Proceedings of the American Physical Society

Minutes of the Meeting of the Metropolitan Section held at Columbia University, New York, November 9 and 10, 1945

A MEETING of the Metropolitan Section of the American Physical Society, the first of the 1945–1946 season, was held on Friday and Saturday, November 9th and 10th, 1945, in the Pupin Physics Laboratories at Columbia University. In view of the paucity, in recent years, of meetings at which physicists could gather to discuss their research, and since the termination of the European and Japanese wars had relaxed the military and war-connected duties of many physicists, it was decided to prepare a program on a scale sufficiently large to ease the log-jam of accumulated research findings of those in the Metropolitan area.

During the two-day session there were presented four invited lectures and thirty contributed papers, as set forth in the programme below. In addition, the Section held a business session, not originally scheduled, for the sole purpose of considering a set of resolutions which had previously been submitted by an informal gathering of physicists. These resolutions were, in essence, a plea for freedom in the dissemination of fundamental scientific knowledge and a suitable international control of weapons of war. After three hours of spirited discussion, the Section formally adopted the resolutions in a modified form. They will be suitably publicized elsewhere.

The attendance at the scientific sessions varied from 150 to 250 persons. A dinner, held Friday evening at the Mens' Faculty Club, was attended by 123 persons.

William H. Crew
Secretary, Metropolitan Section

Abstracts of Contributed Papers

1. On the Nature of the Forces Involved in the Reaction between Antigen and Antibody Molecules. Alexandre Rothen, *The Laboratories of The Rockefeller Institute for Medical Research, New York.*—Specific fixation of homologous antibodies by antigen molecules occurs when the antigen molecules are deposited on a metal slide, in a completely unfolded film 6 to 8A thick. The specific fixation has been demonstrated by an increase in thickness in the adsorbed layer on the plate. Thicknesses are measured optically with an accuracy of ± 0.3A. In the system film of bovine albumin-antibovine albumin rabbit serum, the amount of fixed antibodies increases with the number of underlying films of antigen. Screens consisting of films of stearic acid, octadecylamine or protein deposited on top of the antigen film do not prevent the reaction from occurring to a considerable extent. In certain cases 8 layers of stearic acid are needed to prevent any fixation. Facts are given which speak against the presence of holes in the screens through which the antibodies could reach the antigen. The assumption is tentatively made that the effective range of action between a film of antigen and homologous antibodies might extend to an order of hundreds of A. It is considered possible that such a long range might result from an integrated action of the many elementary units which build up the single large molecules of antigen and antibody in an orderly way.

2. The Sensitivity of the Human Eye on an Absolute Scale. Albert Rose, *RCA Laboratories, Princeton, New Jersey.*—When the sensitivity of a picture reproducing device (e.g. television pick-up tube or photographic film) is limited by the statistical fluctuations inherent in the primary photo-process,[1] the limitation may well be taken to be absolute in the sense that no subsequent link in the chain that forms a picture can avoid it. The performance of the human eye in the range of 10^{-6} to 10^{2} footlamberts is compared with the performance of a model for which the quantum efficiency and statistical fluctuations of the primary photo-process constitute the significant limitations. The performance of the model is given by $B^{\frac{1}{2}}\alpha C = K$ where B is scene luminance, α is minimum resolvable angle, C is contrast, and K is a parameter. The agreement is sufficiently good to recommend the model at least as a summary device. If, in addition, it is taken to be a valid representation, reasonable explanations are suggested for (a) the large ratio between the "sensitivities" of the dark and light adapted eye; (b) the experimental fact that scenes whose luminosities are widely different may still be equally resolved by the eye; (c) the discrepancy between the computed[2] and observed[3] numbers of quanta required for threshold vision. These are one and five, respectively; (d) the observation of fluctuations at very low lights.

[1] A. Rose, Proc. I.R.E. **30**, 215–300 (1942).
[2] H. DeVries, Physica **10**, 553–564 (1943).
[3] S. Hecht, J. Opt. Soc. Am. **32**, 42–49 (1942).

3. Electrodynamic Theory of Piezoelectric Oscillations.* W. F. G. SWANN, *Bartol Research Foundation of the Franklin Institute, Swarthmore, Pennsylvania.*—The problem concerned is that of an x-cut crystal with self-induction and resistance in series, and vibrating with its two ends in different media. It is solved on the basis of Maxwell's general dynamical theory. If p is 2π times the applied frequency, if k is 2π times the lowest natural frequency, and n is an integer, it turns out that if p satisfies the relation, $p^2=n_2^2k^2$, where n_2 is even, there is no resonance, but the crystal vibrates in an infinite number of "odd" modes. If $p^2=n_1^2k^2$ where n_1 is odd, the whole displacement at the two ends of the crystal is given by one single harmonic term of frequency determined by n_1, and the displacements are the same at the two ends. In the latter case, and where the media are the same at the two ends, the radiation pressures are entirely provided by the piezoelectric force which is symmetrical in its action for this purpose. However, when the media are different there arise an infinite number of "even" modes, which add up to zero displacement at the two ends but give unsymmetrical pressures at these ends. Complete expressions for the relevant amplitudes and phase angles are determined.

* Carried on by funds furnished by OSRD.

4. The Order of Magnitude of Piezoelectric Effects. HANS JAFFE, *The Brush Development Company.*—Practical applications of piezoelectric effects until recently were limited to quartz which has a rather low effect and Rochelle salt whose use at elevated temperatures or high power levels is restricted by its decomposition point at 56°C. The selection of piezoelectric materials for various applications depends on the values of different piezoelectric coefficients. Motor devices in air (sound generators) depend on the piezoelectric moduli d. The exceptional value of d_{14} of Rochelle salt justifies its dominant position for such purposes. Voltage generating devices (pick-ups and microphones) operating into typical high impedance circuits require a high "voltage output coefficient" $g=d/\text{diel. const.}$, as well as a high modulus d. Square root of $g\cdot d$ is a suitable figure of merit. In this figure Rochelle salt X-cut is still leading but is ahead of certain more stable crystals only by a factor 3. For generating and receiving ultrasonic waves in liquids, a fairly low elastic compliance, s, is preferable. We arrive at a figure of merit root of $g\cdot d/s$; this is substantially the coupling coefficient which is also decisive for application in filters and oscillator control. Coupling coefficients up to 30 percent are not uncommon among synthetic crystals. Maximum values for the "voltage output coefficient" g can be estimated from atomic models.

5. Relation Between Darkening by X-Ray Irradiation and Permanence of Dauphiné Twinning in Quartz. ELIZABETH ARMSTRONG, *Bell Telephone Laboratories.*—There is a positive correlation between the amount of darkening caused in quartz plates by x-ray irradiation and the permanence of their Dauphiné ("electrical") twin boundaries when subjected to inversion (at 573°±1°C) to the high temperature form and reinversion to low quartz. Of forty-five quartz plates so treated 33 percent resumed their former orientation in all parts of the plate, 11 percent showed changes in less than 5 percent of the plate and 56 percent showed changed orientation in more than 5 percent of the plate. Each plate was then irradiated with x-rays from a copper-target tube at 60 kv and 25 ma for 2 hours. Of the unchanged plates 73 percent became dark, the rest were only slightly darkened. Of the slightly changed plates 80 percent became dark. Of the changed plates 16 percent became dark, 48 percent were only slightly darkened, and 36 percent were inhomogeneously colored. In 75 percent of these last, the lighter areas contained the changed parts of the crystal plate. This correlation between irradiation-darkening and orientation-permanence indicates a common cause for both which is most probably the presence of impurities or defect structures or both.

6. The Elastic, Piezoelectric and Dielectric Constants of Potassium Dihydrogen Phosphate (KDP) and Ammonium Dihydrogen Phosphate (ADP). W. P. MASON, *Bell Telephone Laboratories.*—Measurements have been made of all the elastic, piezoelectric, and dielectric constants of KDP and ADP crystals through temperature ranges down to the Curie temperatures. The piezoelectric properties agree well with Mueller's phenomenological theory of piezoelectricity provided the fundamental piezoelectric constant is taken as the ratio of the piezoelectric stress to that part of the polarization due to the hydrogen bonds. It is found that the dielectric properties of KDP agree well with the theory presented by Slater based on the interaction of the hydrogen bonds with the PO_4 ions. ADP undergoes a transition at −125°C which results in fracturing the crystal. This transition cannot be connected with the H_2PO_4 hydrogen bond system which controls the dielectric and piezoelectric properties for these lie on smooth curves that do not change slope as the transition temperature is approached. It is suggested that two separate and independent hydrogen bond systems are involved in ADP. The transition temperature and specific heat anomaly appear to be connected with hydrogen bonds between the nitrogens and the oxygens of the PO_4 ions, while the dielectric and piezoelectric properties are controlled by the H_2PO_4 hydrogen bonds.

7. Methods of Orienting and Cutting Synthetic Crystals. W. L. BOND, *Bell Telephone Laboratories.*—Improved methods of orienting, cutting and surfacing synthetic crystals have been developed. These include optically orienting on a mounting board, securing by means of fast-setting cement, grinding a reference face at a predetermined angle from the board edges, sawing with solution cooled abrasive blades and grinding to dimension with abrasive belts. The application of these to ADP is discussed. These methods are also applicable to many other crystals. The optical orientation should use reflections from faces habitually quite perfect and in some cases must be supplemented by x-ray orientation to achieve the highest accuracy of orientation. For crystals that crack easily due to cleavage liquid cooled grinding is used. Sawing with abrasive blades works nicely with the proper choice of coolant.

8. Apparatus for Growing Single Crystals from Solution. A. N. Holden, *Bell Telephone Laboratories.*—In growing large crystals from seeds planted in supersaturated solutions two major problems are (1) to provide for the uniform replacement of saturated by supersaturated solution at the crystal surfaces and (2) to prevent the growth of extraneous seeds. In the apparatus described, these problems are largely solved for materials whose solubilities are increasing functions of temperature. Crystals are grown from seeds mounted on radial arms attached to a central shaft alternately rotated several revolutions in one sense, then in the other. The solution through which they move is carried in a cylindrical container heated at the bottom, and thermally controlled for intermittent or continuous decrease of temperature. Spontaneously formed seeds are carried by the centripetal action of the rotating solution to the center of the bottom of the container, where they are dissolved at the slightly higher temperature of the heated portion. The apparatus has been used for many materials; as applied to ammonium dihydrogen phosphate, it has permitted linear growth rates of about 1/16 inch per day for several months of continuous growth.

9. Ionic Conduction in Ammonium Dihydrogen Phosphate Single Crystals. E. J. Murphy, *Bell Telephone Laboratories.*—The ionic conductivity of a crystal is given by $\sigma = \Sigma\sigma_{0i} \exp (W_i/RT)$. In the present work the activation energies W_i, and the other conduction constants σ_{0i}, were determined for four $NH_4H_2PO_4$ crystals; namely, a very pure crystal and three others containing, respectively, known small amounts of Ba, Sn, and SO_4. The results show that this crystal is able to conduct with at least three essentially different activation energies; namely, 10.1 (10.9), 15.8 and 20.4 kcalorie/mole. The 20.4 kcalorie conduction is self-conduction, the 10.1 term Ba-conduction, the 10.9 term SO_4-conduction, and the 15.8 term Sn-conduction. Thus, in a given crystal some impurity ions can conduct with essentially equal activation energies, while others require a substantially different activation energy; a spectrum of energies is revealed by the impurities. This is a hydrogen bonded material and the activation energies may depend upon the breaking of H-bonds. The observed values of σ_{0i} were compared with theory by calculating the lattice constant from the conduction data on the basis of simple assumptions. The values obtained are 6.4 Angstroms from Ba-conduction, 4.5A from SO_4-conduction, 9.5A from self-conduction and 182A from Sn-conduction. The lattice constant for the *c*-direction in this crystal is about 7A.

10. Focusing Aberration in the Flat Powder Specimen X-Ray Spectrometer Technique. John P. Nielsen and William Parrish, *Philips Laboratories, Inc. Irvington, N. Y.*—In an x-ray spectrometer a flat specimen is far more convenient than a curved specimen where the curvature must be changed for each Bragg angle setting to obtain true focusing. However, the flat specimen gives an aberration which broadens the diffracted "line" on the lower Bragg angle side, and hence it is generally thought that a shift in the line position occurs which gives low Bragg angle measurements. A detailed ray diagram was constructed for a flat specimen for a diverging beam at an arbitrary angle. An analysis of the diagram reveals the nature of the broadening which provides means for evaluating the data obtained by the flat specimen technique. Experimental investigation of this theory was carried out with a new type Geiger counter tube focusing x-ray spectrometer on $\{10\bar{1}1\}$ of low temperature quartz powder.

Invited Papers

Meson-Like Entities Composed of Electrons and Positrons. J. A. Wheeler, *Princeton University.*

I. **The Supersonic Reflectoscope.** F. A. Firestone, *University of Michigan.*

II. **Present Aspects of the Theory of Color Centers in the Alkali-Halides.** F. Seitz, *Carnegie Institute of Technology.*

III. **The Quantum Theory of Damping for Scattering Processes of Particles and Radiation.** W. Pauli, *Institute for Advanced Study.*

Contributed Papers

11. Infra-Red Spectroscopic Study of the Halogenation of Unsaturated Compounds. Robert C. Gore and James L. Johnson, *American Cyanamid Company.*—Several absorption bands in the infra-red region between 1000 and 800 cm^{-1} have been correlated with mono-, di-, and tri-alkyl substituted >C=C< groups.* Generally a double bond is reactive to halogen addition. In cases where addition of halogen can be accomplished without destroying the molecule or without too greatly confusing its spectrum, this addition offers a method for checking some of these assignments, and also for investigating certain unsaturated molecules failing to show the 1640 cm^{-1} C=C stretching vibration which is an accepted criterion for unsaturation. In these cases the disappearance of bands at frequencies absorbed by the original molecule may be indicative of the presence of a >C=C< group. One of the more interesting of

these assignments is that of the 830 cm^{-1} band in crepe rubber to the tri-alkyl olefin.

$$\begin{array}{l} \quad\quad CH_3 \\ \quad\quad | \\ -CH_2-C=CH-CH_2 \end{array}$$

When Wijs reagent is used to add halogen across the double bond the 830 cm^{-1} band does not appear in the product. Similarly halogenation causes the disappearance of 990 and 910 cm^{-1} bands attributed to the group $RCH=CH_2$, and the 960 cm^{-1} band associated with the structure $R_1—CH=CHR_2$. Smaller molecules are treated by bromine addition and their spectra studied in the same manner. This procedure has made possible studies on bands attributed to the various $\begin{array}{c} | \\ C=C \\ | \end{array}$ groups mentioned above; the method can also be extended to aryl constituents and cyclic compounds where double bond characteristics are less obvious spectroscopically.

* Thompson and Torkington, Trans. Faraday Soc. 41 246–260 (1945).

12. Ultrasonic Interference at Angular Reflection. G. W. WILLARD, *Bell Telephone Laboratories.*—When a plane-wave ultrasonic beam is reflected at a plane surface the incident and reflected waves may interfere in the region of their coexistence and produce standing waves parallel to the reflector. The spacing of the standing waves, $h=\lambda s/2 \sin\theta$ (λs is the sound wave-length and θ is the angle between beam and reflector), increases rapidly with decreasing angle from $\lambda s/2$ at normal incidence to $h=\lambda s/2\theta \doteq 29\lambda s/\theta°$ at grazing incidence. With a 10-megacycle sound beam in water ($\lambda s=0.15$ mm) the standing waves, as well as the incident and reflected beams, may be imaged on a screen by the ultrasonic light diffraction method, using a parallel light beam through the liquid, pinhole entrance and annular exit apertures (giving a dark field), and a projecting lens beyond the exist aperture. At all angles, from grazing incidence up to normal incidence, the standing waves produce on the screen simple bright bands parallel to the brass reflector. Magnification of the image is necessary except near grazing incidence.

13. The Absorption of Microwaves by Gases. W. D. HERSHBERGER, *RCA Laboratories, Princeton, N. J.*—The absorption by ammonia of electromagnetic waves having a length in the one-centimeter range has been known for some years. An investigation has been made to determine whether other gases show similar absorption for microwaves and as a result fourteen additional gases have been found whose absorption is comparable to that of ammonia. Among these gases are dimethyl ether, a variety of amines and alkyl halides, and several others. Measurements on the absorption coefficient and dielectric constant of these gases are given. The frequency at which the absorption coefficient attains its maximum value is inferred from the curve: absorption coefficients *vs.* pressure. Data on the absorption of several gas mixtures are given. Possible molecular mechanisms adequate to account for the large absorptions observed are discussed together with the conclusions reached.

14. Experiments with Triode Counters. S. A. KORFF, *New York University.*—Further studies of the properties of triode counters have been carried out. Various grid-diameters have been tried. Small diameter grids are found to produce considerable lowering of the over-all operating potential, but also introduce a constructional problem which is readily solved for short counters, but involves mechanical difficulties in the longer types currently used in cosmic ray studies. The application of grid counters to the problem of proportional counting is complicated by the collection of ions on the grid, which introduces uncertainties into the measurement of pulse sizes. The potential difference between the grid and cylinder is found not to be at all critical, and can be varied over wide limits without making appreciable differences in the operation of the counter. Resolving-time measurements show that the resolving-time of counters is made shorter by the introduction of a grid.

15. Reflex Oscillators Utilizing Secondary Emission Current. C. C. WANG, *Westinghouse Electric Corporation.*—One type of electronic oscillator, widely known as a velocity modulation oscillator or klystron uses an electron beam traversing the gap of a reentrant cavity resonator or several gaps in succession. The linear dimensions of such resonator must be made nearly in direct proportion to the wave-length of the electric oscillation to be generated. As the density of an electron beam that can be generated from a thermionic cathode cannot be increased indefinitely, the electron current that can be carried through the gap opening of the resonator will decrease nearly in proportion to the square of the wave-length. On the other hand, the cavity losses relative to the electrical field strength across the gap increase as the wave-length decreases. Consequently, for very short wave-length, it is very difficult to obtain appreciable power output from such tubes. By introducing a secondary emission electrode in the tube at a proper point, much higher beam current can be delivered to the gap where high frequency energy is absorbed from the beam. This results in a substantial increase of efficiency and available useful power output. Since such oscillators have been successfully made to operate as high as 4000 mc, it is apparent that either the average time lag of emission of secondary electrons is small in comparison with one cycle of oscillation or $1/4\times10^{-9}$ sec., or the dispersion of time of lag of emission of the secondary electrons is not very extensive if the average time of lag is not small.

16. Electronic Spectroscopy. G. C. SZIKLAI AND A. C. SCHROEDER, *RCA Laboratories, Princeton, N. J.*—According to Einstein, the electrons leave a photoelectric surface with a velocity proportional to the frequency of the impinging radiation. When a periodically variable potential is applied to a photo-cell, current flow starts at the threshold potential, gradually increasing to the saturation current. The linearity of this current depends on the linearity of the variable potential, the photoelectric surface, and the color content of the light. By double differentiation, the spectral distribution can be directly observed on an oscilloscope which is deflected synchronously with the potential

applied to the photo-cell. With caesium-antimony surfaces, filters of the three primary colors can be easily differentiated, but with improved surfaces considerably better resolutions may be obtained and further improvement may be had by lowering the temperature of the photosurface. The method lends itself readily to color matching, since two similar devices supplying their signal with opposite polarity will give zero output when the two colors match, while it provides a direct indication of the color and magnitude of mismatch when a signal is obtained. The output signal can be utilized for relays or other control devices.

17. A Voltage Regulator for X-Ray Circuits. WHEELER P. DAVEY, *The Pennsylvania State College.*—Power for operating our x-ray tubes is obtained from a 20 kva 110-V 60-cycle alternator. Experiments involving x-ray tubes frequently require a very constant voltage supply of considerable power. Commercially available voltage regulators are not sufficiently sensitive for the purpose. A highly statisfactory type of voltage control can be made as follows. By means of an ordinary four-tube rectifier the 110-volt a.c. line circuit is rectified. Voltage control is obtained in terms of the peak of the wave by connecting a 100 mf condenser across the rectified potential. The rectified potential is then connected across two Ohmite potentiometers in series (a total of 1500 ohms), thus making it possible to pick off definite fractions of the d.c. voltage. The adjustable voltage thus obtained is connected in series with a bucking voltage obtained from dry cells. In series with the dry cells is a Weston Instrument Co. d.c. relay model 534 which requires an operating current of 15 microamperes. The contacts of these sensitive relays operate two Weston Instrument Co. relays model 712, type 4, whose coils operate on 6 volts d.c. with contacts rated at 5 amperes on 110-volt d.c. These relays are especially designed to work with a coil current small enough to be safe for the contacts of the 534 relay. The second relays are in turn connected to two Struthers Dunn mercury contact relays type 22 BXX with double contacts normally open. These mercury relays together act like a double-pole double-throw switch. They actuate the armature of a 1/6 hp d.c. motor. When the rectified line voltage is too high the motor therefore operates in one direction and when the rectified line voltage is too low the motor operates in the opposite direction. The shaft of the motor is connected to Cenco resistances which serve as the field rheostat of our 110-volt 60-cycle alternator. A voltage regulator such as has been described above has been in constant use in our x-ray laboratory for twelve months. It regulates the a.c. voltage to within $\pm 1/50$ of a volt except for the short time intervals required for the motor to set the slider of the rheostats.

18. Secular Magnetic Variations as Transients. WALTER M. ELSASSER, *Columbia University.*—The quadrupole and higher harmonic components of the earth's magnetic field are subject to large secular variations within intervals of time of the order of a few hundred years. Observation indicates that the non-dipole part of the field has very nearly a completely random distribution in time. Its Fourier spectrum consists therefore in the main of components with periods of the order of a few centuries, the constant components being small or zero. The inductance of the earth's metallic core (assuming a fair metallic conductivity) is very large; as a result the periods of spontaneous decay of electric currents in the core, computed by conventional methods, are of the order of 10^4–10^5 years. Under these conditions it can be shown that the electric currents causing the non-dipole part of the field must flow in the top strata of the core. In the case of variable currents flowing at greater depth the upper part of the core shields the outer space from all "short period" Fourier components. The location ascribed here to the currents agrees with earlier results.[1]

[1] Phys. Rev. **60**, 876 (1941).

19. A New Magnetomotive Force Gauge and Magnetic Field Indicator. W. B. ELLWOOD, *Bell Telephone Laboratories.*—A new gauge and method of measurement are described, whereby the distribution of magnetic potential may be determined along the ferromagnetic core of a telephone relay, or similar electromagnetic device, while it is mounted in operating position, without disassembly, special search coils, or even change in adjustment. The gauge is portable, compact, and sensitive. A glass-enclosed, magnetically-operated reed switch, which is used because of its small size, high sensitivity, and magnetic structural features, is held electrically closed by the magnetomotive force which it is desired to measure. This magnetomotive force is opposed by a countermagnetomotive force supplied by a winding on the switch. The current in the winding which opens the switch is the measure of the magnetomotive force. The necessary control circuits and the procedures for their use are described for both manual and automatic operation. The device and method are applicable to the study of permanent magnets as well as electromagnetic structures. The coercive force of the core of a relay may be determined in a nondestructive manner.

20. The Movement of Solid Bodies in Sunlight. FELIX EHRENHAFT, *New York City.*—Experimental proof has been given that in all question of matter and radiation the unipolar north and south magnetic charge has to be taken into account in the same manner as the unipolar positive and negative electric charge.[1] Because of the great intrinsic intensity photomicrographs of microscopic bodies have been obtained during their helical light positive or light negative photophoretic movement in the concentrated beam of sunlight.[2] Photomicrographs permitting quantitative evaluation will be shown. In air of atmospheric pressure smoke particles, for instance, make 125 to 150 regular spaced turns per second. Light positive or light negative copper particles make about 20 turns per second, the helical traces are about 10^{-3} cm in diameter or 20 times larger than the radius of the copper particles. A homogeneous constant magnetic field of 50 gauss parallel to the beam of sunlight was applied half a second on an iron particle during its movement. The diameter of the helical path is about 100 times larger than the radius of the particle when light and the external magnetic field are acting together. The

diameter of the helical path in sunlight alone is much smaller. From the light negative photophoretic velocity in air of atmospheric pressure and the helical traces described above, with and without external magnetic field, the longitudinal constant magnetic field[3] in sunlight and the electric and magnetic charge of the particle has been calculated.

[1] F. Ehrenhaft, Bull. Am. Phys. Soc. Stanford Meeting, July, 1945.
[2] F. Ehrenhaft, Bull. Am. Phys. Soc. Columbus, Ohio Meeting, June. 1945.
[3] F. Ehrenhaft, Science **101** 676 (1945).

21. Law of Equilibrium Between Two Liquids. GEORGE ANTONOFF, *Fordham University.*—Gibbs formulated a mathematical law that at the boundary of two media the tension equals the difference of surface tensions of both. Actually for the liquid phases in equilibrium a law of the same form, but with different numerical values holds true. It can be deduced theoretically subject to condition that both phases contain an equal number of moles per unit volume. In fact, both have identical colligative properties, the reason why they don't mix. Separation into two liquid phases can be regarded as a condensation of a substance within a solvent. It undergoes polymerization resulting in more than one molecular species. Equilibrium depends on a reversible reaction which is time dependent. Thus, physical properties, among them densities, exhibit considerable and sometimes rapid fluctuation which cease at equilibrium. Thus, deviations from the above law cannot be interpreted as surface phenomenon, being due to processes in the bulk of solutions. Systems liquid-liquid present many experimental advantages as compared with other systems, and through them a comprehensive theory of liquids can be formed, which is in perfect agreement with experimental evidence. The theory of liquids is handicapped by want of suitable methods, it can only find solution if one falls back on ideas of Gibbs on equilibria.

22. An Equation of State for a System with a Single Type of Transformation, Including the Metastable States. J. L. FINCK, *The J. L. Finck Laboratories, Brooklyn 25, New York.*—Metastable states (supercooled and superheated fluids, etc.) have not been included among the equilibrium states considered in thermodynamics because such states are considered irreversible. Concept of reversibility is considered, and it is found to depend upon number of independent variables of system. For single homogeneous phase subject only to mechanical and thermal changes, just two independent variables have been considered. This practice requires that some states be characterized as metastable. Justification is offerred for change in this accepted view. Instead of classifying systems in phases, it is proposed to consider systems on basis of number of types of transformation. Single gaseous phase with dissociation will be analogous to liquid-vapor system. Each of these systems will have three independent variables, such as p,v,T, and equations of state will be of form $\epsilon=F(p,v,T)=G(p,T,x)$, and $v=(p,T,x)$ where ϵ is internal energy and x degree of transformation. These equations include all metastable states. On this basis an explicit equation of state for system with single type of transformation is developed, and results in the form

$$h=A+Bv+Cp+Dpv-T(E+Fv+Gp+Hpv)$$

where h = total heat, A, B etc. constants. This equation checks with data on saturated and superheated ammonia to within a few tenths percent. Also, for saturated and superheated steam agreement with steam tables is within several percent over the entire range of tables.

23. The Distribution of Energy in Turbulence. LARS ONSAGER, *Yale University, New Haven, Connecticut.*—The dissipation of energy by turbulence is regarded as primarily a "violet catastrophe." The velocity field of a liquid has an infinite set of Fourier components, whose mutual modulation redistributes the energy among more and more components which belong to ever increasing wave-numbers. In actual liquids this subdivision of energy is intercepted by the action of viscosity, which destroys the energy more rapidly the greater the wave number. However, various experiments indicate that the viscosity has a negligible effect on the primary process; hence one may inquire about the laws of turbulent dissipation in an ideal fluid. The modulation of a given Fourier component of the motion is mostly due to those others which belong to wave numbers of comparable magnitude. Some important applications of this principle are known; but it has not been pointed out before that the subdivision of the energy must be a stepwise process, such that an n-fold increase of the wave number is reached by a number of steps of the order $\log n$. For such a cascade mechanism that part of the energy density which is associated with large wave numbers should depend on the total volume rate of dissipation Q only. Then dimensional considerations require that the energy per component of wave number k equal (universal factor) $Q^{2/3}k^{-11/3}$. The corresponding correlation-function for the velocities at two points r apart has the form $R(r)=1-(\text{const.})\,r^{2/3}$.

24. The Wave Equation in a Medium With a Variable Index of Refraction. PETER G. BERGMANN, *Columbia University (On leave of absence from Lehigh University).*—Occasionally one is confronted with the problem of solving the wave equation when the index of refraction is a continuous function of the coordinates. It is well known that in this case the rigorous wave equation contains a first-order term in addition to the standard terms. This term is usually neglected. Its effect on the propagation of sound has been estimated by means of two different methods. The first-order term can be eliminated for any given frequency by introducing as the wave variable the excess pressure, divided by the square root of the density. The resulting equation contains a modified index of refraction which depends on the frequency. The second method, which is usually employed to examine the relationship between wave and ray treatment, involves the introduction of an amplitude and a phase factor. It is found that the first-order term appears in the "eikonal equation." It is proportional to the square of the wave-length, and it is small compared with the "diffraction term" unless the index of refraction changes appreciably over a distance of the same order as the radius of curvature of the wave front.

25. Space Charge—Limited Beams in Electrostatic Fields. M. E. ROSE,*[1] *Sonotone Corporation.*—The behavior in an electrostatic field of an electron beam limited by space charge is considered. The case dealt with is the circularly symmetric beam of finite cross section. Only first-order optics in which the aberration is due to space charge is treated. From the transformed equation of radial motion it is possible to obtain (a) the shape of the beam r for a given axial potential V, or (b) the axial potential for a given shape of beam. The electrode shapes are then to be obtained from the axial potential, or, *vice versa*, by integrating the Laplace equation. In general a numerical integration of the second-order equation of motion is necessary. However, by introducing $R=rV^{1/4}$ problem (b) may be reduced to a first-order, non-linear equation, which simplifies the procedure considerably, at least in some cases. The electrode design which will collimate an electron beam[2] can be obtained rigorously. The results obtained are in excellent agreement with the measurements carried out in the electrolytic tank.[2] In other cases it is possible to obtain the axial potential, and hence the beam radius, directly from the first-order equation. The problem of the "cross-over" in the presence of space charge is examined and it is concluded that a cross-over is not possible.

* To be read by title only.
[1] Now at Illinois Institute of Technology.
[2] J. R. Pierce, J. App. Phys. 11, 548 (1940).

26. The Ranges of Small Samples. RALPH HOYT BACON, *Fairchild Camera and Instrument Corporation, New York, N. Y.*—The range, or extreme variation, R_n, of a sample of n specimens, is the difference between the largest and the smallest specimen of the sample, and is the simplest statistic for describing the dispersion of the sample. There are applications for which it is of interest to know the distribution, $\psi(R_n)$, of the ranges of small samples drawn from a lot or universe whose distribution function, $\phi(x)$, is known. The distribution of the ranges is related to the parent distribution by the equation,

$$\psi(R_n)=n(n-1)\int_{-\infty}^{+\infty-R_n}\left[\int_x^{x+R_n}\phi(x)dx\right]^{n-2}\times\phi(x)\phi(x+R_n)dx.$$

Except for a few special cases, it is not possible to solve this equation explicitly, although the moments of $\psi(R_n)$ for samples of various sizes drawn from a normal universe were found by Tippett[1] in 1925. In the present work, the parent distribution is replaced by a histogram. Expressions for the number of samples of a given size, n, having a given range, R_n (measured in multiples of histogram intervals), obtainable from the distribution represented by the histogram are easily derived. In the limit (infinite number of histogram intervals of infinitesmal width), these expressions yield series expansions of $\psi(R_n)$, where the coefficients of the terms of the series are functions of certain definite integrals related to the parent distribution function, $\phi(x)$, and of the sample size, n.

[1] L. H. C. Tippett, Biometrika 17, 364 (1925).

27. Relativistic Interaction of Electrons on Podolsky's Generalized Quantum Electrodynamics. D. J. MONTGOMERY, *Princeton University.*—Podolsky[1] has formulated the basis for a generalized electrodynamics involving higher derivatives in the field equations. Podolsky and Kikuchi[2] have developed the theory to include the quantum case, getting natural generalizations of ordinary quantum electrodynamics, and have shown the self-energy and particle-particle interaction to be finite. The present paper extends the formalism, basing the treatment on some work of Fock,[3] and applies the results to the determination of the relativistic interaction of two electrons. In order to obtain an expression for this interaction, the wave equation for a system of particles is first derived, and the wave functional is developed in a series of eigenfunctionals. The resulting equations are transformed into a modification suitable for perturbation treatment, with the unperturbed system taken as two free electrons. The matrix element for the interaction turns out to be a generalization of Møller's formula.

[1] B. Podolsky, Phys. Rev. 62, 68 (1942).
[2] B. Podolsky and C. Kikuchi, Phys. Rev. 65, 228 (1944); 67, 184 (1945).
[3] V. Fock, Physik. Zeits. Sowjetunion 6, 425 (1934).

28. On the Heavy-Electron Pair Theory in the Stong Coupling Limit. JOHN M. BLATT, *Princeton University.**—The pair-theory of Marshak and Weisskopf[1] was investigated assuming strong coupling. The strong-coupling criterion is $A=(Nf/\mu)>5$ where f=coupling constant, μ=heavy electron mass, $N=\int U^2(x)d^3x$, $U(x)$=source function of the nucleon. $N\cong 1/\pi a^3$, where a=source radius (all in units where $\hbar=c=1$). With this condition, the magnetic moment turns out to be of order A^{-1}, and of magnitude too small to account for the observed anomalies. The leading term in the potential of the force between two nucleons (for $r_{AB}>2a$) is independent of the spin orientations, of the coupling constants, and of the type of coupling (as long as no derivatives of the heavy-electron field quantities occur in the coupling term). This potential is identical with the one calculated by Jauch[2] and Houriet,[3] but was not considered by Nelson and Oppenheimer.[4] The next term in the potential is of order A^{-3}. It corresponds to a superposition of a $(\Sigma_A\cdot\Sigma_B)$ term, a tensor force term, and an ordinary force. Being of order A^{-3} it is too small, however, to fit the experimental results.

* Now with RCA Laboratories, Princeton, N. J.
[1] Marshak, Phys. Rev. 57, 1101 (1940): Marshak and Weisskopf, Phys. Rev. 59, 130 (1941).
[2] Jauch, Helv. Phys. Acta 15, 175 (1942).
[3] Houriet, Helv. Phys. Acta 16, 529 (1943).
[4] Nelson and Oppenheimer, Phys. Rev. 61, 202 (1942).

29. Equilibria in Pure Liquids.* GEORGE ANTONOFF, *Fordham University.*—Condensation of vapors into a liquid follows the pattern of systems separating into two liquid layers, with the difference that the solvent is absent, and it takes place so to say in vacuum. Thus, the vapor and liquid in equilibrium are subject to the same laws as systems liquid-liquid. Properties of many liquids have been found time dependent. This is due to the presence of several molecular species. Equilibrium between them is

sometimes reached rapidly, as in the case of ionic substances, e.g. water. In other cases the process is slow. This explains why physical constants of liquids by different authors often vary withing limits exceeding experimental errors.

* To be read by title only.

30. On Position of Uranium Y in Radioactive Series.* GEORGE ANTONOFF, *Fordham University.*—Since I isolated a branch product in uranium which I called uranium Y, various hypothesis were expressed as to its position in the series. It is sometimes regarded as a parent of protactium, in which case the uranium atom would disintegrate at a rate of 98 percent in the main series, and about 2 percent in the direction of the actinium series. There was also expressed the opinion that an element of atomic number 92 and atomic weight 235 may be the parent of uranium Y. This hypothesis is in better agreement with facts known, if one assumes that U^{235} is normally present in uranium in quantity of about 0.7 percent. The amount of uranium Y I ever succeeded in separating never exceeded this amount. The hypothesis that uranium Y may be connected with uranium Z, a branch product of uranium X_1 to the extent of 0.035 percent of the latter, is therefore not supported by experimental evidence, because this figure is of a different order of magnitude.

* To be read by title only.

Proceedings of the American Physical Society

MEETING OF THE NEW YORK STATE SECTION OF THE AMERICAN PHYSICAL SOCIETY AT BUFFALO, NEW YORK, NOVEMBER 10, 1945

THE Fall Meeting of the New York State Section of the American Physical Society was held in Foster Hall, University of Buffalo, Buffalo, New York on Saturday, November 10, 1945. This meeting was sponsored jointly by the Section and the New York State Science Teachers Association, and marks the return of the Section to an active status, the Spring meeting having been cancelled because of the limitations on attendance imposed by the Office of Defense Transportation. An attendance of about fifty persons was recorded at the sessions.

The following program of invited papers was presented:

Morning Session

Address of Welcome, SAMUEL P. CAPEN, *Chancellor, The University of Buffalo.*

Focusing Invisible Light, RAYMOND T. BYRNE, *Batavia High School.*

Problems of the Spectrochemical Analysis of Metals, T. S. JACKSON, *The Bethlehem Steel Company.*

Applications of the Mass Spectrograph, D. L. WOERNLEY, *The University of Buffalo.*

Afternoon Session

Properties of a Sensitive Point Counter, AUSTIN C. MCTIGUE, *Canisius College.*

Some Diffraction Problems in Phase Difference Microscopy, HELEN JUPNIK, *Spencer Lens Company.*

The Wind Tunnel and Airplane Design, F. W. GEIGER, *Curtiss-Wright Corporation.*

W. R. FREDRICKSON
Secretary