PROCEEDINGS

OF THE

AMERICAN PHYSICAL SOCIETY

MINUTES OF THE WASHINGTON MEETING, APRIL 24–26, 1930

The 163rd regular meeting of the American Physical Society was held in Washington, D. C., On Thursday, Friday and Saturday, April 24–26, 1930. The Thursday and Friday sessions were held at the Bureau of Standards in the East Building and the Industrial Building. The Saturday sessions were held at the National Academy of Sciences. The presiding officers were Professor Henry G. Gale, President of the Society, Dr. W. F. G. Swann, Vice-President of the Society, and Professors John T. Tate, Harold W. Webb, and L. P. Sieg. On Thursday afternoon and Friday morning there were sessions devoted to papers on "Applied Physics."

On Friday evening there was a dinner for the members of the Society and their friends in the Gold Room of the Washington Hotel. President Gale presided and the speakers were Professors R. A. Millikan, G. F. Hull, Gregor Wentzel, Karl T. Compton and Doctors W. F. G. Swann and L. W. Nordheim. There were 257 guests at the dinner.

At the regular meeting of the Council held on Friday, April 25, 1930, thirty-five candidates were elected to membership. *Elected to Membership*: William Alter, John C. Batchelor, Ralph D. Bennett, John F. Blackburn, George W. Bloemendal, R. M. Buffington, H. R. Byerlay, Stuart Campbell, Shih-Chang Chen, Frank Coleman, T. C. Hardy, R. C. Hartsough, Curtiss R. Haupt, James A. Hootman, Frederick L. Hunter Jr., Franklin S. Irby, Hubert M. James, Carl Kaplan, Horace H. Lagerpusch, S. Lehrman, Leon B. Linford, Ellice McDonald, R. F. Morris, S. M. Naudé, Mr. Parker, John R. Patty, Herbert B. Roese, Oscar Siedman, Caspar V. Shapiro, Johannes A. Van den Akker, Claude C. Van Nuys, Bertram E. Warren, Carl J. Wiggers, Hugh C. Wolfe and Henry H. zur Burg.

The regular program of the American Physical Society consisted of 114 papers, numbers 1, 9, 15, 47, 48, 64, 65, 66, 74, 84, 105, 106, 107, 110 and 113 being read by title. The abstracts of the papers are given in the following pages, An **Author Index** will be found at the end.

W. L. SEVERINGHAUS, *Secretary*

ABSTRACTS

1. Distribution of non-reacting fluids in the gravitational field. MORRIS MUSKAT, *Gulf Research Laboratory Pittsburgh.*—The paper consists essentially of an analysis of the equation given by Lewis and Randall for the distribution of non-reacting ideal fluids in a gravitational field. When the fluids are incompressible a formal solution is obtained, for a mixture of any number of constituents. But it has not been possible to put it into a form convenient for numerical computation. The ratios of the concentrations of any constituent at the top to that

at the bottom of a vertical column of the mixture are given explicitly, both for incompressible and compressible fluids. When all the molar volumes of the various fluids are equal, the equations are solved completely and lead to a *relative* barometric distribution, and in the particular case of ideal gases, to individual barometric distributions. The physical meaning of this is briefly discussed. The case of binary mixtures is treated in detail, and numerical examples are given, first for a mixture of two paraffins, and secondly for a dilute solution of NaCl in water, which is equivalent to an ideal solution of liquids. As is to be expected, the effect is extremely small, and in the first case it is only one tenth as large as is given by a simple barometric fomula.

2. Capillary retention of liquids in assemblages of homogeneous spheres. W. O. SMITH, PAUL D. FOOTE, P. F. BUSANG. *Gulf Research Laboratory, Pittsburgh.*—The pore space is an assemblage of uniform spheres was initially filled with liquid. After very slow drainage the amount of liquid retained by the spheres was experimentally measured. The liquid is retained in the form of rings at the contacts of adjacent spheres. The radii of curvature of the ring surfaces are computed in terms of surface tension, grain radius and pressure drop across the liquid-vapor interface, permitting calculation of the volume retained per sphere contact. The number of contacts per unit volume of spheres is obtained from porosity measurements using the theory developed earlier. (Phys. Rev. **34**, 1271 (1929).) Computed and observed data on the total volume of retained liquid are in agreement.

3. The mechanism of "atomization." R. A. CASTLEMAN, JR., *Bureau of Standards.*—The process of liquid "atomization" is in wide and important commercial use; yet, so far as the writer knows, no adequate explanation of its mechanism has been offered. The fact, however, that the phenomenon can be used with confidence in the design of machine and other details seems to be sufficient indication of a recognized definite physical background. If we assume that a necessary step in "atomization" is the drawing off, from the unatomized liquid, of ligaments of such size that they will eventually draw up into drops of the size observed in the spray, it appears that a satisfactory explanation of the phenomenon can be obtained by combining Rayleigh's theory of jet disintegration with some recent drop size measurements. For analysis shows that the degree of instability of ligaments of the necessary size is so great that direct observation of either the initial disturbances or even of the ligaments themselves seems improbable. The above assumption appears to be reasonable, necessary and sufficient.

4. Wind pressure on cylindrical stacks. H. L. DRYDEN AND G. C. HILL, *Bureau of Standards, Washington, D. C.*—A summary is given of the published model experiments on the wind pressure on cylinders and of some additional experiments (a) on model cylinders in the wind tunnel, (b) on a large cylinder in the natural wind, and (c) on the power plant stack in the natural wind. The object is to provide a basis for estimating the average wind pressure on stacks and other cylindrical structures at known wind speeds. The conclusions are as follows: 1. The wind pressure on a stack at a given wind speed is a function of the ratio of the height of the stack to its diameter and possibly of the roughness of the surface. 2. Model experiments can not be directly utilized because of a large scale effect. 3. Provision for a wind load equivalent to 20 pounds per square foot of projected area at a wind speed of 100 miles per hour is a safe procedure for stacks whose exposed height does not exceed ten times the diameter. 4. The local values of the pressure may require consideration in the design of thin-walled stacks of large diameter.

5. Airfoils of circular-arc section for use at high speeds. L. J. BRIGGS AND H. L. DRYDEN, *Bureau of Standards, Washington, D. C.*—Experiment has shown that the airfoil sections used in the design of airplane propellers change their aerodynamical properties as the relative air speed approaches the speed of sound. The component of the force in the direction of the airstream (the drag) increases more rapidly than the square of the airspeed, and the component normal to the airstream (the lift) less rapidly. In some earlier measurements, an airfoil which was a segment of a circular cylinder was found to give good results. The present measurements were undertaken to survey the field more thoroughly and to investigate the effect of

rounding the sharp edges. The effect of a moderate rounding was found to be small. At speeds above 0.95 of the speed of sound the circular-arc sections are more efficient than the usual types. At low speeds, (0.5 of the speed of sound), the thick circular-arc sections are much less efficient, but the thin circular-arc sections compare more favorably with the usual types. For propellers operating at high tip-speeds it would be advantageous to use circular-arc sections in the outer parts of the blade.

6. Absorption and velocity of high frequency sound in oxygen. W. H. PIELEMEIER, *Pennsylvania State College.*—Deviations of the experimentally determined absorption and velocity values from their theoretical values in air suggest their determination in oxygen and nitrogen at the same frequencies. The acoustic interferometer and torsion vane methods are used. The torsion vane method is the more reliable but the interferometer makes it possible to make simultaneous measurements of absorption and velocity. The theoretical value of K, the absorption constant, is given by the equation, $K=A/\lambda^2$, where A has the value 0.000365 for oxygen at 20°C. The experimental K is defined by the equation, $I=I_0e^{-Kx}$. The frequency variation of the above deviations can readily be shown by comparing the theoretical value of A, 0.000365, with the observed values. At 1215 kilocycles the radiometer method gave 0.00039. With the interferometer 0.00031 was obtained. At 655.5 kilocycles the radiometer and interferometer both gave 0.00055. Dulong's value for V_0, the velocity at 0°C, of audible sound in oxygen, is 317.2 m/sec. At 1215 and at 655.5 kilocycles the values are 317.1 and 317.4 m/sec respectively. The value given by Laplace's formula is 315.0 m/sec.

7. Influence of the walls enclosing a sounding air column upon the tone quality. DAYTON C. MILLER AND JOHN R. MARTIN. *Case School of Applied Science.*—Three organ pipes are provided, the first made of wood which sounds the tone of $G_2=192$. Two other pipes having the same internal dimensions are made of zinc about 0.5 millimeters thick. One of the zinc pipes is surrounded by a zinc case to form a double walled pipe, with spaces two centimeters wide between the walls. These two pipes have the same pitch, giving a tone a little flater than $F_2=173$. When the single walled zinc pipe is blown in the ordinary manner, its sound has the usual tone quality. By touching this pipe on the outside, extraordinary changes in tone quality can be produced with the formation of inharmonic partial tones, the ratios of which are 1:2.06 :2.66. When the double walled pipe has the space between the walls filled with a liquid the pitch is $E_2=153$. If the liquid is allowed to flow out gradually, the tone quality changes conspicuously during the process with the formation of inharmonic partials having the ratios 1:2:2.9. These experiments indicate that the material of which a musical wind instrument is made may have an important effect upon the tone quality.

8. The excitation of overtones of shear vibrations in Y cut quartz plates. J. R. HARRISON, *University of Pittsburgh.*—It is well known that Y cut quartz plates will function as resonators and oscillators with shear vibrations giving rise to transverse waves in the direction of the Y axis. (W. G. Cady, Phys. Rev. **29**, 617, (1927).) Also it is not difficult to excite the odd overtones, i.e., those frequencies which are approximately odd multiples of the fundamental frequency. With a new type of crystal mounting it has been found possible to excite the even overtones also. To excite the second overtone, a three electrode crystal mounting is used. This mounting consists of two flat electrodes covering the two XZ plane surfaces of the plate and also a frame shaped electrode about one-third as thick as the crystal plate. This third electrode fits around the crystal plate like a frame and is symmetrically disposed with respect to the flat electrodes in the XZ planes. The frame shaped electrode allows fields to be applied between it and the electrodes in the XZ planes in opposite directions. To accomplish this, the flat electrodes are connected together serving as one terminal and the frame shaped electrode as the second terminal. By using two flat electrodes and three frame shaped electrodes, the fourth overtone can also be excited. Similarly, mountings can be constructed for exciting the higher overtones.

9. Torsion of rhombic prisms and of cylinders in the elastic and plastic state. JAKOB KUNZ, *University of Illinois.*—The corresponding problems for isotropic bodies are at first

solved by means of the stress function. The new problems are then reduced to the older ones by means of linear transformations of the variables. The plastic flow is then determined for the elliptic cylinder in a closed form, which however could not be found for the plastic rectangular prism.

10. Some applications of the theory of plastic deformations of ductile metals. A. NADAI, *Westinghouse Elect. Mfg. Co. East Pittsburgh.* (*Introduced by S. M. Kintner*).—A brief account will be given of the principal conditions which are available to express the equilibrium of stress in the plastic state of ductile metals. These conditions will be discussed for the case of rotationary symmetry in a plastic body. As an example several cases of plastic flow in a thick walled cylinder subjected to high internal pressure with and without longitudinal expansion will be treated. The distribution of stress during yielding is given for a long cylinder and for a flat ring both subjected to radial pressure. How yielding and the plastic deformation spread through the walls of the cylinder will be shown.

11. The flarimeter: a clinical instrument for testing circulatory fitness. P. V. WELLS, *Medical Department, The Prudential Insurance Company of America.*—Forced expiration at constant lung pressure of 20 mm provides the most convenient means of placing the circulatory system under standard load. The response in systolic blood pressure is maximum at rates about 36 cc/sec. Among normals, the blow should exceed 50 seconds; its decrease measures shortness of breath, the leading symptom of an impaired heart muscle. The blood pressure normally rises 20 mm in 45 sec, 40 mm before the impulse to breathe stops the blow. The Flarimeter is a simple durable, reproducible, inexpensive, portable instrument designed to enable an individual to perform such a standard test. A 200 cc/sec orifice is also provided, its length of blow giving an accurate measure of vital capacity (the volume of a maximum single expiration). Some investigators have believed the vital capacity to be a measure of shortness of breath because it is so reduced in heart disease. But after exercise the vital capacity is not reduced, while the small orifice blow is shortened to a third of normal length, showing that it is a much better measure of shortness of breath.

12. Suggested explanation of Michelson-Morley-Miller experiment. N. GALLI-SHOHAT, *Mount Holyoke College.*—The complete theory of Michelson-Morley-Miller experiment leads to two effects: one due to the phase difference, another to the "rotation" of the waves produced by reflections from the moving mirrors. P. Epstein has given an estimation of this last effect and has found it too small to be discovered. However, his estimation was based on the orbital velocity of the earth, 30 km/sec, while the velocity of the solar system in space is much greater. Thus if one makes an estimation of the "rotational" effect for $v=300$ km/sec. one gets a displacement about 0.2 fringes in agreement with what Professor Miller has observed under the conditions of his experiment. This suggests the following assumptions: *Phase effect is fully compensated* (*Lorentz contraction*); *effect actually discovered by Miller is a rotational effect* due to the aberration X' observed by Esclangon and discussed in the previous paper. Rotational effect is assumed to be proportional to the horizontal component of X', being $\beta^2 l \cos\theta (\sin^2\theta - \cos^2(v_1\ z))^{1/2} = [\theta = (v_1 l),\ Z\text{-zenith}]$. The curves, representing the variation of the azimuth of the maximum effect and its magnitude, computed for Mt. Wilson, using the apex-declination 68° agrees with the curves given by Miller; the agreement being most striking for the data 1925.

13. The magnetic moment of the lithium nucleus. S. GOUDSMIT AND L. A. YOUNG. *University of Michigan.*—The hyperfine structure observed by Schüler in ionized lithium is of the same order of magnitude as the multiplets in that spectrum. This has led to the belief that the magnetic moment of the nucleus must be of the same order of magnitude as that of an electron. However, the hyperfine structure is produced by the deeply penetrating $1s$ electron whereas the multiplet separation is due to the outside $2p$ electron. These two should thus not be compared and indeed rough calculations show that a nuclear magnetic moment of only a few proton units is sufficient to account for the hyperfine structure. The considerations of H. E, White on lithium as well as other hyperfine structures (Phys. Rev. **35**, 441 (1930)) are

incorrect since he erroneously compares them with singlet-triplet and other "Austausch" separations. His error is caused by a misinterpretation and a too literal application of the vector model.

14. Possibility of bringing mean life directly into Schroedinger equation for the hydrogen atom. A. BRAMLEY AND ALLEN C. G. MITCHELL, *Bartol Research Foundation.*—The possibility of bringing an expression for the mean life of an atom in a given state directly into the wave equation for the hydrogen atom with relative motion of the nucleus, has been investigated. A solution for the electron and proton in their mutual coulomb field has been found which contains a damping term β occurring in the time factor of the equation for

$$\Psi_m{}^t = \Psi_m \exp(2\pi i/h)(E_m + i\beta)t.$$

The value of the constant β is determined from the condition, that if the atom is in the state designated by eigenwert E_m for the electron at time $t=0$, then the probability of making a transition to any other state in all time is unity; or expressed analytically

$$\sum_n \alpha_{mn} \int M_{mn} dt = 1$$

where M_{mn} is the matrix moment of the transition. This leads to a value of β_m (reciprocal of mean life) which is proportional to $[\sum_n \{\int x u_m u_n^* dx dy dz\}]^2$. This expression is similar to the expression derived by Sagiura from the Correspondence Principle for the value of the mean life.

15. Life and radius of the metastable mercury atom. M. L. POOL. *Ohio State University.*—The experimental arrangement described by the writer (Phys. Rev. **33,** 22, (1929)) has been altered in order to lend itself more easily to mathematical treatment. A quartz resonance cell containing mercury vapor at 25°C is placed between two high speed disks which interrupt the total radiation from two symmetrically placed water-cooled and magnetically controlled quartz mercury arcs. A few millimeters of purified nitrogen and a trace of water vapor is admitted into the resonance cell and slowly moved over hot copper and copper oxide. The life of the 2^3P_0 state is measured by the rate of decrease of the absorption of 4047 with increasing time-wait after optical excitation of the mercury vapor. Extrapolation to zero nitrogen pressure gives a natural life of about 2×10^{-3} sec. Admixtures of argon at low nitrogen pressures prevented rapid diffusion of the metastable atoms to the walls of the tube. A treatment of the life-time similar to that outlined by Zemansky (Phys. Rev. **34,** 213 (1929)) gives the radius of the metastable atom to be 2.4 to 3.0×10^{-8} cm depending on the pressure of the admixed nitrogen.

16. Interval rule for sp, sd, sf configurations. E. U. CONDON AND G. H. SHORTLEY, *University of Minnesota.*—A systematic comparison of the known data on the singlets and triplets arising from *sp, sd, sf* configurations with the theory of Houston (Phys. Rev. **33,** 297 (1929)) shows that the theory gives a good account of the deviations from the Landé interval rule which accompany departure from Russell-Saunders coupling. There are numerous significant discrepancies, however. Writing ${}^1L_l$ and ${}^3L_{l+1}$, ${}^3L_l$ ${}^3L_{l-1}$ with $L=P, D, F$, when $l=1, 2, 3$ for the term values, we plot as abscissas $({}^3L_{l-1}-{}^3L_{l+1})/|{}^3L_l-{}^1L_l|$ and $({}^3L_{l-1}-{}^3L_l)/({}^3L_l-{}^3L_{l+1})$ as ordinate if $({}^3L_l-{}^1L_l)$ is positive, otherwise the reciprocal of this quantity. Houston's equations (12) give functional relations between these interval ratios which are compared with the experimental values.

17. The resonance of $(B-A)$ bands of the hydrogen molecule. HUGH H. HYMAN, *Union College.*—Photographs of the extreme ultraviolet spectrum (λ 1100A to λ1640A) have been taken, using a vacuum spectrograph made available to the author at the University of California. A three inch grating, 15000 lines per inch with a three meter focal length, was used, giving a resolving power of 0.1A and a dispersion of 2.76A per millimeter in the second order. The fine structure of sixty eight bands of the first resonance (B−A) system has been studied. The moment of inertia of the normal (A) state is found to be 0.4673×10^{-40} g.cm^2, the nuclear

separation, 0.7500×10^{-8} cm. In the first excited (B) state the moment of inertia is given as 1.4225 g.cm^2 and the nuclear separation as $1.308_4\times10^{-8}$ cm. Resulting constants leave no doubt but that the B state is also the lower state of bands found in the visible and studied by Richardson and Davidson. The proof of the connection between the ultraviolet system and the visible system leads to the conclusion reached by Birge that the ionization potential of the hydrogen molecule is 15.34 volts to within a few hundredths of a volt.

18. Regularities in the spectra of lutecium. WILLIAM F. MEGGERS AND BOURDON F. SCRIBNER, *Bureau of Standards.*—A study of the arc and spark spectra of lutecium (71 Lu) resulted in the separation of the lines into 3 distinct classes. (1) those characterizing neutral atoms, constituting the Lu_I spectrum; (2) those due to singly ionized atoms, the Lu_{II} spectrum and (3) a small number of lines ascribable to doubly ionized atoms, the Lu_{III} spectrum. Regularities have been discovered in each of these spectra. The normal state of neutral Lu atoms is represented by a ^2D spectral term arising from the electron configuration (s^2d); its levels are separated by 1993.9 wave-numbers. The normal state of Lu^+ atoms is described by $^1S(ss)$, and metastable terms ^1D, ^3D (ds), $^3F'(dd)$ have also been established. The relative values are as follows:

$$^1S = 0.0, \quad ^3D_1 = 11796.1, \quad ^3D_2 = 12435.2, \quad ^3D_3 = 14199.0,$$

$$^1D_2 = 17332.5, \quad ^3F_2' = 29406.7, \quad ^3F_3' = 30889.1, \quad ^3F_4' = 32503.7.$$

$A\ ^2S(s)$ term describes the normal state of Lu^{++} atoms; $a\ ^2D$ (d) term has levels at 6304.3 and 8648.1. There is no evidence that f-electrons play any part in the production of the spectra; it is concluded that the fourteen f-electrons in Lu form a closed shell of considerable stability.

19. The spark spectrum of cobalt (Co II). J. H. FINDLAY, *Princeton University.*—A further examination of the Co II spectrum, based on the previous work of Meggers (Journ. Wash. Ac. Sci. **18**, No. 12, 1928), has been made. A magnetic analysis shows that Meggers' classification of the terms $d^7p\,^5F^0$, $^5D^0$ should be interchanged, except for the term $^5F_5^0$. Since Meggers' results were obtained from intensity rules, the author's $^5F\,^5F^0$ and $^5F\,^5D^0$ multiplets show irregular intensities. The strongest lines in these multiplets are, respectively, ^5F_n $^5F_{n-1}$ and ^5F_n $^5D_n^0$. The magnetic analysis also shows that Meggers' terms ^3D should be $d^7s\,^5P$ and that his $^3P^0$, $^3D^0$, and $^3F^0$ should be partly $d^7p\,^5P^0$ and $^5D^0$. In addition, the terms $d^7s\,^3F$, $d^7p\,^3D^0$, $^3F^0$, $^3G^0$, $^5S^0$, and the lowest terms $d^8\,^3F$ have been found. The location of the second member of the $d^7s\,^5F\,^3F$ series gives an I. P. of 16.9 volts from d^7s to d^7 and 17.3 volts from d^8 to d^7, in practically exact agreement with the predictions of Dr. H. N. Russell.

20. A surplus level in the arc spectrum of palladium. A. G. SHENSTONE, *Princeton University.*—The spectrum Pd I has been so thoroughly analyzed that the positions of all the structures to be expected are known. One even level, k_1 of Bechert and Catalan, is apparently not explainable in terms of the Hund theory unless it is a hyperfine structure component of $d^9 5d\,^3P_1$. That explanation is extremely improbable since (1) it makes the hyperfine structure greater than the fine structure and (2) no other levels are known to have structure. The lines due to k_1 are peculiar in being the only diffuse lines in Meggers' list which extends from λ4500 to λ9200.

21. Spectra of gases lighted with strong discharges. E. O. HULBURT, *Naval Research Laboratory.*—Spectra of condensed discharges through hydrogen at pressures up to several cms of mercury showed, as usual, the Balmer lines merging into the continuous spectrum. With increasing strength of the discharge the Balmer lines widened, the higher members of the series disappeared and the continuous spectrum became more intense, until with 1 microfarad at 15 kilovolts (the method of J. A. Anderson, Astrophys. J. **51**, 37 (1920)) there were no Balmer lines left at all, only the continuous spectrum and some absorption lines due to aluminum from the electrodes, etc. Helium, oxygen and nitrogen exhibited similar changes, i.e., with increasing intensity of discharge in helium the lines gave way to a continuous spectrum, and in oxygen and nitrogen the molecular bands gave way to spark lines and these in turn to a continuous spectrum. The continuous spectra from all the gases were alike. The intensity

distribution across the continuous spectrum was rather even and hardly that of a black body. In the strong discharges the external characteristics of the atoms were pretty well effaced and the conditions approached those in the interior of a star.

22. Excitation processes in the hollow cathode discharge. R. A. SAWYER, *University of Michigan.*—The negative glow inside a hollow cathode in a rare gas discharge has often been used to excite metallic spark spectra. The excitation is largely due to collisions of the second kind between gas and metal atoms and ions. The exact processes may be inferred from the observed highest term excited and from maxima or abnormal intensities in the metallic spectrum. The available data have been examined. In general only those processes occur in which the metal can be excited to some term in the spark spectrum with gain or loss of only a small a amount of kinetic energy to balance the reaction equation. If the metal has a low vapor pressure or sputters poorly cathodically the metal atoms in the normal state or a low metastable state if any will be excited by collisions with gas ions and metastable atoms. If the metal has a high vapor pressure metal ions will enter the reactions. In intermediate cases metal ions may or may not enter depending on conditions. The limit of excitation is fixed by the possible reaction yielding the greatest energy; the other possible reactions may produce maxima in the spectra.

23. Collisions of the second kind and their effect on the field in the positive column of a glow discharge in mixtures of the rare gases and mercury vapor. O. S. DUFFENDACK AND L. B. HEADRICK, *University of Michigan.*—Measurements were made of the electric field in the positive column in mixtures of helium-neon, helium-argon, neon-argon, in all proportions and mixtures of each of these gases with mercury vapor. Spectrograms were taken of the radiation from the positive column for each of these mixtures. The electrical and spectral characteristics of the positive column in mixtures of monatomic gases can be explained in terms of collisions of the second kind between the metastable atoms or the ions of one gas and the neutral or the metastable atoms of the other. The necessary condition for a large effect to be produced by a small amount of one gas added to another is that there exists a close resonance between the metastable states of the main gas and the ionized or excited states of the added gas. The introduction of only 0.15% argon into neon produced a marked increase in the electric field and the spectrum emitted changed completely from neon I to argon I, while the addition of 10% neon to argon had practically no effect.

24. Secondary emission from nickel in a neon discharge. W. UYTERHOEVEN AND M. C. HARRINGTON, *Princeton University.*—Continuing experiments on the secondary emission from a negatively charged metal collector placed in a neon discharge (Science **70**, 586, 1929) we obtained additional evidence of a secondary electron current amounting to about 40% of the total current. With the experimental arrangement described before, a perforated collector with a Faraday box behind it, (Phys. Rev. **35**, 438, 1930) an estimate can be made of the electron emission due to metastable atoms. This is found to be much more important than the part due to ion impact, namely about 30 to 35% of the total current. When this is deducted from the total secondary emission, values for the number of electrons liberated per incoming positive ion can be estimated. This comes out of the same order of magnitude (10%) as the values determined directly by Penning (Physica **8**, 13, 1928).

25. The effect of intense electric fields on the photoelectric behavior of thin potassium films. ERNEST O. LAWRENCE AND LEON B. LINFORD, *University of California.*—Photoelectric thresholds of thin films of potassium on tungsten were observed at 5620A with fields drawing the electrons from the surface of 260 volts/cm. Increasing the applied fields shifted thresholds towards the red, for example, to 5880A by a field of 26,000 volts/cm. It is calculated from the data that at distances between $7(10^{-7})$ cm and $12(10^{-7})$ cm of such surfaces the field is entirely the Schottky image field while at greater distances the field exceeds the image field, indicating patched surfaces. Films of potassium on thick layers of oxygen on tungsten show no dependence on fields, indicating either that ion layers exist more than 300 atom diameters from the metal surface which produce fields greater than the Schottky field or that such surfaces are rough. Poor current saturation indicates the latter as more probable. Potassium on a thin oxide layer

has a threshold farthest to the red and exhibits dependence on applied fields assignable to image forces alone. Wentzel's wave mechanics theory of the photoelectric effect is verified in the respects that the whole photoelectric sensitivity curve shifts with the threshold and that the maximum sensitivity occurs at a frequency 3/2 the threshold frequency.

26. A representation of the dynamic properties of molecules by mechanical models. C. F. KETTERING, L. W. SHUTTS AND D. H. ANDREWS, *General Motors Corporation.*—Mechanical models have been constructed to represent the dynamical systems found in the molecule. Assuming that the intramolecular forces lie along lines associated with the chemical bonds and that for small vibrations they obey Hook's law and have the mechanical character of spiral springs, it is possible to get a picture of the forces and masses which can be represented on a large scale by steel balls and spiral springs. Models have been constructed for some of the simpler nonpolar molecules. They are found to have characteristic frequencies which correspond very closely to the frequencies observed in the Raman spectra and it is possible by this means to identify the Raman lines with definite types of motion of particular atoms in the molecule. This substantiates the view that Raman lines correspond very closely to characteristic fundamental molecular frequencies.

27. The fluorescence spectrum of benzene. F. ALMASY, *University of Zurich,* AND C. V. SHAPIRO, *Cornell University. (Introduced by R. C. Gibbs).*—Using an improved technique, the fluorescence spectrum of benzene, excited by the radiation from a quartz Hg arc, has been photographed with a Hilger E_1 spectrograph, whose dispersion in the region under investigation is 3A per mm. Wave-length measurements were made from an Fe spark comparison spectrum. The data so obtained are in excellent accord with those for the absorption spectrum in the range over which the two overlap. An energy level diagram is proposed which accounts for the majority of the bands on the assumption that the electronic origin of the system lies at 37489 cm^{-1} (see following abstract). The vibrational frequencies are 923 cm^{-1} for the excited state and 998 and 160 cm^{-1} for the normal state.

28. Electronic transitions in the spectra of benzene. C. V. SHAPIRO, R. C. GIBBS AND J. R. JOHNSON, *Cornell University.*—A review of the available data on the absorption and emission spectra of benzene, together with new data on the absorption of the vapor at higher concentrations, leads to the definite conclusion that only two electronic transitions need be assumed in setting up an adequate energy level scheme, as opposed to the recent suggestions of 5 and 3 respectively, by Austin and Black, (Phys. Rev. **35**, 457 (1930)) and by Black, (Nature, **125**, 274 (1930)). These two values are 37489 and 38612 cm^{-1} and are identical with those previously assigned by Henri, Structure des Molecules, Paris, (1925), pp. 109, 110. The observed fluorescence spectrum is confined solely to the first of these two systems, while the absorption spectrum is distributed between the two, though showing a much greater intensity in the second. The Tesla luminescence spectrum is very similar to the fluorescence spectrum, except that a few bands corresponding to the most intense of the absorption bands of the second system, do appear.

29. Polarization of sensitized fluorescence. ALLAN C. G. MITCHELL, *Bartol Research Foundation.*—The question of whether or not angular momentum of optical electrons is conserved on a collision of the second kind between an excited mercury atom and a cadmium atom has been investigated. It is well known that under certain conditions mercury resonance radiation is almost completely polarized. It is also known that an excited mercury atom can give its energy to a cadmium atom causing this atom to emit its resonance line λ 3261. In this experiment a mixture of Hg and Cd vapors was radiated by light from a quartz-mercury arc (giving the unreversed 2537A Hg line). The electric vectors of the exciting light were in the X-Z plane. The Hg-Cd mixture was in a magnetic field (300 gauss) directed in the y direction. The fluorescence from the mixture was observed through a Savart Plate and Nicols prism in the X direction. Under the conditions of the experiment (low pressures of Cd and Hg vapors) the fluorescent light consisted of the 2537A line of Hg and the 3261A line of Cd. The Cd line was unpolarized whereas the Hg line was polarized. Had the polarization been carried over on collision one would have expected the Cd line to be polarized in the same direction as the Hg line.

30. The chemiluminescence of metallic sodium. JAY W. WOODROW AND R. M. BOWIE, *Iowa State College.*—It has been known for a long time that metallic sodium and potassium will give off a faint bluish glow when a fresh surface is exposed to the air. This has been attributed to direct oxidation upon contact with the oxygen in the air. A careful check of this effect, however, has shown that it is mostly, if not entirely, due to the water-vapor present. A special apparatus was constructed by means of which it was possible to feed into a gas chamber a fine thread of metallic sodium which always had a fresh surface. When carbon-dioxide or oxygen which had been bubbled through water was passed into this chamber, the sodium thread glowed quite brightly. The effect appeared to be as prominent for the moist carbon-dioxide as for the moist oxygen. On the other hand neither dry oxygen nor dry carbon-dioxide gave an effect which could be detected by the eye even after a half hour in absolute darkness, while at the same time a freshly cut surface of sodium, used as a check, was clearly visible in open air.

31. An electrical method of determining the gelation temperature of starch. E. C. MCCRACKEN, *Iowa State College.*—During an investigation of the electrical properties of the potato, it was observed that there was a discontinuity in the resistance-temperature curve. As the potato was heated by an electric current passing directly through it, a sudden decrease in the resistance took place at a temperature between 87° and 88°C. This effect was undoubtedly due to a disruption of the starch grains. Chapman and others have concluded from measurements with the viscometer that this phenomenon takes place at a temperature near 90°C. The electrical resistance method has been found to be quicker, simpler and more accurate for determining this gelation temperature than that in which the viscometer is used.

32. Absorption of ultraviolet light by lacquer films. W. P. DAVEY AND D. C. DUNCAN, *The Pennsylvania State College and Hercules Powder Co.*—Absorption tests on a series of nitrocotton films, film solutions and their various individual ingredients yielded the following results: None of the films showed selective absorption. They were completely opaque to radiation of wave-length less than about 3300A. Absorption decreased markedly with increasing wave-length, becoming inappreciable for wave-lengths greater than 4000A. The absorption was found to be quite independent of viscosity, nitrogen content and such plasticizers as were used. The limitation of transmission to wave-lengths greater than 3300A was found to be due to ester gum, a constituent common to all of the films. The nitrocotton constituent was quite transparent to wave-lengths greater than 3000A. Similarly, tests on a series of cellulose acetate films, film solutions and their various individual ingredients yielded no evidence of selective absorption. In this series there was no close correlation between the absorption characteristics of the dried films and the solutions from which the films were made. This was found to be due to the fact that the absorption of the solvents present masked that of the other ingredients. Absorption of solvent-free cellulose acetate films for wave-lengths greater than 2900A was found to be due to the particular plasticizer used.

33. Transmission of ultraviolet radiation by lake water. CHARLES D. HODGMAN, *Case School of Applied Science.*—Pure water, relatively transparent to the ultraviolet, is rendered less so by the presence of small quantities of dissolved salts and organic materials such as occur in natural river and lake waters. The extent to which ultraviolet radiation, either from the sun or from artificial sources, penetrates such media is of interest for many reasons. A series of measures of the transmission of unfiltered water from Lake Erie, made by the sector photometer and quartz spectrograph for a thickness of 2 cm shows a relatively low transmission ranging from about 74 percent at 0.40μ to 12 percent at 0.22μ. Determinations are in progress for water from the same source after filtration and as taken from the city water supply as well as from other sources.

34. Measurement of intensity of helium lines with voltage using a photoelectric device. JOSEPH RAZEK AND PETER J. MULDER, *University of Pennsylvania.*—The variation of intensity with exciting voltage for the lines 6678, 5876, 5016, 4713, 4471, of the helium arc spectrum has been measured using the automatic photoelectric spectrophotometer described by Mulder and Razek before the Ithaca Meeting of the Optical Society of America in Oct. 1929. It was found

the results on 6678(1^1P-2^1D), 5878(1^3P-2^3D), 5016(1^1S-2^1P), 4471(1^3P-3^3D) were generally smooth curves, differing somewhat from the results of Hughes and Lowe, (Proc. Royal Soc. **A104,** 1923 Pg. 480) whereas 4713(1^3P-3^3S) shows undoubted maxima near the critical exciting potentials consistent with the results reported by Cornog, (Phys. Rev. **32,** 746–752 (1928)). The radiation was developed in a spherical equipotential space 20 cm in diameter, formed of a hollow copper ball. The equipotential cathode and grid from a commercial power tube formed the internal structure, the sphere itself being the anode. The filament, grid and outer sphere were connected to the positive of a battery, with the cathode as the only part inside the sphere at a lower potential. This resulted in a very uniform potential inside the sphere. Direct light from the cathode was cut out by means of a diaphragm on the window in the sphere through which the light was examined. Arc currents as high as 300 milliamperes were obtained with 50 volts across the tube.

35. Further experiments with an automatic photoelectric spectrophotometer. PETER J. MULDER AND JOSEPH RAZEK, *University of Pennsylvania.*—The automatic photoelectric spectrophotometer described by Razek and Mulder before the Optical Society of America, October 1929, has been satisfactorily applied to a series of problems, some of which are detailed. Certain changes in the instrument made possible operation at about ten times the former sensitivity when desired. In this way differences in very dark samples, having an intrinsic brightness of only a few percent, can be readily shown. By a series of tests on biological pigments, the instrument was shown to be admirably suited for testing any solutions that change color rapidly. Three records were taken on an acid hematin solution in six minutes, showing three different stages in its light transmitting property. Records have also been obtained on a 1% solution of oxyhemoglobin in water, both when fresh and when reduced. One record was obtained showing the oxyhemoglobin in the act of reduction. The effect of surface gloss of the sample was tested and found to be negligibly small. All records mentioned, and various other interesting color analyses will be shown.

36. Pictures in relief made with a large diameter lens. HERBERT E. IVES, *New York City.*—Pictures showing relief through a large range of angles and distances of observation (parallax panoramagrams) have heretofore been made by the use of a moving lens, and an opaque line grating slightly separated from the sensitive plate, both plate and grating also being moved in some schemes. All moving parts may be eliminated if a single stationary large diameter lens is substituted for the small moving lens, and provided (a) the transparency positive is placed in front of the grating instead of behind it, (b) the image is given a single inversion, as by a mirror, (c) a grating is used for viewing which has a slightly greater line spacing than the taking grating. The resulting relief pictures are visible through the angle subtended by the lens from the object. The method has the advantages of simplicity of apparatus and manipulation, and of greatly shortened exposure time.

37. Alloys for vacuum-tight glass-metal joints. BY D. E. OLSHEVSKY, *Yale University.*—Joints between materials possessing different physical properties constitute an essential feature of much apparatus involving high vacuum. A glass-metal solder joint occupies—as far as assembling and disassembling is concerned—a position intermediate between direct metal-glass seal and the classical ground joint. In an attempt to find suitable solders ternary alloys of Pb, Sn and Bi were investigated first and characteristic breakages occurring some time after solidification were found to be due to little hard crystals growing out of the interface and pressing against the surface of glass. Several alloys laying on straight lines $E-$Pb, $E-$Sn and $E-$Bi as well as in the $E-e_1$, $E-e_2$, and $E-e_3$ valleys (Int. Crit. Tables, v. II, p. 418) were investigated by pouring into Pyrex tubing moulds. An alloy lying on the $E-$Pb straight line (Pb 50, Bi 37.5, Sn 12.5) was found to possess small glass cracking tendency. This is attributed to separation of soft Pb crystals on cooling. In agreement with the above, alloys obtained by shifting from the eutectic of Pb–Bi–Sn–Cd on a straight line toward the Pb corner (as Pb 31.1, Sn 12.5, Bi 47, Cd 9.4) were also found to have no tendency to burst glass, even in thin layers between glass and metal. The vacuum-tightness of the alloys is still unsatisfactory and joints must be backed by cement for high vacuum work. The joints proved in actual service to be mechanically strong, rigid, vacuum tight and replacable. Further study is in progress.

38. Studies in contact rectification, II. The cupric sulfide-magnesium junction. MILTON BERGSTEIN, J. F. RINKE, AND C. M. GUTHEIL, *Research Laboratory, P. R. Mallory & Co., Inc.*—The commercial cupric sulfide-magnesium rectifier junction consists of a disk of heat-treated, compressed, cupric sulfide powder contacted with the suitably oxidized face of a magnesium disk. The efficiency of the rectifier unit increases with operating temperature within usual working limits. The phenomenon of "reverse rectification" (i.e. rectification in the direction opposed to normal) is related to the a.c. voltage across the junction. Oscillograms show that there is formation of a film which possesses resistive properties in one direction, that the film may be partially destroyed by continued passage of current in the conductive direction, that application of sufficient voltage in the resistive direction causes re-formation of the film in less than 0.004 sec., that there is no battery effect or thermoelectric effect sufficient to account for rectifying properties, and that formation of the film is probably electrothermic rather than electrolytic in origin.

39. The effect of cyclones and anticyclones upon the intensity of radio signals. R. C. COLWELL, *West Va. University.*—Observations made up by the signal variation of station KDKA at Pittsburgh have shown that the signal intensity increases after nightfall provided there is a low pressure area between Pittsburgh and Morgantown. Hence an increasing intensity after nightfall is an indication of cloudy or stormy weather the next day. An area of high pressure between Pittsburgh and Morgantown will cause the night signal to decrease, so that this type of signal curve indicates fair weather. If the low pressure area passes south of Morgantown, it does not effect the signal. Such a low pressure brings rain with an east wind changing to north and a storm of this kind is unpredictable by observations upon a station to the north of the observer. As with the barometer, the readings indicate weather conditions twenty-four hours in advance.

40. Reflection of radio waves from the surface of the earth. LAL C. VERMAN, *Cornell University. (Introduced by E. Merritt.)*—The reflection of an elliptically polarized electromagnetic wave from partially conducting and perfectly conducting surfaces is studied in detail. It is shown that in either case the interference of incident and reflected waves gives rise to a psuedo-stationary wave field above the surface of the reflector. This field is bodily propagated along the horizontal projection of the direction of the incoming wave with a velocity greater than that of light, i.e. $c/\sin\alpha$, where α is the angle of incidence. The resultant electric and magnetic vectors at any given point above the reflector describe two field ellipses lying in two different planes, whose orientation vary with height. This fact is made the bases of experimental measurements.

It is found that the 43 meter wave from WIZ, located in New Brunswick, N. J., holds its polarization and angle of incidence constant during morning hours at Ithaca, N. Y. The rapid fading that accompanies the signal is to be attributed to amplitude fluctuations. Observations on this station are analyzed on the basis of the above theory to obtain the angle of incidence and the polarization of the incoming wave. Polarization is found to be generally elliptical.

41. The x-ray fiber structure of alloys containing precipitated crystals. CHARLES S. BARRETT, *Naval Research Laboratory, Washington, D. C.*—Dahl, Holm, and Masing (Wiss. Veröffentlich. Siemens-Konzern **8,** 154–185, 1929) prepared cold drawn wires of Be in solid solution in Cu which showed [111] and [100] directions along the wire axis. Annealing these at 350° precipitated a compound of CsCl structure with both [110] and [100] directions in the axis of the wire, the first of which is "a typical crystal position for (fibered) body-centered lattices." Their comparison to ordinary body-centered fibering is without significance because the precipitate was absent when the wire was drawn. The preferred orientation of the precipitate is not due to processes of slip in the precipitate itself, but is due to the precipitate forming with definite orientation on certain planes of the solid solution. Young (Proc. Roy. Soc. **A112,** 630, 1926) observed such a relation of orientation in meteorites. Similarly, a solid solution of Ag in Al (21.3% Ag) precipitates on (111) planes, with (00.1) hexagonal close-packed precipitate planes parallel to (111) solid solution planes and with [11.0] and [110] directions in these planes parallel, as determined by an analysis of x-ray diffraction from wires.

42. An x-ray determination of crystal orientation in silver sheet, produced by cold rolling. CLEVELAND B. HOLLABAUGH, *The Pennsylvania State College.* (*Introduced by Wheeler P. Davey.*)—Sheet silver, 99.9%, free from preferred orientation was rolled in 2 1/4 inch rolls and the orientations determined after each pass using the method of Davey, Nitchie and Fuller. (Mines and Met. Tech. Pub. **243,** E, 88.) Two symmetrical orientations were found which were independent of the technique of rolling. To picture the resulting preferred orientation, visualize a face-centered cube, with the cube face parallel to the surface of the sheet and with the face diagonal in the direction of rolling. Using the other face diagonal as an axis, rotate the cube until this diagonal makes an angle of not less than 10°, nor more than 42° with the surface. Allow this cube to be rotated at random about the rolling direction as an axis. Any point in this random rotation is within the preferred ranges, provided the face diagonal is in its range of positions. In one of the preferred orientations the direction of rotation is such as to raise that end of the face diagonal which points to the end of the foil entering the rolls first. The other orientation lowers this end of the face diagonal.

43. Radial-asterism in multi-crystalline materials. C. NUSBAUM, *Case School of Applied Science.*—The phenomenon of radial asterism as seen in a Laue photograph of a distorted single crystal is generally attributed to internal strain, whether the strain is produced by a uniform bending moment, compression or tension. It is thus a suitable means for the detection of the presence of internal strains in multi-crystalline materials. A study has been made of radial asterism in such iron samples when subjected to a variable but uniform bending moment. The results are qualitative in nature but are related to the magnitude of the distortion.

44. An x-ray study of very pure iron. O. L. ROBERTS. *The Pennsylvania State College.*—Iron, from chemically pure ferric nitrate, (Baker's Analyzed), was precipitated as the hydroxide and reduced to the metallic state by oxygen-free, dry hydrogen. The metallic powder was pressed into wire form, sintered and swaged. This should give a strictly carbon-free iron. Spectroscopic tests show that the iron is especially free from these impurities. Diffraction patterns were obtained at various temperatures close to the recalescence temperature so as to find the lowest temperature which would cause the change from the body centered to face centered cubic structure. The whole apparatus, including photographic film, was inclosed in an atmosphere of hydrogen. Grain growth was found to take place to a large extent. Face centered cubic structure exists at 921°C.

45. The effect of an electric field on the x-ray diffraction pattern of a liquid. RONALD L. MCFARLAN, *University of Chicago.*—An investigation is made of the effect produced on the x-ray liquid diffraction pattern by an electric field so designed as to give the Kerr effect for the liquid under examination. The liquid diffraction pattern is obtained by replacing the crystal of a Bragg spectrometer with a cell containing the liquid. The electric field is applied approximately normal to the x-ray beam. Under a potential gradient of 9 kv per cm nitrobenzene shows a 2.3 percent increase in the intensity of the diffraction peak, while for a gradient of 5 kv per cm it shows an 0.8 percent increase. Benzene, which shows no Kerr effect for the type of field used, gives a 0.3 percent decrease in peak intensity, the potential gradient being 9 kv per cm. The probable error in all these cases is 0.3 percent. There is thus indicated a small but detectable tendency of the nitrobenzene molecules toward a definite orientation with respect to the electric field.

46. X-ray diffraction in water 2° to 98° C: The nature of molecular association. G. W. STEWART, *State University of Iowa.*—X-ray diffraction ionization curves of water show (1) the presence of two definite peaks corresponding to the separation of diffraction planes of 3.27A and 2.11A; (2) the practically constant diffraction intensity of one peak over the temperature range, 2° to 98°C as compared with the gradual disappearance of the second peak with increasing temperature; (3) correspondence in angle of diffraction between these peaks and the chief diffraction intensities with ice crystals; and (4) the increase of peak width with increasing temperature with a movement indicating less distance of planes. It is difficult to reconcile these results with what was formerly regarded as the alteration, in complexity of

the water molecule. The simplest explanation emphasized by all the experiments in x-ray diffraction in liquids, is that the so-called molecular complexity is the arrangement of molecules in more or less orderly groups with intermolecular forces of distinct magnitude. With temperature increase the nature of the group changes, one set of planes becoming more poorly defined because of more slippage and less orderly arrangement. The alteration in grouping is also shown by the decrease in distance between planes. The group arrangement (cybotactic condition) describes the nature of what has formerly been termed "association" and what is now regarded by Longinescu as "molar concentration."

47. Electron distribution in the chlorine ion. G. G. HARVEY AND G. E. M. JAUNCEY, *Washington University, St. Louis.*—Jauncey and Claus (Phys. Rev. **31,** 717 and **32,** 12 (1928)) have obtained theoretical F values for the chlorine ion in rocksalt from the assumption of a Bohr model in which the Compton effect has been taken into account according to the method of Jauncey (Phys. Rev. **29,** 757 (1927)). These theoretical values were in fair agreement with the experimental values. It occurred to the writers to subject both the Jauncey and Claus theoretical F curve and the experimental F curve for chlorine to a Fourier analysis, thus obtaining a U curve. The U curves for different values of D, the grating space, calculated from the experimental F values are independent of the value of D used, being practically superposable. Such is decidedly not the case with the theoretical curves, the general shape changing as well as the peaks shifting. This seems to show that the Compton effect cannot be taken account of in the way proposed by Jauncey and supports the theoretical finding of Waller (Phil. Mag. **4,** 1228) and Wentzel (Zeits. f. Physik **43,** 1 and 779) that a Schroedinger charge density may be assumed for the atom and the Compton effect disregarded in calculating F values.

48. Temperature effect in diffuse scattering of x-rays from rocksalt. W. D. CLAUS, *Washington University, St. Louis. (Introduced by G. E. M. Jauncey.)*—According to Debye (Ann. d. Physik **43,** 49 (1914)), the intensity of x-rays diffusely scattered in a direction ϕ from a crystal should be equal to that scattered from an amorphous substance, multiplied by the temperature factor $(1-e^{-M})$. Experiments by Jauncey (Phys. Rev. **20,** 421 (1922)) show that the intensity scattered is proportional to $\sin(\phi-\theta)/\{\sin(\phi-\theta)+\sin\theta\}$ as predicted, where θ is the crystal angle. Experiments are at present being conducted to test the temperature effect. In the temperature range 295° to 135°K, a decrease of approximately 50 percent in intensity is to be expected (depending on slightly different assumptions used in calculation) for $\phi=30°$ and 60°. Results to date indicate a decrease of not more than 5 percent, in no wise comparable to the expected effect.

49. Spectroscopic analysis of scattered x-rays. J. A. BEARDEN, *Johns Hopkins University.*—Davis and his collaborators using a double crystal spectrometer have found a fine structure in the spectra of scattered x-rays. Several investigators using a single crystal method have failed to find any fine structure. The present experiment is a repetition of Davis' experiment using a double crystal spectrometer on the unmodified line. Greater scattered x-ray intensity has been obtained by using a line focus tube and placing the scattering blocks of aluminum and graphite about 5 mm from the focal spot. Two wave-lengths were used, the $K_{\alpha_1}K_{\alpha_2}$ line of silver and the $K_{\alpha_1}K_{\alpha_2}$ line of copper. The capacity of the electrometer system was about 12 cm and the sensitivity of the electrometer 20,000 scale dimension per volt. No fine structure lines of one tenth the intensity of the K_{α_2} line have been observed. Chemical analysis of the scattering blocks showed no trace of copper or silver as an impurity. Measurements have also been made on the Compton shift which agree very closely with the equation $\delta\lambda=(h/mc)(1-\cos\theta)$.

50. Scattering of x-rays and the distribution of electrons in helium. ARTHUR H. COMPTON. *University of Chicago.*—An analysis of the theory of scattering of x-rays by monatomic gases makes it possible to express the probable distribution of the electrons in the atom as a Fourier integral. To evaluate this integral it is necessary to know the intensity of scattering of x-rays of known wave-length at different angles. With data recently obtained by C. S. Barrett the distribution of electrons in atoms of helium gas is thus determined. This distribution agrees

satisfactorily with that calculated by Pauling from wave-mechanics but differs by more than the experimental error from that predicted from Bohr's theory.

51. A direct-reading two-crystal spectrometer for x-rays. F. K. RICHTMYER, S. W. BARNES AND E. RAMBERG. *Cornell University.*—The two-crystal spectrometer developed by Bergen Davis and others provides a means of obtaining monochromatic x-rays of high intensity. Such a spectrometer, reading wave-lengths directly in angstroms, has been constructed, using the principle described by Nicholas (J.O.S.A. & R.S.I. **14,** 61, Jan. 1927) for the single crystal instrument. Details of construction and adjustment are described; and sources of error are discussed. The instrument is capable of absolute measurement of wave-lengths, with very high precision.

52. A vacuum spectrograph for the precision measurement of x-rays of long wave-length. CARL E. HOWE, *Oberlin College.*—The spectrograph has four unique features which make it fitted for precision measurements. (1) A slit system, consisting of five slits each one thousandth of an inch wide, excludes optical light and gives excellent collimation of the x-rays. (2) An x-ray tube with interchangeable targets, mounted on a micrometer slide enables the focal spot to be readily lined up with the fixed slit system. (3) A universal grating support permits the plane grating to be set at any desired angle and to be removed in vacuo from the path of the x-rays without disturbing any adjustments. (4) A set of two parallel plate holders at a fixed and known distance apart, placed at right angles to the slit system, permits accurate measurements of angles from the lines recorded on the two plates at different distances from the grating. The slit system and grating support are mounted as one unit which may be completely removed from the rest of the spectrograph for the purpose of making adjustments.

53. An instrument for high-voltage x-ray spectrography and radiography. FREDERICK SILLERS, JR., *Follansbee Bros. Co.* (*Introduced by Wheeler P. Davey*).—The increasing application of the x-ray diffraction method of crystal analysis to the study of materials of construction has led to the desire, in certain fields, for a more rapid method of obtaining results. Such a method may involve the adoption of higher voltages than are now in general use for this type of work. An instrument suitable for use with these higher voltages (in the neighborhood of 200 kv) will be described. The instrument consists essentially of a lead-lined drum equipped with four pin-hole or slit diffractometers, as well as an opening for radiographic exposures. It is adapted to a standard 200 kv installation employing a Coolidge tube. The instrument is so designed that comparable intensities of x-rays at all four diffractometers are available, rendering practicable the comparison of different patterns. Through the use of the present instrument x-ray spectrograms, by direct transmission, of coarse-grained polycrystalline material; e.g., high-silicon sheet steel about 0.02 in. thick for electrical uses, may be obtained in less than an hour. If radiographs are desired during the course of any study, they may be obtained by rotating the tube 90° on its axis.

Points to be discussed deal with strained materials, intensifying screens, optimum voltage, intensity variations, and radiography of fine effects.

54. The dielectric constants of aqueous KCl solutions. ALLEN ASTIN, *National Research Fellow, The Johns Hopkins University.*—Probable causes of the many discrepancies in existing data on the dielectric constants of aqueous electrolyte solutions have been determined and methods of either eliminating them or correcting for them worked out. It is shown that by use of a voltage resonance method, (Jezewski, Zeits. f. Physik **48,** 123 (1928)); (Kneikamp, Zeits. f. Physik **51,** 95 (1928)); (Lattey and Gatty, Phil. Mag. **7,** 985 (1929)) and (Astin, Phys. Rev. **34,** 300 (1929)), the necessary corrections are considerably simplified. The voltage resonance curve is also shown to be symmetrical, regardless of the amount of damping. The corrected results show that the dielectric constants of aqueous KCl solutions from concentrations of 0.00025N to 0.01N are no different from that of water, at least within the limit of error of the measurements. The probable error of the corrected results is 2 parts in 1000 at 0.001N. and 6 parts in 100 at 0.01N. The uncorrected results show an apparent decrease of the dielectric constant similar to that reported by most other observers. The magnitude of this apparent

decrease may be varied by changing either the frequency, the size of the test condenser or the dimensions of the leads. The lowering of the dielectric constant in solutions which was predicted by Hückel (Phys. Zeits. **26,** 93 (1925)) is much smaller than any reported experimentally and is too small to be detected with the limit of error reported here. Frequency employed is 1.8×10^{6}.

55. Time lag in changes of electrical properties of rubber with temperature and pressure. ARNOLD H. SCOTT, *Bureau of Standards.*—When the temperature of rubber is suddenly (within five minutes) changed from one value to another, the electrical properties do not at once assume their final values. Two hours or more may be required for the dielectric constant, power factor, and resistivity to become constant. Part of the data for one specimen are given in the following table:

Time after specimen reaches 150°C (125° Change) Minutes	Dielectric Constant	Power Factor Percent	Equilibrium Temp. corresponding to dielectric constant and power factor
3	3.07	2.96	107°C
15	3.52	7.83	120
25	3.83	8.87	128
63	4.32	6.22	144
155*	4.39	4.42	150

* (Equilibrium)

This time lag was studied with specimens of several compositions from soft to hard rubber following temperature changes varying in amount from 75 to 125°C. Data on the time lag with pressure were obtained on only one specimen using pressures between 1 and 700 atmospheres. Twenty-four hours were required for the electrical properties to become constant.

56. Changes in the specific resistance of aluminum. G. E. DAVIS AND GILBERT GREENWOOD, *University of Rochester.*—Measurements on aluminum wires confirm previous investigations concerning the increase of specific resistance with cold-working. Tammann attempted to explain this increase by assuming particle orientation. Such orientation has since been found in the fibrous texture of drawn wires. This explanation, however, requires anisotropic electrical properties of the metallic crystals. Such anisotropy is most unlikely in cubically crystallized aluminum. Furthermore aluminum wires, annealed until the increase in specific resistance is lost, show distinctly fibrous texture. The increase in specific resistance has sometimes been ascribed to lattice distortions caused by the stresses of cold working. v. Arkel investigated such distortions by the effects produced in Debye-Scherrer photographs. The α-lines in such photographs are actually doublets ($K\alpha_1$ and $K\alpha_2$), the sharpness of resolution of which decreases with increasing lattice distortion. Aluminum, completely annealed or cold-worked to different degrees, always shows a sharp resolution of these doublets. Distortions of the v. Arkel type cannot, therefore, be responsible for the increased resistance. Dehlinger discussed distortions extending throughout very minute regions of the lattice—possibly only along the surfaces of the particles. Such distortions would not cause a decrease in the sharpness of the doublets, and might be responsible for the increased specific resistance.

57. Contact resistance and microphonic action. F. S. GOUCHER, *Bell Telephone Laboratories.*—An experimental study of single contacts between granules of microphone carbon, the contact forces being of the order of 1 dyne. For established contacts Ohm's Law is obeyed up to 0.1 volt. The resistance decreases with increase of temperature, the temperature coefficient of resistance being of the same order of magnitude as that of solid carbon wires produced by a heat treatment which is similar to that used in the preparation of the microphone carbon.

Above 0.1 volt (up to 1.0 volt) there are departures from Ohm's Law which can be accounted for by the theory of contact temperature as a function of voltage when a reasonable value of the Wiedemann Franz ratio for carbon is assumed. The conclusion is that the conducting portions of such contacts are carbon to carbon. The temperature coefficient of resistance of a contact varies in a reproducible, but non-systematic manner as the resistance is changed in a reversible resistance force cycle. This shows that new surfaces having coefficients different from the average value are inserted into or removed from the circuit during the cycle.

58. A theory of the resistance of alloys. L. W. NORDHEIM, *University of Goettingen* (*Introduced by Alpheus W. Smith.*)—According to the new (Sommerfeld-Houston-Block) theory of metallic conductivity any resistance in a conductor is due to an imperfection of the crystal lattice. Thus the ordinary resistance is due to the heat motion of the atomic ions, and, therefore, is essentially dependent on the temperature, and vanishes at the absolute zero point. In alloys an additional disturbance is introduced because of the irregular distribution of the constituents. This disturbance can be calculated and gives the additional resistance, which is independent of temperature. Most facts about the resistance of alloys are easily explained by this picture. Formulae are given for the simplest cases, which are in good agreement with experiment.

59. Shot effect of the emission from oxide cathodes. H. N. KOZANOWSKI (*Introduced by N. H. Williams, University of Michigan.*)—Fluctuations in the electron space current from barium-strontium oxide cathodes at low accelerating potentials are many times as large as those observed in the case of currents from metallic emitters. When space charge is obliterated by the use of high accelerating potentials, the true value of the electronic charge, as predicted by Schottky, is obtained. The results indicate that at low accelerating potentials, positive ions leave the emitter, and travel into the space charge region under the action of the reverse space charge field. Due to the low mobility of the positive ion, large groups of electrons are affected by each positive ion, thus causing large, sudden variations in the space charge. A tube containing a tungsten filament and a Kunsmann emitter surrounded by a cylindrical collector gives the normal shot effect when only the tungsten is heated. The same abnormally high values observed with the barium-strontium emitter are obtained with this tube with a low accelerating potential when positive ions emitted from the Kunsmann emitter interact with the electron space charge around the tungsten filament. Even in this case, the true value of the electronic charge is obtained when the space current is temperature limited.

60. Effect of positive ion shot effect on space charge limited electron currents. LLOYD P. SMITH, *Cornell University.*—A transcendental equation has been derived which relates the electron current between two parallel plane electrodes (one of which is a hot cathode emitting positive ions as well as electrons, and the other is a collecting electrode at a potential positive with respect to the cathode) to the total positive ion emission as well as the difference of potential between the electrodes, their distance apart, etc. Curves have been plotted which give the electron current to the collecting electrode as a function of the total positive ion current at various collector voltages. From such relations, the variation in the electron current produced by statistical variations in the positive ion emission can be obtained. Such variations are large compared to the ordinary shot effect. This is to be expected since a positive ion moves relatively slowly through the space charge region liberating a group of electrons during one transit. From the curves it is possible to obtain the difference of potenial between the electrodes, at which the fluctuations of the positive ion current produce the greatest variation in the electron current.

61. Studies of abnormal shot effect in gaseous discharges. JOHN S. DONAL, JR., *University of Michigan.* (*Introduced by N. H. Williams.*)—Space charge limited electron currents from hot filaments have been found to exhibit extremely abnormal fluctuations when the tube contained argon gas. The abnormality is due to the release of groups of electrons from the space charge region by the positive argon ions. A detailed study has been made of the variation of the abnormal fluctuations with the field, filament temperature and gas pressure, the results

have obvious application to the elimination of extraneous noises in vacuum tubes. Positive ion currents of the order of one microampere have been obtained from tungsten filaments undergoing attack by oxygen. These ions, when trapped in the minimum of potential surrounding a hot cathode, produce very abnormal fluctuations in space charge limited electron currents. An expression for the resulting shot voltage has been developed, which permits the calculation of the average anode current increase due to each positive ion, and the average time of life of the ions in the space charge region. When the positive ions are accelerated to a cold cathode, an abnormal shot voltage is obtained which is unusual in being independent of the positive ion current.

62. Effect of adsorbed thorium on the thermionic emission from tungsten. WALTER H. BRATTAIN, *Bell Telephone Laboratories.*—The thermionic emission from a tungsten ribbon filament on which thorium was deposited, has been investigated. The thorium was derived from a thorium filament placed parallel to one face of the tungsten ribbon. For each successive equal amount of thorium deposited, the corresponding increase in the logarithm of the emission, for a given temperature of the tungsten ribbon, was smaller and smaller until the emission reached a maximum. Continued deposition of thorium caused the emission to decrease and finally approach a stationary value. Further investigation indicated that migration of the thorium to the back side of the tungsten ribbon took place at an appreciable rate at 1500°K. At approximately 1800°K. there was definite evidence of diffusion of thorium into the tungsten ribbon. At higher temperatures, the thorium evaporated from the tungsten surface.

63. The ion-grid theory of the decrease in work function for composite surfaces. J. A. BECKER, *Bell Telephone Laboratories.*—When electropositive atoms are adsorbed on electronegative surfaces, some of the atoms are ionized. These adsorbed ions act like a positively charged grid very close to the cathode. For a large plane surface, this ionic grid produces strong fields close to the surface but only small fields at larger distances. As a result, the work function is reduced by $4\pi\sigma l$ and the emission current saturates as well as it does for clean surfaces. σ = charge per cm^2; l = distance of ions above surface. In most experiments, however, the surface consists of irregularly oriented facets or else the ions form clusters due to the presence of electronegative gases. In these cases the distribution of the fields is greatly dependent upon the size of the facets or clusters. Computation shows that for small applied fields, the work function is decreased by a *fraction* of $4\pi\sigma l$. As the applied field increases, this fraction increases and the emission current increases much more rapidly than for clean surfaces. For large fields, the current saturates as well as or even better than for clean surfaces. Numerous experimental observations are accounted for by the finite extent of the ion-grid.

64. Grid glow tube relays. D. D. KNOWLES AND S. P. SASHOFF, *Westinghouse Elec. & Mfg. Co., East Pittsburgh.*—The name Grid Glow Tubes applies to a line of gaseous discharge glow and arc tubes, the breakdown of which is controlled by means of a grid. They are, then, essentially relays having a discontinuous grid-voltage plate-current characteristic These tubes are made in two general types: tubes with a cold cathode and tubes in which the negative electrode is a hot filament—the characteristics of both types being similar. Grid Glow Tubes have been made in sizes ranging from a few milliamperes of plate current up to several hundred amperes. They can be filled with one of the inert gases neon, argon, or helium or with mercury vapor. A study of the behavior of these devices must necessarily include that of the type of circuit in which they are to be used. A series of curves plotted for both a.c. and d.c. voltages on the plate, a.c. and d.c. grid bias and various self biasing schemes are given. The effect of phase shift between the grid and plate voltages when alternating current is used is also illustrated.

65. The radioactivity of Stone Mountain. JAMES A. HOOTMAN AND W. S. NELMS, *Emory University.*—The radioactive content of the waters which issue from the base of the unique geological formation known as Stone Mountain (Georgia) was determined. Tests were made of a number of large springs well distributed around the base of the mountain, and of other shallower sources above and below the 1000 foot level. The method employed was the Schmidt

Shaking Method, in which a known volume of water is thoroughly shaken with a known volume of air in a closed container. The resulting mixture of air and radium emanation is then pumped into an electroscope, and the rate of fall of the leaf is a measure of the radioactivity of the water. The electroscopes were calibrated by means of the Duane and Laborde formula, and corrections were made for temperature and pressure. This method has been shown by Ramsey to have an accuracy of about 3%. A majority of the springs tested were highly radioactive, the value for the highest being $15{,}980\times10^{-12}$ Curies per litre. This value is nearly twice the maximum reported by Boltwood for fourty-four radioactive springs, and more than half as large as the maximum reported by Lester for one-hundred-seventy-eight mineral waters of Colorado.

66. The measurement of the intensity of gamma rays of radium in r-units. OTTO GLASSER AND V. B. SEITZ, *Cleveland Clinic Foundation.*—Determinations of the intensity dsitribution of gamma-rays were made under various experimental conditions with a condenser intensitometer previously described. By using small ionization chambers and a system unaffected by penetrating radiations the difficulties usually encountered in such measurements were greatly reduced. The intensities obtained are given in r-units.

67. Disintegration constant of actino-uranium and ratio of actinium to uranium. ALOIS F. KOVARIK, *Yale University.*—With data of Fenner-Piggot and of Aston for br ggerite, Karlhus, Norway, and also Aston's 206, 207, 208 line intensities in common lead mass spectrum in conjunction with my age formula (Phys. Soc., April 1929) amounts of common lead and AcD are calculated. AcD, uranium, and actinium: uranium ratio (3%) lead to $\lambda=2.5\times10^{-9}$ yr^{-1} or $T=2.7\times10^{8}$ yr. Boltwood's 8% (N. Car. uraninite), Hahn-Meitner's 3% (pitchblende) and others, including recent work of Wildish, indicate a variation of the ratio with age of mineral. Considerng actino-uranium an isotope of uranium initially in correct proportion to UI, the ratio should vary and 400 million years difference in the age of the minerals will bring Boltwood's and Hahn-Meitner's values into agreement. Furthermore, calculation of this ratio for the age of Keystone, S. D., uraninite (1462 million years) gives 0.6% and for Sinyaya Pala, Carelia, uraninite (1852 million years) gives 0.25%. The latter values receive a check if AcD is practically the only lead isotope left after subtracting RaG and ThD from the total. Broggerites and cleveites do not give such a check because considerable amount of common lead is present.

68. An attempt to detect deBroglie waves of hydrogen atoms. THOMAS H. JOHNSON, *Bartol Research Foundation.*—Earlier work on the reflection of atomic hydrogen from NaCl failed to reveal deBroglie wave diffraction patterns. This was not unexpected because of the low intensity of the specular reflection and the great intensity of the diffuse background, arising principally from the reemission of adsorbed atoms. Lithium fluoride presents a much more favorable opportunity for detecting the wave character of atomic hydrogen. The specular beam is very intense and there is no reemission of monatomic hydrogen. The MoO_3 detecting plate therefore records only elastically reflected atoms. First order surface-grating bands from the LiF lattice were expected with abrupt maxima separated from the specular beam by 20° to 30°. These bands were found, showing that the total number of atoms going into any one is certainly less than 5% of the number in the specular beam. If the crystal was heated to 600° C a diffuse band appeared extending asymmetrically to about 20° on either side of the the specular beam. With the crystal at room temperature this largely disappeared.

69. Satellites of electron diffraction beams. H. E. FARNSWORTH, *Brown University.*—While investigating electron diffraction by a copper crystal, for normal incidence on a (100) face, certain beams have been found which require a refractive index of unity. A search for other weak beams of this nature reveals a whole set of such beams which accompany the intense diffraction beams. In many cases these satellites are so close to the regular beams that they are not completely resolved, and hence are not observed by the usual method of measurement. In the (100) azimuth the satellites which accompany the 4 first-order beams below 325 volts all occur within 2 volts of the theoretical values for unit refractive index;

that of one second-order beam occurs within 11.9 volt; that of the other second-order beam is missing. In the (111) azimuth, the satellites of 3 first-order beams are within 2.7 volts of theoretical values; that of the other first-order beam below 325 volts is within 7.3 volts; those of 2 second-order beams are within 5 volts; that of the other second-order beam is within 19.5 volts; that of 1 third-order beam is within 5 volts. These satellites are as sharp in voltage and colatitude angle as the main diffraction beams, and are not confined to large colatitude angles. Hence they are not due to a two-dimensional surface grating. The significance of these diffraction beams is discussed.

70. The capture of electrons by alpha-particles. A. H. BARNES, BERGEN DAVIS AND H. L. HULL, *Columbia University.*—Abstract of this paper is withheld for revision by the authors.

71. Absorption of sodium vapor in the extreme ultraviolet. S. A. KORFF AND J. L. NICKERSON, *Princeton University.*—Employing a vacuum spectrograph, sodium vapor was examined for absorption in the region from 1300 to 300 Angstrom units, againt a background of many lines. Vapor pressures used ranged up to 1 mm of Hg. No broad absorption peaks were observed in this region. Extremely narrow peaks would not be distinguishable, however, by this test. This region includes the point at twice the series limit, or 1205.9 Angstrom units. In general, sodium vapor was found to be almost perfectly transparent to radiation in the observed range.

72. Most probable 1930 value of the electron and related constants. R. A. MILLIKAN, *California Institute of Technology.*—This paper discusses, in the light of Zwicky's results on the block structure of crystals, the reliability of old and new measurements on the relations of e and h, and by combining experimental and theoretical considerations assigns most probable 1930 values to these constants.

73. The nature of cosmic radiation. L. F. CURTISS, *Washington, D. C.*—Two Geiger-Müller tube counters placed vertically above each other show, in addition to accidentals, coincidences which have been ascribed to cosmic rays. Absorption experiments by Bothe and Kohlhörster indicate that these rays are corpuscular. The author has made observations with the poles of a large electromagnet between two counters, recording the number of coincidences with and without the magnetic field. With the field used of 7000 gauss over an area 24 cm in diameter, a parallel beam of 10^9 volt electrons which passes through the upper counter would be deflected sufficiently just to miss the lower counter in spite of the fact that the $H\rho$ for such electrons is approximately 3×10^6. Since the radiation is actually diffuse with a maximum in the vertical direction, using two counters one can expect only a slight decrease in the coincidences if they are caused by high-speed electrons. However, if they are due to ultra γ-rays, no such effect should be observable. Making the theoretical allowance for accidentals, a decrease of the order of 25% has been observed in the coincidences which may be attributed to cosmic radiation. This confirms the existence of a corpuscular radiation of very high energy.

74. The absorption of acetylene and ethylene in the near infrared. RICHARD M. BADGER, *California Institute of Technology. (Introduced by Richard C. Tolman).*—The absorption spectra of gaseous acetylene and ethylene have been investigated photographically in the region 6800A–9200A. In the case of acetylene a band with very sharp lines, and showing marked intensity alternation was found, with center at about 7886A. It resembles a band found by Levin and Meyer at 3.0μ, of which it is probably a harmonic, but shows strong convergence on the short wave length side indicating a considerable increase in the average moment of inertia due to oscillation. In the case of ethylene a band was found with center at about 8706A which apparently also shows convergence, but which has a rather complex structure. An investigation of the structure of these bands is in progress.

75. The effect of high pressure on the near infra-red absorption spectra of certain liquids. J. R. COLLINS, *Cornell University.*—The state of polymerization of liquids composed of polar molecules is supposed to depend on the temperature, pressure, etc. The near infra-red absorption

bands of these substances, which are due to molecular vibrations, should be affected by changes in the state of polymerization, and hence also by changes in the temperature, etc. Experiments have shown that changes in the temperature changed the spectral position and intensity of absorption bands of water and certain alcohols, while the bands of benzene, a nonpolar substance, were unaffected by changes of temperature. The present experiments are measurements of the absorption of water, methyl alcohol, and iso amyl alcohol as examples of polar substances, and of toluene as a nonpolar substance, when these substances were subjected to pressures up to 5000 atmospheres. The pressure chamber was designed by P. W. Bridgeman and the measurements were made in the Jefferson Laboratory at Harvard University. No change was found in the position of any of the absorption bands studied. The conclusion is made that, in this pressure range, the state of polymerization does not depend on the pressure.

76. Bismuth-black and its applications. A. H. PFUND, *Johns Hopkins University.*—If a bit of bismuth be evaporated from a spiral of incandescent tungsten wire in a space evacuated to a pressure of about 0.25 mm of mercury, the bismuth is deposited as an intensely black film. For visible light, the diffuse reflectivity of "bismuth-black" is but one sixth that of camphor black. Tests have shown that bismuth-black films which are opaque to visible light, transmit and reflect at normal incidence, less than 1% of infra-red radiation out as far as 13μ. It was decided to use this new material on the receiving areas of delicate thermopiles, radiometer vanes, etc. Quite apart from the blackness and small heat capacity of bismuth-black, a further advantage is gained because of the circumstance that the most delicate surfaces may be blackened without the least danger of harming them. Because of the fineness of the particles, films of bismuth-black on plate glass reflect specularly at grazing incidence. Films which are rough at all angles of incidence may be produced by depositing, first, an extremely thin (grayish) film of soot from burning camphor upon which the bismuth-black is subsequently thrown down. It appears that the soot particles act as centers of condensation and, as a result, the bismuth-black is built up in the form of minute pyramids. Delicate surface bolometer's were made by forming a layer of nitrocellulose so thin as to show first-order Newton's colors. Upon this film was deposited a highly reflecting film of bismuth. The best attainable vacuum—less than 10^{-4} mm Hg—was required. This film was an excellent conductor for electricity. Air was then admitted so as to raise the pressure to 0.25 mm and the absorbing film of bismuth-black was thrown down. This general mode of procedure is being applied to the construction of thermopiles.

77. The effect of aberrations in limiting the resolving power of infra-red spectrometers. R. BOWLING BARNES AND A. H. PFUND, *Johns Hopkins University.*—Because of the increasing demand for high dispersion infra-red measurements, it seems timely to call attention to some of the difficulties which arise when very small "slit-widths" are used, and to a method of overcoming them. In the usual spectrometer, concave mirrors must be used off the optic axis, and unless these are parabolized along the proper axes, noticeable aberrations are present. Due to astigmatism and coma the slit image is broad and accompanied by a diffuse wing. If the eye is placed behind S_2, and the grating viewed in monochromatic light only a small portion of it will be illuminated, the jaws of the narrow slit having blocked out the light from some parts. One then, never gets the advantage of the full aperture, and the spectrum used is very impure. By a method somewhat similar to that described by Pfund (J.O.S.A., April 1927), spherical mirrors of aperture $f \cdot 4$ can be used along the optic axis, and to full advantage. The radiation, after falling upon each of the spherical mirrors, M_1 and M_3, is reflected along the axis to the plane mirrors, M_2 and M_4 respectively. These mirrors, containing oversized slits at their centers, are placed just in front of the slits S_1 and S_2, and are inclined to the optic axes at the desired angles. With this arrangement the eye looking through S_2, sees the entire grating filled with light no matter how narrow the slits are made. This is a necessary result if one wishes to work with very small "slit-widths".

78. On the theory of the Brownian motion. L. S. ORNSTEIN, *University of Utrecht, Holland* AND G. E. UHLENBECK, *University of Michigan.*—Using a method first indicated by Ornstein (Proc. Acad. Amst. **21,** 96, 1917) the mean values of *all* the powers of the velocity

u and the displacement s of a free particle in Brownian motion are calculated. It is shown that $u-u_0\exp(-\beta t)$ and $s-u_0/\beta[1-\exp(-\beta t)]$ where u_0 is the initial velocity and β the friction coefficient divided by the mass of the particle, follow the normal Gaussian distribution law. For s this gives the exact frequency distribution corresponding to the exact formula for S^2 of Ornstein and Fürth. Discussion is given of the connection with the Fokker-Planck partial differential equation. By the method exact expressions are obtained for the square of the deviation of a harmonically bound particle in Brownian motion as a function of the time and the initial deviation. Here the periodic, aperiodic and overdamped cases have to be treated separately. In the last case, when β is much larger than the frequency and for values of $t>\beta^{-1}$, the formula takes the form of that previously given by Smoluchowski.

79. A test of the Dalton-Gibbs law of partial pressures. LOUIS J. GILLESPIE. *Massachusetts Institute of Technology (Introduced by F. G. Keyes.)*—According to Gibbs' formulation the pressure of a gaseous mixture equals the sum of the partial pressures, $P=\Sigma_1 p_1$, when p_1 is conceived as the pressure of pure gas 1 that would just prevent the gas 1 in the mixture from escaping through a membrane permeable to it alone. This can be shown equivalent to the statement: The "density" (or concentration) of a gas is the same at equilibrium on either side of a membrane permeable to it alone. Examination of the data of Larson and Black and of Lurie and Gillespie shows the following: (1) The mole fraction of ammonia mixed with 3:1 hydrogen-nitrogen mixture at temperatures from -20 to $+20°$ C, and of ammonia mixed with nitrogen at 45°, is greater than that calculated from the Gibbs formulation, by an amount that increases with the pressure at low pressures (50 atm. plus). (2) In the case of the hydrogen-nitrogen mixtures the difference appears to pass through a maximum at 100-300 atmospheres. (3) The difference may reach 25% of the observed mole fraction. (4) Considered as a possible basis for the thermodynamic treatment of gaseous equilibrium the Gibbs formulation must be regarded as approximate, like its analog, the fugacity rule of Lewis and Randall.

80. A rational basis for the thermodynamic treatment of mixtures of real gases. JAMES A. BEATTIE, *Massachusetts Institute of Technology.*—In the treatment of the thermodynamic properties of gas mixtures several assumptions are necessary. It is now found that two assumptions suffice: One relates to the isothermal variation of the energy of pure gases and the other to the isothermal variation of the ratio of the equilibrium pressure of a gas in a mixture to the total pressure multiplied by the mole fraction of the gas. From these two assumptions it can be shown that at infinitely low pressures the following relations hold for all real gases: (1) The laws of Boyle and Avogadro, (2) the energy, entropy, heat content and thermodynamic potentials of a mixture of gases are equal to the sums of the corresponding quantities for the component gases existing each by itself with the same value of its volume, temperature and chemical potential as in the gas mixture; (3) the energies and heat capacities of gases and gas mixtures are functions only of the temperature; (4) $pv=nRT$ for pure gases and $pv=\Sigma_1 (n_1)RT$ for gas mixtures where T is thermodynamic temperature.

81. A thermodynamic theory of excitation of nerves. N. RASHEVSKY, *Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.*—In their ionic theory of nervous excitation, W. Nernst (Pflugers Archiv, **122,** 275, 1908) and A. V. Hill (Journal of Physiology, **40,** 190, 1910) considered the motion of ions near a membrane, correspondingly between two membranes. Though the last case, worked out mathematically by Hill, accounts for the general features of the experimental excitation time curve, it does not account, without additional hypothesis, for the fundamental fact that the rate of increase of the exciting current is of prime importance. In the present paper, it is first pointed out that the boundary conditions, used in the mathematical treatment of Hill, cannot correspond to physically real cases, and a modified treatment is considered. Furthermore, it is shown that not only the general shape of the excitation time curve, but also the dependence on the rate of change of the exciting current, can be accounted for by purely thermodynamical considerations, which do not involve any special hypothesis about the ionic mechanism of excitation, and are based on considerations of systems with several equilibria.

82. The energy of dissociation of normal Cd_2. J. G. WINANS AND R. ROLLEFSON, *University of Wisconsin.*—Kapuscinski and Jablonski (Zeits. f. Physik **57,** 692, 1929) give an interpretation of the Cd absorption flutings between λ2825 and 2590 which yields 1.0 volts for the dissociation energy of normal Cd_2. From an interpretation of the Cd absorption band at λ2212 Winans (Phil. Mag. **7,** 555, 1929) obtained 0.20 volts for this dissociation energy. Walter and Barrett found that cadmium vapor from which electronegative elements had been excluded failed to show the λ2825–2590 flutings but still gave the 2212 band in absorption. They attributed the flutings to impurities in the cadmium and the 2212 band to cadmium molecules. The value of the dissociation energy obtained from the flutings is therefore doubtful. Also one should not expect an energy of dissociation as high as one volt for molecules like Cd_2. Since cadmium is a closed shell atom, a molecule formed by the union of two unexcited Cd atoms must be held together by polarization forces only. That such forces are too small to account for a large energy of dissociation of Cd_2 is made very plausible by consideration of the fact that the alkaline earths and helium which have a similar electronic configuration show no molecular absorption. The work of Koernicke on Hg_2 indicates that the energy of dissociation of such molecules is of the order of 0.1 volts.

83. The composition of the interior of the earth. A. A. BLESS, *University of Florida.*—The high density of the whole earth as compared with the density of the crust is usually accounted for by the hypothesis that the core of the earth is composed of iron. This hypothesis is inadequate for a number of reasons, the chief of which is that it gives an iron content for the earth much too high compared with the abundance of this element in the sun or in other stellar bodies. Without introducing such a radical hypothesis the high density of the interior of the earth may be explained as being due to the ionization of the materials composing the core, the ionization being produced by the collision of atoms moving with the high velocity of thermal agitation. A temperature sufficient to cause ionization by collision would be reached at a depth of 2000 miles if the temperature gradient observed near the surface remains constant for this distance. At a comparatively short distance from the surface the high temperature would cause decomposition of molecules. The permanent gases so liberated would form an envelope around elements which are solid at ordinary temperatures, these elements forming the core. The ionization of the material of the core by decreasing the size of the atom, would increase the density sufficiently to account for the observed mass of the earth. The suggested distribution of the material gives the proper value for the moment of inertia of the earth, and is also in qualitative agreement with data concerning the propagation of seismic waves.

84. Striations and magnetic effect in electrodeless discharges. J. TYKOCINSKI-TYKOCINER AND JACOB KUNZ, *University of Illinois.*—Electrodeless tubes filled with H_2 (0.01 mm Hg) were placed in the field of a coil with high frequency currents (3000–12000 kc.) of constant amplitude. Striations appearing in pairs were observed. Their number decreases with current density. Moving a tube away from a flat spiral coil is equivalent to decreasing the density of the discharge current, consequently the number of striations increases. At a certain critical distance the striations pass through a transitory stage of irregular movements to and fro and disappear then altogether giving place to a uniform glow. Striations were also obtained with the axis of the tube directed perpendicularly to the axis of the exciting coil, showing that the striations are not necessarily connected with ring discharges. A magnetic field applied perpendicularly to the axis of the tube produces a rotational deflection of each striation clockwise and perpendicular to the direction of the magnetic field. This deflection may be interpreted by the Biot-Savart action of the magnetic field on the radial component of currents formed by carriers moving spirally with increasing radii around the axis of the tube and directed outward. A similar interpretation is applicable to striations produced by high frequency discharges in tubes supplied with inner or outer electrodes.

85. High frequency electrodeless discharge characteristics. OTTO STUHLMAN, JR., M. D. WHITAKER, M. L. BRAUN, *University of North Carolina.*—These discharges are classed as primarily due to electrostatic and to electromagnetic fields. Excitation by damped and by un-

damped frequencies are considered. The investigation involved the production of a glow discharge in mercury vapor as a function of frequency, pressure, current, and visual intensity. With a predominant electrostatic excitation and damped frequencies no simple relation was found to exist between visual intensity of the discharge and pressure, current, or frequency. However, consistent irregularities, characteristic of the gas and the mode of excitation, were obtained. With continuous wave and predominant electromagnetic excitation the minimum currents necessary to initiate, and necessary to sustain, the glow discharge were investigated at pressure ranging from 0.1 to 2.0 mm. For each frequency there exists a critical pressure at which the current through the coil required to initiate the glow discharge, and the current required to sustain it, are at minimum values. The ratio of these two currents is not constant for all pressures, but generally increases with increase in pressure. A characteristic arc transition from spark discharge at high pressure to arc discharge at lower pressures, occurred near 0.025 mm.

86. Relative intensities of arc and spark lines of the electrodeless discharge in mercury vapor. O. P. HART AND O. STUHLMAN, JR., *University of North Carolina.*—Excitation of discharge took place in a 12.5 cm spherical bulb placed inside a helical coil 14.5×44 cm when the latter was supplied with damped high frequency current. Three sets of spectrograms were taken—(A) Radiation intensity as a function of pressure with frequency and potential constant. (B) Intensity as a function of frequency with potential and pressure constant. (C) Intensity as a function of potential with frequency and pressure constant. Spectrogram series (A) showed that as the pressure was decreased (0.026 to 0.0005 mm) the intensity of the arc lines increased, whereas the intensity of the spark lines decreased. Series (B) showed that as the frequency of the excitation current was increased the intensity of the arc lines increased. No spark lines were observed at low pressures (0.0002 mm). Series (C) showed that as the potential between the terminals of the coil was increased the intensity of the arc lines increased. No spark lines appeared at this pressure (0.0002 mm). At low pressure and with increasing potential the triplet 4358, 5460, 4047 first appeared followed by the singlets 5790, 4347, 3906 in order of decreasing intensities.

87. Time lags in spark discharges at high overvoltages. J. C. STREET, *University, Va.*—Further studies of the long time lags in dry filtered gases at high overvoltage, first reported by Beams and Street (Phys. Rev. **35,** 658 A), have been made. Surge potentials were applied and the time lags were measured by a comparison method. Several enclosed gaps were constructed and tested, care being taken to remove the residual ions. In each case for air, nitrogen or hydrogen at atmospheric pressure the lags remained longer than 10^{-6} sec. until fields of about 3×10^5 volts per cm were reached. With an increase to 3.3×10^5 volts per cm the lags became less than 5×10^{-8} sec. The magnitude of the field, at which the transition from long to short lags begins, is little affected by increase in pressure, amounting only to about 3.4×10^5 volts per cm at three atmospheres. On the other hand it is remarkably increased by a previous treatment consisting of discharges between the electrodes at reduced pressures in hydrogen. After this procedure, fields of 6×10^5 and 5×10^5 volts per cm for spherical electrodes of brass and steel respectively were required to produce lags shorter than 10^{-6} sec. Fields of the same order of magnitude as those just mentioned were required to produce a spark under the same circuital conditions in high vacuum between the same electrodes.

88. A direct measurement of the velocity of cathode rays. CHARLOTTE T. PERRY AND E. L. CHAFFEE.—The method used in this experiment makes no assumptions as to the law of deflection of moving electrons in magnetic and electric fields but measures the time of flight of the electrons directly in their passage over a distance of about 75 cm. Electrons are projected through a long tube by a potential E. In their journey they pass through two very localized alternating electric fields. These deflecting fields are produced by a very high frequency oscillator connected so that the fields are 180° out of phase. Only those electrons which pass when the fields are zero reach the end of the tube. The time required to travel the distance between fields is an even multiple of the half period of oscillation of the fields. The accuracy of determination of velocity is better than 0.1% and results are given for various driving voltages E.

89. The ionization of helium and neon by electron impact. PHILIP T. SMITH AND JOHN T. TATE, *University of Minnesota.*—The total positive ion current per electron per centimeter path has been measured as a function of the energy of the impacting electrons up to 3000 volts in neon and up to 4500 volts in helium, using a modified Jones type of apparatus (T. J. Jones, Phys. Rev. **29,** 822 (1927)). Both helium and neon exhibit well-defined maxima which occur at 110 and 170 volts respectively. The ratio of the positive ion current to the electron current per centimeter path reduced to 1 mm pressure and 0°C at the maxima was 1.256 for helium and 3.056 for neon. At 3000 volts the ratio was 0.172 for helium and 0.605 for neon. It was found that for energies from about 500 volts to 3000 volts the efficiency of ionization of neon is a linear function of $V^{-\frac{1}{2}}$, where V is the energy of the impacting electrons in volts. In helium the efficiency is a linear function of $V^{-1/2}$ from about 500 to 2000 volts. Beyond 2000 volts the efficiency approaches a linear function of V^{-1}. The empirical formula

$$3.383\,(V_0/V)^{1/2}\left[1-\exp\left(-\frac{54V_0}{V}\right)\right]^{1/2}\left[1-\exp\left(-\frac{V-V_0}{2.28V_0}\right)\right]$$

expresses the efficiency of ionization of helium, within the experimental error, from the ionization potential V_0 to 4500 volts. The above results were free from any effects due to secondary electrons, and were independent of the pressure, electron current, and the magnetic field.

90. The absorption coefficient for slow electrons in gases. C. E. NORMAND AND R. B. BRODE, *University of California.*—The absorption coefficients or the effective collision cross sections have been measured in H_2, He, Ne, A, N_2 and CO for velocities of the electrons from 0.5 to 400 volts. With a higher resolution of velocity a fine structure in the absorption coefficient curves has been found for all of these gases. At the lowest velocities, about 0.5 volts, all of the curves are rising with decreasing velocity. The minimums in the absorption coefficients occur between 0.5 and 1.2 volts for these gases. Ramsauer and Kolloth (Ann. d. Physik **4,** 91 (1930)) have reported minimums for He and A and none for the other gases. Their scale of velocity is, however, in disagreement with the velocities measured here, being 0.5 volts lower. When adjusted for this difference the data are in agreement.

91. Heating of a cathode by positive gas ions, and their "accommodation coefficient." C. C. VAN VOORHIS AND K. T. COMPTON, *Princeton University.*—Positive ions of helium, neon or argon were produced by a low voltage arc at low pressure and were made to bombard a spherical molybdenum collector with regulated velocities up to 140 volts. The resulting heating of the collector was measured by a thermal junction and found to be *considerably less* than the product of current by bombarding voltage. The problem was to account for the undetected remainder of the energy. Both calculations and experimental tests showed that this cannot possibly be explained as the result of part of the apparent ion current actually consisting of secondary electron emission or of ions losing energy at collisions with molecules. After making all such corrections, we are still forced to conclude that a fraction of the kinetic energy of the incident ions is carried away by ions (atoms) after neutralization. The fractions of their energies delivered to the cathode by the ions are the following "accommodation coefficients": He 0.4 to 0.5, Ne 0.7, A 0.8, which are strikingly similar to the gas kinetic values. There are a number of interesting applications of this discovery.

92. Angle and energy distribution of electrons rebounding from gaseous molecules. A. L. HUGHES AND J. H. MCMILLEN, *Washington University, St. Louis.*—The distribution of electrons rebounding at definite angles from gaseous molecules was investigated. An electrostatic re-focusing arrangement was used to analyse the energies of the electrons. In helium, it was possible to identify the following energy losses at several angles, 21.12, 22.97, and 23.62 volts for a primary electron beam of 100 volts, but not the 19.77 and 20.55 volt losses. The number of electrons, rebounding without loss of energy, was measured for different angles of rebound (7° to 80°) from argon, helium, and molecular hydrogen molecules, and for various energies (50 to 15) volts). In almost all cases, the number decreased rapidly as the angle in-

creased. The higher the energy of the electrons, the more rapidly did the number fall off with increasing angle. The steepness of the curves increases as we go from argon to helium to hydrogen for the slower electrons. For the faster electrons their curves are practically superposable.

93. An attempt to detect collisions between photons. G. E. M. JAUNCEY AND A.L. HUGHES, *Washington University, St. Louis.*—It has been shown that if two photons, of identical frequency, moving along paths making an angle of 120° with each other, collide, and produce one photon travelling forward along the line bisecting the 120° angle, and another photon traveling in the opposite direction, the frequency of the photon traveling forward must be 1.707 of the frequency of the original photons (Hughes and Jauncey, Phys. Rev. **33,** 290 (1929)). This suggested the following experiment. Two beams of sunlight (one suitably deflected by a mirror), filtered through red glass, were passed through lenses 10 inches in diameter, so that the beams, whose axes made an angle of 120° with each other, intersected at a common focus. As the diameter of the beams at the focus amounted to only 4 mm, great concentration of light was obtained. The point of intersection of the beams was examined through a green filter with the eye which had been rested in total darkness for periods up to an hour. No light was detected. It was estimated that if the photon has a cross section, effective for the type of collision here contemplated, it must be less than 10^{-11} cm.

94. On the principle of Huyghens. G. E. UHLENBECK, *University of Michigan.*—Attention is called to the general formula:

$$\int_0^\infty d\nu \int_{-\infty}^{+\infty} f(\xi) \sin \nu(x - \xi)\, d\xi = P \int_{-\infty}^{+\infty} \frac{f(\xi)}{x - \xi} d\xi$$

where P denotes Cauchy's principal value. An exact (not published) proof of this has been given by Droste, when $f(\xi)$ fulfills the Dirichlet conditions. One has to compare this with the Fourier's integral theorem:

$$\int_0^\infty d\nu \int_{-\infty}^{+\infty} f(\xi) \cos \nu(x - \xi) d\xi = \pi f(x).$$

By integrating the wave equation in n dimensions $(\partial^2/\partial t^2 - \Delta_n)\psi = 0$ with given initial values for ψ and $\partial\psi/\partial t$ according to the method of Fourier-Cauchy, one can show that the curious difference between the formula's (1) and (2) reflects the well-known fact that the principle of Huyghens is not valid in spaces with n even number of dimensions and valid in spaces with an odd number.

95. The Stark effect near the series limit. JANE DEWEY, *University of Rochester.*—The number and position of the lines appearing near the limit in a hydrogen-like spectrum have been investigated on the Bohr theory, extending the work of Robertson and the writer (Phys. Rev. **31,** 973 (1928)). From a study of the limiting cases, for which the complete equatian can be handled more easily than in the general case, it appears that only orbits with principal quantum number less than a given number (approximately $43/F^{1/4}$) are periodic in the presence of a field. The region in which both lines and continuous spectrum appear is due to the large displacement of the lines. The outer components of the last group of lines appearing in a field of 1 e.s.u. per centimeter are displaced 50 cm^{-1}. For small fields the position of all the lines is given correctly by the perturbation theory if the second order terms are taken into account, as lines for which the series would not converge do not appear. The large displacements and large number of lines which appear near the series limit in a field make it probable that the lines observed in discharges in this region are the central components of the group of lines having the same principal quantum numbers and that the other components are spread over the background by the stray fields necessarily present. The apparent sharpness of the lines is thus not a criterion for no spreading out of the lines and an experimental investigation of the effect would be very difficult as it would probably not be possible to maintain a field sufficiently constant to observe the higher series members distinct from one another.

96. Zeeman effect in the calcium hydride band spectra. WILLIAM W. WATSON AND WILLIAM BENDER, *Yale University.*—The Zeeman effect in the red CaH bands has been investigated at several field strengths to 30,000 gauss, with a dispersion of 2.1A per mm. For $K<7$ in the $^2\Sigma\rightarrow{}^2\Sigma$ system, the P_1 and R_1 lines (parallel S) are unaffected at all fields, while the P_2 and R_2 lines (anti-parallel S) mostly become diffuse doublets shading away from the no-field position. All P_1 and R_1 lines of higher K value have at low fields only a strong, broad component shifted to the red with the extreme edge at about $\Delta\nu_{norm}$, the breadth decreasing as K increases. At 30,000 gauss a broad weak violet component appears. The P_2 and R_2 lines with $K>8$ are merely broadened to the violet, the overall width being approximately $\Delta\nu_{norm}$. The lines of low K values in the $^2\Pi\rightarrow{}^2\Sigma$ band give field patterns as expected from Hill's theory. For $K>22$, the lines involving F_1 states rapidly broaden out, and for highest K values are of negligible intensity. The lines arising from F_2 levels, remain sharp and strong for all high rotational states, but shifted to the violet by about $1/2(\Delta\nu_{norm}.)$ These effects can be explained by a consideration of the "rho-type" doubling involved.

97. Electro-optical modifications of light waves. L. H. STAUFFER, *University of California (Introduced by Ernest O. Lawrence.)*—Broadening of the satellites of the Hg green line λ5461 was observed when the light passed between the plates of a Kerr cell on which was impressed a varying E.M.F. having a frequency of 2×10^7 sec^{-1}. The E.M.F. was obtained by superposing the output of a vacuum tube oscillator upon a steady potential of about 7000 volts. The maximum oscillator voltage was about 5000 volts. With this voltage the fine structure of the Hg green line became so diffuse that two satellites having a separation of 0.045A were scarcely resolved by the Lummer-plate. The broadening was observed to increase rapidly with the oscillator voltage. The observed effect is predicted by the classical electromagnetic theory and constitutes a proof of the generalized Doppler principle. The high frequency voltage effects a rapid variation of the refractive index of the nitrobenzene in the Kerr cell which in turn produces a corresponding variation in optical path, giving the source a virtual velocity. The observed broadening is in agreement with the predictions of classical theory.

98. The electric double refraction in gases. J. W. BEAMS AND E. C. STEVENSON, *University of Virginia.*—A method for the study of the electric double refraction or Kerr effect in gases as a function of pressure has been devised. Light of known frequency was passed through a Nicol prism, between two parallel metal plates, through a second Nicol prism and into a photoelectric cell. The two Nicols and the metallic plates across which the electric potential was applied were inclosed in a heavy steel tube with glass ends. As a result, the Kerr effect in the gas could be studied at a few hundred atmospheres pressure without introducing errors due to strains in the windows. Intense electric fields could also be employed because of the large value of the dielectric strength of the gas at high pressures. The precision of the method was limited only by the precision with which the potential across the plates could be measured. The results indicate that in the case of CO_2 the Kerr constant per molecule does not change by as much as 2 percent between 15 and 45 atmospheres pressure at 21° C. An easily measurable Kerr effect was observed in O_2 and N_2 at 100 atmospheres pressure.

99. Spontaneous temperature changes accompanying magnetization in steel. W. B. ELLWOOD, *Columbia University.*—The purpose of this experiment is to determine the dissipation of energy accompanying magnetization in iron by observing the change in temperature of a test specimen produced by a change in the magnetizing force at consecutive intervals in a single cycle of magnetization. The test specimen is in the form of an ellipsoid consisting of 104 bars of #57 drill rod alternate with 104 similar copper rods arranged in coaxial concentric cylinders. One hundred and two thermocouples in series are constructed by connecting adjacent copper and steel bars with 3 mm lengths of constantan and copper wire. Adequate thermal insulation isolates the specimen from the magnetizing solenoid in which it is placed. A temperature change of 3×10^{-6} degrees Centigrade can be detected. The specimen is put in a cyclic magnetic state and allowed to come to thermal equilibrium. On traversing the hysteresis loop from +290 to +20 gauss, heat is evolved by the iron and is measured as an increase in temperature.

On further demagnetization from +20 to −6 gauss the iron cools suddenly. From −6 to −90 gauss, the iron heats most rapidly. Increase of the field to −290 gauss is accompanied by cooling of the iron. Temperature-magnetization curves for various other magnetic paths are described.

100. The propagation of large Barkhausen discontinuities along wires. K. J. SIXTUS AND L. TONKS, *General Electric Co.*—Preisach has shown that by applying increasing tension or torsion to a wire of nickel iron allloy, the Barkhausen discontinuities in magnetization become larger and larger. Finally, at a tension near to the elastic limit, a rectangular hysteresis loop is produced whose discontinuous change in magnetization includes 97 percent of the whole difference between positive and negative saturation. Langmuir suggested that this sudden change in magnetization starts at a nucleus from which it propagates along the wire. Investigation based on this view shows that the nucleus forms in a uniform field at a somewhat variable critical field strength, and at different points along the wire, depending apparently on uncontrolled factors. The nucleus can be made to form at a definite point, however, by applying locally a small additive field, and the discontinuity will then propagate into the uniform portion of the field, the strength of which can be smaller than the critical field strength. The velocity of propagation increases for a given sample with increasing field strength and tension. A 10% Ni−90% Fe wire of 0.038 cm diameter showed velocities up to 14000 cm sec^{-1}

101. The mobilities of ions in moist and dry air. JOHN ZELENY, *Yale University.*—Using the method recently described (Phys. Rev. **34,** 310, 1929) the distribution of mobilities of aged ions in *dry air* has been determined and the values for moist air remeasured because of a neglected correction. The dissymmetry in the distribution of mobilities around the most numerous kind noted in the previous paper for *negative ions* in moist air, was found more pronounced in air dried by calcium chloride. In air dried further by passage through coils and filters immersed in liquid air a second distinct group of negative ions constituting about 35 percent of the total number and having a peak mobility of about 1.45 cm/sec was partially resolved. Under the last conditions the positive ion distribution curve also shows some dissymmetry indicating a possible group with a peak mobility of about 1.5 cm/sec. The mobility of the ions at the main peak of the distribution curve *decreased* for *positive ions* from 1.36 cm/sec for air with a water content of about 2 mg/liter to 1.05 cm/sec for the driest air used. Under similar circumstances the mobility of the *negative ions increased* from 2.08 cm/sec to 2.45 cm/sec. The existence of the two groups of negative ions is ascribed to a difference in size of the ion clusters arising from a difference in constitution at or near their centers.

102. Restriking of short a.c. arcs. F. C. TODD AND T. E. BROWNE, JR., *Westinghouse Elec. and Mfg. Co., East Pittsburgh.*—The restriking after zero current of short a.c. arcs with melting electrodes and of rapidly moving arcs with cold electrodes was investigated with a cathode ray tube of the Braun type. Long exposure photographs and observations of the volt-ampere traces on the fluorescent screen show the effect of the electrode vapor on the magnitude and variation of the restriking voltage. Brass, copper, iron, tungsten, and carbon were used as hot electrodes. The restriking characteristics of rapidly moving cold electrode arcs are influenced by the condition of the electrodes, magnitude of the driving magnetic field, and rate of rise of the voltage after current zero.

103. Extinction of short a.c. arcs between brass electrodes. T. E. BROWNE, JR. AND F. C. TODD, *Westinghouse Elec. and Mfg. Co., East Pittsburgh.*—Results are given which show that the dielectric recovery after current zero of short, stationary, a.c. arcs between brass electrodes is similar to that of cold-electrode arcs previously investigated and described. These results also show that the rate of recovery of dielectric strength of hot-electrode arcs after a current zero may be greatly increased by reducing, within limits, the electrode separation. An explanation is suggested on the basis of ionic diffusion to the electrode surfaces and the deionizing action of blasts of metal vapor from the boiling electrodes.

104. Problems suggested by an uncertainty principle in acoustics. G. W. STEWART, *State University of Iowa.*—At the suggestion of Professor A. Landé the principle adopted is

$\Delta\nu \cdot \Delta t \sim 1$, where ν is the intrinsic frequency of an acoustic signal and Δt is its time duration. Applying this principle one finds that it is consistent with experiments on the change in ν in the vibrato and the failure to detect it by ear, with recorded tests on minimum perceptible differences in frequency, and with the minimal time for tone perception. The problems suggested by the principle are: (1) variations in Δt and $\Delta\nu$ by an artificial vibrato with aural observations of detectable $\Delta\nu$, (2) redetermination of minimum perceptible differences in frequency as dependent upon Δt and (3) an examination of Δt required for tone perception with varied values of $\Delta\nu$ required for so-called tone perception.

105. The dispersion formula and Raman effect for the symmetrical top. MORRIS MUSKAT, *Gulf Research Laboratory Pittsburgh.*—Schroedinger's theory of dispersion is applied to the symmetrical top. The dipole of the top is assumed to lie along the axis of symmetry, and the wave-length of the incident light to be large as compared with the dimensions of the top. An explicit expression is derived for the index of refraction of a gas composed of symmetrical tops, as a function of the frequency of the incident light. As the perturbed eigenfunction is a linear function of only three unperturbed eigenfunctions, the dispersion formula, for a given state, consists of only two terms. The moments for the Raman effect transitions for the symmetrical top are also computed. Simple closed expressions are obtained, again because of the simplicity of the perturbed eigenfunctions. The polarization of the Raman radiations is computed with the result that the unshifted lines are unpolarized, whereas for the shifted lines, $|m_x|^2/|m_x|^2=4/3$.

106. The measurement of the variation in intensity of the helium lines with voltage by means of selected filters and a photoelectric cell. PETER J. MULDER AND JOSEPH RAZEK, *University of Pennsylvania.*—A method has been developed by which the variationsin the intensity of individual spectrum lines can be measured without resolution through a spectroscope, making use of a photoelectric cell and the recording amplifier described by Razek and Mulder as part of their automatic spectrophotometer (other paper, this meeting). This method has its application in the spectrophotometry of weak sources. We have used the method to study the variation of intensity of helium arc lines with voltage. The deflection of the amplifier galvanometer with various filters of known transmission coefficients for the lines to be measured interposed successively in the beam is noted. Assuming that all the energy recorded is limited to n lines, and that n filters are used, n equations soluble for ϕ_s of the form $L_a=a_1\phi_1+a_2\phi_2+\cdots+a_n\phi_n$ can be written, where L_a is the total light intensity as recorded with filter a interposed, $a_1 \cdots a_n$ are the appropriate filter transmission coefficients, and $\phi_1 \cdots \phi_n$ are the intensities of the lines multiplied by a factor depending on the wave-length sensitivety of the cell. To increase accuracy, more filters may be used and a reduction made to n normal equations by Gauss' method. In our work the helium lines were treated in four groups to reduce computation. The results generally checked with those obtained independently by a direct method.

107. The polarization and the electric moment of tung oil. A. A. BLESS, *University of Florida.*—The dielectric constant of a solution of tung oil in benzene of different concentrations was measured for three frequencies 10^6, 4×10^5, 10^5, using an electrical resonance method. The molar polarization of the solutions was calculated by the aid of the Clausius-Mosotti relation. The molar polarization proved to be a linear function of the mole fraction of tung oil, showing that the interaction of the polar molecules is in this case negligible. The polarization of the pure oil was found to be—364 cc, giving an electric moment of 2.195 e.s. units. The values found are substantially the same for each of the three frequencies for which the electric constant was measured.

108. Methods of acoustic interferometry for the measurement of velocity and absorption of sound in gases. J. C. HUBBARD, *Johns Hopkins University.*—In the well known acoustic interferometer of Pierce (Proc. Am. Acad. **60**, 271, 1925) the piezoelectric plate serves at the same time as generator of electric and acoustic oscillations. In order to eliminate the crystal as an essential part of the power circuit and use it only as a source of sound waves, thus to secure greater adaptability to the study of sound velocity and absorption over a range of temperatures and pressures, the writer has applied the method of forced piezoelectric vibrations used in the

sonic interferometer for liquids developed in collaboration with Mr. A. L. Loomis (Phil. Mag. June, 1928; J.O.S.A., Oct. 1928). The audible beat note of two Hartley circuits is adjusted in unison with a tuning fork, one of the circuits being provided with a secondory coil connected to the electrodes of the piezoelectric plate of the interferometer system. Cyclic variation of beat note as the gas column is lengthened is compensated by a vernier condenser in the exciting circuit, from the readings of which the velocity and attenuation of the sound in the gas are deduced. Acknowledgment is made to the Rumford Fund of the American Academy of Arts and Sciences, and to Mr. A. L. Loomis for the use of quartz plates.

109. Independence of x-ray absorption on temperature. J. A. BEARDEN, *Johns Hopkins University.*—Measurements have been reported (Read, Phys. Rev. **27,** 373 and Phys. Rev. **28,** 898) which indicated a change in the absorption coefficient of x-rays with change in temperature of the absorbing screen. Due to the theoretical importance of this effect the measurements have been repeated with much higher precision than was obtained in the previous work. The present method consists in comparing the intensity transmitted by two screens, first with both screens at the same temperature (about 24°C) and then with one screen raised to a higher temperature while the other was retained at 24°C. It can be shown that the percent change due to the expansion of the hot screen should be equal to $2\alpha T\mu\chi$ where αT is the linear expansion of the metal, μ the linear absorption coefficient of the transmitted beam, and χ the thickness of the screen. By making χ and μ large the expected change due to expansion in the present experiments was equal to 10 to 18 percent at 600°C. Measurements with wave-lengths from 0.4A to 1.5A showed no change from the expected change due to expansion.

110. On the heat of formation of molecular oxygen. L. C. COPELAND (*National Research Fellow in Chemistry*) (*Introduced by E. C. Kemble, Harvard University.*)—Molecular oxygen at pressures of 0.1 mm to 0.4 mm has been dissociated by the electrodeless discharge. The percent dissociation in the flowing gas was determined from pressure measurements on the high pressure side of a set of small orifices, using Knudsen's formula. Palladium black freshly deposited on a platinum surface has been shown to cause total recombination. A calorimeter consisting of such a surface fastened to a Beckmann thermometer and calibrating resistance coil with Woods metal was used to measure the energy of recombination. It has also been shown that the palladium black surface, poisoned with mercury vapor, or a shiny platinum surface do not cause total recombination. Several preliminary experiments have been made with about twenty-five percent dissociation at a rate of flow of 0.75 cc per minute.

111. On the mechanism of very absorbable radiation emitted by compressed crystalline substances under high potentials. ISAY A. BALINKIN, *University of Cincinnati* (*Introduced by S. J. M. Allen.*)— Following the work of Reboul, the emission from specially designed "radiating cells" was studied photographically. Powdered alum with the average size of the grains 0.0032 in. was subjected to a pressure of 300 kg/cm^2 in an atmosphere of 55% relative humidity. Under a potential difference of 5000 volts the emission from the cell was completely absorbed by celluloid, $t=0.13$ mm, and only partially absorbed by cellophane, $t=0.02$ mm. This corresponds to a range between very soft x-rays and short ultraviolet. A similar effect on the photographic film can be obtained by passing a spark discharge in an electrostatic field of about 1000 volts per centimeter in which the negative and positive ions are separated and then drawn into a recombination chamber. A Bunsen flame as an ionizing agent under the same circumstances, produces the same effect. The mechanism of the radiation emitted by the "radiating cell" under high potentials is explained by the external recombination of the ions which were produced in the interstices of the compressed crystalline substance. The wave-length of the emitted radiation corresponds to the ionization potentials of oxygen and nitrogen as given by the relation, $h\nu = Ve$. For a value of 14 volts, $\lambda = 900$A which agrees with the results given by the experiment.

112. A 21 ft. vacuum spectrograph for intensity measurements in the Schumann region. GEORGE R. HARRISON, *Stanford University.*—A 21 ft. concave grating ruled by Wood with 15,000 lines per inch and having a very bright first order has been mounted in vacuum for use in the Schumann region. The case consists of a 20 ft. vanadium steel tube of 16 inch internal

diameter, closed with tinned bronze castings. Three oil pumps exhaust this volume of 863 liters to 0.01 mm pressure in two hours; four large steel condensation pumps using n-dibutyl phthalate trapped with CO_2 lower the pressure to less than 10^{-4} mm in three more hours after. 50 hours of outgassing with the pumps off. The camera box holds 4 x 16 inch plates or films, recording at one setting a range of 900A with a dispersion of 2.7A per mm. Thirty exposures to different sources can be made without destroying the vacuum. The instrument, designed particularly for making intensity measurements on multiplets of multiply ionized atoms using the photometric methods developed by Leighton and the author for the Schumann region, has only been used to photograph the region 2200–1300A thus far; the strength of the spectrum indicates that 1000A should be reached without difficulty

113. Photographic record of the first order diffraction of hydrogen atoms by a lithium fluoride crystal. THOMAS H. JOHNSON, *Bartol Research Foundation*—A beam of hydrogen atoms was reflected from a cleaved surface of a crystal of lithium fluoride at an angle of incidence of 30°. The plane of incidence made an angle of 45° with the cleavage edges of the crystal. In addition to the specularly reflected beam, first order beams appeared on the MoO_{13} detecting plates having the positions calculated from the wave-length $\lambda = h/mv$ and from the grating spacing of the rows of similar ions.

114. Double crystal spectra of scattered x-rays. NEWELL S. GINGRICH, *University of Chicago.*—To get high scattered intensity, two molydenum metal x-ray tubes of small diameter were used with a graphite scattering block between them. A total current of 95 m.a. at 50 k.v. was used. The effective scattering angle was about 109 degrees. Successive spectra taken in the neighborhood of the $K\alpha$ lines are not identical, since the experimental error is relatively large when measuring weak ionization currents. Nevertheless it can be said from the spectra obtained that the intensity of any fine structure line in the unmodified spectrum is probably not greater than 10 or 15 percent that of the $K\alpha$ line. The spectrum of the modified $K\alpha$ lines is observed at the position calculated from the equation $\delta\lambda = 0.0243\ (1-\cos\phi)A$. No evidence is found of fine structure lines in the modified spectrum as reported by Davis and Purks.