Proceedings of the American Physical Society

MINUTES OF THE NEW YORK MEETING, OCTOBER 29–31, 1936

THE 208th regular meeting of the American Physical Society was held in New York City at the Pennsylvania Hotel on Thursday, Friday and Saturday, October 29, 30 and 31, 1936 in conjunction with the general program of the American Institute of Physics Incorporated, which was celebrating its fifth anniversary. On Friday afternoon the contributed papers were divided into three sessions at which the presiding officers were F. K. Richtmyer, President of the American Physical Society, H. M. Randall, Vice President, and John Zeleny.

On Friday evening the various cooperating societies had a dinner at which John T. Tate presided. He called upon Karl T. Compton for an address in which he outlined the development of the American Institute of Physics Incorporated with the help of the Chemical Foundation. After the remarks of Dr. Compton the Chairman called upon Mr. John Mulholland to entertain the guests with magic. The attendance at this dinner was about five hundred.

A complete statement of the general program of the American Institute of Physics will appear in the December issue of the *Review of Scientific Instruments*.

Meeting of the Council. At its meeting held on Thursday, October 29, 1936 the deaths of three fellows (J. B. Brinsmade, S. M. Kintner and Edward Weston) and one member (Alfred H. Cash) were reported. One candidate was transferred from membership to fellowship, and eighty candidates were elected to membership. *Transferred from membership to fellowship:* C. Drummond Ellis. *Elected to membership:* Robert A. Ackley, James S. Allen, George H. Bancroft, V. P. Batha, V. L. Bollman, Ralph B. Bowersox, Facundo Bueso-Sanllehi, Philip B. Bucky, Robert O. Burns, Phillip R. Carlson, Elbert P. Carter, Paul E. Charton, Edward B. Cooper, M. Alden Countryman, Dean B. Cowie, Joseph Demers, George A. Downsbrough, Louis F. Ehrke, H. Feistel, Michael Ference, Jr., Sherwood Githens, Jr., Nicholas Golovin, Martin J. Gould, Arthur Haas, Clarence A. Hall, Joseph P. Harper, Sherwood K. Haynes, Donald G. Hurst, Yoshiro Ikedo, Hans von R. Jaffe, Walter E. Jordan, Joseph Kaminsky, L. D. Percival King, Bernard B. Kinsey, Christian C. Larson, Vivian A. Long, Albert D. Loring, Irving F. Matthysse, J. L. McKibben, Eugene H. Melvin, J. M. W. Milatz, Frank Morgan, Forrest H. Murray, R. Andrew Nelson, Doyle L. Northrup, Leonard O. Olsen, Arthur C. Omberg, Mituo Ono, Lawrence Ott, V. Lawrence Parsegian, J. O. Perrine, Gilbert Plain, J. A. Prins, Theodore G. Psilolihnos, J. Emilio Ramirez, Norman F. Ramsey, Willis M. Rayton, H. E. Ruff, Francis Segesman, Thomas R. Shugart, H. J. Sprengel, Frederick W. Stallmann, Hans Staub, R. Meldrum Stewart, John N. Street, Sugeno Takesi, Richard Taschek, Delia A. Taylor, John D. Trimmer, James Van Allen, Harold G. Vogt, Arthur von Hippel, Alan T. Wager, Thomas H. Wallace, I. Warshawsky, Charles P. Wells, E. C. Wiersma, Harold W. Woolley, Frank H. Yeargers, and Carroll L. Zimmerman.

The regular scientific program of the Society consisted of thirty-eight contributed papers. The abstracts of these papers are given in the following pages. An Author Index will be found at the end.

W. L. SEVERINGHAUS, *Secretary*

ABSTRACTS

1. Ferromagnetic Anisotropy in Alpha Iron and in Gamma Nickel-Iron and Nickel-Cobalt-Iron at and above Room Temperature. L. W. MCKEEHAN, R. G. PIETY AND J. D. KLEIS, *Yale University.*—Oblate spheroids cut from single crystals have been examined by the pendulum magnetometer method. Magnetization curves along fourfold, threefold and twofold axes have been obtained at room temperature and at two or more higher temperatures below the Curie points. In alpha iron (of exceptional purity) and in gamma nickel-iron the results are qualitatively similar to previous results of others. In iron the anisotropy vanished just above 600°C. In the nickel-iron series the anisotropy changes its type at 76 percent nickel. In gamma nickel-cobalt-iron with from 40 to 80 percent nickel there is evidence supporting the finding of J. W. Shih,[1] that in gamma nickel-cobalt the anisotropy changes type twice between 80 and 97 percent nickel.

[1] J. W. Shih, Phys. Rev. [2] **50**, 376–379 (1936).

2. Magnetic Analysis of Evaporated Bismuth Films. C. T. LANE, *Yale University*.—By using a compensated Gouy method in conjunction with a Sartorius microbalance, the magnetic susceptibility of Bi films from 0.1μ to 4μ thick has been determined. The films are deposited on thin glass plates (water cooled) from vapor in high vacuum. The susceptibility is determined as a function of film thickness for the case where the plane of the film is perpendicular to the magnetic field. For films above 0.5μ the susceptibility is independent of film thickness and equal to that of a single crystal with [111] parallel to the field. At angles other than the above, for films above 0.5μ, the susceptibility obeys the same $\cos^2$ law as a single crystal, with its trigonal axis in the plane of the field. Below 0.5μ the susceptibility decreases as film thickness is reduced. Bismuth films (thickness $>0.5\mu$) deposited on Au, Cu and Sn are identical with those deposited on glass. On the basis of a comparison between known results for single crystals and colloidal powders respectively and the present work, it is suggested that these films possess fiber structure of normal particle size above 0.5μ and show microcrystalline fiber structure below this thickness.

3. The Magnetic Susceptibility of Molecular Hydrogen. ENOS E. WITMER, *University of Pennsylvania*.—For molecular hydrogen the molar magnetic susceptibility χ_m is given by the formula[1]

$$\chi_m = -\frac{L\bar{e}^2}{6mc^2}\Sigma r^2 + \frac{2}{3}L\sum_{n'\neq n}\frac{|m^0(n^1;n)|^2}{h\nu(n^1;n)}. \qquad (1)$$

The two terms on the right have been evaluated by using the wave functions for the normal state of hydrogen given by James and Coolidge. The values of the first term evaluated from their eleven-term functions for different internuclear distances R are given in the following table:

R (atomic units)	First term $\times 10^6$
1.2	−3.578
1.3	−3.774
1.4	−3.998
1.5	−4.253

These values were averaged by using a Morse wave function for the vibrational state $v=0$. The resulting value of the first term is -4.151×10^{-6}, if $R_0=1.40$ is taken as the point of minimum electronic energy. Experimentally $R_0=1.418$. With this value of R_0, the resulting value is -4.198×10^{-6}. The second term in Eq. (1) was evaluated for the *five*-term function of James and Coolidge, and yielded 0.285×10^{-6}, using the approximation of Van Vleck and Franck. The resulting values of χ_m are -3.87×10^{-6} for $R_0=1.40$ and -3.91×10^{-6} for $R_0=1.418$. Considering the scattering in the *original* observation of Soné and Wills and Hector, either of these values appears to be in harmony with experiment, although the latter is in better agreement with the average values obtained experimentally.

J. H. Van Vleck, *Electric and Magnetic Susceptibilities*, p. 275.

4. Propagation of Potential in Discharge Tubes. L. B. SNODDY, J. W. BEAMS AND J. R. DIETRICH, *University of Virginia*.—The investigation of the propagation of potential in long discharge tubes recently reported[1,2] has been continued with the use of the same type of apparatus. The velocity of 124 kv impulses has been measured as a function of pressure when the 5-mm diameter glass discharge tube was filled with air, CO_2 and hydrogen, respectively. In the case of each of the above gases the graph of pressure *versus* velocity of propagation is roughly linear over the pressure range from 0.02 mm to 0.2 mm. At the higher pressures the velocity increases at a much slower rate. In the case of each of the gases the velocity of propagation was varied over wide ranges without distortion or attenuation of the voltage waves, at least for a ten-meter tube. For example, in air from 9×10^8 (0.08 mm pressure) to 43×10^8 cm/sec. (5.4 mm pressure. This pressure was previously[1,2] incorrectly stated). It is believed that the above phenomena is similar to that usually observed in the lightning flash.

[1] Phys. Rev. **50**, 469 (1936).
[2] Nature **138**, 167 (1936).

5. Films Formed on Electrodes During Activation of Oxide Coated Cathodes. L. B. HEADRICK AND E. A. LEDERER, *RCA Manufacturing Company, Inc., Harrison, New Jersey*.—Deactivation of oxide coated cathodes has been observed in numerous types of electron tubes when an electrode close to the cathode is bombarded by electrons. The deactivation has been shown to be due to decomposition, by electrons of 7 to 25 volts, of a film formed on the side of the electrode exposed to the cathode. The film is formed during the activation of the oxide coated cathode and is not decomposed by electrons of 5 volts or lower. These films are attributed to the formation of polymerized carbon oxygen compounds by surface reaction at the electrode surface facing the cathode. Chemical tests have shown that the films are composed of carbon compounds and barium compounds, probably oxides. The deactivation of the cathode when the film is decomposed is attributed to oxygen liberated from the film under electron bombardment. In tubes where the film is formed on part of an electrode exposed to the cathode, it is shown that the cathode is deactivated only when current is drawn to the part of the electrode covered by the film. The films may have high values of electrical resistance. A method of activating oxide coated cathodes without the formation of such insulating films is discussed.

6. Electronic Voltage Stabilizers. F. V. HUNT AND R. W. HICKMAN, *Harvard University*.—Most of the voltage stabilizing circuits employing thermionic tubes can be classified into three groups, according to their derivation from (1) the bridge circuit for measurement of the variational amplification factor, (2) the bridge circuit for measurement of the transconductance, or (3) the simple amplifier circuit with degenerative auto-bias. Each of these simple circuits admits several variations in multi-tube arrangements wherein the control voltage is amplified before application to the grid of the control tube. This classification not only includes most of the stabilizing circuits recently published but suggests several new circuits and indicates the manner in which the circuits can be extended to meet various specifications. Computation of

the internal output impedance and the voltage stabilization ratio allows the performance of these circuits to be predicted for variations of output load as well as input voltage. These parameters are given for all of the circuits considered. It is usually possible to eliminate polarizing batteries by the use of glow discharge tubes or an auxiliary stabilizing circuit of group (1) or (2). Examples will be given of the actual performance of the most useful of the new circuits.

7. A Spectroscopic Study of the Magnetron Discharge. OVERTON LUHR AND FRANK J. STUDER, *Union College.*—The spectra from magnetron discharges in various gases have been studied with the aim of investigating the efficiency of this type of source in producing the higher states of ionization. The study of helium was of particular interest since in a mass-spectrograph study of this type of discharge made by one of the writers, it was impossible to distinguish the He^{++} from the H_2^+ ions which were always present. The discharge between a tungsten filament and a nickel cylinder was operated at widely varying voltages, currents, and gas pressures. The most satisfactory results were obtained at about 250 volts, 0.5 ampere, and pressure of 0.1 mm of mercury. A magnetic field of the order of 200 oersteds parallel to the axis of the cylinder greatly intensified most of the lines in the region of the spectrum investigated between 7000 and 2000A. Higher members of the series in both the He I and He II spectrum were brought out with good intensity compared to results obtained with other types of discharge. The magnetron should thus be an efficient source of He^{++} ions. In the case of nitrogen and mercury many lines of the N II, N III, N IV, and Hg II spectra were identified.

8. Measurements of the Diffusion of Ions in Mercury Vapor. K. H. KINGDON AND H. E. TANIS, JR., *Research Laboratory, General Electric Co., Schenectady, N. Y.*—Current from a 60-cycle source is passed through a mercury vapor tube and stopped abruptly at the peak. The residual ions are allowed to diffuse away for a definite (variable) time (ϕ) under relatively field-free conditions. Then a negative voltage is applied to a probe and the peak ion current (i_+) to the probe is measured. This has been done in several different tubes under widely varying experimental conditions. In general the plots of $\log i_+$ against ϕ consist of two straight lines, with the part of the curve at small ϕ having several times the slope of that at large ϕ. For example, after passing a current of 50 amp. through a tube 7 cm in diameter, with the mercury reservoir at 40°C, the time constant (time for i_+ to fall to $1/e$) for the first part of the curve was 88 microseconds, and that for the second part was 241 microseconds. The tentative interpretation of the change in slope is that during the first part of the curve the ion temperature is falling rapidly, whereas during the second part the diffusion of ions takes place substantially at wall temperature.

9. Some Factors Influencing the Sparking Potential in Hg Vapor. E. J. LAWTON AND K. H. KINGDON, *Research Laboratory, General Electric Co., Schenectady, N. Y.*—The sparking potential between closely spaced Ni electrodes in Hg vapor at 0.002 mm pressure was found to be reduced as much as 15-fold following a few minutes bombardment of one electrode with 2000-volt positive ions. Smaller reductions in the sparking potential were found as the time of bombardment was decreased and also as the ion voltage was decreased. The electrode after bombardment also showed an increased field emission. A reduction of some 4-fold was found after an electron current of several amperes had been passed between the electrode and a barium oxide cathode. The sparking potential was not altered appreciably if the electron current was great enough to heat the electrode to a red heat. The field emission following the current treatment was not always measurable. Bombarding the electrode after the current treatment usually resulted in a further lowering of the potential to that corresponding to the bombardment failure. The effect produced by either the ion bombardment or the current treatment was very easily destroyed by sparking the electrodes at high voltage several times. In fact, as few as six sparks were sufficient to age the electrodes from 5 kv to 75 kv.

10. Ionization of Mercury Vapor by Positive Sodium Ions. ROBERT N. VARNEY, *New York University.*—A balanced space charge method for detecting feeble ionization, which is entirely uninfluenced by secondary electrons liberated from surrounding walls, was used for detecting the inset potential for ionization of mercury vapor by positive sodium ions. The potential was found to be 89 volts. The method has been used previously to detect similar ionization in noble gases. The results, when properly compared, indicate that this inset potential for Na^+ in Hg is not in disagreement with conclusions drawn from the noble gas results. The efficiency of ionization above the inset is very roughly estimated to be less than one-fifth of that for Na^+ in Ne under corresponding conditions. Hg vapor is the only gas other than noble gases in which ionization by positive alkali ions has been observed by this method.

11. Alpha-Particle Bombardment of Neon, Argon and Calcium. ERNEST POLLARD AND CHARLES J. BRASEFIELD, *Yale University.*—We have detected protons from neon and calcium when bombarded by Th C′ alpha-particles but not from argon. Only one group is found from each element. We ascribe the emitted particles to the two reactions,

$$He^4+Ne^{20}=Na^{23}+H^1(-2.6_4 \text{ Mev}),$$
$$He^4+Ca^{40}=Sc^{43}+H^1(-4.2_3 \text{ Mev}),$$

with the nuclear energy changes as indicated. The fact that in the first reaction no second group was found of range greater than 10 cm means that the separation between the ground level and the first excited state of Na^{23} exceeds 2.2 Mev while for the analogous product nuclei Al^{27}, P^{31}, Cl^{35} it has been found to be less than 1 Mev. The neon reaction is therefore exceptional. No decision is possible for the calcium reaction as the maximum range is already so short that a second group could hardly be detected. From the neon reaction we derive the value 22.9972 for the mass of Na^{23} using Aston's recent value for Ne^{20}.

12. The Absorption of Slow Electrons in Cl_2. J. B. FISK,* *Massachusetts Institute of Technology.*—Measurements of the total cross section for scattering of electrons from 2 to 50 volts energy in Cl_2 have been carried out. A scattering chamber similar to that of Brode[1] was used, and allowance made for a continual flow of the gas. A pure tungsten filament drawing 0.5 amp. when fully activated was used as the electron source. Measurements were first made with N_2, the results comparing very well with those of previous investigations[2] and with the theory of elastic scattering.[3] The chlorine cross section, in the energy range indicated, varies between 800 and 2000 sq. atomic units (whereas the N_2 maximum is but 90 of these units). A calculation of the expected elastic cross section gives a very high peak at less than $0.5\sqrt{V}$ and a curve similar to that observed for Na and Cs, but this theory cannot account for the large maximum observed at $2.65\sqrt{V}$. The chlorine cross section must then be attributed to a number of processes besides elastic impact: dissociation, various types of excitation, formation of negative ions, et cetera. The probabilities of some of these processes is presumably high as, for example, the dissociation energy of Cl_2 is but 2.47 volts. Calculations of these inelastic processes have not as yet been carried through for diatomic molecules.

* Now at Harvard University, Society of Fellows.
[1] J. B. Brode, Proc. Roy. Soc. **125**, 134 (1929).
[2] Brüche, Ann. d. Physik **81**, 532 (1926); Brode, Phys. Rev. **25**, 636 (1925).
[3] J. B. Fisk, Phys. Rev. **46**, 167 (1936).

13. $K\alpha$ Satellite Lines for Elements Zn(30) to Pd(46). C. H. SHAW, *National Research Fellow,* AND L. G. PARRATT, *Cornell University.*—With a two-crystal spectrometer, ionization curves of the $K\alpha_{3,4}$ group of x-ray satellite lines have been recorded for elements Zn(30) to Pd(46). In this satellite group are found four component lines for elements $30 \leq Z \leq 33$, three components for $34 \leq Z \leq 40$ and two components, α_3' and α_4, for $41 \leq Z \leq 46$. The wave-length position, relative intensity, and line width at half-maximum intensity of each component has been measured. A sharp and anomalous decrease (with increasing Z) in the total satellite intensity relative to the α_1 intensity is found in the region of Y(39). Curious and anomalous intensity relations are also found among the individual satellite components.

14. In^{115}, Hyperfine Structure Deviations and Electric Quadrupole Moment. R. F. BACHER AND D. H. TOMBOULIAN, *Cornell University.*—Measurements of the hyperfine structure of the lines of In II, using a Fabry-Pèrot interferometer, have shown that there are deviations from the interval rule. These deviations are of two types. The line $\lambda 7852 (5s6p\ ^1P_1 - 5s6s\ ^1S_0)$ has only three components and these can be measured accurately. By using 3 and 5 mm separators the separations are found to be -0.4318 and -0.3612 cm^{-1}, showing that the intervals are irregular. The line $\lambda 7183 (5s6p\ ^3P_1 - 5s6s\ ^3S_1)$ also shows that the intervals in the $^3P_1$ level are not regular. For this second line however the deviations are due to the presence of the $^3P_0$ level near at hand, as has been shown by Paschen[1] particularly for higher series members. For the $^1P_1$ level the perturbing effect on the regularity of the intervals by the only levels in the vicinity is negligible. The observed deviations from interval rule can be accounted for by the existence of an electric quadrupole moment of the nucleus, as for Bi. This leads to a nuclear quadrupole moment $\overline{R^2} = 1.0 \times 10^{-24}$ cm^2. No trace of the isotope In^{113} was found although the components of In^{115} were greatly overexposed on some plates.

[1] Paschen, Sitzungsber. Preuss. Akad. **24**, 430 (1935).

15. Absorption of Some Metallic Halides in the Schumann Region. H. M. O'BRYAN AND E. G. SCHNEIDER, *Harvard University.*—In order to extend the measurements of Hilsch and Pohl[1] on the ultraviolet absorption bands of the alkali halides below 1600A, lithium fluoride has been used as a support for thin films of the salts. Selected lithium fluoride plates of one millimeter thickness when properly cleaned were consistently transparent to 1050A. The compound to be studied was distilled onto the lithium fluoride within a Thibaud spectrograph. A silver solder-carboloy hot spark and Ilford Q plates were used to make the measurements. Comparison of spectra transmitted by the lithium fluoride plates with and without absorbing films of approximately 0.06 micron thickness show, in addition to the bands reported by Hilsch and Pohl, a number of bands below 1600A whose widths vary between 0.3 and 1.3 electron volts. Observations made on some of these compounds by A. Smith[2] using a less direct method agree very poorly with these measurements. A comparison of the observed bands with the computations by A. v. Hippel[3] shows a partial agreement. Results on several alkaline earth halides show only a series of sharp absorption edges with continuous absorption toward shorter wave-lengths.

[1] Hilsch and Pohl, Zeits. f. Physik **59**, 812 (1930).
[2] A. Smith, Phys. Rev. **44**, 520 (1933).
[3] A. v. Hippel, Zeits. f. Physik **101**, 680 (1936).

16. Wave-Length Standards in the Extreme Ultraviolet. KENNETH R. MORE* AND CAROL A. RIEKE, *Massachusetts Institute of Technology.*—In order to be certain that the wave-length standards in the extreme ultraviolet are not subject to the small errors inherent in the method of overlapping orders the wave-lengths of several lines of carbon, nitrogen, and oxygen have been determined by a method which is free of that objection. This has been accomplished by the comparison, using a two-meter focus normal incidence vacuum spectrograph, of the first order of the lines in question with the first order of certain lines of the Cu II spectrum. The wave-lengths of these Cu II lines have been computed with considerable accuracy by Shenstone[1] by the use of the combination principle. The values obtained in the present investigation are in good agreement with those of Boyce and Rieke,[2] and of Weber and Watson,[3] which were obtained by the method of overlapping orders. Since the results of three investigations are now in satisfactory agreement, mean values, suitably weighted, are suggested for use as wave-length standards in the extreme ultraviolet.

* This research was carried out during the tenure of a Royal Society of Canada Fellowship.
[1] A. G. Shenstone, Phil. Trans. Roy. Soc. London **235**, 195 (1936).
[2] J. C. Boyce and C. A. Rieke, Phys. Rev. **47**, 653 (1935).
[3] R. L. Weber and W. W. Watson, J. O. S. A. **26**, 307 (1936).

17. The Infrared Absorption of Heavy Acid Solutions. E. K. PLYLER AND DUDLEY WILLIAMS, *University of North Carolina and University of Florida.*—The infrared absorption of deuterium oxide and of DCl, D_2SO_4, and D_3PO_4 solutions has been measured in the spectral region between 2μ and 12μ. In addition to the characteristic bands at 2.9μ, 4.0μ, 6.8μ, and 8.2μ, a band was found at 10.4μ in the spectrum of deuterium oxide. In the spectra of all the heavy acids studied intense absorption bands appear at 3.4μ and near 5.5μ in addition to the bands characteristic of the solvent. The solutions of D_2SO_4 and D_3PO_4 give rise to characteristic SO_4 and PO_4 absorption in addition to the above-mentioned bands. The bands appearing at 3.4μ and 5.5μ are attributed to hydration effects.

18. The Infrared Absorption of Hydrogen Chloride in Nonionizing Solvents. DUDLEY WILLIAMS, *University of Florida.*—The infrared absorption of hydrogen chloride in four nonionizing solvents has been measured. In every solution studied the HCl fundamental vibrational frequency was found to be lower than for the gaseous state and the variation in frequency was found to increase with increasing dipole moment of solvent as long as the solvents were of the same chemical nature. Benzene, chlorobenzene, nitrobenzene, and *m*-nitrotoluene were used as solvents. In every solvent used the coefficient of absorption of the dissolved gas was greater than the coefficient of the free gas. The results obtained were attributed to the combined effects of dipole interaction and the formation of complexes.

19. Pressure Broadening of Potassium Resonance Lines by Argon and Nitrogen. GORDON F. HULL, JR., *Sloane Physics Laboratory, Yale University.*—Broadening of the potassium resonance lines in absorption by argon and nitrogen pressures from 1 to 40 atmospheres has been observed. Half-widths and shifts of the lines, when plotted against "relative density," yield curves that are straight lines up to relative density 14, indicating that in this pressure region the Lorentz type of broadening predominates. At about relative density 14, "statistical" broadening sets in, and the curves depart from linearity. The results are in accord with Margenau's theory,[1] and also partly in agreement with the previous work done by Watson and Margenau[2] using nitrogen as the perturbing gas. Theoretical contours for pressure broadened spectral lines, given by Margenau, have been fitted to those of experiment. Agreement is quite satisfactory, considering the approximations made in evaluating the theoretical curves. Three independent methods of calculation yield for the van der Waals constant b the values $24(10)^{-32}$ and $18(10)^{-32}$ cm^6 sec.$^{-1}$ for argon and nitrogen respectively.

[1] H. Margenau, Phys. Rev. **48**, 755 (1935).
[2] W. W. Watson and H. Margenau, Phys. Rev. **44**, 748 (1933).

20. The Effect of Pressure on the Absorption and Optical Activity of Water. R. H. ZINSZER, *Indiana University. (Introduced by J. B. Dutcher.)*—The set-up included a cylindrical pressure chamber 60 cm long with glass windows 1.9 cm thick supported on a steel surface; a tungsten lamp as the projection source; and a photo-cell as the receiver. Readings were taken for the wave-length region 6000 to 7000A, at pressures up to 700 kg/cm^2. One feature of the work was to correct for the lens effects as described by Poulter[1] and to determine the magnitude of these effects relative to the expected effect due to pressure alone. Stops were introduced into the pressure chamber by which it was possible to show the divergence produced by the windows under pressure on the light beam passing through the chamber. This was also attempted with heterogeneous light and similar results were obtained. By plotting the percent transmission as a function of the pressure it was possible to show that the results grouped themselves according to the stop size. By plotting the log absorption as a function of the log of the area of the stops the relation between the absorption and the stop area becomes apparent. This divergence was due to the symmetrical stress produced on the window as a result of the unsupported area. These results indicated that until proper correction is made for the divergence of the windows it will be almost impossible to obtain quantitative values for the absorption effect due to pressure.

[1] Thos. C. Poulter and Carl Benz, Phys. Rev. **40**, 872 (1932).

21. The Integral Proof of Lorentz and the Michelson-Morley Experiment. W. B. CARTMEL. *Université de Montréal.*—It is known to everyone that when the source and mirror move together, the angle of reflection at a 45° mirror is 90°. Fig. 19 in Lorentz' paper[1] of 1886, Fig. 3 in Voigt's paper[2] of 1887, and Fig. 9 in *The Theory of Electrons*,[3] all show this angle as a right angle. From this figure Lorentz deduced, by means of his integrals, a v^2/c^2 shift of the fringes, but the analysis of Voigt shows that there is no shift, which is in agreement with experiment in the case of an ideal interferometer.

Voigt's remarkable paper which seems to have been entirely overlooked, is based on potential theory, and embodies some results contained in an earlier paper,[4] leading to the relation (p. 47), $T'=T/(1-v^2/c^2)$ which is similar to what was found by the present writer.[5] In the earlier paper, by combining Euler's dynamic equations with the wave equation, he takes into account something that Lorentz did not.

The analysis of Lorentz leads to three integrals derived from a triangle of vectors. (Reference 3, p. 177.) But these are time vectors, and need special treatment (see Webster's *Dynamics*,[6] par. 6, pp. 9–11). If properly analyzed we find a curl, giving us a fourth integral, which brings his solution into agreement with experiment.

[1] H. A. Lorentz, Archives Néerlandaises **21**, 103 (1887).
[2] W. Voigt, Goettinger Nachrichten, 1–21, 177 (1887).
[3] H. A. Lorentz, *The Theory of Electrons* (G. E. Stechert, New York, 1916).
[4] W. Voigt, Goettinger Nachrichten, 1–21, 41 (1887).
[5] W. B. Cartmel, Phys. Rev. [2] **49**, 647 (1936).
[6] A. G. Webster, *Dynamics* (G. E. Stechert, New York, 1904).

22. Electric Impedance of Nerve. KENNETH S. COLE AND HOWARD J. CURTIS, *Department of Physiology, College of Physicians and Surgeons, Columbia University.*—Alternating current measurements on excised nerve have been made over a frequency range from 20 to 2,500,000 cycles by means of a Wheatstone bridge, both axial and transverse to the fiber axis. The axial measurements have not been particularly satisfactory and the lack of an adequate theoretical analysis has prevented their interpretation.

The problem is further complicated by evidence of several variable impedance elements. It was found that the presence of the nerve sheath in many cases almost completely obscures the characteristics of the axons. The transverse measurements on stripped nerve may be interpreted on the basis of a suspension of uniform cylinders whose membranes show a polarization impedance. On the other hand, when a statistical distribution of fiber diameters and membrane capacities is assumed, measurements on the frog and cat sciatic nerves lead to static capacities of the membrane for the average fibers of 1.0 and $0.6\mu F/cm^2$, respectively. The lack of an understanding of the impedance characteristics is a considerable handicap to the analysis of electric excitation.

23. An Ionization Chamber for Neutron Measurements in Biological Experiments. G. FAILLA, *Memorial Hospital.*—A neutron beam of sufficient intensity to be used for biological investigations, produces enough ionization to be measured readily. While the ionization is largely due to high speed protons, it is well to arrange the experimental conditions so as to measure all the ionization no matter how it is produced. For biological investigations it is necessary to measure the ionization under the actual conditions in which the biological change to be studied is produced. The investigation of a similar problem in connection with the therapeutic uses of x-rays, has led the writer to the development of a new type of ionization chamber, which with slight modifications is also suitable for neutron measurements. The chamber is so constructed that the walls can be of exactly the same material as the living organism at the point where the biological effect is to be studied (*viz.*, skin, muscle, bone, tumor etc.) at the proper tissue depth, and with the same geometric contour as the living test object. The air volume in which the ionization is produced is eliminated by extrapolation.

24. Physics in Textile Research. IRVING J. SAXL. *Providence, R. I.*—It is only recently that it has been realized that one of the oldest industries in the world, the textile industry, is based upon the understanding and proper application of physical principles. Textile materials are primarily physical materials, characterized by such physical constants as breaking strength, elongation, Young's modulus, dielectric strength, specific properties of light, reflection and absorption, special behavior in polarized light, and many more. The investigation of these phenomena required the development of a new experimental technique. A number of instruments are described and lantern slides of them shown, and the various methods discussed, which have been recently developed for bringing about a better understanding of the physical properties of textile fibers, and the industrial application thereof to improvements in manufacture of better fabrics and textile materials.

25. An Apparatus for Measuring the Thermal Conductivity of Refractories at High Temperatures. J. L. FINCK, *The J. L. Finck Laboratories, New York, N. Y.*—In the design and construction of industrial furnaces, much attention has been given of late to the question of heat insulation, and a large number of heat insulating refractories have appeared on the market. It is therefore necessary to have a means for measuring the thermal conductivity of refractories at temperatures up to 2000°F, and in some cases at even higher temperatures. This apparatus is designed to measure thermal conductivity over the range from room temperature to about 2000°F. The theory of the design and method of test are discussed. Numerous details in design and operation are considered.

26. Effect of Nuclear Motion in the Dirac Equation. IRVING S. LOWEN, *New York University.*—Since the Dirac Equation $\{E/c+\alpha\cdot p+\alpha_4 mc\}\psi=0$ is derived only for the one-body case, it is inapplicable to the discussion of the effect of the nuclear "mitbewegung" on the energy levels even of the one-electron problem, for a rigorous discussion of which one would need an accurate two-body relativistic equation. In the absence of such an equation relativistic corrections to the one-body Hamiltonian to the order $(m/M)^2$ and $(v/c)^2$ have been obtained, with the aid of the Breit relativistic two-particle interaction.[1] It turns out that the contribution of the terms in $(m/M)^2$ to the energy is negligible, the final Hamiltonian to terms of the order m/M being

$$\{E/c+Ze^2/rc+-ZeV_1+\boldsymbol{\alpha}_2\cdot\mathbf{p}_2+\alpha_{24}mc-p_1^2/2Mc+\mathbf{u}_1\cdot\mathbf{H}_1$$
$$+e/c\mathbf{u}_1\cdot\mathbf{r}\times\boldsymbol{\alpha}_2/r^3+Ze^2/2Mc^2[(\boldsymbol{\alpha}_2/\mathbf{r})\cdot\mathbf{p}_1+(\boldsymbol{\alpha}_2\cdot\mathbf{r}/r^3)\mathbf{r}\cdot\mathbf{p}_1]\psi=0$$

where the subscript 1 refers to the heavy particle with charge Ze, mass M, and magnetic moment $\mathbf{u}_1$ while subscript 2 refers to electron, $\mathbf{r}$ being the vector distance between both particles pointing from particle 1 to 2 and $\mathbf{H}_1$ the external magnetic field. Calculation of the terms

$$\Delta W=Ze^2/2Mc[(\boldsymbol{\alpha}_2/r)\cdot\mathbf{p}_2+(\boldsymbol{\alpha}_2\cdot r/r^3)\mathbf{r}\cdot\mathbf{p}_2]+p_2^2/2M$$

where the substitution $\mathbf{p}_2=-\mathbf{p}_1$ has been made for a 1 *s* electron in the field of a nucleus of charge Ze gives a result in agreement with that for the Schrödinger treatment of mitbewegung to terms of the order m/M.

[1] G. Breit, Phys. Rev. **34**, 553 (1929).

27. Electron Exchange in the Theory of Metals. JOHN BARDEEN, *Cambridge, Mass.*—A discussion is given of the general principles underlying the application of the Fock equations, which include the effects of electron exchange, to such problems as the specific heat of electrons, conductivity, thermionic emission, thermoelectricity, etc. The energy parameter, $E(k, T)$, of the Fock equation corresponding to the wave function $e^{ik\cdot x}\psi_k(x)$, depends on the distribution of the remaining electrons in k space, and is thus a function of the temperature. The usual distribution formula for Fermi-Dirac statistics applies with $E(k, T)$ replacing the individual electron energy, ϵ_k, even though the total energy is no longer given by $\Sigma E(k, T)$. Since the exchange energy is a function of k, the distribution will be modified even if the electrons are free except for their mutual electrostatic interaction. The specific heat of free electrons goes to zero at $T=0$ as $aT/\log(\epsilon/kT)$. At ordinary densities and temperatures it is smaller than that predicted by the usual theory by a large factor ($\sim$3–7). The theoretical value of the resistivity of a metal like Na,

the electrons of which are essentially free, is reduced by the same factor. Expressions for the total current resulting from a given distribution of electrons are discussed in their relation to the problems of conductivity, thermionic emission, and thermoelectricity.

28. Action of Nonelectric Forces on Electrons and Positrons. W. H. FURRY, *Harvard University.*—Considerations of Inglis* on nuclear doublet separations have led the writer to discuss* the introduction of nonelectric forces into the Dirac equations. When such forces are applied to an electron-positron distribution, one expects to find that they deflect both sorts of particles in the same direction, in contradistinction to the action of electric forces. This expectation is easily verified in the case of low velocity particles. A further confirmation is found in the discussion of processes in which the occurrence of electrons and positrons is transitory only. On account of the opposite action of electric forces on the two signs of charge, the odd orders in the perturbation calculations of such effects must vanish identically, provided only electric forces act. This selection rule must be suitably modified when nonelectric forces are present.

* Physical Review, in press.

29. Vertical Distribution of Ozone in the Upper Atmosphere. BRIAN O'BRIEN, F. L. MOHLER, H. S. STEWART, *Institute of Optics, University of Rochester, National Bureau of Standards, University of Rochester.*—Measurements of the vertical distribution of atmospheric ozone on the 1935 Stratosphere Flight of the National Geographic, U. S. Army Air Corps previously reported[1] have been extended beyond the 22 km ceiling reached by the balloon, using spectra photographed with a second spectrograph receiving light from the sky just above the horizon. By taking into account primary scattering only it has been shown that for zenith angles of the sun small compared to that of the region of sky illuminating the instrument, the apparent ozone as measured by it is a function of the concentration immediately above as well as of the total ozone. It is thus possible to arrive at the form of the ozone distribution several kilometers beyond the balloon ceiling. While the distribution thus found is not a single valued function nevertheless the distribution can be found within narrow limits if a sufficient number of sky spectra are available at slightly different elevations near the top of the flight. A sharp concentration of ozone centering at 22 km has been found to fit best the sky spectrograph observations. From a maximum of 0.018 cm S. T. P./km at 22. km the concentration falls to half this value at about 24. km, and less rapidly beyond that. The sky observations are in good agreement with those of the instrument receiving direct sunlight up to 22. km. This sharp concentration is approached by observations on the umkehr effect made by Meetham and Dobson at Tromso.[2]

[1] O'Brien, Mohler, Bull. Am. Phys. Soc. **11**, 24 (1936).
[2] Meetham and Dobson, Proc. Roy. Soc. **A148**, 598–603 (1935).

30. A Possible Critical Latitude Phenomenon Limited to Altitudes Above Sea Level. W. F. G. SWANN, *Bartol Research Foundation of the Franklin Institute.*—The writer has formerly developed a theory of cosmic-ray phenomena based upon the production of secondaries and founded upon a law of absorption of primary energy of the form $-dE_x/dx=\alpha+\lambda E_x$ where E_x is the primary energy at the depth x below the top of the homogeneous water equivalent atmosphere, α is the loss per unit of path by ionization and λE_x is the loss per unit of path by secondary production. It results that if the "secondary hump" in the intensity-altitude curve is to be attributed to a range phenomenon of one group of the primaries, the corresponding value of λ is such that the rays which penetrate the earth's magnetic field at the equator cannot penetrate the atmosphere. Hence, in addition to the normal critical latitude phenomenon observable at sea level and having its origin in one set of primaries there should exist another set of critical latitude phenomena; but, they are confined to altitudes above a certain minimum which is of the order of 0.6 meter of water. Starting at the equator the critical latitude in question gradually works its way out to higher latitudes with increasing altitude.

31. Geiger-Müller Counters for Special Purposes. GORDON L. LOCHER, *Bartol Research Foundation of the Franklin Institute.*—The design, construction, and operating characteristics of various new forms of Geiger-Müller counters are described. These include: *Gamma-ray counters* for gamma-rays, x-rays, and corpuscular cosmic rays; *particle counters* with thin glass windows, Cellophane windows, and thin glass walls; *neutron counters*, with thin soft glass walls and silver cathodes, for measuring low intensities of slow neutrons by means of the activation of the cathode; and *photoelectric counters* with stable surfaces and high sensitivity, for measuring weak visible and ultraviolet light. The operating characteristics of counters filled with vapor, instead of gas, are described; these vapors include dimethylaniline, anisole, bromine, and iodine.

32. Further Observations of Cosmic-Ray Tracks in Photographic Emulsions. T. R. WILKINS, *University of Rochester.*—A continuation of our study of the plates sent on the stratosphere flight of the Explorer II has yielded a further number of tracks due to high energy particles. The cyclotron has been used to give intense beams of proton tracks to check the figures previously used to differentiate between alpha-rays and protons on the basis of average grain spacing. A number of cosmic-ray tracks have been photographed at various settings of the fine adjustment of the microscope to show the dip of the tracks in the emulsion. Examples of small angle scattering (about 3 to 5 degrees) have been observed and in a number of cases short branch tracks of 4 or 5 grains occur at the bends. In several instances these branch tracks go to the same side as the main deflection, apparently indicating that the short track cannot be due to a collision-recoil but to a disintegration without capture of the high energy particle. The phenomenon of disintegration without capture has not heretofore been reported as far as is known. On accepted theories it would not be expected at small angle scattering.

33. The Triangle Proof of Lorentz. W. B. CARTMEL, *Université de Montréal.*—This was based on his proof in the form of integrals in which he considered the angle of reflection to be 90° as shown in *The Theory of Electrons*, Fig. (9). In Fig. (9), the ray in the arm at right angles to the ether-drift, goes out to the end mirror and returns to the *same point* on the plate. If we now consider axes fixed in the ether so that our mirrors are shown displaced instead of the mirrors being fixed with the ether drifting by, and suppose that the laws of geometrical optics still hold, we will undoubtedly arrive at the triangle construction of Lorentz. But this is not in agreement with experimental optics. When we give the mirror a displacement of pure translation, the beam of parallel rays is displaced parallel to itself and a different ray passes through the optical center of the observing telescope. We cannot suppose that the motion of the plate bends the ray over so as to make the same ray pass through the center of the lens. From the viewpoint of the pure mathematician, however, a transformation from moving axes to fixed axes gives us the triangle. But when we follow the methods of the pure mathematician we must use his safeguards. Our moving axes are affected by the curl of the vector causing them to rotate (see Webster's *Dynamics*,[1] p. 246). Therefore in making a transformation of coordinates, we must use rigorous mathematics if we require accuracy to the second order. The elementary triangle proof merely tells us that there is no first-order effect in an ideal interferometer.

[1] A. G. Webster, *Dynamics* (G. E. Stechert, New York, 1904).

34. Apparatus for Transmitting Cosmic-Ray Data from the Stratosphere. RICHARD L. DOAN,* *University of Chicago.*—Improvements in design of apparatus first described two years ago[1] will be reported. Ionization is measured by a Dershem-type electrometer in conjunction with a 22.1 spherical air-tight chamber made of 0.018 in. steel and filled with 5 atmos. of argon. A light beam reflected from an electrometer mirror falls on the slit of a photo-cell and closes a permalloy relay thus sending out the signal over short wave transmitter and also grounding the collecting system for the start of a new cycle. Atmospheric pressure is measured by means of an evacuated sylphon bellows with a steel spring inside. Changes in length of the bellows cause a metallic pointer to move around the circumference of a 3 in. dial consisting of brass contacts embedded in Bakelite, thus varying the resistance in a neon-tube flasher circuit, which consequently pulses with a frequency dependent on pressure. The pulses are also transmitted by radio and received, together with the cosmic-ray signals, at the ground station on a National A.G.S. short wave receiver feeding into a tape recorder. The total weight of gondola (Dow metal) plus equipment is in the neighborhood of 20 lb.

* Now at Phillips Petroleum Co., Bartlesville, Okla.
[1] J. M. Benade and R. L. Doan, Phys. Rev. **47**, 198 (1935).

35. Nuclear Radius and Many-Body Problem. H. A. BETHE, *Cornell University.*—In the old theory of Condon-Gurney and Gamow, the probability of α-decay of a radioactive nucleus was given directly by the transmission of the potential barrier. According to the many-body concept of nuclei introduced by Bohr, a factor must be added representing the probability that an α-particle is formed in the nucleus and the energy concentrated upon it. This factor is certainly quite small, according to the evidence from slow neutron experiments. To compensate for it, the transmission of the potential barrier must be assumed much larger than in the Gamow theory; in other words the potential barrier must be smaller, and the nuclear radius larger than that deduced by Gamow. If we assume that the concentration of energy on a radiaoctive α-particle is as probable as on a neutron of the same wave-length, the radius of radioactive nuclei turns out to be about 13×10^{-13} cm $\pm$10 percent, as compared to 9×10^{-13} cm in the Gamow theory. The new radius makes understandable why heavy nuclei can be disintegrated quite easily by deuterons of only moderate energy (4–5 MV). The cross section observed by Lawrence for such disintegrations, *viz.* about 10^{-28} cm^2, agrees with reasonable theoretical expectations when the new radius is used but is much too large to be explained on the basis of the old radius.

36. Transmutation Functions and the Many-Body Model of the Nucleus. H. A. BETHE AND E. J. KONOPINSKI,[1] *Cornell University.*—The Bohr nuclear picture leads to lower coulomb barriers than the ones formerly accepted.[2] For example, the Mg^{26} barrier for deuterons has now a height of 2.9 MV instead of the old value, 4.2 MV. According to the Gamow-Condon-Gurney theory, the yield from reactions produced by deuteron bombardment of Mg^{26} should therefore not increase for bombarding energies greater than 2.9 MV. In contrast to this, the experiments[3] give a continued increase in the yield up to 3.5 MV. This may be explained with the help of the Breit-Wigner theory, according to which the yield is given by:[4] $2\pi^2R^2\Gamma_i\Gamma_0/\Delta\Gamma$ (R=nuclear radius; $\Gamma_i\Gamma_0$=nuclear level widths corresponding to the emission of incident and outgoing particles; Γ=total width; Δ=spacing of the levels). The continued increase of the yield may be explained by the decrease in the spacing and by the increase of Γ_0 expected because more final states become possible for the nucleus produced. The latter factor, in particular, fits in with the fact that the yield of α-particles from the $Mg^{26}+H^2$ reaction increases more rapidly with the energy than the proton yield. For 1.3 MV deuterons, the α-particle energy is just greater than the barrier height only if the residual Na^{24} is left in its ground state, while for higher deuteron energy the α-particle can also escape leaving Na^{24} in an excited state.

[1] National Research Fellow.
[2] See preceding abstract.
[3] M. C. Henderson, Phys. Rev. **48**, 855 (1935).
[4] Bethe, Phys. Rev. **50**, 977 (1936).

37. On Magnetic Moments of Light Nuclei in the Individual Particle Model. H. A. BETHE AND M. E. ROSE, *Cornell University.*—On the basis of the individual particle model Feenberg and Wigner[1] have found for the ground states of light nuclei the following results: for Li^6, N^{14} and B^{10} (^3S), for Li^7, Be^7, Be^9, B^9, B^{11}, C^{11}, C^{13}, N^{13}, N^{15}, O^{15}, (^2P), and for Li^8 and B^{12} (^3P). For the P terms the ambiguity in the nuclear spin J in the ground state may be removed by using the considerations of Inglis[2] concerning spin-orbit

coupling in nuclei. In this way one finds an inverted multiplet for Li^7 Be^7 (ground state $J=\frac{3}{2}$) and for Li^8 ($J=2$) with regular multiplets for C^{13}, N^{13}, N^{15}, O^{15}, ($J=\frac{1}{2}$) and for B^{12} ($J=0$). For the nuclei Be^9, B^9, B^{11}, C^{11}, special consideration is necessary because for a given parent term of neutrons and protons the spin-orbit energy vanishes. The calculation indicates a regular doublet for these nuclei. By using the spins found in this manner the magnetic moments are determined. Recent experiments of Rumbaugh and Hafstad[3] show a doublet fine structure in the proton group from $Li^6+H^2=Li^7+H^1$ which agrees in sign and order of magnitude with the spin-orbit splitting of the ^2P state of Li^7 predicted by the theory. Similar fine structure should be observable in the proton groups from the reactions $C^{12}+H^2=C^{13}+H^1$ and $N^{14}+H^2=N^{15}+H^1$ if thin targets are used.

[1] E. Feenberg and E. Wigner, Phys. Rev. (in press).
[2] D. R. Inglis, Phys. Rev. **50**, 783 (1936).
[3] L. H. Rumbaugh and L. R. Hafstad, Phys. Rev. **50**, 681 (1936).

38. Production of Neutrons with Low Voltage. W. H. ZINN AND SAMUEL SEELEY, *Columbia University.*—An investigation has been carried out to determine if the reaction $D_1^2+D_1^2\rightarrow He_2^3+n_0'$ provides a useful neutron intensity at voltages of the order of 60 kv. A low voltage arc source of the type described by Tuve, Dahl and Hafstad,[1] which gives ion positive currents of 4 ma with a probe hole 1 mm $\times$5 mm has been developed. Magnetic analysis shows, for hydrogen, 15 to 20 percent protons. It is found that the neutron yield from a D_2O ice target at 60 kv is 1 mc per μA of positive ions. One hour's bombardment with a power input into the target of 15 watts produces no change in neutron intensity due to the disappearance of the ice. With 25 watts input the intensity decreases slightly after 15 minutes bombardment. Neutron intensities equivalent to a 500 mc Ra—Be source have been obtained using 0.5 ma of ions in a sharply focused beam.

[1] Phys. Rev. **48**, 241 (1935).

AUTHOR INDEX TO ABSTRACTS OF NEW YORK MEETING