Proceedings of the American Physical Society

MEETING AT COLUMBUS, JUNE 15 AND 16, 1945

THE 266th meeting of the American Physical Society was held at Columbus (Ohio) in the Mendenhall Physics Laboratory of the Ohio State University on Friday and Saturday, June 15 and 16, 1945. This was our first experience with a meeting under the regime of limited attendance prescribed by the Office of Defense Transportation. The applicants for authorization to come to the meeting from outside of Columbus were fewer than fifty, so that none had to be denied; fewer than forty-five came. Attendance from Columbus raised the total to about seventy at the dinner and to nearly one hundred at the most largely attended scientific session. The meeting was accordingly akin to the small congenial meetings of "the old days," and the limitation on discussion could be loose as the limitation on attendance was strict. The Local Committee was headed by Dean Alpheus W. Smith, to whom and to whose colleagues the gratitude of the Society is due and is expressed.

Early plans for a large **Symposium on Biophysics,** intended to stimulate interest and to encourage the formation of a group in this field, were severely reduced in scope when the limitation on attendance became certain; but as a token of the interest of the Society in this field, D. W. Bronk was asked to arrange a half-day symposium, and responded by procuring four notable invited papers of which his own could unfortunately not be given. The actual speakers and titles were:

E. NEWTON HARVEY, *Princeton University:* **Bubble Formation in Blood and Tissues.**

ALEXANDER HOLLAENDER, *National Institute of Health:* **Studies of the Mechanism of the Effect of Ultraviolet Radiation on Microorganisms.**

K. S. COLE, *Columbia University:* **Electrical Properties of Nerve.**

The Division of Electron and Ion Optics held its second annual meeting, under the chairmanships of L. Marton and L. P. Smith. There were three contributed papers of which the abstracts are appended under the denotations **B1, B2, B3,** and five invited papers which were the following:

LLOYD P. SMITH, *RCA Laboratories:* **Quantum Effects in High Frequency Control of Electron Beams.**

FRANK GRAY, *Bell Telephone Laboratories:* **The General Solution for an Electron Stream in a Parallel Plane Diode.**

J. HILLIER AND R. F. BAKER, *RCA Laboratories:* **High Resolution Electron Diffraction.**

EUGENE FEENBERG, *Sperry Gyroscope Company:* **The Theory of Cascade Bunching.**

A. F. PREBUS AND IGNACE ZLOTOWSKI, *Ohio State University:* **The Accuracy of Electrolytic Trough Measurements.**

The abstracts of twenty-one contributed papers on the general programmes of the Society are appended hereinafter.

The dinner of the Society was held at the Deshler-Wallick Hotel on the evening of Friday, June 15, Harvey Fletcher presiding. Brief addresses were made by Alpheus W. Smith; by C. C. Williams of the Battelle Memorial Institute, on metallurgy in wartime; by A. R. Olpin of the Ohio State University Research Foundation, on research foundations generally; by E. U. Condon; and by the President.

The Council of the American Physical Society had met previously at New York in order to minimize travel for the majority of its members; the meeting occurred on May 5. Three candidates were elected to fellowship and seventy-four to membership. By delegation of power to the Secretary the Council assured the election to membership of candidates whose nominations should be received not later than June 30. Thirty-eight candidates were elected to membership under this delegation.

Lost through death: (as reported through June 30): H. C. Richards (*University of Pennsylvania*, F), E. C. Wiersma (*University of Delft*, M), P. I. Wold (*Union College*, F), R. C. Young (*William and Mary*, M).

Elected to Fellowship: P. Y. Chou, K. A. Norton, Dorothy Wrinch.

Elected to Membership: John Backus, Fred W. Billmeyer, Jr., David Bohm, John Wallace Carlson, George C. Dacey, Adrian Hilman Dahl, Philip J. Donald, Robert Bayard Edmonson,

Spofford G. English, Harold K. Farr, E. F. George, Leon R. Grove, George L. Jenkins, Eleanor Karasak, Richard Latter, John Seth Laughlin, Gordon M. Lee, Alan Roland Liss, Frederick P. Longwell, Gene McDaniel, Ralph O. McIntosh, Ernest Mayer, Arild J. Miller, Salwa C. Nassar, Nathan Grier Parke, III, Joseph Pierson, David Pomeroy, Merrill Rassweiler, Dexter H. Reynolds, Albert M. Rubenstein, W. Lewis Shetler, Bernard A. Shoor, Frank Milton Sparks, Ralph T. Squier, Charles W. Tope, Ferd Elton Williams, George W. Wood, John Lamar Worzel.

KARL K. DARROW, *Secretary*,
American Physical Society,
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ABSTRACTS OF CONTRIBUTED PAPERS

B1. The Paths of Ions and Electrons in Crossed, Non-Uniform Electric and Magnetic Fields. NORMAN D. COGGESHALL, *Gulf Research and Development Company.*—The integration of the force equations for charged particles moving in certain types of non-uniform magnetic fields has been reported earlier.[1] It has been found that the force equations for a charged particle moving in the presence of particular types of crossed, non-uniform electric and magnetic fields may be integrated by a generalization of the same method. The cases which admit of the integration are those such that the electric and magnetic fields are crossed and are both functions of the same coördinate, either Cartesian or cylindrical. The integration may be done numerically by a direct method if the field variations are too complicated for analytical evaluation or if the fields are known only experimentally. Using this approach the calculations for some of the known types of crossed field mass spectrographs and beta-ray spectrographs are shown to be special cases of the general method. From the functions involved in the quadratures it is possible to deduce certain properties of the orbits such as periodicity, spatial extension, dependence on initial conditions, etc. The dependence of the calculated orbits upon initial energies, field strengths, particle masses, and starting direction will be shown and discussed for a number of physically interesting cases.

[1] N. D. Coggeshall and M. Muskat, Phys. Rev. **66**, 187 (1944).

B2. Anomalies in the Electron Diffraction Pattern of Magnesium Oxide. J. HILLIER AND R. F. BAKER, *RCA Laboratories.*—Magnesium oxide smoke and magnesium oxide reagent were examined by a transmission electron diffraction camera possessing a resolving power at least an order of magnitude higher than used previously. Under these conditions a number of the rings become multiple indicating that magnesium oxide does not have an accurately cubic structure. The (111) ring appears as a doublet with $d(111)=2.451$A and 2.398A. The (200) line appears single and sharp. The 220 had an unusual contour on the ring patterns but was resolved into five rings by studying single crystal reflections. The spacing corresponding to the five rings are as follows: 1.468, 1.477, 1.485, 1.493, 1.502. (222), (224), (226), and (333) rings were also observed as doubled. No structure has been found which explains satisfactorily all the observed rings and single crystal reflection patterns.

B3. The Electron Optics of Mass Spectrographs and Velocity Focusing Devices. R. G. E. HUTTER, *Stanford University.**—The well known results of the theory of mass spectrometers and velocity focusing devices are derived again by a different method which is simpler than the ones previously used. This method brings out more clearly the electron optical nature of the deflecting and focusing properties of the fields employed in the mentioned types of instruments.

* Now with Sylvania Electric Products, Inc.

C1. Effect of Excitation Frequency on Spectrum of Gaseous Discharges. KEITH J. HAYES, J. GIBSON WINANS, AND WARREN CULP, *University of Wisconsin.*—It has been observed by radio experimenters that commercial neon bulbs show a purple tinge when excited at frequencies above 10 megacycles. Spectroscopic studies of this effect were made with frequencies .29, .34, .75, 1.5, 8, 16, 32, 64, 130, 390, and 600 mc as well as 60 c and d.c. The purple glow appears at about 10 megacycles and increases in intensity up to 600 mc. The purple color is due to the excitation of the violet lines of argon which is present in small quantity in the tubes. The change occurred at the electrode as well as in the gas. A tube containing pure neon gave no noticeable change in spectrum with change in excitation frequency. A similar effect was observed with commercial argon filled bulbs. The spectrum at 60 cycles consisted almost entirely of the violet second positive bands of nitrogen. At frequencies above 10 mc, however, the orange first positive bands of nitrogen were obtained with high intensity, and the color of the discharge was orange instead of violet. Tubes containing pure nitrogen did not show this effect. These results show that in gas mixtures which show these effects, the spectra requiring the smaller excitation energy gain in intensity with increase in excitation frequency.

C2. Raman Spectra of Spiropentane and 1,1-Dimethylcyclopropane. FORREST F. CLEVELAND AND M. J. MURRAY, *Illinois Institute of Technology.*—Murray and Stevenson[1] synthesized a C_5H_8 hydrocarbon by the debromination of pentaerythrityl bromide with zinc dust and assigned to it the spiropentane structure (symmetry D_{2d}) on the basis of its Raman spectrum, chemical properties, and method of preparation. This structure has recently been confirmed by an electron diffraction investigation.[2] In the

present work, the depolarization factors of the Raman lines of spiropentane have been obtained by use of the method previously described.[3] Raman frequencies, estimated relative intensities, and qualitative depolarization factors have also been obtained for 1,1-dimethylcyclopropane. The spectra of the two compounds, each of which has at least one three-membered ring, are compared and discussed in the light of the group theory selection rules.

[1] M. J. Murray and E. H. Stevenson, J. Am. Chem. Soc. **66**, 812 (1944).
[2] J. Donohue, G. L. Humphrey, and V. Schomaker, J. Am. Chem. Soc. **67**, 332 (1945).
[3] Forrest F. Cleveland, J. Chem. Phys. **13**, 101 (1945).

C3. The Infra-Red Spectra of Chloroform and Bromoform. GEORGE L. JENKINS AND JOSEPH W. STRALEY. *University of North Carolina.*—The infra-red spectra of $CHCl_3$ and $CHBr_3$ has been observed in both the liquid and vapor states in the region from 2–15μ. A number of overtone and combination bands have been observed. The contour of several fundamental bands has been well enough established to warrant an approximate calculation of the moments of inertia and other molecular magnitudes. The frequencies in cm^{-1} of the fundamental bands which lie in the region examined are:

	$CHCl_3$		$CHBr_3$	
	Liquid	Vapor	Liquid	Vapor
δ_2	762.2	771.0	—	—
δ_5	3018.4	3034.4	3012.0	3049.2
δ_6	1216.5	1218.9	1142.4	1147.7

C4. Further Measurements on ω_1 and ω_2 of CD_3Cl in the Infra-Red. HARALD H. NIELSEN AND ALVIN H. NIELSEN,* *The Ohio State University, Columbus, Ohio.*—Of the vibration-rotation bands of CD_3Cl reported on at an earlier meeting,** ω_1 and ω_2 have been completely remapped in the first order of a 7200 line-per-inch Wood replica grating instead of in second order of an 800 line-per-inch grating. The parallel vibration ω_1 has been so well resolved, that a good knowledge of the rotational spacing is now available. This spacing, averaged over the whole band, is about 0.7 cm^{-1} instead of 1.01 cm^{-1} as previously reported. The value 0.7 cm^{-1} is in good agreement with the $\Delta\nu$ observed for the other parallel bands ω_3 and ω_5. The moment of inertia I_A calculated from this spacing is 80.1×10^{-40} g cm^2. Complete resolution of the Q branches in the perpendicular vibration ω_2 is also effected. It is believed that the positions of the rotation lines in both bands is known to ±0.07 cm^{-1}.

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** Chicago, December, 1944.

C5. Some New Measurements on ω_3 of $C^{12}O^{16}_2$ and $C^{13}O^{16}_2$. ALVIN H. NIELSEN* AND Y. T. YAO,** *The Ohio State University, Columbus, Ohio.*—The vibration designated ω_3 for the molecules[1,2] $C^{12}O^{16}_2$ and $C^{13}O^{16}_2$ with band centers at 2350 cm^{-1} and 2284 cm^{-1} have been completely remapped with a prism-grating spectrometer employing a 7200 line-per-inch Wood replica grating. In all portions of the bands where no overlapping occurs, the resolution of the rotation lines is complete. In the region where the P branch of the $C^{12}O^{16}_2$ overlaps with the R branch of the $C^{13}O^{16}_2$, though not complete, the resolution is sufficiently good to permit the identification of the lines of both bands. The grating was calibrated with a mercury arc, and it is believed that the rotation lines are now known to ±0.07 cm^{-1}. In mapping these bands galvanometer deflections were read at intervals of 0.07 cm^{-1} and plotted *versus* frequencies in cm^{-1}. The slits were set to include a frequency interval of 0.3 cm^{-1}. The data is being analyzed with a view to recalculating some of the constants relating to ω_3 and the convergence of the rotation lines.

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** The National University of Peking, Kunming, China.
[1] P. E. Martin and E. F. Barker, Phys. Rev. **41**, 291 (1932); D. Cameron and H. H. Nielsen, Phys. Rev. **53**, 246 (1938).
[2] Alvin H. Nielsen, Phys. Rev. **53**, 983 (1938).

C6. Absorption Bands in the Spectrum of Butadiene. Y. T. YAO, *National University of Peking, Kunming, China* (at present at *Ohio State University, Columbus, Ohio*). (*Introduced by H. H. Nielsen.*)—The absorption region in the spectrum of butadiene near 3.2μ has been examined using an echellette grating at intervals corresponding to 0.29 cm^{-1}. The slits subtend an interval of approximately 0.4 cm^{-1}. It was revealed that this region consists of at least two bands, one with its center at 3.21μ and the other with its center at 3.3μ. Some indication of rotational structure is found. The bands at 9.86μ and 11.01μ have been observed with a grating ruled with 800 lines per inch at intervals corresponding to 0.29 cm^{-1} and 0.214 cm^{-1}, respectively. A rotational separation of about 1.9 cm^{-1} is observed. This structure is better defined in the 11.01μ band than in the 9.86μ band.

D1. Width of Nuclear Levels. M. GOLDHABER, *University of Illinois.*—An extension of the analysis of the width of the known RaC′ levels, based on the data of Rutherford, Ellis, Lewis, and their co-workers, supports the view, recently expressed,[1] that the maximum gamma-ray width has been considerably underestimated in the past. Among the states of 2–3 Mev excitation energy, there appear to be several with a width of the order of a few ev, in contrast to the sharp states previously analyzed, which have widths of the order of 10^{-3} ev.[2] This suggests the possibility that some slow neutron groups of large total width, hitherto ascribed to an agglomeration of a large number of sharp compound nucleus states[2] may be due to wide compound nucleus states (see following abstract). The larger values for the radiation width bring the Bohr theory of nuclear reactions into better agreement with experiment in several other respects (e.g., probability of fast neutron capture, level density). A number of difficulties arise, however, if one tries to account for the sharp neutron groups (width $\lesssim$0.1 ev).

[1] M. Goldhaber, Phys. Rev. **67**, 59 (1945).
[2] See H. A. Bethe, Rev. Mod. Phys. **9**, 69 (1937).

D2. Evidence of Wide Neutron Groups. A. A. YALOW AND M. GOLDHABER, *University of Illinois.*—We have carried out a systematic search for wide neutron groups using various methods of investigation (self-absorption, absorption in boron, overlapping of levels; and combinations of these methods). Among the known groups of large

total width the Ag (22 sec.) B group and the Br (18 min. and 4.4 hr.) group have been studied in some detail and appear to be due to single wide levels. The B group was investigated by isolating it with a "double filter" of Cd+Au which removes C and A neutrons. A number of new cases of overlapping of neutron resonance levels of different elements have been observed. Evidence for fairly wide levels in Re and Ir has been obtained. With these elements as absorbers a considerable reduction is found in the activity produced by R neutrons in the following detectors: Mn (2.59 hr.), As (26.8 hr.), Br (18 min.), Pd (13.0 hr.),[1] Ag (22 sec. (B) and 2.3 min.), I (25 min.), W (24.1 hr.).

[1] See H. Feeny and F. Rasetti, Can. J. Research **A23**, 12 (1945).

D3. Search for (n, α)-Reaction in Rare Earth Elements with Slow Neutrons. H. D. ARNETT, GERTRUDE SCHARFF-GOLDHABER, AND G. S. KLAIBER,* *University of Illinois.*—The (n, α)-reaction can be expected to be exothermic in the rare earth region. If the ratio r of α-particles emitted per slow neutron captured, as well as the energy E released, were kyown, the width of the compound nucleus level could be calculated and compared with the directly measurable width of the neutron resonance level. Such measurements would yield valuable information about the nature of the sharp neutron resonance levels found for the rare earths. As a first step, we have renewed the attempt to detect α-emission from Sm under the action of slow neutrons,[1] and extended the work to a number of neighboring elements. Some improvements in technique were made and the arrangement calibrated with the $B^{10}(n, \alpha)$-reaction. No α-emission could be detected for C neutrons within the limits attainable in our experiment. For Sm and Gd we can deduce $r < 10^{-4}$. If the sharp levels were compound nucleus levels with a width ≤ 0.1 ev[2] and if we assume $E \geq 8$ Mev we obtain a theoretical estimate $r \gtrsim 10^{-3}$.

* Now at General Electric Research Laboratory, Schenectady, New York.

[1] J. Chadwick and M. Goldhaber, Proc. Cam. Phil. Soc. **31**, 612 (1935).

[2] H. H. Goldsmith and F. Rasetti, Phys. Rev. **50**, 328 (1936).

F1. Accelerational-Velocital Magnetic Forces. F. W. WARBURTON, *University of Kentucky.*—Magnetic potential energy as a function of relative position, velocity and acceleration of two electrical charges, when used in the generalized Lagrangian equations of motion and extended to include terms in $1/c^3$, provides expressions for the mutual force of one charge on the other containing the product of the velocity of one charge and the acceleration of the other. When averaged over a circular orbit oriented at random, one such term gives a net force due to electrons accelerated in starting or stopping a longitudinal conduction current in a bar of magnetic material, which appears sufficient to account for the shock effect studied by Perkins and Doolittle.

F2. Scattering of Electrons by Matter. GEORGE WINCHESTER, *Rutgers University.*—The scattering of electrons within an absorber is probably due to the non-uniform force fields within the material. The amount of matter (thickness or g cm^{-2}) necessary to absorb one-half of a certain intensity, let us say, of beta radiation from a radioactive material depends upon the force fields existing between the atoms of that particular absorber. If the force fields of any particular absorber (or scatterer) are changed then the one-half thickness value will also change, regardless of the number of atoms involved in the scattering. The scattering of beta particles of RaE by hard rolled and by annealed aluminum is definitely different (up to 17 percent, depending on the method of annealing) and can readily be shown experimentally. Also, the scattering of beta particles by a sheet of aluminum before and after prolonged gentle tapping is definitely different, the tapped condition causing the largest scattering. This may be due to an increase in the number of crystals per mm^2. It would thus appear that the coefficient of absorption of beta particles by a certain absorbing material depends upon its state of aggregation.

F3. Composition and Diffraction Effects in X-ray Microradiographs. J. M. HURD, C. M. LUCHT AND R. SMOLUCHOWSKI, *General Electric Research Laboratory.*—X-ray microradiographs provide a convenient method for the study of various phenomena in metals. A fine grain photographic emulsion allows the use of medium high magnifications (100 to 200). Variation of composition between various constituents can be detected and what is particularly interesting concentration gradients within a solid solution can be observed. These gradients are well nigh not detectable by other methods. Depending upon the orientation of a grain, various sets of crystallographic planes diffract the radiation and affect the transmitted intensity. Along grain boundaries dark and light lines and shadows are observed which are also explicable as a diffraction effect. In certain cases these shadows make an interpretation of concentration effects difficult.

F4. Magnetic Behavior of Molecularily Dispersed Iron. GEORGE ANTONOFF, *Fordham University.*—If an iron salt is electrolyzed with a mercury cathode, some of the iron penetrates into mercury forming an amalgam, and some of it settles on the surface in form of small dendrites of metallic iron. A test tube was taken of the size just to fit into the gap between the poles of an electromagnet. Some mercury was inserted into it to act as a cathode. The test tube was filled with a saturated solution of ferrous sulphate. An anode of soft iron was inserted into the upper part of the test tube. A current of about 1 amp. was passed through. After a certain time one could observe the formation of an amalgam near the surface. Then application of magnetic force caused sinking of the amalgam and reappearance of the free surface of mercury. Looking on the surface of mercury one also observed deposits of small particles of iron near the two poles. The reversal of poles produced no visible effect. This behavior was different from that described by Reynolds who worked with a colloidal solution of ferric hydroxide which deposited only on north pole. In this case the ferrous sulphate solution was apparently in a molecularily dispersed state in the initial stages, and the effect was dipolar.

F5. Flow of Fluids with Non-Uniform Viscosity in Tubes with Distensible Walls: Blood Flow. ALLEN L. KING, *Dartmouth College.*—Three important factors influence the rate of blood flow through a blood vessel: the non-uniformity of plasmal viscosity, the elasticity of the vessel wall, and the presence of erythrocytes and other corpuscles. If the viscosity η of an incompressible fluid depends on speed v and gradient dv/dr in a cylindrical tube, then at any cross-section of radius r the volume flowing by per unit time is $Q=\pi r^2\int_0^{v'}v\eta dv/\int_0^{v'}\eta dv$. The speed at the tube wall is assumed to vanish and that at the center v' to be a function of r. The denominator equals $-1/4(d(pr^2)/dx)$, where r and pressure p are functions of distance x along the tube axis. If the wall material consists of randomly distributed and twisted long chains of molecules, then by methods developed for the analysis of rubber, a relation between p and r may be found and used in the equation for Q. Often the presence of particles, such as erythrocytes in blood, is assumed to affect η; thus the term viscosity becomes less well-defined. In general, the rate of blood flow is not proportional to the difference in pressure between the ends of a blood vessel.

F6. A Correction of G. M. Counter Data. HENRY B. MANN AND J. D. KURBATOV, *Ohio State University.*—Two models have been offered for the correction of G.M. counter data, due to the finite resolving time τ. In the first it is assumed that in order for a counter to register a particle, that particle must be preceded by an interval τ during which no particle arrives at the counter.[1] In the second model it is assumed that any number of particles may arrive during this interval provided no discharge is produced during this time.[2] In the present work it is shown that, according to the second model, the mean number $B(T)$ of discharges during any time T is given by

$$B(T)=\int_0^T[1-p(t)]a(t)dt, \qquad (1)$$

where $a(t)$ is the total density of radiation penetrating the tube at the time t and $p(t)$ is the solution of the integral equation:

$$p(t)=\int_{t-\tau}^{t}[1-p(x)]a(x)dx, \qquad (2)$$

for $t>\tau$ and $p(t)=1-e^{-at}$ for $0\leq t\leq\tau$. $B(t)$ is explicitly obtained for the case that $a(t)$ is constant. In this case it is also shown that

$$aT=\frac{B(T)-\eta}{1-[B(T)-\eta]\dfrac{\tau}{T}}, \quad |\eta|\leq\frac{(a\tau)^2}{1-(a\tau)^2} \quad \text{for} \quad a\tau<1.$$

[1] L. I. Schiff, Phys. Rev. **50**, 88 (1936).
[2] B. V. Gnedenko, J. Exper. Phys. U.S.S.R. 11, 101 (1941).

F7. An Ionization Gauge of Simple Construction. CHARLES FOGEL, *National Union Research Laboratories.*—A new ionization gauge is described for measuring pressures from 10^{-4} to less than 10^{-8} mm of mercury. Except for a multiplying factor of 10, it gives a direct reading of residual air pressure. The gauge employes two plates, as the electron and ion collector respectively. They are located on opposite sides of the filament, but equidistant from it. This allows easy outgassing of parts, either by electron bombardment or by r.f. heating. A protective shield in front of the ion collector aids in reducing the electrical leakage to that element. Danger of filament burn-out due to vacuum leaks has been removed by the choice of an oxide-coated filament.

F8. An Adsorption Isotherm of Radon. BENJAMIN P. BURTT AND J. D. KURBATOV, *Ohio State University.*—A procedure has been developed for obtaining an adsorption isotherm of minute quantities of radon from an air-radon mixture at atmospheric pressure and $t=25°$. Quantities of radon from 2.0×10^{-13} to 4.4×10^{-11} gram were used. These quantities were determined by means of an ionization chamber and electrometer calibrated against a radium standard. Silica gel was used as adsorbent. The quantity of silica gel and the water contained in it were such that below 3.6×10^{-13} gram of radon the adsorption isotherm followed Henry's law and at higher quantities the exponent of isotherm equation became less than unity allowing therefore, the determination in this region of unknown quantities of radon directly from the isotherm. The apparatus and procedure will be described.

F9. The Use of Frequency Modulation in a Sensitive Micrometer. G. M. FOLEY, *Battelle Memorial Institute. (Introduced by H. W. Russell.)*—In order to measure the unimpeded displacement of an object, one plate of a small air condenser is attached to the object. The other plate is fixed close to the moving plate, and the condenser is used to tune a radio frequency oscillator. The change in frequency which results from motion of the object is converted into proportional d.c. voltage by a receiver similar to a frequency-modulation radio receiver. Voltages of plus or minus 300 are obtained from small displacements, and a magnification of the motion of 10,000 to 100,000 times can be obtained, permitting detection of displacements of less than 10^{-6} inch. The apparatus is rugged and stable, and requires no electrical connection with the object whose position is being measured. Two such micrometers were placed at right angles to measure the rotation of a precision lathe spindle in its bearings, the outputs of the two micrometers being applied to two axes of a cathode ray oscilloscope. A similar micrometer was used as a high speed recording dilatometer to follow the allotropic transformation of steel on heating and cooling.

F10. Note on the Hydrodynamic Theory of Journal Bearings. J. C. BELL, *Battelle Memorial Institute. (Introduced by H. R. Nelson.)*—A type (a) of journal bearing being studied by A. F. Underwood[1] supports a rotating radial load of constant magnitude, but has no rotation of the two surfaces.[2] In order to describe the hydrodynamic lubrication in this bearing, Reynolds' classic equation is generalized to allow for both tangential and normal relative motions of the surfaces. Except for a factor 2, the lubrication in this bearing has the same differential equation as that for either (b) a shaft rotating together with a radial

load of constant magnitude or (c) a rotating shaft with a unidirectional load. Thus, the hydrodynamic lubrication is the same for all these types, except that in Type (a) a given thickness of film can support twice as great a load as in the others. Since the service behavior in Types (b) and (c) is known to depend on film thickness, an alternative explanation is offered for the greater load-carrying capacity of bearings of Type (b) over Type (c).

[1] General Motors Research Laboratories.
[2] Described in preprint for 1944 Annual Meeting of A.S.M.E.

F11. Ponderomotive Forces of Light upon Matter as Shown by Experiments. FELIX EHRENHAFT, *New York City.*—In a vertical beam of light, particles of Cr, Fe, Ni, Mn, CuO_2, etc., of a size of about the order of the wavelength of light, fall vertically, while some of those slightly larger describe, in falling, distinct helical paths in the beam of light. This helical movement, appearing in the horizontal beam of light as sine curves or spirals have already been described and later were found independently by Whytlaw-Gray and Patterson[1] in repeating my experiments in photophoresis.[2] It was determined in experiments made with Richard Whitall that often the bodies made five to ten revolutions per second around the axis of the helix. The radius of this helical path is very large compared with the radius of the body. The path has been observed with linear polarized and natural light and with and without parallel external magnetic fields. These observations added to the light-positive and light-negative movements of photophoresis show that light can exert repulsion, traction, and torsion on matter free to move with three degrees of freedom. New experiments using sunlight will be described. The principle of the conservation of linear and angular momentum of electrodynamics will be generalized.

[1] Whytlaw-Gray and Patterson, *Smoke, A Study of Aerial Disperse Systems* (Edward Arnold and Company, London, 1932), p. 120.
[2] F. Ehrenhaft, Ann. d. Physik **56**, 81 (1918); See also J. Frank. Inst. **233**, 235 (1942).

T1. The Electric Counterpart of Oersted's Experiment. FELIX EHRENHAFT, *New York City.*—In the sense of Oersted-Ampere, a single magnetic charge rotates around the electric current. An Alnico 5 magnet—60,000 maxwells—was fitted with two circular cylindrical pole pieces ending in truncated cones 5 mm in diameter and 1.5 mm apart. The horizontal opposing pole faces were covered with a thin electrically insulating layer of Picein. The rotation of ferric hydroxide particles suspended in a cylindrical drop of ferrous chloride solution placed in the homogeneous field between these pole-faces-can be observed to be counterclockwise when looking at the South pole and to be independent from the influence of light under the conditions of illumination described.[1] Connecting the poles of the magnet with a piece of soft iron of small cross-section, the rotation of the particles is slower. With a piece of larger cross section the rotation ceases. Upon adding a trace of NH_4OH to the droplet, the rotation diminishes. Adding more the rotation ceases; further additions reverse the rotation. Obviously this phenomenon can-not be explained by Biot-Savart-Lorentz force nor by Faraday, Quincke movements. If we term the magnetic vortex detected by Oersted the magnetic action of electric currents, the above described electric vortex should be termed the electric action of magnetic currents.

[1] F. Ehrenhaft, J. Frank. Inst. **233**, 236 (1942).

T2. Polarity of Magnetism. FELIX EHRENHAFT, *New York City.*—In continuing the experiments reported previously[1] a cell was used having separate compartments for the poles. With the electromagnet formed of one piece of iron, and dilute H_2SO_4 in the cell, a greater evolution of gas, often 100 percent more, was observed when the magnetic field was in action than when the gas was evolved by chemical action alone. Whereas in the first experiments reported more oxygen was detected in the gases evolved than could be accounted for by the air dissolved in the water, following the reports of J. T. Kendall[2] and others the earlier experiments were repeated without duplicating the first results. It therefore seems necessary to investigate the whole matter further in order to solve the old Fresnel-Ampère dispute.[3] However, in using a cell with one or two compartments, two kinds of gas bubbles were observed when the magnetic field was in action, one kind circulates counter-clockwise when looking on the south pole, the second kind being repelled or attracted by one of the poles in the homogeneous part of the field. The first kind behave as if they bear an electric charge, the second a magnetic charge. Both reverse with the field. From these observations one must again conclude that magnetism has to be described as a polar vector.

[1] F. Ehrenhaft, Phys. Rev. **63**, 461 (1943); **65**, 287 (1944); Nature (September 30, 1944).
[2] J. T. Kendall, Nature (February 5, 1944).
[3] Augustin Fresnel, Oeuvres T 2, 676.