ballistic galvanometer and fine wires, so that effects due to eddy currents are negligible. When the current in the magnetizing solenoid is cut off the flux in the iron specimen may continue to change appreciably for as long as a minute after the field is removed. By adjusting resistances and condensers the time required to remove the magnetizing field may be varied. It is found that the mode of decay of the magnetizing field influences very decidedly the magnitude of the viscosity. Under certain conditions of nonoscillatory decay magnetic viscosity will not appear at all. A cathode-ray oscillograph has been used in estimating rates of removal of the magnetic field and in detecting oscillations. Under certain conditions magnetic viscosity can be observed even though a reverse current is produced in the solenoid by an oscillation at break.

63. A Few Related Experiments with Fast Neutrons. M. L. Pool, *Ohio State University.*—The angular distribution of the fast neutrons produced from the deuteron bombardment of lithium was measured by the radioactivity induced in a number of substances placed symmetrically about the neutron source. The cyclotron at the University of Michigan was used to produce 6.3 Mev deuterons. The intensity variation of the radioactive samples of silver indicated a very distinct forward throw of the neutrons. A similar conclusion can be drawn from the radioactivity induced in Al, Sn, In, Pt and Au. With decreasing bombarding voltage of the incident deuterons on lithium, the change of intensities of the fast neutron reactions was compared with the change of the slow neutron reactions. The intensity of the radioactivity in

Ag (24.5 min.), Cu (10.0 min.) and Sc (4.0 hr.) decreased much more rapidly than did the activity in Dy (2.5 hr.), Cu (12.8 hr.) or Al (14.8 hr.). A number of elements were bombarded with deuterons for the purpose of finding other sources of fast neutrons. Cu, Sc, Ag and Al were used as detectors. Under fast neutron bombardment several nuclei were found to eject a proton, two neutrons and an alpha-particle. The branching ratios for these nuclei have been calculated from the observed intensities of the induced radioactivities.

64. Preliminary Experiments with a Cosmic-Ray Telescope. W. H. PICKERING, *California Institute of Technology.*—An attempt to discover astronomical influences on the cosmic radiation is in progress. For this purpose a Geiger counter telescope having very large counters has been mounted on a polar axis. The instrument is arranged so that, in addition to the usual right ascension and declination axes, the plane of the counters can be rotated around an axis lying in that plane, parallel to the direction in which the telescope is pointing. The counters are spaced so that the solid angle over which at least half the counter area is effective is about $5°\times15°$. With the counters oriented so that their axes were parallel to the Milky Way, observations have been taken at two declinations, $+20°$ and $-25°$. A series of points spaced one hour apart in right ascension give the intensity of the radiation in two bands around the sky. The results to date indicate that if astronomical bodies in these regions affect the radiation, their effect must be very small, or else the earth's magnetic field so distorts the paths of the rays that it cannot be found at the earth's surface.

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