# Proceedings of the American Physical Society

MEETING AT STANFORD UNIVERSITY, CALIFORNIA, JULY 14, 1945

THE 267th meeting of the American Physical Society was held at Stanford University, California, on Saturday, July 14, 1945. The attendance at the meeting varied from 60 to 65, which is practically a pre-war figure. Almost all of those present came from the San Francisco commuting zone. Over sixty members and guests had luncheon together in the Stanford Union. At the conclusion of the luncheon Professor J. W. McBain gave a most interesting and significant account of his trip to Moscow, as one of the invited delegates to the International Scientific Conference recently held there. Brief remarks were made also by Dr. K. K. Darrow.

The morning session opened at 9:30 A.M. and adjourned just at noon. It was devoted to the first six contributed papers and to the first invited paper. This paper, entitled **Decompression Sickness as a Medical-Physical Problem,** was read by Dr. C. A. Tobias, of the Division of Medical Physics, University of California. Dr. John Lawrence, who is in charge of this newly created division of the department of physics, and who was to read the paper, was unable to be present.

The second invited paper, by Dr. Paul Kirkpatrick, Stanford University, was postponed to the afternoon session, which by agreement was started at 1:45 P.M. The paper was titled **The Continuous X-Ray Spectrum in Theory and Experiment.** It was followed by the remainder of the contributed papers. Only paper No. 8 was read by title. The meeting adjourned at 4:50 P.M., after which tea and cake were served by the wives of staff members.

R. T. BIRGE
*Local Secretary for the Pacific Coast*

## ABSTRACTS OF CONTRIBUTED PAPERS

**1. Combination Voltage and Current Regulation of an X-Ray Tube.** JAMES F. MCGEE, *Stanford University.*—The voltage regulation section is of the degenerative type while current regulation is accomplished by modulating the r.f. filament supply by the voltage drop across a resistance in series with the anode of the x-ray tube. The regulator is entirely a.c. operated, the usual reference battery being replaced by a highly regulated low voltage d.c. supply. The latter plays several roles in the operation of the combination regulator. It serves as a reference voltage to "detect" voltage fluctuations while at the same time serving as a reference for the emission current fluctuations. It supplies the plate voltage for the d.c. amplifiers located in the voltage and current regulation sections respectively. Finally, it provides plate supply for the modulated r.f. oscillator, the output of which heats the x-ray tube filament. Capacitance voltage division is used to increase the "detected" fraction of any rapid voltage fluctuation. While the range has been restricted to 0–50 kv and 0–3 ma for thin target x-ray studies, higher ranges are possible. The combination regulator has maintained voltages to 0.01 percent and currents to 0.02 percent for periods less than five minutes. Electron microscopy and electron diffraction are obvious additional fields of application.

**2. Mechanism of Charge Production in Thunderclouds.** SEVILLE CHAPMAN, *Stanford University.*—The well-known conflicting theories of Wilson (charge separation on falling drops by induction in the earth's electric field) and of Simpson (breaking drops) are both quantitatively inadequate. Furthermore, Wilson's theory makes no use of rising air currents characteristic of thunderclouds; Simpson's theory yields the wrong polarity. While early measurements showed positive charge retained on breaking drops and negative charge in the air, either the *net* negative charge in the air was measured, or air blast conditions differed substantially from thundercloud conditions. The author's measurements of *spray* electrification[1] showed negative and positive charges in the air in *nearly equal* numbers, negative predominating, but the charge ratio varied markedly with spraying or bubbling procedure. If the charge ratio approaches unity by the breaking drop mechanism of thunderclouds, another order of magnitude of charge is available. Thus breaking drops may provide the required charges of both signs in the air, which may be separated by the Wilson mechanism in nonturbulent regions of the cloud, yielding, as observed, a positive cloud top and negative cloud center and bottom, except for a localized volume in the updraft region containing positive charge on the breaking drops.

[1] S. Chapman, Phys. Rev. **54**, 520 and 528 (1938).

**3. Cosmic-Ray Mesotron Ionization in Helium and Argon Gases.** LESTER L. SKOLIL, *University of California.*—Counter-controlled cloud-chamber photographs of cosmic-ray mesotron track have been taken in helium and

argon gases. The chamber was operated as previously described[1] in the case of hydrogen. A triple-coincidence counter telescope was used with sufficient lead above the chamber so that electron tracks could be distinguished from mesotron tracks. The expansion of the chamber was delayed to allow the ions to diffuse sufficiently for drop counting. The clearing field was reduced after sufficient time for the track to be separated into positive and negative ion columns. Studies of condensation efficiencies for a wide range of alcohol-water vapor mixtures indicate that whenever more than 50 percent of the negative ions have formed drops, then all of the positive ions have formed drops. From photographs of tracks taken under these conditions, the average specific ionization has been determined by counting the number of positive ion drops per cm of path.

[1] Lester L. Skolil, Phys. Rev. **66**, 158 (1944).

**4. The Intensity of Cosmic-Ray Electrons Relative to Mesotrons at Sea Level.** B. LOMBARDO, JR. AND W. E. HAZEN, *University of California.*—Counter measurements in other laboratories have indicated fewer electrons than one expects on the usual assumptions concerning the properties of mesotrons. A suggested explanation has been decay into two neutrinos and one electron. In this laboratory, measurements have been made by direct observation of absorption in lead plates in a cloud chamber. For the lower energies, where the absorber was primarily glass and radiation losses were relatively small, the results should be quite accurate. For the higher energies the results depend on radiation theory and there is a consequent decrease in reliability. Even for the cases of energies >100 Mev, where the energy is estimated from the nature of the cascade shower, the results are more reliable than counter results since the detailed history of the shower is observed. The number of electrons with energy >6.6 Mev was 38 per hundred mesotrons with $H\rho > 4.2 \times 10^5$, the momentum necessary for penetration of all the absorbers. The predicted value is 35, which is within the estimated uncertainty. The shape of the energy distribution and the other absolute values agree reasonably well with theory. Since the assumed decay products are one neutrino and one electron, this experiment favors the usual picture of mesotron decay.

**5. Cascade Showers in Lead.** SALWA C. NASSAR, *University of California.* (*Introduced by W. E. Hazen.*)—Cascade showers initiated by cosmic-ray electrons of energy less than 700 Mev, have been studied in a cloud chamber placed in a magnetic field of about 1000 gauss. The chamber was counter-controlled with three counters above it so that the entire history of each shower was observed. The absorbing power of the counter telescope was made very small in order to minimize the possibility of starting a shower outside the chamber. The chamber contained four lead plates, each 0.7 cm thick. In each shower the total number of particles of energy greater than 3 Mev was determined. A plot of the total number *versus* the number at the maximum was made. Since all shower curves (average number of particles *versus* depth in shower units) have essentially the same shape, the above plot should be a straight line whose slope depends on the ratio of height to area of the shower curve. Preliminary results from 20 showers indicate that the ratio of height to area of the experimental shower curve is 1.8 times that of the theoretical one. This value may be too large to be accounted for by the 20 to 30 percent uncertainty estimated in the most recent calculations by Bhabha and Chakrabarty.[1]

[1] H. J. Bhabha and S. K. Chakrabarty, Proc. Roy. Soc. **A181**, 267 (1943)

**6. Decay Electrons from Neutral Mesotrons of Small Mass.** P. GERALD KRUGER AND LYLE W. SMITH, *University of Illinois.*—In an earlier report[1] it was suggested that a new neutral radiation might consist of neutral small mass mesotrons. To test this hypothesis the penetrating radiation has been examined with a cloud chamber, which was surrounded by a ring (19 cm thick) of lead blocks (6″ high) in the horizontal plane. Several hundred stereoscopic pictures were taken with the cloud chamber in a magnetic field of about 1000 oersteds. Three aluminum foils 0.8 mm thick were spaced 5 cm apart in the cloud chamber. Observation of the loss of energy suffered by an electron in passing through the foils makes it possible to determine the direction of motion of the electron. If a neutral mesotron decays into positive and negative electrons, both having the same energy, tracks showing a decrease in energy in opposite directions along the track should be observed. Several such pictures have been obtained. From measurements it appears that the decay electrons have energies between 2.5 and 6 Mev and the rest mass of the neutral mesotron varies between 13 and 24 $mc^2$.

[1] Groetzinger, Kruger, and Lloyd Smith, Phys. Rev. **67**, 52 (1945).

**7. A Simple, High Voltage, Electrostatic Voltmeter.** L. MARTON, *Stanford University.*—A very simple and inexpensive electrostatic voltmeter consists of a cylindrical steel container as one electrode and a disk-shaped electrode made of any other metal in its center. This latter is mounted on a bushing passing through a tightly closed cover of the steel container. The container is provided with a cylindrical well at the bottom center, which is filled with mercury. A thin circular steel disk floats on top of the mercury. The well communicates with an inclined glass capillary through which the position of the mercury meniscus can be observed. The upper end of the glass capillary is connected to the top part of the steel container. All the space above the mercury is filled with an insulating liquid. When a field is applied, the mercury-pool level is raised and a corresponding retraction of the meniscus is produced. The range of the instrument can be conveniently changed by altering the distance between the disk-shaped electrode and the mercury pool. A variation of the same principle consists of building in a flexible metallic bellows in the well instead of filling it with mercury, and using two nonmiscible liquids in the capillary.

**8. Magnetism as a Polar Vector.** FELIX EHRENHAFT, *New York City.*—In previous bulletins,[1] the author presented experimental proof that magnetic ions and consequently magnetic currents exist, and that magnetism should be described not as an axial vector but as a polar vector. That the magnetic cell discovered in the Stefan-Loschmidt laboratory,[2] and later investigated by many workers cannot be interpreted by the axial theory of magnetism has been conceded.[3] The following experiment made with Rhichard Whitall is presented in evidence. Two pole pieces of soft Swedish iron electrically insulated from one another could be attached to either one or two so-called permanent magnets of Alnico Blue Streak alloy, and their opposing pole faces immersed in 4-percent $H_2SO_4$. The potential differences between the pole pieces were measured by a potentiometer. With two magnets alternating with one magnet in position, the average of the successive readings taken at five minute intervals was 0.0031 volt with two magnets, and 0.0022 volt with one magnet. In both cases north was positive. Thus the potential difference is seen to depend on the pole strength, and the polarity of magnetism is evidenced. It is clear that the polar theory of magnetism will facilitate the understanding of heretofore unclear magnetic phenomena.

[1] F. Ehrenhaft, Phys. Rev. **60**, 169 (1941); **61**, 733 (1942); **63**, 216, 461 (1943); **64**, 43 (1943); **65**, 62, 256, 287, 394 (1944); **66**, 38 (1944); **67**, 63, 201 (1945); and Bulletin 266, Meeting at Columbus, Ohio, June 1945.
[2] Gross, Wiener Akad. Ber. **92**, 1378 (1888).
[3] S. R. Williams, *Magnetic Phenomena* (1931), p. 146.

**9. Conditions for Small Grid Current in Types 38 and 954 Pentodes.** CARL E. NIELSEN, *University of California.*—The magnitude and constancy of the grid current in a vacuum tube place a lower limit upon the photoelectric or ionization current measurable with that tube. The 38 and 954 pentodes have been so operated[1] as to have grid currents much smaller than usual in common vacuum tubes. Published applications of these tubes have, however, not required the minimum grid current, and other considerations have influenced the operating potentials chosen. A study of grid currents of 6C8G, 38, and 954 tubes with various potentials applied to the elements has led to some understanding of the influence of various factors upon grid current in these tubes. Under proper conditions a grid current as small as $2\times10^{-14}$ ampere (less than one-tenth of the value previously reported) was observed in the 954. This result suggests that the 954 is a suitable substitute for "electrometer tubes" in applications not requiring the maximum possible sensitivity. A balanced circuit may be successfully employed with the 954 tube. Such a circuit is desirable for a photo-cell amplifier, even when only moderately high sensitivity is required, because of its convenience and stability.

[1] Strong, *Procedures in Experimental Physics* (Prentice-Hall Inc., New York, 1938), pp. 427, 428.

**10. Advancing and Receding Contact Angles in Glass Capillaries and the Partial Removal of Contamination by Water and Soap Solutions.** HARENDRA K. ACHARYA* AND J. W. MCBAIN, *Stanford University. (Introduced by Paul Kirkpatrick.)*—If a capillary (0.025−0.05 cm in diameter) freshly drawn from a Pyrex glass tube is dipped in distilled water, the advancing and receding heights are equal at the same depth, indicating a clean capillary surface with zero-contact angle. If the capillary is contaminated with oleic acid, the advancing height is only about one-third as great. Washing of the contaminated capillary with distilled water increases the receding height up to that for a clean tube, while the advancing height remains constant at the first value. Hence water leaves a residual film of oleic acid on glass even though the receding contact angle becomes zero. Washing with 0.03-percent sodium oleate solution has practically the same effect as washing with distilled water. However, the still partially contaminated glass is perfectly wetted by the soap solution, advancing and receding contact angles both being zero. Repeated washing with higher concentrations of sodium oleate solution (0.3 and 3.0 percent) removes the residual oleic acid and equalizes the advancing and receding heights with those for the clean capillary. Aerosol OT solution (0.3 percent) has the same effect as washing with distilled water.

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**11. The Application of Stokes' Law to the Electrical Conductivity of Organic Ions.** EMANUEL GONICK, *Stanford University. (Introduced by Paul Kirkpatrick.)*—The application of Stokes' law to the ionic conductances of univalent ions leads to the following equation for $\lambda$, the limiting equivalent conductance of the ions

$$\lambda=(e.96500\times10^{7})/6\pi\eta r. \qquad (1)$$

This equation is shown to be applicable to organic ions, and the effective radius, $r$, is shown to be proportional to a fractional power of the number of carbon atoms contained in the ions, provided none of these is a substituted carbon, the value of this fractional power depending on the type of ion. From Eq. (1) by appropriate substitutions are developed equations from which the van der Waals radius of the methylene radical and substituted methylenes may be calculated. The calculated value of the methylene radical agrees with that obtained from crystallographic data. An equation is also developed by which the limiting equivalent conductances of organic ions can be calculated when experimental data are lacking. The method applies to ions containing unsaturated linkages and substituted methylenes as well as to saturated, unsubstituted ions. As a check the conductivity of the hexanolammonium ion is calculated and is found to agree exactly with the experimental value found in this laboratory.

**12. Silver Plated Constantan Thermopiles for Skin Temperature Measurements.** J. E. GULLBERG, C. A. TOBIAS, AND H. WELTIN, *Aero Medical Unit, University of California.*—Thermocouples by electro-deposition were first constructed by Wilson and Epps[1] whose work has been adapted to an instrument, making possible the quick measurement of skin temperatures. If 200 turns per inch of 1.5 mil constantan wire are wrapped around a suitable form of polystyrene and the wires are plated with 50 micrograms per cm of silver by partly submerging the form in

a plating solution, one obtains 400 junctions of very small mass, and hence of low heat capacity. One-half of the junctions are placed in contact with a copper block insulated by a very thin piece of mica; the other half are placed in contact with the surface whose temperature is to be determined. The potential from 200 turns per inch is 6.5 millivolts per °C, which cannot be greatly increased by a heavier deposit of silver. Methods of calibration, linearity, and sensitivity are discussed. A radiometer of similar design has been constructed. Both instruments promise to be of particular interest to the clinician as a diagnostic aid in the evaluation of peripheral vascular diseases. The work was carried out under a contract between the University of California and the Office of Scientific Research and Development on the recommendation of the Committee on Medical Research.

[1] W. Wilson and P. D. Epps, Proc. Phys. Soc. **32**, 326 (1919–20).

**13. Rapid Least-Squares Solution of Polynomials.** R. T. BIRGE AND J. W. WEINBERG, *University of California.*—When the abscissa values are equally spaced, and the observations are of equal weight, the least-squares solution of a polynomial of any degree becomes greatly simplified and the result can be obtained in a number of forms. The Birge and Shea form involves the evaluation of the coefficients of the usual power series, $f(\epsilon)=\sum_{k=0}^{j} a_{kj}\epsilon^k$, in terms of orthogonal polynomials, expressed explicitly in terms of the observations $y_i$. The required coefficients $a_{kj}$ are given by $\sum_{t=k}^{j} R_{kt}a_{tt}$ and Birge and Shea gave a general formula for $a_{tt}$. By means of a useful modification of Tchebycheff's recursion formula, explicit expressions have now been obtained for all $R_{kt}$ functions needed in the case of polynomials of the tenth or lower degree. These check in detail published results of F. E. Allan, who based his work on an entirely different formula. Furthermore, a general expression has been derived for $t!a_{tt}$ in the form of a weighted average of the finite differences $\Delta^t y_i$, for any value of $t$. Tables of values of the required weight of each $\Delta^t y_i$ have been calculated for $t=1$, 2, 3 and 4, and for $n$ (=number of observations) up to 20.

**14. Probable Errors for Least-Squares Solutions of Polynomials.** J. W. WEINBERG AND R. T. BIRGE, *University of California.*—Inability to evaluate the probable errors of the coefficients or of the function itself has hitherto constituted a serious defect in all of the proposed special methods, including that of Birge and Shea, for obtaining the least-squares solution of a polynomial (see preceding abstract). A general expression has now been obtained for the weight $N_t$ of the final coefficient $a_{tt}$ of a polynomial of degree $t$. A set of such coefficients (with $t=k$ to $j$) is required for the evaluation of each coefficient $a_{kj}$ of the $j$th-degree polynomial. Due to the orthogonal character of the solution, the various members $a_{tt}$ of such a set act like *independently* observed quantities, and this fact has been explicitly proved. Hence the law of propagation of errors can be applied to any *function* of the $a_{tt}$, including the expressions for the $a_{kj}$ and for the function itself. Thus an explicit expression for each desired probable error is readily obtained. Finally, the value of $\Sigma v^2$ ($v$=residual) for the $j$th-degree polynomial, needed in the calculation of the various probable errors, is given by the simple formula $\Sigma y^2-\sum_{t=0}^{j} N_t a_{tt}^2$. Tables of numerical values of $N_t$ have now been calculated, for $t=0$ to 5, and for $n$ up to 20.

**15. Short Range Interatomic Forces.** W. HORNING, W. O'CONNELL, AND J. WEINBERG. (*Introduced by R. T. Birge.*)—Because of the large momenta involved in the collision of ions with atoms, the corresponding elastic scattering may be analyzed by classical mechanics. In experiments on the collision of argon ions with helium atoms at energies of the order of hundreds of volts,[1] the dependence of cross section upon energy and scattering angle indicates the presence of a repulsive force of exclusion which varies inversely as the cube of the distance. At the distances of approach calculated from this force law, considerable overlapping of the electron clouds of ion and atom takes place; and the average duration of a collision compared to atomic periods is such that the electron distribution has time to become adjusted to the influence of both nuclei. A Fermi-Thomas statistical model of the two-center system should therefore provide a good approximation to the potential energy as a function of nuclear separation. This problem has been solved with the aid of the variational method, for the case of two nuclei of equal atomic number; and the potential energy-function obtained is in satisfactory agreement with the main features of the data. A detailed comparison with experimental results will shortly be possible on the basis of calculations now in progress.

[1] W. J. Hamm, Phys. Rev. **63**, 433 (1943).

**16. Absolute Intensity of Cu $K\alpha$ Radiation from a Thick Target.** W. L. BRAXTON, A. V. BAEZ, AND PAUL KIRKPATRICK, *Stanford University.*—Copper $K\alpha$ radiation emerging at a grazing angle of 10° from a thick target was isolated by Ross filters of cobalt and nickel and received in a large air-filled ion chamber standardized for absolute energy measurements. After making allowances for continuous radiation, for absorption in the target, the tube and chamber windows, the intervening air and the filters, it is concluded that the $K\alpha$ energy produced in the target by electron bombardment at 15.5 kev is $2\times10^{-12}$ erg per electron. The efficiency of the production of Cu $K\alpha$ radiation in thick targets at this bombardment energy is about 0.01 percent. Slightly less than half of the produced radiation emerges from the target face. Corresponding figures for other tube voltages are easily obtained from *relative* intensity measurements. The observed intensities were approximately predicted on the basis of earlier measurements of the intensity of $K\alpha$ radiation from thin targets of nickel.

**17. Some Observations Made Upon the Surface Properties of Solutions of Detergents in Water.** JAMES V. ROBINSON, *Stanford University*. (*Introduced by Paul Kirkpatrick.*)—This paper is a discussion of some of the more interesting observations made during the course of an uncompleted study. Peculiarities in the surface behavior of high molecular weight substances in aqueous solutions have been observed. Surface tension-concentration curves obtained from measurements upon detergent solutions show minima or broad horizontal sections as the rule rather than the exception. The absolute surface adsorption of one of these solutions was measured, and found to disagree with that predicted from the adsorption theorem, calculated in the usual way. The surface tension of certain detergent solutions, at the concentration where a minimum in surface tension occurs, may be further lowered by the addition of another surface-active agent. The addition of large amounts of surface-inactive materials to the detergent solutions is shown to produce almost no change in surface tension, in contrast to the large changes in surface tension demonstrated upon the addition of small amounts of surface active material. Some of the detergents apparently hydrolyze. Bubbles rising through solutions of detergents in long tubes accumulate large concentrations of the detergent at their surfaces. The surface concentration on the bubbles may be equivalent to hundreds of molecular layers.

**18. Diffraction of X-Rays by Aqueous Solutions of Hexanolamine Oleate.** SYDNEY ROSS, *Stanford University*. (*Introduced by Paul Kirkpatrick.*)—A number of papers published in Germany since 1937 by K. Hess, H. Kiessig, and W. Philippoff have reported results on the diffraction of x-rays by soap solutions. This paper presents results on a series of aqueous solutions of hexanolamine oleate, varying in concentration from 92 percent to 25 percent by weight of soap. As the solutions become more dilute, the long spacing increases linearly from a value of 54A at 92 percent to 135A at 30 percent of solute. The value of the side-spacing is about 4.6A, independent of changes of concentration. Solutions of 60 percent and less show two orders of the long spacing, corresponding to the 002 and 004 diffraction orders. The linear relation pursues its course through a range of concentration in which great changes in viscosity and anisotropy are taking place. It is therefore conclusively shown that changes of viscosity and gel/sol transitions in soap solutions are due to rearrangements of the primary micelles with respect to each other. The internal structure of the micelle itself is meanwhile independently maintained. The presence of lamellar micelles in aqueous solutions of this colloidal electrolyte is proved directly by these results.

**19. Foam Volumes and Foam Stabilities.** SYDNEY ROSS, *Stanford University*. (*Introduced by Paul Kirkpatrick.*)—Ease of foam formation, foaming volume, and the stability of the foam once formed, do not necessarily bear any relation to each other. Most writers have confined their attention to the measurement of stability. The present paper provides further data to show the relation between foam stability and foaming volume and to determine the conditions under which foaminess may be accounted an intrinsic property of the liquid, independent of the fortuitous mechanical conditions attendant on its production. A method of measuring foam volume is described and investigated to establish the critical factors in its operation. Data on foaming volumes and foam stabilities are given for a series of hydrocarbons and for a range of concentrations of aqueous ethylene glycol solutions. It is shown that the amount of foam formed depends on the machinery of its production as well as on its stability. The stability of the foam produced, within specified mechanical limitations chiefly of a nature that would tend to affect the size of the bubbles in the foam, is primarily a function of the liquid.