PROCEEDINGS
of the
AMERICAN PHYSICAL SOCIETY

MINUTES OF CAMBRIDGE MEETING, FEBRUARY 25–27, 1932

The 176th regular meeting of the American Physical Society was held in Cambridge, Massachusetts, on Thursday, Friday and Saturday, February 25, 26 and 27, 1932, as a joint meeting with the Optical Society of America. The presiding officers at the regular session of the Physical Society were Dr. W. F. G. Swann, President of the Society, Professors L. W. McKeehan and Leigh Page. All sessions on Thursday were held at the Massachusetts Institute of Technology and on Friday and Saturday at Harvard University.

The joint sessions with the Optical Society on Thursday morning consisted of informal conferences on "Electron Emission and Surface Conditions"; "Perturbation Effects in Spectra"; "Demonstration and Discussion of Mechanical Aids to the Solution of Equations"; and "X-ray and Photomicrographic Studies in Metallurgy". On Thursday afternoon there was a joint session, presided over by Dr. W. F. G. Swann, and a symposium on "Properties of Matter". The invited papers were on "Interferometric Measurements of Single Molecules" by Professor P. Debye of the University of Leipzig; "Crystal Structure of the Silicates" by Dr. B. E. Warren of the Massachusetts Institute of Technology; and "Molecular Shape and Orientation in Liquids" by Professor C. P. Smyth of Princeton University. There were in addition three contributed papers on this program. (See abstracts 21, 22, 23.) At noon the members of the two Societies and their friends were luncheon guests of the Institute of Technology. About 180 were present. In the evening a public lecture, under the auspices of the American Institute of Physics, was delivered by Professor Henry Norris Russell of Princeton University, on "Revealing the Universe through the Spectroscope". Dr. K. T. Compton presided at this meeting with about 400 in attendance.

Thursday's meetings marked the official opening of the Institute's new and remarkably planned and equipped Spectroscopy Laboratory.

On Friday and Saturday the sessions were held at Harvard University, offering an opportunity to inspect the recently enlarged and improved facilities in the Jefferson and Cruft Laboratories.

On Friday morning the sessions were devoted to the reading of contributed papers. At noon the members of the two Societies and their friends were the luncheon guests of the University at Leverett House, one of the recently built residence houses for undergraduates. On Friday afternoon the two Societies convened in New Lecture Hall on Oxford Street for a symposium of invited papers on "Electronic Devices and their Applications to

Research with Special Reference to Radiation Sensitive Devices". The papers were "Electronic Devices as Aids to Research" by A. W. Hull of the General Electric Company; "Some Practical Applications of Electronic Devices" by N. Rashevsky of the Westinghouse Electric and Manufacturing Company; and "Special Tubes for the Amplification of Small Voltages" by G. F. Metcalf of the General Electric Company. Professor E. L. Chaffee of Harvard University arranged the program and presided at the meetings.

On Friday evening the Society joined with the Optical Society for dinner at the Parker House. Dr. E. C. Crittenden, President of the Optical Society, presided. Professor George B. Pegram, on behalf of the Optical Society, made the formal presentation of the Frederic Ives Medal to Professor Theodore Lyman, who then responded with an expression of his appreciation of the honor conferred upon him. The other after dinner speakers were K. T. Compton, H. A. Barton and W. F. G. Swann. On motion of F. W. Loomis a unanimous rising vote of thanks was extended to the hosts at the Institute and at Harvard University for the exceptionally fine and complete arrangements made for the comfort and enjoyment of the members and friends of the two Societies in attendance.

On Saturday morning, after short sessions for the reading of contributed papers, the two Societies joined in Room 110, Pierce Hall for a lecture by Professor P. W. Bridgman of Harvard University on "Anomalies in the Behavior of Solids under Pressure". Dr. E. C. Crittenden presided.

Throughout the three days there was provided a very interesting "Program for Visiting Ladies".

Meeting of the Council. At its meeting on Thursday, February 25, 1932, the Council received a request from members of the Society in New England for the formation of a "New England Section of the American Physical Society". A proposed constitution for the Section was also presented, favorably received and referred to the Committee on Modification of the Constitution for consideration. This is the first request for the formation of a local section in accord with the constitutional modification adopted at the New Orleans meeting.

The Treasurer reported that there was received on January 20th from the Treasurer of the National Academy of Sciences a check for $1200 being a grant to aid the Society in meeting the increased cost of Science Abstracts for the year 1931 in continuation of an earlier grant for the same purpose.

The Council elected one person to fellowship. Twenty-nine persons were elected to membership. *Elected to fellowship:* Cornelius Lanczos. *Elected to membership:* H. A. Abramson, Edgar T. S. Applegard, Lester F. Borchardt, John H. Clements, M. Estes Cocke, Harold E. Edgerton, Wolfgang Finkelnburg, R. A. Fisher, Charles K. Hayden, Emerson W. Kern, Raymond I. Lawley, C. Anthony McCane, Eugene McDermott, G. M. Murphy, Oscar Norgorden, Donald N. Read, Howard A. Robinson, Louis C. Roess, Nathan Rosen, Arthur E. Schuh, Frederick Seitz, Jr., Theodore E. Sterne, Wendell B. Steward, Everett W. Thatcher, Agnes Townsend, S. M. Troxel, Yuching Tu, Charles W. Ufford and Bruce B. Vance.

The titles and abstracts of papers presented before the Optical Society of America will be found in the Proceedings of that Society, published in the Journal of the Optical Society.

The regular scientific program of the American Physical Society consisted of 64 papers. Numbers 9, 24, 39, 50, 51, 53, 55, 56, 60 and 63 were read by title. The abstracts of these papers are given in the following pages. An *Author Index* will be found at the end.

W. L. SEVERINGHAUS, Secretary

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ABSTRACTS

1. Dielectric losses in rocksalt. P. L. BAYLEY, *Lehigh University.*—The dielectric constant and the phase angle for rocksalt have been measured over a range from 1 to 1000 kilocycles per second. The sample was $60\times70\times0.9$ mm, was exceptionally transparent, and was free from any visible flaw. Mercury electrodes of 20.2 cm^2 were used, making a capacity of 125.1 mmf. Very slight traces of surface moisture or surface impurities cause large changes in the power loss but no change in the capacity. Traces of organic impurities on the surface may produce a peak in the power factor curve at a certain frequency, giving an apparent dipole effect. The sample when thoroughly dry and clean had, throughout the frequency range, a power factor of less than 0.0001 and probably of the order of 0.00001. The dielectric constant was 6.3. Neither the capacity nor the power factor was appreciably changed by a 3 hour exposure to strong x-rays or by intense coloration by cathode rays from a Coolidge tube.

2. The Joule magnetostrictive effect in a series of cobalt-iron rods. S. R. WILLIAMS, *Amherst College.*—The magnetostrictive oscillators of Pierce (Proc. Amer. Acad. Sci. **63,** 1 (1928)) have brought out the fact that the phenomena of magnetostriction may still have some practical significance, even if Arstall's (Phil. Mag. **30,** 76 (1847)) idea of a reciprocating engine, based on the come and go of a rod changing its length in a varying magnetic field, did not materialize. In some measure the value of magnetostrictive oscillators depends upon the magnitude of the Joule effect. A series of cobalt-iron rods have been studied in this paper in order to see how the static magnetostrictive Joule effect varies with increasing amounts of cobalt in a series of cobalt-iron alloys. Later the dynamic magnetostrictive effects will be studied and compared with the static effects. This study shows that cobalt-iron alloys have a very much larger magnetostrictive effect than does nickel.

3. Temperature changes accompanying magnetization in nickel. AGNES TOWNSEND, *Columbia University.*—The object of this experiment is to determine the relation between temperature and magnetic field intensity in a specimen of polycrystalline nickel during a single cycle of magnetization. The method used is that described by Ellwood (Phys. Rev. **36,** 1066, (1930)). The ellipsoidal test specimen is composed of 104 hard drawn nickel rods of 1mm diameter. The purity of the nickel is indicated by the following analysis: Cu 0.07; Fe 0.18; Mn 0.044; Si 0.21; C 0.065; Ni 99.42. The following is typical of the behavior of this material. On reducing the magnetic field intensity in successive steps from 230 gauss, the temperature increases gradually and then more rapidly until the knee of the hysteresis curve is turned, after which the temperature decreases sharply and then more gradually until the initial magnetization is completely reversed. Thus the H-T curve has a cusp in region in which the intensity of magnetization in changing most rapidly. The temperature at this point is four times the final rise in temperature for the half cycle. The sharp minimum near $J=0$ observed by Ellwood in carbon steel is entirely absent in the nickel.

4. On the ultra high-frequency oscillation of the magnetostatic vacuum tube. W. DEHLINGER, *Westinghouse Elec. & Mfg. Co., East Pittsburgh.*—A physical picture of the phenomena during the electronic oscillation in the magnetostatic oscillator is given. The notion of a critical radius for plate voltages varying between a larger and a smaller value than the critical voltage for a given constant magnetic field is developed. The value of the critical radius is calculated as a function of the voltage differences and the potential distribution. The flying time of the electrons is discussed in its relation to the voltage distribution, and the falling angle is expressed in a simple way.

5. The converse piezoelectric effect in mixed crystals isomorphous with Rochelle salt. S. Bloomenthal, *Research Division, RCA Victor Co., Inc. Camden, N.J.*—The temperature dependence of the piezoelectric strain constant d_{14} was investigated as a function of the amount of $C_4H_4O_6NaK\cdot 4H_2O$ in mixed crystals isomorphous with Rochelle salt. Crystals oriented for utilization of the predictions of the Voigt theory for the converse piezoelectric effect in the hemihedral class of the orthorhombic system were grown at constant temperature from supersaturated solutions of Rochelle salt containing known quantities of isomorphous impurity $C_4H_4O_6NaNH_4\cdot 4H_2O$ or $C_4H_4O_6NaTl\cdot 4H_2O$ and measurements of d_{14} were made in the range 10° to 35°C. Below a critical temperature Θ_m, d_{14} is of the order 5×10^{-4}. At Θ_m, d_{14} decreases to about 10^{-5} and diminishes further as the temperature increases. For crystals containing small quantities of impurity (1 percent or less) observed critical temperatures agree approximately with those given by

$$\Theta_m = \frac{p}{p + \dfrac{Mp_1}{M_1}}\Theta,$$

a formula which one derives on the basis of the dipole theory, assuming that the molecular field constant for the mixed crystal equals that for pure Rochelle salt multiplied by the Rochelle salt fraction of the total number of molecules present. Θ is the critical temperature for pure Rochelle salt, $(273+25)$°K. M_1 and p_1 are the molecular weight and percentage by weight of impurity; M and p those of pure Rochelle salt.

6. The depth of origin of photoelectrons. Herbert E. Ives and H. B. Briggs, *Bell Telephone Laboratories.*—Previous work (Phys. Rev. **38,** 1477 (1931)) showed that the photoelectrons from a silver plate covered with an equilibrium film of alkali metal follow the wavelength distribution of energy just above the silver surface, i.e., in the alkali metal. This question has been further investigated with particular reference to alkali metal films in their early stages of development, where their average depth is less than one atom. Just above a silver surface the energy exhibits a deep minimum at 3260A for light polarized with the electric vector in the plane of incidence. This minimum is absent from the calculated bulk or surface absorption of silver. If the function of the alkali metal film in its early stages is merely to facilitate the escape of electrons from the silver it may be expected that the minimum of emission previously found will be missing for sparsely covered silver. Experimental test, made with sodium films from their earliest measurable state throughout their whole development history always shows the minimum at 3260A. It is concluded that the majority of the photoelectrons originate under all conditions in the alkali metal films. In the very thinnest films there is some indication of emission ascribable to the silver plate.

7. On thermal electronic agitation in conductors. N. H. Williams, *University of Michigan, and* E. W. Thatcher, *Union College.*—Statistical variations in charge density within a conductor result in the establishment of minute fluctuating potential differences between its terminals. A measurement of these fluctuations has been made the basis of an independent determination of Boltzmann's constant, k, by Johnson (Phys. Rev. **32,** 97 (1928)). Adaption of methods used in certain phases of work in shot effect has thrown further light on the problem, and has provided some improvements in technique. Consideration of the response characteristics of the amplifier is eliminated in the present work. As a coupling stage, use has been made of the FP-54 pliotron which is capable of operation with an input resistance in excess of 10^{14} ohms. Pure thermal fluctuations have been investigated in three classes of conductors (1) metal wires, (2) sputtered metal films, (3) dried films of a suspension of carbon in suitable binder. With the first linear dependence of the mean square voltage fluctuation on resistance has been established. From these data, values of k have been computed with a mean value of

1.378×10^{-16} erg deg.$^{-1}$. (2) and (3) have shown fluctuation levels which without exception fall *below* those indicated by theory for high values of resistance. Of the same three classes, only the last exhibited additional fluctuations due to random changes in resistance when carrying a current.

8. Total secondary emission of electrons from metals as a function of primary energy. Paul L. Copeland, *Massachusetts Institute of Technology.*—The ratio (R) of the total number of electrons leaving a target to the number incident upon it has been studied as a function of the energy of the incident electrons. The results obtained for different metals are similar in their general aspects. The ratio (R) is very low for small primary velocities and increases very nearly linearly with the energy of the incident electrons; it reaches a broad maximum at a position characteristic of the metal, and then declines almost linearly with further increase in the energy of incidence. A comparison of the results obtained for different metals seems to indicate that this decline of secondary emission at high energies for the incident electrons is related to the density of the target. If the decline of the ratio (ΔR) beyond the maximum is divided by the corresponding increase in potential (ΔV) times the absolute value of the ratio (R), the resulting quantity ($\Delta R/R\Delta V$) for the various targets may be plotted against the density of the targets to give a fairly linear graph.

9. Radiation from caesium bombarded by slow speed electrons. C. Boeckner, *Bureau of Standards, Washington, D.C.*—A small electrode (Langmuir probe) positive to the surrounding space in a gas discharge draws very intense currents of slow speed electrons. A probe under such bombardment is found to emit visible and ultraviolet radiation having a continuous spectrum. (F. L. Mohler and C. Boeckner, B. S. Jour. Research, **7**, 751 (1931)). A method has been devised for condensing caesium vapor upon a probe surface in a caesium discharge, thus making it possible to study the radiation from this metal when bombarded by slow electrons. The method insures that the caesium surface be very clean. It is found that the radiation emitted is closely similar in intensity and spectral intensity distribution to that from other metals used as probes. The very large atomic volume of caesium and the small spread of energies of its free electrons renders this fact of interest in connection with the theory of the effect.

10. The positive column of a caesium discharge. F. L. Mohler, *Bureau of Standards.*—Probe measurements of the electrical characteristics and thermopile measurements of the radiation have been made for a positive column in a tube 1.9 cm in diameter. Vapor pressures ranged from 0.001 to 0.024 mm and discharge currents from 0.15 to 1 ampere. The energy input, as given by the voltage gradient times the current, ranged from 0.1 to 0.3 watts per cm. The fraction of this energy accounted for by the flow of ions to the tube walls increased with the current from 0.034 to 0.235 at 0.003 mm pressure. As nearly the complete caesium spectrum is transmitted by glass, direct measurements give the total radiation. The evidence is that nearly all of the energy not accounted for by the flow of ions to the walls is radiated. Experimental results show a nearly constant efficiency of 0.94 with a mean error of 0.04 not including the calibration error which may be greater than this.

11. Some spectrographic studies of negative point discharges at low pressures. Willi M. Cohn. *A. D. Little, Inc. Cambridge, Mass.*—It is shown that negative point discharges may be maintained to as low a pressure as 10^{-4} mm Hg. The spectrum of the discharges at 10^{-4} mm Hg is continuous, with a few bands and lines from the gas content of the tube indicated. The maximum of the continuous spectrum is found photographically at 4600A, the spectrum can be traced from 6200 to 2150A. With increasing pressure in the tube, bands and lines from the gas and vapor contents of the tube appear with increasing intensity. The intensity distribution of the continuous spectrum of point discharges is similar to that of the continuous spectra caused by electron bombardment of gases, vapors and solid bodies. It is assumed that the continuous spectra are excited in the same way in both cases.

12. Notes on the luminescence of glass, fluorite and quartz. Theodore Lyman, *Harvard University.*—In the first part of this paper a simple method for showing the relation between the absorption of light and the resulting luminescence in glass is described The second part contains some observations on the luminescence of fluorite and of quartz in the extreme ultraviolet. This luminescence seems to consist of two parts. In the first place, there is a broad band extending from the neighborhood of 2450A to 3810A. Secondly, there are sharp lines at 3812, 3144 and 3133.

13. The g-value of the normal state of Bi I. R. F. BACHER, *National Research Fellow.* JOHN WULFF, *Massachusetts Institute of Technology.*—The hyperfine structure of the strongest line of the bismuth arc spectrum (λ3067, $6p^3\,{}^4S^0{}_{1\,1/2}-1_{1/2}$) has been studied with the 21 foot Tuebingen grating with an applied magnetic field of 43350 gauss and also without field. Photographs were obtained in both cases showing the pattern without reversal. A comparison of the result with the theory of the Zeeman effect for hyperfine structure permitted an accurate determination of the g-value of the normal state of bismuth as $g=1.65(4)$. This value shows a large deviation from that expected for a normal ${}^4S_{1\,1/2}$ state ($g=2$) due to the intermediate coupling of the three p electrons. The value of g for the normal state, as found here, is in disagreement with the value found from the Stern-Gerlach experiment, $g=1.45$.

14. Dispersion of oxygen in the ultraviolet. R. LADENBURG AND G. WOLFSOHN, *Kaiser Wilhelm Inst. f. physik. Chemie, Berlin-Dahlem.*—Dispersion measurements in O_2 between 6000 and 1920A made with a special fluorite interferometer can be represented with good accuracy by the usual dispersion formula with only two resonance wave-lengths $\lambda_1=1470$ and $\lambda_2=550$A, the corresponding f-values being 0.2 and 5.9 respectively. These wave-lengths are to be considered as centers of gravity of two regions of absorption, the Schumann band system and another much stronger band system in the far ultraviolet. It follows, furthermore, from the dispersion measurements that the discontinuous part of the Schumann band system is very much weaker than the continuous part, a result which coincides with direct absorption measurements of O_2 in the Schumann region and also with calculations of the potential energy-curves of O_2.

15. Perturbed series in line spectra, A. G. SHENSTONE, *Princeton University.*—There occur many line series in atomic spectra which do not even approximately fit a Ritz formula. They display either a sudden rise in the value of n^*-n towards high term values or a gradual fall of almost a unit. The latter type contains an extra term due to some other structure and becomes similar to the first type after the removal of that term. All such series obey approximately a series formula of type $\nu_n=R/n^{*2}$ in which $n^*=n+\mu+\alpha\nu_n+\beta/\nu_n-\nu_0$ (Langer, Phys. Rev. **35**, 649 (1930)) and ν_0 is the wave number of some level of the same type not strictly belonging to the series. The constant β is always negative and the terms therefore appear to repel each other. It is interesting theoretically that a perturbation does not always occur when it is expected. The phenomenon of auto-ionization is closely related to the series perturbation problem, the position of the perturbing level determining alone which of the two will occur.

16. The structure of the third positive group of CO-bands. G. H. DIEKE AND J. W. MAUCHLY, *The Johns Hopkins University.*—The bands were photographed in the second and third order of a 21 foot concave grating with 20,000 lines per inch. So far the bands $0\rightarrow0$ to $0\rightarrow4$ with heads at λ2833, 2977, 3134, 3305 and 3493A were studied. The bands are due to a ${}^3\Sigma\rightarrow{}^3\Pi$ transition. The triplet separation of the ${}^3\Sigma$ state is unnoticeable for $f<20$. Under these conditions we must expect 15 branches if the resultant spin is not yet completely coupled to the rotational axis. (Transition from case a to case b.) We found 13 of these branches and traces of the remaining two which are too faint to be observed among the strong main branches. The five heads which are characteristic for the bands under low dispersion are the heads of the $O_3-O_2-P_3-P_2-P_1$ branches. (In the simplified notation of case b). The initial level shows very strong perturbations from about $K=16$ on, and slight irregularities even for very small K values. The moment of inertia for the final state is $16.5\cdot10^{-40}$, and for the initial state approximately $14.3\cdot10^{-40}$. The character of the λ-doubling and the number of missing lines near the origin identifies the final electronic state as a regular ${}^3\Pi$ state. Our results are not in agreement with the analysis of Asundi (Proc. Roy. Soc. **A124**, 277, 1929) who classified these bands at ${}^5\Sigma\rightarrow{}^5\Pi$ transitions.

17. The absorption and dispersion of celluloid between 300A and 1000A. H. M. O'BRYAN, *Massachusetts Institute of Technology.*—A sample of celluloid has been studied in the region from 300A to 1000A in a vacuum spectrograph with a "hot spark" source. Direct measurements of absorption by celluloid films weighing from 10^{-6} to 10^{-5} grams per cm^2 show no appreciable deviations from the expression

$$I = I_0{}^{-\mu\rho t}.$$

The maximum value of μ is 7×10^5 and occurs at 800A. A film weighing 2×10^{-6} grams per cm^2 transmits 55 percent at 300A and 40 percent at 1000A. Reflection measurements from celluloid mirrors on glass permit the calculation of both μ and the refractive index. The values of μ obtained by this method agree with those obtained by direct measurement of absorption. The refractive index passes through unity at about 800A becoming less than one for shorter wave lengths. Values of μ at intervals of 100A show only one broad absorption band in this region. These values are several times greater than those given by Holweck, ("De la lumiere aux rayons X, page 69) who gives the maximum absorption at 300A.

18. **Interferometric measurements on single molecules.** P. Debye, *University of Leipzig.*

19. **Crystal structure of the silicates.** B. E. Warren, *Massachusetts Institute of Technology.*

20. **Molecular shape and orientation in liquids.** C. P. Smyth, *Princeton University.*

21. **Diffraction of electrons by metal surfaces.** C. J. Davisson and L. H. Germer, *Bell Telephone Laboratories, New York City.*—We have directed beams of electrons upon etched metal surfaces at angles averaging two degrees from grazing (G. P. Thomson method). Scattered electrons are photographed and the diffraction patterns studied. Diffraction patterns have been obtained from polycrystalline gold, tungsten, molybdenum, cobalt, nickel, chromium and platinum, and from single crystals of nickel and tungsten. Electron speeds correspond to voltages from 13,000 to 55,000. The metals gold, tungsten, molybdenum, and cobalt give Debye-Scherrer rings characteristic of the known structures of the metals. About 20 rings are usually found. Nickel gives simultaneously rings of Ni and Ni O. Chromium etched in dilute HCl gives hexagonal chromium rings. After re-etching in warm concentrated HCl the pattern consists only of spots. Their radial distances are not inconsistent with the rhombohedral structure of $CrCl_3$ (large crystals). The nickel crystal gives two orders of Bragg reflection from the (111) surface planes. The tungsten crystal gives four orders of Bragg reflection from the (110) surface planes. Re-etching produced, in addition, five orders of Bragg reflection from planes of unknown origin spaced at 2.97A. After standing in air a month the pattern consisted only of fifteen small rings which indicate a body centered cubic structure of constant 7.4A.

22. **Dielectric losses in insulating materials.** Hubert H. Race, *General Electric Co., Schenectady.*—In order to study the causes of dielectric loss in insulating materials, capacitance factor (dielectric constant) and loss factor for representative liquid and solid insulators have been measured at frequencies between 15 and 2,000,000 cycles per second and at temperatures between 30° and 150°C. Observed changes in capacitance and loss in liquids and solids are apparently explained by assuming three physical mechanisms, namely, (a) orientation of polar particles in a viscous medium, (b) translation of charged particles either for relatively long distances as at low frequencies in a liquid, or for very short distances as at high frequencies in a liquid or within the cells of a solid, (c) formation of space charges at the electrodes. The physical conditions determine which mechanism is predominant. For example in the same oil (a) may be predominant at low temperature (high viscosity) and high frequency while (b) is most important at high temperature and low frequency. In an attempt to check the theory that the variations observed in certain solids result from conduction in restricted paths, capacitance and loss measurements have been made on fused quartz tubes in which liquids of differing conductivities had been sealed. Similar measurements on certain partially cured synthetic resins have shown very large increases in both capacitance and loss with increasing temperature and decreasing frequency. It appears that these changes are also explainable on the basis of mechanism (b) and they indicate the causes of similar effects which are found on a very much smaller scale after the resins have been cured.

23. The mosaic structure of cobalt crystals. FRANCIS BITTER, *Westinghouse Research Laboratories, East Pittsburgh.*—Since making a preliminary report on the detection of magnetic inhomogeneities by means of magnetic powders, (Phys. Rev. **38**, 1903 (1931)) cobalt, having a hexagonal lattice, has been produced in slabs with large grains and a shiny smooth surface. Very distinct deposits were obtained on these samples before they were magnetized. The patterns may be classified into two types; first, a series of parallel straight lines roughly similar to those found in nickel and iron; and second, a deposit which divides the metal into regions of various sizes (roughly from 0.1 to 0.01 mm in diameter) more or less regularly arranged at the corners of adjacent hexagons. The general aspect of this latter type of pattern resembles a delicate lace-work. When the samples are magnetized this breaks up into a series of parallel lines, which are in general not quite straight. Until conclusive experimental verification is available, it seems reasonable to assume that these two types of deposits occur on grains whose hexagonal axes are in and normal to the surface respectively. These results furnish direct experimental verification of the existence of a block structure, as predicted by Zwicky.

24. The mathematical theory of Chladni plates. R. C. COLWELL, *West Virginia University.*—By a slight modification of Ritz' theory for a square plate, it is possible to express many of the nodal lines with the formula

$$A \cos\frac{m\pi x}{a}\cos\frac{n\pi y}{a} + B\cos\frac{n\pi x}{a}\cos\frac{m\pi y}{a} = 0.$$

From this formula, we can deduce several theorems of general interest. There are three cases for $A = B$. First, when m and n are both even, the plate breaks up into four equal squares each of which has the constant $m' = m/2$, $n' = n/2$. Second, when m and n are both odd, there are always two perpendicular nodal lines through the center of the plate; these divide the plate into four equal squares, all of which have similar vibrations: they must be determined ab origine and are not related to lower values for m and n as in the first case. Third, when m is odd and n even (or vice versa) one diagonal is always a nodal line. In this case $A = -B$ is a mirror image of the curve $A = B$. If m and n are kept constant while A and B are varied, the curves originally symmetrical for $A = B$ change into other forms. All of these can be obtained by substituting the proper values for A, B, m and n in the general equation.

25. The theory of acoustic filtration in solid rods. R. B. LINDSAY AND F. E. WHITE, *Brown University.*—The transmission of sound through a long solid bar loaded at equal intervals with equal heavy masses is treated by a method analogous to the so-called "branch transmission" theory of acoustic filtration in air (W. P. Mason, Bell System Technical Journal **6**, 258 (1927), see also Stewart and Lindsay: "Acoustics," p. 334 ff.). The masses are assumed to be so concentrated that they move as a whole and longitudinal motions alone are considered. Transmission bands are found for those frequencies such that $-1 \leqq \cos 2kl - km/2\rho_0 S \cdot \sin 2kl \leqq 1$, where $k = 2\pi\nu/c$ (ν being the frequency and c the velocity of sound in the rod), m the mass of the concentrated load, S its effective cross section normal to the rod, ρ_0 the density of the rod material and $2l$ the distance between consecutive loads. The loaded rod acts effectively like a low-pass filter with cut-off frequency given by the transcendental equation: $m/2\rho_0 Sl = 1/kl \cdot \cot kl$. To illustrate: for a steel rod with $m = 1$ kg, $S = \pi$ cm^2 and $2l = 20$ cm, the cut-off appears at about 5200 cycles. The next transmission band does not appear until about $\nu = 12{,}000$ cycles. As the loading mass is increased, other things being equal, the cut-off frequency is decreased. Moreover for constant m, increasing l decreases this frequency. Thus in the illustration mentioned doubling l produces a decrease in the cut-off frequency of approximately 35 percent. These results are in qualitative agreement with the experiments of G. W. Stewart and his students (cf. "Acoustics," p. 186). Further calculations indicate the theoretical possibility of high-pass filters by replacing the loading masses with appropriate attachments.

26. Sound velocity in reacting mixtures of real gases. DAVID G. C. LUCK, *Massachusetts Institute of Technology. (Introduced by John C. Slater).*—Einstein's calculation of frequency dependence of sound velocity in reacting mixtures of acoustically transparent ideal gases is extended to the case of real, absorbing gases. The new results differ only slightly from the old in form. Their relation to experimental technique is considered, in connection with the determination of reaction rates.

27. New terms in the energy level formula of a rotating vibrator. J. L. DUNHAM, *Harvard University.*—A detailed calculation has been made of the energy levels of a general type of rotating vibrator as predicted by the quantum mechanics and new terms have been found which are of importance in the interpretation of the spectra of hydride and helium molecules. The new terms slightly alter the coefficients which are already known, e.g. they add a correction to the coefficient of $(v+\frac{1}{2})$ in the energy level formula so that it is no longer simply ω_e. Similarly it is found that B_e is not exactly the coefficient of $K(K+1)$ etc. The corrections are negligible except in molecules for which the ratio of B_e to ω_e is comparatively large (i.e., hydrides and helium) in which case they are appreciable though small. The corrections to ω_e, $\omega_e x$, B_e, α_e and D_e have been calculated and prove to depend on some of the finer details of the nuclear potential function. Methods for applying them to numerical cases are being developed.

28. The exchange of translational and vibrational energy in gas reactions. O. K. RICE, *Harvard University.*—The rate constants for many unimolecular gas reactions decrease at low pressures, as the number of activating collisions diminishes. In a number of decompositions of organic compounds addition of sufficient hydrogen restores the rate constant to its high pressure value, the hydrogen apparently being able to cause activation. However, helium and gases like carbon dioxide, consisting of relatively heavy atoms, do not have this effect. In order to gain a better understanding of these phenomena, calculations have been made of the probability of exchange of energy between the colliding molecule (hydrogen, for example) and the oscillators in the decomposing molecule. This has been done by use of a simplified model, following the work of Zener (Phys. Rev. **37**, 556 (1931)), with some refinements in the calculations. It appears from these calculations that hydrogen should exchange energy with the organic molecules with a reasonably large probability, and that the tendency of the other gases to exchange energy should be less; but it seems that the theoretical difference between hydrogen and helium is not quite sufficient to account for the actual difference in their abilities to cause activation. All the gases tend to exchange energy with the carbon-carbon vibrations (which involves less energy at each exchange) with greater probability than with the carbon-hydrogen vibrations of the organic molecule, the difference being least in the case of hydrogen.

29. Elastic reflection of atoms form crystals. CLARENCE ZENER, *National Research Fellow, Princeton University.*—In the classical theory all collisions of atoms with a crystal are inelastic. However, the quantum theory shows the number of elastic reflections to be finite. An approximate calculation gives the fraction of collisions in which all the quantum states of the crystal remain unaltered to be

$$\exp\left\{-3\pi^2(m_1/m_2)(t_1/\Theta)^2(t_2/\Theta)/(1+4\pi d/\lambda)\right\}.$$

m_1, m_2 are the masses, and t_1, t_2 are the temperatures, of the free atoms and the lattice atoms, respectively. Θ is the characteristic temperature of the crystal. λ is the wave-length of the free atom. The constant d is the distance in which the repulsive potential of free atom and lattice decreases to one e'th its value.

30. Analytic atomic wave functions. J. C. SLATER, *Massachusetts Institute of Technology.*—Good analytic approximations to Hartree's atomic wave functions would be of great value, for all cases where these functions are to be used for further computation. The writer has used an approximation $r^n e^{-(Z-s)r/n}$, where n is the quantum number, Z the nuclear charge, s a screening constant, but this function takes no account of the nodes. The hydrogen-like function $e^{-(Z-s)r/n}(r^n - a_1 r^{n-1} \cdots \pm a_{n-l+1} r^{l+1})$ has nodes, but not in the right places. It is found, however, that a sum $\sum_{k=l+1}^{n} A_k r^k e^{-c_k r}$, differing from the hydrogen-like function by using a different exponential for each term of the polynomial, is capable of representing the true wave function to a considerable degree of accuracy. The best way to find the constants seems to be to fit Hartree's curves, where those have been computed. A sample computation for Rb^+ has been worked out. The resulting functions are almost orthogonal, and can be made exactly so by small change of the constants, without seriously impairing their agreement with Hartree's values. For more accurate purposes, we could use these orthogonal functions, and expand Hartree's functions in terms of this orthogonal set, the expansion converging very rapidly.

31. Wave functions for many electron atoms. L. A. YOUNG, *Massachusetts Institute of Technology.* (*Introduced by John C. Slater*).—Screening constants as function of atomic number are obtained by a simple variational method. The resulting single electron wave functions have considerable flexibility, being of the form (see abstract by J. C. Slater)

$$u_{n,l}(r) = \sum_{k=l+1}^{n} A_k r^k e^{-\alpha_k r/n}$$

the A_k being determined by requiring that these functions be orthogonal. The α_k are determined by maximizing the total energy operator with respect to these functions, neglecting exchange. The α_k are written as $Z-S_k$ and the S_k, called "screening constants," may be compactly tabulated for various configurations. Hartree's single electron functions may be expanded as a series in these functions, the expansion coefficients being determined by variational methods, although it is possible to bring electron exchange into the problem in such a way that the results obtained will be essentially those given by Fock's modification of Hartree's method.

32. The spin-orbit interaction for many electron configurations. M. H. JOHNSON, JR., *Harvard University.*—The method of treating the spin-orbit interaction for two electron configurations (Phys. Rev. **38**, 1628 (1931)) is extended to apply to configurations containing any number of electrons. One starts with all the angular momentum vectors uncoupled. These vectors are then coupled together in any prescribed order to give a resultant $\boldsymbol{L}$ and a resultant S for the whole atom. At each step in the coupling process the matrix components of $\boldsymbol{l}_k$ and s_k are determined by the formulas given on pages 1633–4 of the above reference (the quantum numbers L, S and J are, of course, replaced by the quantum numbers of the vectors being coupled together). The final coupling of $\boldsymbol{L}$ and $\boldsymbol{S}$ to give $\boldsymbol{J}$ yields the formulas for $\boldsymbol{l}_k \cdot \boldsymbol{s}_k$ given on page 1635 of the above reference with $l_{k}{}_{L'S}^{LS}$ and $s_{k}{}_{LS'}^{LS}$ replaced by the more general quantities as calculated above. Knowing the electrostatic energy matrix, one readily obtains secular equations for the configuration under consideration. The method does not give correct results for a group of *more* than two *equivalent* electrons. This indicates a general failure of vector model conceptions as applied to the individuals in a group of equivalent electrons due to the symmetrization required by the Pauli principle.

33. A remark on Gamow's treatment of radioactive disintegration. G. BREIT, *New York University.*—Objections have been made from time to time to the use of complex energies in Gamow's treatment. For the special case of rectangular potential walls d'Atkinson has given arguments in favor of the method. It is now shown by a simple calculation that independently of the shape of the potential wall it is possible to form a wave-package satisfying standard boundary conditions and resembling the complex energy solution very closely. The energies entering the composition of the wave-package lie within a narrow band the center of which is the real part of Gamow's complex energy. The half value breadth ΔE of the band is related to the disintegration constant λ by $\Delta E = \lambda h/2\pi$. Inside the nucleus the solution is practically identical with Gamow's. Initially $(t=0)$ the wave-package vanishes outside. At the time t the wave-function is very small at distances $> tv$ where v is the group velocity corresponding to the center of the energy band. It vanishes at infinity. For distances $< tv$ the solution is nearly the same as Gamow's. The essential point is that our solution satisfies the standard boundary conditions; it is normalized and represents particles in the finite region of space. Gamow's method is thus justifiable as a means of finding the probable energies and the disintegration constant.

34. Relativity and the uncertainty principle. N. ROSEN AND M. S. VALLARTA, *Massachusetts Institute of Technology.*—A simple ideal experiment to measure simultaneously the position and the momentum of a free electron, also its kinetic energy and the instant when this kinetic energy is measured, taking into account the finite velocity of propagation of light as embodied in the Lorentz transformation, is proposed. This experiment is as follows: an observer sends out a photon which strikes a given free electron and returns along its own track. From measurements made on the outgoing and returning light the required quantities, and the uncertainties in their measurement, are calculated. In the absence of detailed knowledge of the nature of the interaction between photon and electron, it is found that for any initial electronic velocity between O and c, $\Delta p\Delta x$ and $\Delta E\Delta t$ have an upper and a lower bound which are functions of the outgoing frequency and always enclose a value of $\Delta p\Delta x$ (or $\Delta E\Delta t$) of the order of magnitude of h. These bounds come close together for low frequencies and diverge for high frequencies; their separation increases as the initial electronic velocity increases, and becomes ∞ for the limit $v=c$. In the limit $c\rightarrow\infty$ the upper and lower bounds coalesce for all frequencies and all electronic velocities giving Heisenberg's results.

35. The Hall effect with audio-frequency currents. Lawrence A. Wood, *Cornell University.*—The magnitude and phase of the Hall e.m.f. in tellurium have been investigated at frequencies up to 25,000 cycles per second. A vacuum-tube oscillator furnishes the longitudinal current for the specimen, which is placed in a constant magnetic field. The Hall e.m.f. is amplified by a resistance-coupled vacuum-tube amplifier, and observed on a cathode-ray oscillograph. A comparison method and a null method agree in the conclusion that within the limits of observation throughout the audio range of frequencies, the magnitude of the Hall e.m.f. is unchanged with frequency, and that there is no phase difference between the Hall e.m.f. and the longitudinal current producing it.

36. Reversals of Hall effect in tellurium. P. I. Wold, *Union College.*—In Phys. Rev. **7**, 169 (1916) the writer reported on the galvano- and thermo-magnetic properties of tellurium. An outstanding characteristic was that, as the temperature rose, the Hall effect changed from a large positive value to a negative value and then to a positive value. An explanation was suggested on the basis of two crystalline forms of tellurium. The specimen last worked with at that time has been preserved and now has been restudied both to see what changes may have occurred in that time and to examine more fully the effect of different heat treatments. The same remarkable double reversal of the Hall effect is found. By very slow cooling from 300° one comes to a point, below 50°, where the Hall constant changes from about -600 to about $+700$ in a 20° range. On the other hand, by rapid cooling, the Hall constant may be kept always positive. The changes in resistance of the tellurium, with temperature, were also observed. The present behavior can, it seems, be best explained on the basis of three forms of tellurium, with transition points in the general neighborhood of 50° and 240°.

37. Ionization of organic acids. Hugh M. Smallwood, *Harvard University.*—The extent of ionization of organic acids in aqueous solution has been shown to depend mainly upon the presence and orientation of electric moments in the anion. The method of calculation is approximate, but gives satisfactory agreement with the experimental data in those cases in which it may be expected to apply. This affords a quantitative verification of the current interpretation of the effect of substituent groups upon acid strength.

38. Some factors involved in the disappearance of hydrogen in the presence of potassium or lithium ion sources. C. H. Kunsman and R. A. Nelson, *Bureau of Chemistry and Soils, U. S. Department of Agriculture, Washington, D.C.*—The experiments were carried out with filaments coated with K-glass (Rev. of Sci. Instr. **1**, 654) and spodumene, sources of K and Li ions respectively, and were similar to those recently reported by Mitchel (J. Frank. Inst. **210**, 269) and Leipunsky and Schechter (Zeits. f. Physik **59**, 857). The rate of decrease of the hydrogen pressure in a chamber immersed in liquid air was varied through wide ranges from fast rates comparable to those reported by Leipunsky and Schechter to slow rates similar to those obtained by Mitchel. Our results indicate that this clean-up of H_2 is due to the formation of water vapor on the surface of the hot filament, and that the electrolytic decomposition of the K-glass and spodumene is a controlling factor. The hydrogen clean-up was larger when the electrolytic potential was such to drive the K or Li ions into the glass than with the potential reversed and in the direction to draw positive K and Li ions to the surface. The disappearance of H_2 in the gas phase under bombardment of K and Li ions up to 150 volts was negligible.

39. The nature of electrical contact between metals. T. H. OSGOOD AND E. HUTCHISSON, *University of Pittsburgh.*—Two circular, optically flat, metal plates, about 4 cm in diameter, supported at their edges, are separated by a distance of a few thousandths of a cm. One is bent towards the other by a variable load applied at its center. The gap is thus one between a sphere and a plane. Electrical currents across the gap are measured for varying voltages and separations of the plates. The smallest currents measured are about 10^{-9} amp; the voltages used range from 0.5 volt for large gaps to 0.0001 volt for small gaps. The method of investigation possesses advantages in (a) control of gap distance and (b) use of voltages far below any known ionisation potential. Results indicate, at atmospheric pressure, the presence of a conducting layer at least 1×10^{-4} cm thick at the surface of each plate. (Similar highly elastic layers are found in ordinary experiments on Newton's rings.) At 0.01 mm pressure, after mild heat treatment (250°C) the thickness of the layer does not alter appreciably. The current across the gap decreases, for a fixed voltage, approximately exponentially as the gap widens. Ohm's law is not obeyed. Simple applications of wave-mechanics, in conjunction with the work of contemporary investigators, suggest that the transfer of electricity across thin films of air (or liquids) is more akin to electrolysis than to metallic conduction. Plans are being made to extend the investigations to surfaces which are as free as possible from adsorbed gases.

40. The propagation of luminosity in long discharge tubes. J. W. BEAMS AND M. PODTIAGUINE, *University of Virginia.*—The speed with which luminosity traversed a long discharge tube, containing an un-ionized or weakly ionized gas, when a high electrical potential was suddenly applied to one electrode (the other electrode being grounded) has been studied by means of a rapidly rotating mirror described by one of us (R.S.I. **1**, 667, (1930)). Air and hydrogen at pressures from 0.03 mm to 0.5 mm with and without small amounts of water vapor were used in the tubes. The luminosity started from one electrode and progressed toward the other as previously observed by Thomson (Recent Researches p. 115, (1893)) and Beams (Phys. Rev. 36, 997, (1930)). With pressures below 0.08 mm and impressed potentials of 20,000 to 40,000 volts, the luminosity progressed toward the grounded electrode regardless of the sign of the impressed potential. However above 0.08 mm approximately, this rule is no longer true. In a glass discharge tube 5 mm in diameter with tungsten electrodes, the luminosity, after first progressing a few centimeters from one electrode, traversed the remainder of the tube with a speed of from 10^9 to 10^{10} cm per sec. depending upon the pressure. With constant applied potential surges the velocity increased with decrease of pressure over the range studied. In the immediate vicinity of the electrode the velocity was influenced by the magnitude of the potential as well as by the size and shape of the electrode and surrounding walls of the tube.

41. A new type of electric discharge characterized by electron emission from the walls. IRVING LANGMUIR AND CLIFTON G. FOUND. *General Electric Co., Schenectady, N.Y.*—If the walls of a glass tube containing gas (2 mm) emit electrons into the gas, a type of electric discharge results radically different from ordinary discharges at low pressures. Such emission may be caused by metastable atoms (neon or helium) generated by resonance radiation transmitted considerable distances from a discharge in another part of the tube (Phys. Rev. **36,** 604 (1932)). Although the emitted electrons make elastic collisions with molecules, they continually return to the walls (replacing those emitted) thus giving up any energy acquired from an applied longitudinal field. Although 200 volts may be applied to a tube 20 cm long, the electrons thus never reach velocities sufficient to cause excitation or ionization, and therefore the conductivity follows Ohm's law even at these high voltages. A very minute trace of a gas (ionizable by metastable atoms) causes the gas to become positively charged so that electrons are trapped (a plasma forms) and then low voltages can cause further ionization. The trapping of electrons also greatly increases the conductivity, concentrating the potential drop at the cathode and further increasing the tendency for easy ionization.

42. Ionization of the upper atmosphere. E. O. HULBURT, *Naval Research Laboratory.*—Continuing the work on the ionization of the upper atmosphere due to the ultraviolet light of the sun (Phys. Rev. 35, 240 (1930)) the ionization at night is calculated by taking into account the effects of recombination, temperature diffusion and electric-magnetic drift of the ions. After sunset the ionized region is found to separate into two banks, one with a maximum of ionization at about 110 km and one with a maximum at about 140 km. Agreement is found with the skip distances and other phenomena of wireless waves and with various facts of terrestrial magnetism. Tables are prepared of the ion and electron densities over the earth.

43. A wide angle magnetic spectrometer. CHARLES D. BOCK, *Yale University.*—In a magnetic spectrometer of the Dempster type, ions which diverge from the source, or entrance slit, are brought approximately to focus at the measuring slit by the geometrical arrangement chosen. The error in focus is proportional to $(1-\cos\theta)$ where θ is the angle of divergence from the main circular trajectory. A better focus can be obtained by choosing the proper variation of the deflecting magnetic field, H. The calculation is carried out in cylindrical coordinates, r, ϕ, z, with origin at the center of the main trajectory. With Hartree's weighting factor, $\sin\phi$, for the mean effective H, an integral equation is obtained for the proper variation of H for refocusing. For convenience in forming the pole pieces, H is chosen to be a function of r only. The pole surfaces are assumed equipotential, and dH/dz is neglected, so that these surfaces are simply $Hz=\text{constant}$. A very close approximation to the required field can be obtained, as the variation in H is small. A spectrometer is being built which takes advantage of this refinement.

44. A mass-spectrograph. K. T. BAINBRIDGE, *Bartol Research Foundation of the Franklin Institute, Swarthmore, Pa.*—A mass-spectrograph of high resolving power ($M/\Delta M=500$) has been developed. The mass scale is linear and for a mass difference of one percent the dispersion varies from 1.6 mm at one end of the plate to 3.8 mm at the other end. A single spectrum covers 1.4 octaves of mass. Ions of energies from 5000 to 20000 electron-volts are introduced through a slit (0.05 mm wide) into a region of crossed electric and magnetic fields. Ions traversing this section of the apparatus without deflection have a velocity, $v=X/H$ within narrow limits. Ions emerging from the slit at the far end of the "velocity filter" are introduced into a uniform magnetic field, the "camera" section of the apparatus, and are incident on the surface of a photographic plate after describing a circular path for 180°. As $R=mv/eH$, and v, e, and H are constant, both theoretically and experimentally a linear mass scale is secured. With Schumann plates the exposure times range from 30 seconds for the three isotopes of neon to seven minutes for the isotopes of mercury. Special Velox plates require exposures approximately ten times as long. Typical spectra will be shown.

45. The isotopes of hydrogen as studied with a mass spectrograph. WALKER BLEAKNEY, *National Research Fellow, Princeton University.*—A mass spectrograph has been designed and built for the purpose of studying gaseous ions at very low pressures. The vacuum tube is made entirely of glass, tantalum and tungsten. A large solenoid supplies the magnetic field. The whole tube is surrounded by a furnace so that it may be well baked to eliminate residual gases. The slits are long so that good intensity is achieved at low pressures. The apparatus is admirably adapted to a study of the isotope effects in hydrogen because at low pressures the relative importance of secondary effects is reduced. After the discovery of an isotope of mass 2 by Urey, Brickwedde and Murphy the author began a study of the hydrogen ions of mass 3 using a sample of hydrogen which had been prepared by them. The results show a large increase in ions of mass 3 over ordinary hydrogen and this increase, moreover, varied linearly with the pressure. Since the intensity of the triatomic ion $(H^1H^1H^1)^+$ varies as the square of the pressure it is assumed that the linear part is due to $(H^1H^2)^+$. At the present stage of the investigation it seems entirely possible to extend this method to a determination of the relative abundance of the isotopes in ordinary hydrogen.

46. The response of various photographic emulsions to alpha-rays. T. R. WILKINS, *University of Rochester.*—The formula $D=K/a(1-e^{-knta})$ has been derived and found to fit various photographic emulsions. D = photographic density; a = cross section of grain in mm^2; t = time in secs.; n = number of particles/mm^2./sec.; k = number of grains in the track of an alpha-ray of given residual range. If $knta$ is less than 0.1, D can be taken as proportional to the number of alpha-rays. If a plate is mounted above a source at a critical distance, the decrease in k at points along the plate can be shown to balance the decrease in n. So for a given value of t, the densities at points along the plate will be proportional to the number of alpha-rays. This chance compensation explains an apparent reciprocity defect reported earlier. No real reciprocity defect has been found by us in the emulsions so far studied. The values of n have been determined by scintillation counts. Once K, k and a have been determined, the accuracy of the photographic counts is surprising.

47. Electronic devices as aids to research. A. W. Hull, *General Electric Co.*

48. Some Practical Applications of Electronic Devices. N. Rashevsky. *Westinghouse Electric and Manufacturing Company.*

49. Special tubes for the amplification of small voltages. G. F. Metcalf, *General Electric Co.*

50. Thermal expansion of nickel steels. Peter Hidnert and H. S. Krider, *Bureau of Standards.*—Data on the linear thermal expansion of some nickel steels containing from 36.4 to 42.2 percent nickel were published by Hidnert and Sweeney in Physical Review, (**29**, 911 (1927)). Similar data have recently been obtained on 35 and 36 percent nickel steels produced in Germany by Deutschen Edelstahlwerken A. G. Krefeld (Rhineland). These steels which also contain about 1 percent manganese, were forged to 10 mm diameter, annealed at 900°C for 2 hours and cooled in 6 to 7 hours. The following table gives some of the results.

Nickel content	Critical point	Average coefficients of expansion per degree centigrade	
		20°C to critical point	Critical point to 400°C
Percent	°C	$\times 10^{-6}$	$\times 10^{-6}$
35.0	160	4.5	14.4
36.0	210	3.4	13.5

51. Surface energy and heat of vaporization of liquids. Louis S. Kassel, *Bureau of Mines*, and Morris Muskat, *Gulf Research Laboratory, Pittsburgh, Pa.*—The total surface energy of a liquid has been computed in a more direct way than that used by Margenau; it appears that he had calculated the maximum work rather than the total energy. The forces were taken from the quantum mechanical theory, and are the same as those Margenau used. The present calculations were made both on the assumptions of: (a) a uniform spatial distribution of molecular centers within the liquid, and (b) a Maxwell-Boltzmann distribution. The former assumption led to results less than the experimental values, while the latter led to higher values. Similar calculations were carried out for the heats of vaporization, and the experimental values again were between those for the uniform and for the Maxwell-Boltzmann distributions. It thus appears that the heat of vaporization and the surface energy could be obtained with fair accuracy from the quantum mechanical forces, if the correct distribution within the liquid were known. The calculations yield some evidence that zero-point energy is of importance in liquid helium.

52. Surface forces of the sea urchin egg. Kenneth S. Cole, *Columbia University.*—The spherical egg, 75μ in diameter, is compressed between parallel planes. The movable plane is the free end of a gold strip galvanometer suspension. The compressing force is applied and measured with a sensitivity of 1.7×10^{-4} dyne/scale division by the flexure of the strip. The axially symmetric egg surface has a meridian line resembling a portion of an unduloid. With the areas of contact on the planes and the mean curvature of the free surface, the initial pressure is calculated to be 40 dynes/cm^2 and the surface force, 0.08 dyne/cm. The increase of surface force with surface area indicates that the egg membrane has a Poisson ration near 0.5 and that the normal area is about 30 percent above the unstretched area. The measurements on the fertilized egg indicate that its membrane tension increases 150 times more rapidly than that of the unfertilized egg and that the fertilization membrane is normally unstretched.

53. Spontaneous dispersion of small liquid systems which are the seat of physico-chemical reactions. N. Rashevsky, *Westinghouse Elec. & Mfg. Co., East Pittsburgh.*—A more general thermodynamical treatment of the problem than that given hitherto by the writer in several previous publications is made. It is shown that regardless of any assumptions which we may make about the surface properties of such systems, a spontaneous dispersion will occur above a certain critical size, whenever a rather general type of reactions occur in the system. The critical size, thus calculated is of the order of magnitude of the sizes of living cells. The time it takes a system to divide in two can also be calculated, and is also found to be of the same order of magnitude, as the time of a cell division.

54. Shielding of an electrode from a high potential gradient by means of a charged dielectric. C. M. Slack, *Westinghouse Research Laboratory, Bloomfield, N. J.*—The potential gradient necessary to draw an appreciable current of electrons from glass has been found to be in excess of that from pure cold metals. This fact was made of use in shielding the metallic parts of the cathode in high voltage discharge devices. In one design a double walled reëntrant glass cylinder is made to extend beyond the metallic focussing cup. The adjacent surfaces of the glass are coated with a conductor which in turn is connected to the cathode. Such a scheme exposes only, the glass surface to the high electric fields and yet allows one to use the customary type of filament mounting. The glass shield has the same focussing effect as a metallic cylinder of the same diameter. X-ray tubes of small dimensions and close spacings have been operated at 400 kv under oil using this design.

55. Examining by a densitometer new lines in K series x-ray spectra. William Duane, *Harvard University.*—A new photometer, or densitometer, has been used to examine the new K series x-ray lines reported last February at the New York meeting of the Physical Society. The instrument projects a photographic negative of the spectral lines onto a vertical surface (the lines being horizontal). A photoelectric cell lies behind a very narrow horizontal slit in this surface. Suitable mechanism causes this slit together with the photoelectric cell to rise or fall slowly across the projected lines. Above the slit and cell, and mechanically attached to them, is a photographic plate in a vertical position. The photographic plate and the slit and photoelectric cell are on the same solid body, and therefore they all move together, up or down. The circuit of the photoelectric cell contains a D'Arsonval galvanometer. A very fine beam of light is reflected by the mirror of the galvanometer to a horizontal narrow slit, which is held in a fixed position opposite the photographic plate. This reflected light, representing the current through the photoelectric cell, therefore draws a curve on the photographic plate. In addition to the new features of the x-ray spectra, certain difficulties that have been encountered and more or less overcome are described.

56. The shapes and widths of L absorption limits of mercury. H. L. Hull, *Columbia University.*—An investigation of the shape and width of the L_{II} and L_{III} absorption limits of mercury has been made with the double x-ray spectrometer. Mercury in the liquid and vapor form and in chemical combination was used. The absorption breaks are found to be unsymmetrical. Approaching the limit from the long wave-length side, the intensity of the transmitted beam falls off rather sharply at first, followed by a more gradual decrease to the minimum value. This effect is clearly shown for the vapor and liquid states. Qualitatively, the observed curves would appear to bear out the suggestion by Kossel that the ejected electron may sometimes not be removed completely from the atom by the absorbed quantum, but only to an unoccupied outer orbit. The curves for the vapor are of the order of 3 x. u. wide. The curves for the liquid state are practically identical at the long wave-length side, with the liquid curve falling off in intensity more slowly as the wave-length is decreased. The curves for the compounds are in general wider than those for the liquid and vapor.

57. Satellites of the x-ray lines $L\alpha_1$ and $L\beta_2$ for the high atomic number elements. F. K. Richtmyer and S. Kaufman, *Cornell University.*—The satellites accompanying $L\alpha_1$ and $L\beta_2$ in the atomic number range 40–50 are relatively intense but fade out rapidly above Sn(50) and are not observed above Xe(54). Beginning in the neighborhood of W(74) there appears on the short wavelength side of $L\beta_2$ a faint line which has previously been thought to be the same satellite of $L\beta_2$ as is observed below Xe(54). The frequency-difference Moseley graph, characteristic of satellites, shows however that this high atomic number satellite is a new line, nearer to $L\beta_2$ than would be predicted by extrapolation from the atomic number range 40–50. Similarly, a broad band suggestive of a group of unresolved satellites is found associated with $L\alpha_1$ above Au(79), but closer to $L\alpha_1$ than would be predicted by extrapolation. It is suggested that these high atomic number satellites originate in a "double jump" in which there is combined with the parent line a transition involving an "outer electron jump" one electron shell farther out than that which produces the satellites in the 40–50 atomic number range. An attempt is being made to resolve this high atomic number satellite of $L\alpha$.

58. Precision wave-length measurements with the double crystal x-ray spectrometer. J. A. Bearden, *Johns Hopkins University.*—The average diffraction angle in the 4th order for the molybdenum $K\alpha_2$ line using calcite crystals from four different sources was 27° 51′ 34.4″ (Phys. Rev. **38**, 2093 (1931)). This value is probably more precise than any previous determination. Thus in the present experiment it has been used as a primary standard and the diffraction angles of the silver, copper and iron $K\alpha_1$ lines have been measured relative to this value. The diffraction angles were measured using the double crystal spectrometer as described in the above reference. The results corrected for slit heights and reduced to 18°C were

5th order Ag$K\alpha_1$ − 27° 21′ 54.6″ or $\lambda = 0.558006$A
4th order Mo$K\alpha_1$ − 27° 51′ 34.3″ or $\lambda = 0.707517$
3rd order Cu$K\alpha_1$ − 49° 34′ 25.35″ or $\lambda = 1.536717$
2nd order Fe$K\alpha_1$ − 39° 37′ 31.0″ or $\lambda = 1.931135$.

The wave-lengths were calculated with the true grating constant $d = 3.02810$A at 18°C. The average variation from the mean was approximately 0.1″ in each case. Thus the probable error is meaningless as no graduated circle can probably be relied upon to better than 0.1″ or 0.2″. The diffraction angles for the lower orders of these lines were also measured and the index of refraction of these wave-lengths in the calcite crystal was calculated. The results agreed to within experimental error with the theoretical values.

59. The theory of complex spectra—Part II. Itensities. M. H. Johnson, Jr., *Harvard University.*—Intensity formulas for any electronic configuration possessing a definite coupling arrangement of angular momentum vectors, are first considered. We start with the angular momentum vectors uncoupled and then coupled them together in a prescribed order. The electric moment of the jumping electron is determined at every step of the coupling process in exactly the same manner as the individual angular momentum vectors in the previous paper (See abstract number 32). Thus the required intensities are found. Just as before, the process yields incorrect results if the jumping electron belongs to a group of *more* than two *equivalent* electrons. The method applied to two electrons in LS coupling yields Kronig's formulas. Analogous formulas are obtained for two electrons in *jj* coupling. The intensities in intermediate coupling can be determined if the whole energy matrix is known for any definite coupling scheme having a resultant total angular momentum, *J*. By the above process the intensities can be found for this coupling. From the energy matrix the transformation into intermediate coupling is obtained. The application of this transformation to the intensities, yields the intensities in intermediate coupling.

60. Some problems of theoretic physics connected with cell physiology. N. Rashevsky, *Westinghouse Elec. & Mfg. Co., East Pittsburgh.*—A general mathematical treatment of the diffusion of food substances into a heterogeneous cell, connected with their transformation within the latter, is given. The possibility is shown of calculating the corresponding diffusion and permeability constants from observations on the rates of metabolism of the food substance in question.

61. Mixed crystals in statistical mechanics. T. E. Sterne, *National Research Fellow, Harvard University and the Massachusetts Institute of Technology. Introduced by E. C. Kemble.*—We may consider the complete set of linearly independent wave functions capable of representing an assembly made up of the gaseous and crystalline phases of a number of substances. Restricting ourselves for simplicity to the case of an assembly containing only two substances, we know that if the particles (atoms or molecules) of the two varieties in the crystalline phases are sufficiently similar, then the total vapor pressure is equal very nearly to $p=\sum_{1,2}D_r p_r$ if the particles can mix in all fashions in the crystalline phase. Here D_1 and D_2 are the gram molecular fractions of the two substances, and p_1 and p_2 are the vapor pressures of pure crystals of the separate substances at the temperature in question. If the two varieties can not mix at all in the crystalline phase, then the vapor pressure $p=\sum_{1,2}p_r$. In the intermediate cases where mixing is possible to intermediate extents, it is easy to show by the methods of Statistical Quantum Mechanics that

$$p=p_1[\alpha_1 D_1/(\alpha_1 D_1+\alpha_2 D_2)]^{\alpha_1}+p_2[\alpha_2 D_2/(\alpha_1 D_1+\alpha_2 D_2)]^{\alpha_2}$$

where α_1 and α_2 are two constants which may be called the "mixing coefficients" of the particles of the two varieties, and which specify the extent to which mixing may occur.

62. A new low noise vacuum tube. G. F. METCALF AND T. M. DICKINSON, *Vacuum Tube Engineering Dept. General Electric Co. Schenectady, N. Y.*—When commercial vacuum tubes are used to amplify small low frequency voltages it is found that random disturbances of the order of 100 to 1000 microvolts are present in the anode circuit. These disturbances exist almost entirely in the range below 100 cycles per second, and therefore fix the minimum voltage which can be measured over this low frequency band to 10 to 100 microvolts. These disturbances are shown to be caused by any or all of the following: (1) Insulating material in or near electron path. (2) Irregularity of filament emission. (3) Gas. (4) Positive ions emitted by filament. (5) Insulating or foreign deposits on grid wires. A tube has been developed in which the above effects are removed or reduced to a point where the disturbances are nearly that of the shot-effect of the electrons, as limited by space-charge. This allows the amplification of low frequency voltages of less than 1 microvolt over the entire frequency band below 100 cycles.

63. The "Inner Force" of Lorentz and the statistical calculation of the dielectric constant and magnetic permeability. OTTO HALPERN, *New York University.*—The dielectric constant and magnetic permeability of an ideal dilute gas may be determined by calculating the average moment of each atom acted upon by the external field only and by summing over all individual atoms. Considering matter of higher density the introduction of Lorentz' inner force was supposed to account fully for the modifications caused by atomic interaction. (Conf. Lorentz' derivation of the Clausius-Mosotti equation.) The present report tends to show that this procedure is fundamentally unsound because the method of determining the average moment by the use of Lorentz' inner force is in discordance with the principles of statistics. Therefore, it can not be expected that the Clausius-Mosotti and similar relations will generally hold; it will also be necessary to revise some well known equations for thermal and elastic effects accompanying both magnetization and electrization.

64. A new method of measuring x-ray intensities employing an electronic photo-cell. PAUL R. GLEASON, *Colgate University.*—An investigation of the sensitivity of Weston Photronic cells to x-rays has been carried out. By suitably shielding the cell and lead wires from electrostatic disturbances the Photronic cell was found to respond in the x-ray region. Absorption measurements indicated sensitivity to all the wave-lengths emitted by a 30 m.a. radiator type, Coolidge tube with tungsten target operated by a 70,000 volt, 2 k.v.a transformer. With a typical cell when the x-ray tube was operating at capacity separated by a distance of 44 cm a current of 1.5×10^{-6} amp. was obtained when only a sheet of black paper was in the path of the beam, a current of 1.0×10^{-6} amp. when the usual glass window was in position and a current of 0.09×10^{-6} amp. when in addition a sheet of commercial copper 0.47 mm was interposed. Application to lecture demonstrations of simple x-ray phenomena, and application to "dosage meter" are apparent.