used in the vaporization and reflectivity studies have not been able to modify with certainty the surface structure of the metal. The indications are that in extremely high vacuums certain changes in the vaporization rate and in the reflectivity of a metal should be produced by the application of sufficiently high electrostatic fields to the metal surface. In the case of reflectivity, in order to observe such effects, an improved form of apparatus would probably be required.

ACKNOWLEDGMENT

The author wishes to express his gratitude to Dr. Elmer Hutchisson, who suggested this problem and under whose guidance the research was started; to Dr. A. G. Worthing, who acted as advisor during the absence of Dr. Hutchisson in the present emergency, and made helpful suggestions in the preparation of the manuscript; and to Dr. A. J. Allen and other members of the Physics Department who offered suggestions.

PHYSICAL REVIEW VOLUME 65, NUMBERS 9 AND 10 MAY 1 AND 15, 1944

Letters to the Editor

PROMPT publication of brief reports of important discoveries in physics may be secured by addressing them to this department. The closing date for this department is the third of the month. Because of the late closing date for the section no proof can be shown to authors. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents. Communications should not in general exceed 600 words in length.

Note on Events Distributed According to Chance

ARTHUR E. RUARK
University of North Carolina, Chapel Hill, North Carolina
April 17, 1944

IN a recent paper[1] I have shown how to calculate the chance W_n that n events will occur in a domain of several dimensions described by variables x, y, etc. W_n can always be found if we are given the chance $f(x, y)dxdy$ that an event will occur in $dxdy$. In this note, I wish to record a development which arose in a problem dealing with surface flaws and volume flaws in glass and other brittle materials. It turns out that the method can easily be extended to give us the chance W_n that n flaws will be found in the volume V and on the surface S of a specimen. Let f be the volume density of interior flaws and f' the surface density of flaws on the boundary (which may be of the same kind, or of a different kind). Then, if f and f' are *constant*, we find, putting $fV+f'S=b$, that $W_n=b^ne^{-b}/n!$ This Poisson formula will be obvious to those who happen to be familiar with the result of superimposing random distributions, dependent on a single variable, but perhaps not so obvious to the majority of physicists interested in the faults of brittle materials. For more general cases, where f and f' are not constant, differential equations analogous to those in the above-mentioned paper have been set up. The methods of integrating them are in general the same as in the previous paper.

I take this opportunity to correct an error in the above-mentioned paper; a minus sign is needed in the second line below Eq. (10).

[1] A. E. Ruark, Phys. Rev. 65, 88 (1944).

The Decomposition of Water by the So-Called Permanent Magnet and the Measurement of the Intensity of the Magnetic Current

FELIX EHRENHAFT
New York, New York
April 28, 1944

THE magnetic current manifests itself in many phenomena. The polar movement[1] of bodies in an homogeneous magnetic field, reversing their direction of movement with the reversal of the field, showing that they bear an excess of north or south magnetic charge, constitutes a magnetic current. Thus the Peregrinus experiment becomes positive when performed with sensitive means. The well-known breaking experiment quoted by Maxwell[2] that a magnet when broken *ad infinitum* invariably gives always two separate magnets with equal poles cannot be found in the scientific literature, and it cannot be performed. This idealistic experiment does not prove that there is no true magnetism, north or south, because each breaking creates constriction, and from each constriction there is produced magnetism.

The decomposition of water into oxygen and hydrogen by the electromagnet[3] and the circulation of positively or negatively charged bodies and bubbles in the same plane, and at the same time, in directions opposite to one another, in the constant homogeneous vertical magnetic field, reversing their direction of circulation with the reversal of the field,[4] proves the existence of the magnetic current by the same criteria from which the existence of the electric current was deduced.

It has been observed that electrically evolved hydrogen bubbles in dilute acid, and iron hydroxide particles in a solution of iron chloride bearing a positive charge circulate counterclockwise, while electrically evolved oxygen bubbles in dilute acid, and copper particles in a solution of copper sulphate bearing a negative charge move clockwise when looking on the face of the south pole of the electromagnet. Of course there can be circulation of the liquid itself if it bears charges. This also proves the existence of the magnetic current.

Water can be decomposed also by the permanent magnet, and the fact that it loses a portion of its pole strength in the magnetolytic process gives us the possibility of measuring the intensity of the magnetic current. The magnet and cell used in these experiments are shown in Fig. 1. A semicircular Alnico Blue Streak magnet with outer radius of 5.1 cm, 1.75 cm thick, was used. Two pole pieces of soft Swedish iron are fitted to it, one electrically insulated from the magnet by a piece of paper. A metallic connection between the two poles is shown. The pole pieces are fitted into a glass cell through rubber gaskets. This cell is divided into two equal parts by a glass partition pierced with four holes plugged with asbestos, so that while there is a liquid contact between the two parts, the gases evolved could be collected separately from the two poles. In another arrangement two magnets were used. In this case the magnets are in a horizontal position, the two north poles against one pole block, and the two south poles against the other. These two arrangements, because of the fact that the poles were metallically connected, give in effect one piece of iron with the ends in the solution. A 4 percent solution of sulphuric acid by volume was used.

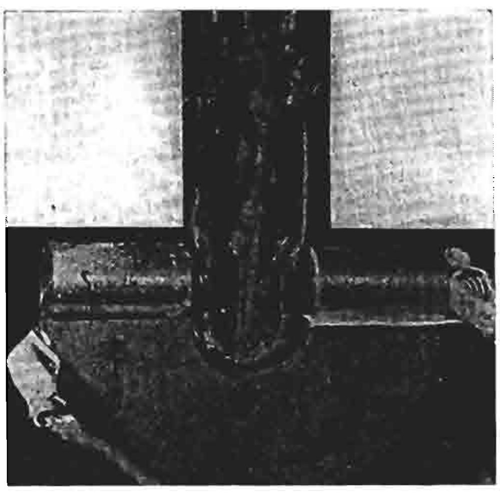

FIG. 1. Alnico blue steel magnet. Outer radius 51 mm, inner radius 15.8 mm, thickness 17.5 mm. Pole pieces are of soft Swedish iron having circular cylindrical extensions 10 mm in diameter, 12.5 mm long, and terminate in a truncated cone 6 mm in diameter. The circulation of gas bubbles is counterclockwise as one looks at the south pole.

Four points should be emphasized. First, the volume of gases evolved under identical conditions is greater when the magnetic field is applied than when the hydrogen is being formed by chemical action in its absence—in one case an 8.3 percent increase was noted. This increase in

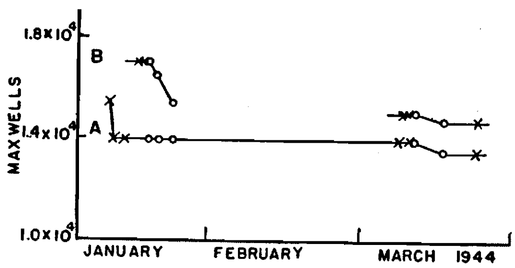

FIG. 2. Measurements of the strength of the Alnico magnet.

volume was also noted in experiments with the electromagnet. Second, when the magnetic field is applied, pure hydrogen is no longer evolved, but a mixture of oxygen and hydrogen comes from both poles, and in every case a greater percentage of oxygen comes from the north than from the south pole. In three cases it was 1.43 percent and 1.12 percent, 0.87 percent and 0.57 percent, and 0.25 percent and 0.16 percent, respectively. This is a proof that magnetism is polar. Since the field strength of the permanent magnet was less than one-tenth of that employed with the electromagnet, where two to twelve percent of oxygen in the mixture of gases was found, it appears from this and other observations that the percentage of oxygen evolved depends on the field strength and the acidity.[5]

Third, the magnets A and B used in these experiments lost a considerable portion of their pole strength during the time of the magnetolytic processes. In Fig. 2 the pole strength is plotted against time. Before and after each magnetolytic process it was determined by search coil and ballistic galvanometer controlled by a simple method of the author that the flux value of the magnets was at a steady state.[6] The two magnets were used in separate tests in January. A lost about 1500 maxwells in 24 hours, and B lost 1600 in 108 hours. Two months later A and B were used in combination as described above, and the two together lost a total of 670 maxwells in 101 hours. From these figures one can readily calculate the loss in gauss per second, which gives at once the average intensity of the magnetic current flowing between the pole faces in absolute magnetostatic units. In the practical system, if one defines the unit as is done in electrical measurements, i.e., 3×10^9 larger, the intensity of the magnetic currents, measured in practical units, will be as follows: In the first case 9.4×10^{-13}, in the second, 2.2×10^{-13}, and in the third 1.0×10^{-13}.

The fourth point is that while water was being decomposed as evidenced by the appearance of oxygen in the evolved gases and the permanent magnets lost a portion of their pole strength, further evidence of the expenditure of energy by the magnet is given by the observation of the circulation of gas bubbles around the axis of the horizontal magnetic field. These bubbles could be seen even by the naked eye to be circulating in a counterclockwise direction, when looking upon the face of the south pole. This movement carried them downwards, even against the force of bouyancy.

Referring to the above-mentioned circulation of bubbles with the electromagnet, it is clear that the bubbles are charged electrically in this case also.

Until now it has been formulated that only a stream of electrostatically charged bodies or matter—the so-called convection current—moving at such great speed that it creates its own magnetic field can be influenced by an external magnetic field (Rowland-corpuscular rays). But now there is evidenced a force exerted by the magnetic field on electrostatically charged matter substantially at rest. The observation of the circulating bubbles is the inverse case of Oersted's experiment. He found that a magnetic needle was deflected by a wire connecting the poles of Volta's pile. This was interpreted by Ampere as the circulation of a single magnetic pole around the wire carrying an electric current. The phenomena herein described show that a single electric charge circulates around the magnetic current.

It is the belief today that there exist in nature only two general forces, the force of gravity and the magnetic action of electric currents (Oersted, Biot-Savart, Lorentz).[7] But we have here a third force, the electric action of magnetic currents. The intensity of the magnetic current has been measured magnetically. From this third force it becomes possible to define the intensity of the magnetic current electrically by the equation

$$\int_0 E ds = I_n.$$

Oersted found, to use his own words, a vortex around the wire connecting the two poles of Volta's pile. The phenomena here reported show that there is a vortex around the poles of an electro- or permanent magnet. In Oersted's experiment, the pile lost its pole strength. In the experiment with the permanent magnet, the magnet lost its pole strength. In Oersted's experiment, we have to deal with electrodynamic rotations. In the new case, we have to deal with magnetodynamic rotations. Both rotations are the result of the expenditure of energy, one from Volta's pile, the other from the magnet.

If the single magnetic pole is fixed and alone in action, the opposite pole being remote, as is done in Faraday's experiment, and the wire conducting the electric current is free to move, the wire will rotate around the single pole. This is the principle of the electric motor. Conversely, in accord with the principle of action and reaction, if the wire conducting the electric current is fixed, and the single magnetic pole is free to move, we also have an electric motor.

In the new case, in comparison with the last example, we have two fixed magnetic poles, with the electrically charged matter free to rotate around the magnetic current. This is, *in principio*, the magnetic motor. We are here using our third force. One cannot tell how a motor operated by this force can be utilized, but this is not our immediate concern. Of greater importance is the necessity to define more clearly the part that the inseparable twins, electricity and magnetism, play in their interaction, one on another, and to determine if, in the future, they can best be defined by one symbol only.

[1] F. Ehrenhaft, Comptes rendus **190**, 263 (1930); Physik. Zeits. **31**, 478 (1930); Phil. Mag. **11**, 140 (1931); Ann. de physique **13**, 151 (1940); J. Frank. Inst. **230**, 381 (1940); *ibid.* **233**, 235 (1942); Nature **147**, 25 (1941); Science **94**, 232 (1941); *ibid.* **96**, 228 (1942); E. Reeger, Zeits. f. Physik **71**, 646 (1931).

[2] J. C. Maxwell, *Treatise on Electricity and Magnetism* (Ed. Oxford, 1873), 377–379, etc. F. Ehrenhaft, J. Frank. Inst. **233**, 242–243 (1942).

[3] F. Ehrenhaft, Phys. Rev. **63**, 216, 461 (1943).

[4] F. Ehrenhaft, Phys. Rev. **63**, 461 (1943); **64**, 43 (1943); **65**, 62, 256 (1944).

[5] The chemical analyses were made by Foster D. Snell, Inc., Brooklyn, New York in the presence of the author and Richard Whitall. The determinations were made using alkaline pyrogallol in a Hempel pipet.

[6] Measurements by search coil and ballistic galvanometer (Rawson fluxmeter) were made by H. O. Nilsson of the Nilsson Electrical Laboratories, Inc., New York City, and also by the author and Richard Whitall.

[7] H. A. Lorentz, Encycl. d. Math. Wiss. **5**, 2, 156. A. Becker, *Theorie der Electricitat, Vol. II, Electronentheorie* (Neubearbeitete auflage von Max Abraham, 1933).

Note. The author wishes to thank Richard Whitall for his kind assistance in measuring by a potentiometer the potential differences between the pole pieces. These were found to occur in every experiment, usually of the order of 0.001 volt or less. In experiments where the poles were not metallically connected, analysis showed that oxygen was evolved.

On the Mixed Meson Theory of Nuclear Forces

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AND

Ning Hu, *Institute for Advanced Study, Princeton, New Jersey*

April 21, 1944

SCHWINGER'S[1] modification of the Møller-Rosenfeld[2] mixture of a pseudoscalar with a vector meson has been investigated quantitatively. In this theory the masses κ and μ of the pseudoscalar and vector mesons, respectively, are assumed to be different ($\kappa<\mu$), thus leaving open the possibility for an unstable vector meson with a lifetime of the order of 10^{-8} sec., the value required for the meson theory of the β-decay.[3] The observed lifetime of the cosmic-ray mesons of 2×10^{-6} sec. would then be almost exclusively due to the pseudoscalar mesons. With this theory inadmissible singularities in the tensor force are removed if the values of the coupling constants of the dimension of a length are assumed to be the same for the two kinds of mesons. Moreover, the tensor force has the correct sign so

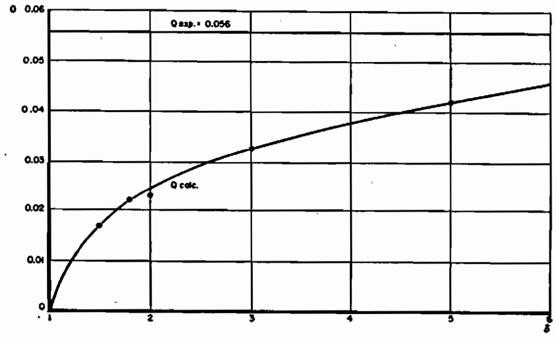

FIG. 1. The quadrupole moment Q for the deuteron in arbitrary units as a function of the mass ratio $\delta=\mu/\kappa$.

as to lead to a positive value of the electric quadrupole moment of the deuteron.

sumably be measured. The theoretical value of the sum of their moments is

$$\mu_{\mathrm{H}^3}+\mu_{\mathrm{He}^3}=\mu_n+\mu_p-\tfrac{2}{3}(\mu_n+\mu_p-\tfrac{1}{2})(3\,{}^4D+2\,{}^2P-{}^4P),$$

where the state symbols indicate the probability that the system be found in the corresponding state. It is likely that the ground states of these nuclei are predominately ${}^2S+{}^4D$ and thus, if ${}^4D=5$ percent, $\mu_{\mathrm{H}^3}+\mu_{\mathrm{He}^3}=0.841$ nuclear magneton, which is to be contrasted with the deuteron moment (0.857), the expected theoretical value if $L-S$ coupling holds rigorously. The moments of the individual nuclei depend on the detailed structure of the ${}^4D$ function but if a particularly simple form[1] is assumed one finds

$$\mu_{\mathrm{H}^3}=\mu_p-\tfrac{2}{3}(2\mu_p+\mu_n-\tfrac{1}{2})\,{}^4D,$$

whence $\mu_{\mathrm{H}^3}=2.68$ and $\mu_{\mathrm{He}^3}=-1.84$.

[1] E. Gerjuoy and J. Schwinger, Phys. Rev. 61, 138 (1942).

8. On the Algebraic Theory of Higher Spins. M. Dresden, *University of Michigan.*—It has been shown that particles of spin 0, ½, 1, can be described by a set of linear equations of the Dirac type. An attempt to a possible extension of this type of equation has been made. The method starts, using a method of factorization due to Rainich,[1] by obtaining all possible commutation relations which will insure that the second-order wave equations are satisfied by each wave function as a consequence of the first-order equations. This is done by writing down the conditions on the coefficients for the splitting of a quadratic form into 2 linear forms, then the condition for the splitting of a quadratic form in a linear and a quadratic form and so on. The general relations are of the form $\sum_P \beta_{n_1}\beta_{n_2}\cdots\beta_{n_s}=\sum_P \delta_{n_1n_2}\beta_{n_3}\cdots\beta_{n_s}$. They allow many special solutions among others the Dirac and Duffin relations. The next complicated will be presented and its physical contents discussed.

[1] G. Y. Rainich, Bull. Am. Math. Soc. 48, No. 1, p. 41.

9. The Magnetic Current in Gases. Felix Ehrenhaft.—In analogy with the definition of the electric ion a magnetic ion is a body which moves in a *homogeneous* magnetic field in the direction of the lines of force, reverses its direction of motion with the reversal of this field, etc. A magnetic current consequently is the movement of magnetic ions in the homogeneous magnetic field. To this extension of physical conceptions the author has been forced since he observed movements in homogeneous magnetic fields which hitherto were unknown. In an homogeneous magnetic field *some* particles of various finest metal powders, especially such of ferromagnetic elements, move from one homogeneous magnetrode (the plate of a magnetic condenser) to the opposite one, while the others remain at rest. A particle suspended in gas irradiated by light moves in the homogeneous magnetic field in the lines of force and reverses its direction with the reversal of the field. The determination of the charge on these ions and the change of charge on them are discussed. The author has made these experiments in cooperation with L. Banet. He restricts himself to the reports of the investigations on gases while the latter will report about the movements in liquids, and give some references.

10. The Magnetic Current in Liquids. Leo Banet. (*Introduced by Felix Ehrenhaft.*)—The above-given definitions of magnetic ions and magnetic currents can also be applied to movements in liquid mediums. The following observations have been made: Colloidal particles of nickel[1] are deposited equally on two homogeneous (gold-plated) magnetrodes.—Single particles of these colloids can be observed moving toward the magnetrodes by means of a microscopic arrangement. Some particles of finest metal powders move in the homogeneous magnetic field toward the magnetrodes in various liquids. These movements cease instantly if the magnetic field is shut off and start just the same way.

[1] F. Ehrenhaft, Anzeiger d. kais. Akad. d. Wiss. Wien 18 (July 10, 1902); Phil. Mag. 11, 140 (1931); Ann. d. Physique 13, 151 (1940); J. Frank. Inst. 230 381 (1940); Phil. Sci. 8, No. 3 (1941); Science 94, 232 (1941); J. Frank. Inst. 235 (March, 1942); F. Ehrenhaft and L. Banet, Phil. Sci. 8, No. 3 (1941); J. C. Maxwell, *Treatise*, art. 377–379 (Oxford, 1902).

11. The Characteristic Radiations of CO^{60}. Martin E. Nelson, M. L. Pool, and J. D. Kurbatov, *Ohio State University.*—The 10.7-minute Co^{60} was produced by a $Co(d, p)$ reaction in an intensity several thousand times that obtained from $Co(n, \gamma)$ and $Ni(n, p)$ reactions. Ionization chamber measurements indicated that approximately one gamma-ray was emitted for each beta-ray. The lead absorption coefficient for the gamma-ray activity was 0.58 cm^{-1}, corresponding to an energy of 1.5 ± 0.2 Mev. The beta-rays were measured with a magnetic beta-ray spectrometer and were found to be continuous. Allowing for the slight tail due to gamma-ray recoils the endpoint was measured at 1.35 ± 0.1 Mev. This is probably an allowed transition. The 5.3-year Co^{60} was produced by a $Co(d, p)$ reaction. Chemical separations removed the long life impurities. Absorption measurements, in agreement with those previously reported,[1,2] indicated the presence of a 1.7 ± 0.2 Mev gamma-ray and a 220 ± 20 Kev beta-ray. However, no higher energy electrons were observed. From these data it seems evident that an isomeric transition between the 11-minute and 5.3-year periods does not occur but that the activities decay independently. An energy level diagram summarizing the data will be shown.

[1] J. R. Risser, Phys. Rev. 52, 768 (1937).
[2] J. J. Livingood and G. T. Seaborg Phys. Rev. 53, 847 (1938).

12. Photoneutrons Produced in Beryllium by the γ-Rays of Radio-Antimony (60 d). G. Stanley Klaiber and Gertrud Scharff-Goldhaber, *University of Illinois.*—Previous work[1] has shown, that the energy of neutrons generated in Be by the hard γ-rays of RdY (100 d) is equal to that of RdTh+D neutrons (220 Kev). This result was obtained by counting the proton recoils produced by the photoneutrons in a hydrogen filled ionization chamber as a function of the discriminator voltage. From the photoneutron energy the energy of the γ-ray can be calculated (1.87 Mev). Now this work has been extended to the γ-ray of Sb^{124} (60 d). A sample of a few millicuries

Awbery, Arnold M. Bass, J. G. Bennett, Seymour Benzer, Daniel Bershader, William H. Billhartz, John Markus Blatt, Lyle B. Borst, Robert Stephen Burpo, Jr., Owen Chamberlain, Rev. Ernest Clarke, Alden P. Cleaves, Howard S. Coleman, Norman Davids, Pauline V. Davidson, James J. Donoghue, Bernard Epstein, Herman Theodore Epstein, Vincent Fitzgerald, Elizabeth F. Focht, Edward M. Fryer, Donald N. Gideon, Gerhart Groetzinger, Harold Palmer Hanson, Rudolph G. E. Hutter, J. Wesley Kemp, Capt. Paul J. Kopp, Louis W. Labaw, Robert W. Leonard, John Holton McGinn, Arthur E. Middleton, Elliott W. Montroll, Thomas M. Moore, Herbert C. Muether, Raymond L. Murray, Edward J. Nagy, J. Burton Nichols, Newton Hays Odell, William Elwood Ogle, H. Lowell Olsen, Francis Perrin, Fritz Pordes, H. Eugene Powell, Paul P. Reichertz, Dale W. Rinehart, Salomon Rosenblum, H. Gunther Rudenberg, Noel W. Scott, Gerald Lionel Simard, William Warner Sleator, Jr., John B. Smyth, A. O. Stanesby, Richard G. Stephenson, Rodolphus A. Swan, Jr., Vernon Thornton, Charles B. Vance, George Warfield, Richard Nicholas Work, Kenneth P. Yates, Ignace Zlotowski.

Joint resolution of the American Physical Society and the American Association of Physics Teachers:

WHEREAS the Army and Navy College Training Programs as so far announced provide for the training of technical personnel for use almost solely, if not entirely, within the Armed Forces, and

WHEREAS other war agencies, whose effective functioning is essential to the support of the Armed Forces in expediting the prosecution of the war, also need technically trained personnel in large numbers, and

WHEREAS these other war agencies, such as war industry, war research, and war training staffs are now confronted with the closing off of the usual avenues of supply of technically trained personnel from the same groups now being drawn upon through induction and enlistment.

THEREFORE BE IT RESOLVED that the American Physical Society and the American Association of Physics Teachers in joint session in New York City on January 23, 1943, urge that effective steps be taken at the earliest possible date to provide an over-all War Training Program to meet *all* of the needs of the Army, of the Navy, of War industry, and of war research in scientific and technological fields.

That in such a program adequate provision be made to insure such a flow, of personnel trained in the field of physics into war research, into war industry, and into training staffs, as will be necessary to prevent serious impairment of the critical war services to be rendered by these agencies. That copies of these resolutions be sent to the Chairman of the War Manpower Commission, to the Secretary of War, to the Secretary of the Navy, to the Chairman of the War Production Board, to the Director of the Office of Scientific Research and Development and the Chairman of the National Defense Research Committee.

KARL K. DARROW, *Secretary*,
American Physical Society
Columbia University, New York, New York

ABSTRACTS OF CONTRIBUTED PAPERS

1. Decomposition of Matter Through the Magnet (Magnetolysis). FELIX EHRENHAFT.—I have stated already that microscopic bodies, especially of ferromagnetic elements, do move in homogeneous magnetic fields, reversing their direction with the reversal of the field. In the spirit of M. Faraday and J. C. Maxwell one must therefore conclude that these test bodies carry an excess of north- or south-magnetic charge and consequently have to be called magnetic ions. Therefore we have to establish the equation; Div $B \gtreqless 0$. A consequence of these facts is the phenomenon of magnetophoresis already published.* Lately I have discovered that the magnet causes chemical composition and decomposition of matter in several cases. The quantity of gas, originated in certain chemical processes occuring between the magnetrodes and the magnetolyte (e.g., acidulated water) is considerably increased by the application of the magnetic field. The gas created is a mixture of hydrogen and oxygen. Herewith is proved that the poles of a magnet break up water through magnetolysis, the same as electric poles break up water by electrolysis. Now the way is open to measure the intensity of the magnetic current.

It should be mentioned that the same electric potential of the magnetrodes is secured, be it by using one piece of metal for the magnet, or two pieces which are metallically connected.

* Science **94**, 232 (1941): **96**, 228 (1942); Phys. Rev. **61**, 733 (1942).

2. The Effect of Oblique Incidence on the Conditions for Single Scattering of Electrons by Thin Foils. GERALD GOERTZEL AND R. T. COX, *New York University*.—In setting up and applying criteria for the single scattering of electrons by thin foils, it has been usual to assume that the principal deviations from single scattering are caused by the combination of small deflections with one large one. It is here shown that with electrons obliquely incident on dium receives as the front of the wave train advances over it an average velocity in the direction of propagation of the wave train. This results from the second-order effect of the magnetic field of the wave train on the first-order transverse velocities, lagging in phase, of the material particles. If there is no "frictional" resistance, this velocity is lost as the back of the wave train passes, the medium is left undisturbed, and the wave train is propagated undisturbed. If "frictional" resistance (which may be the statistical effect of waves passing in other directions) damps out the velocity in the direction of propagation, the wave train as a whole is gradually reddened. The whole process is coherent and occurs even in the approximation of geometrical optics. It would not be expected that it should be possible to observe it under laboratory conditions, because a velocity of the medium in the direction of propagation of the wave train is then opposed by elastic restoring forces.

5. A Recording Relay For An Infra-Red Spectrograph. ELY E. BELL, *Ohio State University*.—A recording photoelectric bridge has been constructed for use with an infrared, grating spectrograph which is able to reproduce the 2.7-mu water vapor band with detail equivalent to that previously obtained with point-by-point measurements under similar conditions. A single base, mounting a light source, a Moll bifilar galvanometer, and a pair of phototubes is supported inside of a heavy metal tank containing the spectrograph. Here the relay is relatively free from temperature fluctuations and from vibrations. An unbalance of light on the photo-tubes is applied to commercial recording milliammeters through a bridge circuit similar to that of McAlister, Matheson, and Sweeney[1] except that an additional stage of amplification has been added. A provoked potential of 10^{-8} volt in the thermocouple is recorded as readily distinguishable from the background.

[1] E. D. McAlister, G. L. Matheson, and W. J. Sweeney, Rev. Sci. Inst. **12**, 314 (1941).

6. The Infra-Red Spectrum of Methyl Fluoride at 9.5μ. K. P. YATES AND V. MILLER, *Ohio State University*.—The infra-red band, ν_5, at 9.5μ in the spectrum of methyl fluoride was first investigated under high dispersion by Bennett and Myer in 1928 who showed it to be of the parallel type. The data seemed to indicate, however, that some of the rotational lines, particularly in the P branch, were complex in structure. This has been investigated by the writers under higher dispersion than that available to Bennett and Myer. The curve obtained agrees with that of Bennett and Myer in general details, but most of the rotational lines in both the P and R branches are split up into component structure. The effect appears to be related to the convergence of the lines in the band and it seems reasonable to ascribe it as due principally to a Coriolis resonance interaction between the parallel type vibration ν_5 at 1048 cm^{-1} and the perpendicular type vibration ν_6 at 1200 cm^{-1}. The contour of the band ν_6 of CH_3F is at present being obtained in order to determine in what manner the resonance interaction affects this vibration.

7. Raman Spectra of Diisobutylene, Cyclohexene, and Dipentene. FORREST F. CLEVELAND, *Illinois Institute of Technology*.—In continuing work on olefinic hydrocarbons, Raman frequencies, relative intensities, and depolarization factors have been obtained for diisobutylene, cyclohexene, and dipentene. The relative intensities and depolarization factors were obtained by use of a Gaertner microdensitometer. Diisobutylene is a mixture of the two isomers 2,4,4-trimethyl-1-pentene and 2,4,4-trimethyl-2-pentene, the present sample containing only about 15 percent of the latter isomer. Raman frequencies and estimated intensities for the two isomers have been obtained previously (Rank and Bordner), but the present investigation provides the first polarization data and more accurate measurements of the intensities. Raman frequencies and estimated intensities have also been reported for cyclohexene and dipentene, but only qualitative polarization data for cyclohexene seems to exist in the literature. Dipentene has a ring structure identical with that of cyclohexene and it is thus of interest to compare the spectra of these two compounds. The olefinic frequencies at 1653(447)0.14, 3022(508)0.19, and 3058(19) in the cyclohexene spectrum appear at 1682(219)0.35, 3012(54)P, and 3050(26)P in the spectrum of dipentene. The olefinic frequencies previously observed at 1303(52)0.64, 1414(108)0.81, 1653(203)0.20, 1674(55)P, 2978(253)P, and 3077(47)0.70 for 2-methyl-1-heptene, which contains the group $XYC=CH_2$, appear at 1236(104)-0.63, 1410(155)0.62, 1644(161)0.33, 1658(51)0.60, 2977-(790)P, and 3072(32)0.71 for diisobutylene and at 1290-(46)0.72, 1376(127)0.70, 1648(213)0.38, 2983(115)P, and 3078(16)D for dipentene.

8. Magnetolysis and the Electric Field Around the Magnetic Current. FELIX EHRENHAFT, *New York City*.—Between the vertical cylindrical poles (magnetodes) of an electromagnet of soft Swedish iron, whose bases form a horizontal gap (pole diam. 8 mm, gap 1–2 mm) acidulated water (one percent H_2SO_4 by volume) is decomposed into oxygen and hydrogen gas. Hereby the old problem of the alchemists about the decomposition of water through the magnet has been solved. As long as the two poles immersed in the solution are not magnetized we get pure hydrogen, but as soon as the two poles are magnetized we get a mixture of hydrogen and oxygen (about 2–12 percent oxygen). The amount of gases evolved magnetically is proportional to the magnetic field (first magnetolytic law). Microscopic observation shows that magnetically evolved gas bubbles carry either a North or South magnetic charge.* Magnetolysis and electrolysis have been superposed. After a swarm of positive electrically charged hydrogen bubbles are produced, the magnetodes were short-circuited electrically. Each of these positive charged gas bubbles moves in a circle around the gap between the magnetodes, through which a constant magnetic current flows, reversing its direction on reversion of the magnetic field, exactly as a single magnetic pole would circulate around the constant electric current, reversing its direction with the reversal of the electric field (Oersted, Faraday). The magnetic current is surrounded by circular electric lines of force (second method of measuring the magnetic current). Photographs demonstrating these phenomena will be shown. The experiments can be seen at C. Zeiss Inc., New York, whom the author thanks for their hospitality.

* Papers by F. Ehrenhaft: *Science* 1941, 1912; *Phys. Rev.* 1941, 1942, 1943; *J. Frank. Inst.* 1940, 1942; *Phil. Sci.* 1941—some of which with L. Banet.

9. Combined Electron Diffraction and Microscope Apparatus. A. F. PREBUS, *The Ohio State University.* (*Introduced by Alpheus W. Smith.*)—A modified magnetic electron microscope is described which permits the observation of both highly magnified images and transmission electron diffraction patterns of identical microscopic specimen areas.

10. Investigation of Large Cosmic-Ray Bursts in Iron. R. E. LAPP, *The University of Chicago.*—During the past year experiments have been carried out with a Model C ionization chamber operated specifically to record cosmic-ray bursts. The steel chamber was completely shielded by 35 cm of iron and bursts with 150 to 3000 particles were recorded. Mesotrons producing bursts of such magnitude must have energies up to 6×10^{11} ev. Comparison of the size frequency distribution curve of large bursts in 35 cm of iron was made with the theoretical calculations of Christy and Kusaka.* The observed burst frequency was in agreement with a mesotron having spin 0 or $\frac{1}{2}$, but was in definite disagreement with spin 1. In addition, the recording system of the ionization chamber was coupled so as to record simultaneously coincidences of G-M counter coincidence sets placed above the apparatus. The counters in each 2-fold set were separated by from 2 to 10 meters to detect air showers. Preliminary results indicate that bursts under 35 cm of iron are not coincident with air showers to an accuracy of less than 10 percent. With the chamber completely unshielded and with negligible material in the vicinity, coincidences were observed between bursts and air showers. The experiments are being continued with 2-, 3-, and 4-fold coincidence sets and experiments are also in progress with a 12-cm iron shield around the ionization chamber.

* R. F. Christy and S. Kusaka, Phys. Rev. 59, 414 (1941).

11. Measurements of Cascade Showers Produced by Ionizing and Non-Ionizing Radiation in the Stratosphere. JULIUS TABIN AND MARCEL SCHEIN, *University of Chicago.*—By using a cosmic-ray balloon apparatus, electron-produced and photon-produced cascade showers were measured below a 2-cm lead plate. The showers were detected by means of four Geiger-Müller counters placed below and an additional anticoincidence counter placed above the lead. The apparatus reached an altitude corresponding to 2.5 cm of Hg pressure. At a pressure of 3 cm Hg (first radiation unit from the top of the atmosphere) it was found that 71 percent of the showers below the lead were produced by non-ionizing and 29 percent were produced by ionizing radiation.

12. Factors Influencing the Plateau Characteristics Of Self-Quenching G-M Counters. W. SPATZ, *New York University.*—Investigations of factors influencing the starting potential and plateau slope of self-quenching G-M counters show: I. Impurities such as air or oxygen increase the plateau slope and starting potential of argon-alcohol counters. II. Operation of the counter causes changes in plateau characteristics as follows: (a) Immediately after use, the plateau slope increases slightly, (b) With continued use the plateau slope becomes steeper. (c) For moderate use the counter recovers when inactive, but never to the original characteristics. (d) With further use, the counter loses its plateau and does not recover. (e) The pressure in an argon-alcohol counter was observed to increase as a function of the total number of counts recorded. III. For argon-alcohol counters the useful life in these experiments was found to be about 10^9–10^{10} counts; for argon-methane, 10^7–10^8 counts. The lifetime may be seriously shortened by operating at high overvoltages, by allowing breakdown to occur, or by using any circuit permitting large currents to flow. The observed changes of characteristics are presumably due to the decomposition of the organic vapor by the discharge.

13. Threshold for the Nuclear Photo-Effect. G. C. BALDWIN AND H. W. KOCH, *University of Illinois.*—With the method previously described[1] for controlling the peak energy of the x-rays from the 20-Mev betatron, (γ, n) reactions have been observed and their thresholds determined in the following elements since the last report: Zn (39 min.) 11.6 ± 0.4 Mev; N (10 min.), 11.1 ± 0.5 Mev; In (1.1 min.), 9.5 ± 0.6 Mev; Ag (2.3 min.), 9.3 ± 0.5 Mev; Se (17 min.), 9.7 ± 0.5 Mev. These values are upper limits for the thresholds. Ag and Se also show strong 25- and 57-minute activities, respectively. Analysis of decay curves taken at varying energies indicates that these activities have higher thresholds than those listed above. An improved determination of the $O^{16}(\gamma, n)O^{15}$ threshold has been made, giving 16.3 ± 0.4 Mev. This and the nitrogen threshold are in fair agreement with values predicted from mass data. Chief sources of error in the method are (1) gradual change in energy calibration with time and (2) low ratio of activity to counter background near threshold, making estimation of a lower limit difficult.

[1] G. C. Baldwin and H. W. Koch, Phys. Rev. 63, 59 (1943).

14. The Relative Intensities and Characteristic Radiations of Radioactive Scandium. CARL T. HIBDON, M. L. POOL, AND J. D. KURBATOV, *Ohio State University.*—A reinvestigation of the radioactive isotopes of scandium has yielded a new isotope of half-life 3.4 days. This isotope emits electrons of 0.46 Mev but no gamma-rays. Other data obtained by appropriate bombardments of K, Ca, Sc, Ti, and V with alpha-particles, deuterons, protons, slow and fast neutrons include the following:

Isotope	Half-life	Energy of β in Mev	Energy of γ
Sc^{43}	3.92 hr.	1.13 positrons	1.65 Mev
Sc^{44}	3.92 hr.	1.33 positrons	1.33 Mev
Sc^{44}	2.44 day	1.33 positrons	0.28 and 1.33
Sc^{48}	1.83 day	0.57 electron	1.33 Mev

system, and C is a constant derivable from the relationship found between shear strength and normal stress for the particular material being cut. This relationship is found to be in good agreement with experiment.

D3. Resistance of Carbon to Carbon Contact. W. B. PIETENPOL AND F. C. WALZ, *University of Colorado.*—The contact resistance of plane carbon surfaces was measured at constant temperature over a pressure range of 78.88 to 31803.6 grams per sq. cm. A potentiometer method was used with current approximately 0.1 ampere. Corrections were made for the resistance of solid carbon and resistances were measured to four significant figures with pressures determined to 0.1 gram per sq. cm. After pressures are increased the contact resistances decrease with time and at low pressures do not reach equilibrium values until approximately 24 hours have elapsed. When pressures are decreased contact resistances increase with smaller time lags. The equilibrium contact resistance-pressure curves are in good agreement with the theory summarized by Windred* where the values are expressed by the equation $R=k/P^n$ and the constants differ for increasing and decreasing pressures.

* G. Windred, J. Frank. Inst. 231, 547 (1941).

D4. Low Angle Scattering of X-Rays. M. H. JELLINEK, *M. W. Kellogg Company* AND I. FANKUCHEN, *Polytechnic Institute of Brooklyn.*—Recently there has been increased interest in the low angle scattering of x-rays. All studies to date have used photographic methods for recording the scattered radiation. Where discrete maxima, whose location is to be determined, are concerned, this is no handicap but for some studies a continuous scattering must be studied over an intensity range of over 1000 to 1. We have used a Geiger counter and amplifier to measure this sort of low angle scattering. The intensities available are easily within the range of this instrument.

D5. Low Angle X-Ray Scattering. I. FANKUCHEN, *Polytechnic Institute of Brooklyn* AND M. H. JELLINEK, *M. W. Kellogg Company.*—In published work on low angle scattering, use has always been made of sharply defined beams of essentially monochromatic x-rays and long specimen-to-film distances. We have tried another entirely different method which seems to hold some promise. This utilizes two good single crystals, one as a monochromator and the other as an analyzer. The specimen is placed between the two crystals and a Geiger counter circuit is used to record the x-ray intensity as a function of the setting of the analyzing crystal. We have used the second crystal in the anti-parallel position and later as suggested to us by Dr. H. Friedman* in the parallel position.

* Naval Research Laboratory, Anacostia Station.

D6. Molecular Theory of the Scattering of Light in Fluids. BRUNO H. ZIMM, *Columbia University (Introduced by M. Goeppert-Mayer).*—A direct molecular theory of the scattering of light by fluids of isotropic molecules is developed utilizing recent advances in the statistical mechanics of condensed phases. The extent of the interference between the wave trains scattered from different molecules of the fluid is calculated with the aid of spatial molecular distribution functions. The integrals of these functions which are encountered are simply related to the concentration and volume derivatives of the free energy. The results are the same in first approximation as those of the continuous theory based on fluctuations originally proposed by Smoluchowski and Einstein. Higher approximations of the molecular theory are especially suitable for the study of critical opalescence and scattering by fluids consisting of very large molecules.

D7. The Continuum at the Mercury Arc Cathode. CHARLES G. SMITH. *Raytheon Manufacturing Company, Newton, Massachusetts.**—Micro-photographs of the arc spot on a quiescent mercury surface were secured by employing an arc gliding lengthwise over a long bead of mercury held between magnetic poles in a vacuum. The arc moved in the characteristic retrograde direction. The motion of the generated vapor being opposite to that of the arc, and the rapid progress of the cathode spot, prevented both the moving vapor and the arc pressure from disturbing the surface. The photographs show a well delineated source of light in the mercury surface or within 0.0005 cm of it, the intensity of which greatly exceeds that anywhere in the plasma. The continuous spectrum originates only at the cathode and doubtless comes from within the liquid from the electronically excited region that gives rise to the electron emission of the apparently cool mercury in accordance with the author's emission theory[1] of the mercury arc.

* Experiments performed at Harvard University.
[1] C. G. Smith, Phys. Rev. 62, 48 (1942).

D8. Motion of Electrolytes in a Magnetic Field. CLIFFORD E. SWARTZ, *University of Rochester (Introduced by W. van der Grinten).*—Investigation of the rotation of certain electrolytes ($FeCl_3$, HCl, $SnCl_3$) between and in contact with magnetic poles, has been carried out with many variations on the original Ehrenhaft experiments.[1] These variations do not differ fundamentally from the original experiments because the rotation and sense of rotation are unaffected by some inhomogeneity of the field. Ferromagnetic substances need not be used; the rotation is dependent on a chemical reaction. These rotations can be explained by assuming potential differences throughout the solution caused by the presence of the metal. This assumption has been verified by means of a special potentiometer and probe arrangement.

[1] F. Ehrenhaft, Bull. Am. Phys. Soc. 19, 3, 10 (June 23, 1944).

D9. The Measurement of Single Magnetic Charges and the Electrostatic Field around the Permanent Magnet. FELIX EHRENHAFT, *New York City.*—It has been observed in the microscopic dark field that in a magnetic condenser with horizontal homogeneous field established by an Alnico 5 permanent magnet test bodies of various substances fall vertically and undeflected in gases, or are deflected at various measurable angles to either condenser plate, their paths crossing the center line. Observing these falling bodies, the north or south magnetic charge of a single test body can be measured, applying the method of the author[1] in determining the positive or negative electric charge on a single particle. Applying a horizontal inhomogeneous axially symmetrical magnetic field, it has been observed that the force of charge qH exceeds the force of polarization so that even diamagnetic particles (e.g., Sb, Cu, C) move to the denser lines of force. A new fact added to past experience[2] is that the general path of a body bearing simultaneously electric and magnetic charges is a helix (spiral) in the constant field of a permanent magnet. The region of observation is shielded electrostatically. The electric field is created by the permanent magnet. Electricity and magnetism are aspects of a single phenomenon. Demonstrations will be provided at Manhattan College, New York City.

[1] F. Ehrenhaft, Anz. d. Wien. Akad. d. Wiss. No. VII (Mar. 4, 1909).
[2] F. Ehrenhaft, Nature **154**, 426 (1944); Phys. Rev. **65**, 287 (1944).

D10. Theoretical Implications of the Magnetic Current. GABRIEL KANE, *Manhattan College*.—The symmetrical form of Maxwell's field equations containing terms with magnetic charge and magnetic current is already in the literature.[1] The wave equations for electromagnetic waves traveling in a conducting medium may be deduced from these field equations. It is found that such wave equations contain terms in E and H in addition to the usual first and second derivatives of E and H with respect to time. The theoretical necessity of a magnetic current can be demonstrated by a process of reasoning similar to that which led Maxwell to the hypothesis of a displacement current. The nature of the magnetostatic potential will be discussed and the essential differences between the field of a permanent magnet and that of a steady current indicated.[2] The influence of magnetic current and magnetic charge on the concepts of the vector potential and the Hertzian vector will be considered.

[1] Page and Adams, *Electrodynamics* (D. Van Nostrand Company, New York, 1940), p. 160.
[2] Abraham and Becker, *Classical Electricity and Magnetism* (Blackie & Sons, London, 1943), p. 131.

D11. The Action of a Magnetic Field on Ferric Hydroxide. CHARLES B. REYNOLDS, *Hearst Radio, Inc., New York*.—A solution of ferric hydroxide was prepared for study of its action under the influence of a magnetic field. Upon application of a magnetic field the solution was observed to clear, a deposit appearing on the north pole of the electromagnet. The action was immediate and violent. It was found that reversal of the field reversed the deposit and that reversal could be accomplished three or four times. The composition of the deposit will be discussed. It was noted that the action was a function of the amount and concentration of the base used to form the hydroxide,[1] the nature of the base as well as the nature of the iron salt from which the hydroxide was precipitated.[2] It further appears that the ferric hydroxide is ferromagnetic since the action is also a function of magnetic field intensity.[3] The foregoing seems to offer some support to Ehrenhaft's claims as to the polar nature of magnetism.[4]

[1] R. Chevallier and S. Mathieu, Comptes rendus **206**, 1469, 1955 (1938).
[2] A. Quartaroli, Gazz. Chim. Ital. **64**, 161 (1934).
[3] P. Selwood, *Magnetochemistry* (Interscience Publishers, Inc., New York, 1943), p. 226.
[4] F. Ehrenhaft, Phys. Rev. **65**, 287 (1944).

E1. The Application of Network Analysis to Some Electron Optical Problems. ALBERT F. PREBUS AND IGNACE ZLOTOWSKI, *Ohio State University and* GABRIEL KRON, *General Electric Company*.—By suitable correlation of the variables, the trajectory equation

$$\phi(z)\cdot\frac{d^2r}{dz^2}+\tfrac{1}{2}\phi'(z)\cdot\frac{dr}{dz}+\tfrac{1}{4}\left[\phi''(z)+\frac{e}{2mc^2}H^2(z)\right]\cdot r=0$$

of an electron lens may be identified with the differential equation describing the dependence of the voltage distribution upon the impedance characteristics of a simple type of ideal inhomogeneous transmission line. By choosing the specific impedances as functions of the independent variable z [distance along the axis of symmetry] and the parameters $H(z)$ and $\phi(z)$ [z component of the magnetic field and electrostatic potential, respectively, on the axis], the values of the dependent variable $r(z)$ [radial displacement of the electron] correspond to voltages along the line. The equivalent network provides a rapid means of obtaining accurate numerical solutions of the trajectory equation. Application of this method is demonstrated for the case of a strong magnetic lens by comparing the results with the exact solutions given by Glaser.[1] The usefulness of a two-dimensional network for determining the electrode configuration of an electrostatic lens from a given axial potential distribution is discussed.

[1] W. Glaser, Zeits. f. Physik. **117**, 285 (1941).

E2. Capture Cross Section of Hydrogen for Slow Neutrons. LEROY G. SCHULZ* AND M. GOLDHABER, *University of Illinois*.—The capture cross section of hydrogen for slow neutrons is of great theoretical interest. The most accurate experimental method for its determination is probably that devised by Frisch, v. Halban, and Koch,[1] who determined this cross section by measuring the ratio of the capture cross section of boron to that of hydrogen. As later measurements made by various other methods did not agree well with their result, it seemed worth while to repeat their experiment with some modifications and increased accuracy. We find for the ratio of the capture cross section of B to that of H the value 1954 ± 24, in good agreement with the value 1940 ± 100, obtained by Frisch, v. Halban, and Koch. If we assume for B a capture cross section of 600×10^{-24} cm^2 we obtain for H a capture cross section of 0.307×10^{-24} cm^2, which should be compared with the theoretical value of 0.302×10^{-24} cm^2 given by Rarita and Schwinger.[2]

* Now at the Haskins Laboratories, New York, New York.
[1] O. R. Frisch, H. v. Halban, and J. Koch, Proc. Danish Acad. **15**, 10 (1938).
[2] W. Rarita and J. Schwinger, Phys. Rev. **59**, 436 (1941).

E3. Evidence for the Production of a Non-Ionizing Radiation other than Neutrons and Gamma-Rays by 10-Mev Deuterons. GERHART GROETZINGER, P. GERALD KRUGER, AND LLOYD SMITH, *University of Illinois*.—An arrangement of two Geiger-Mueller counters in coincidence shielded by various thicknesses of lead up to 19-cm thickness has been used to investigate non-ionizing radiations produced by a cyclotron. The cyclotron was enclosed by watertanks of 120-cm thickness. Electrons have been