PROCEEDINGS

OF THE

AMERICAN PHYSICAL SOCIETY.

MINUTES OF THE SEVENTY-FIFTH MEETING.

A REGULAR meeting of the Physical Society was held in Randall-Morgan Laboratory of the University of Pennsylvania December 29, 1914, to January 1, 1915. It was a joint meeting with Section B of the American Association for the Advancement of Science. Morning and afternoon sessions were held on Tuesday, Wednesday, and Thursday. Vice-President Anthony Zeleny of Section B presided on Tuesday and Wednesday afternoons, and President Merritt at the other four sessions.

On Tuesday afternoon the program consisted of the vice-presidential address before Section B on "Recent Evidence for the Existence of the Nucleus Atom" by A. D. Cole and the presidential address of the American Physical Society on "Luminescence" by Ernest Merritt. On Wednesday afternoon there was a symposium on the Use of Dimensional Equations, led by E. Buckingham, who was followed by A. C. Lunn, A. G. Webster, W. S. Franklin, and others.

The following program of papers was presented:

An A. C. Bridge for the Measurement of the Dielectric Loss and Dielectric Constant at High Voltages and Low Frequencies. CHESTER A. BUTMAN.

Influence of the Concentration of Electrolyte upon Electrode Potentials. ARTHUR W. EWELL.

A New Method of Obtaining a Hysteresis Loop. W. N. FENNINGER.

On Rotation and Magnetization. S. J. BARNETT.

Note on Thermo E.M.F.'s in which the Resultant Peltier Effect is Zero. H. C. BARKER.

Linear Resistance Change with Temperature of Certain Molten Metals. E. F. NORTHRUP.

The Effect of Temperature on the Dielectric Strength, the Dielectric Loss and the Dielectric Constant of Paraffine Oil. CHESTER A. BUTMAN.

A Preliminary Note on the Variation of Stray Power Losses in a Dynamo. W. N. FENNINGER.

Relation Between the Energy of the Cathode Rays and the Frequency of the X-Rays Produced by Them. WILLIAM DUANE.

Thermionic Currents from a Wehnelt Cathode. W. WILSON.

Mobility of Ions at Different Temperature and Constant Gas Density. HENRY A. ERIKSON.

The Radioactive Content of Certain Minnesota Soils. JAMES C. SANDERSON, read by H. A. ERIKSON.

Conducting Gas Layer at a Metallic Surface. G. W. STEWART.

X-Rays From the Electrical Discharge. ELIZABETH R. LAIRD.

X-Rays Produced by Slow-moving Cathode Rays. ELIZABETH R. LAIRD.

Light Due to Recombination of Ions. C. D. CHILD.

Electric Furnace Evidence on the Relation of Spectrum Lines Having Constant Differences in Wave-Number. (By title.) ARTHUR S. KING.

The Mechanical Equivalent of Light. H. E. IVES, W. W. COBLENTZ, and E. F. KINGSBURY.

Fluorescence of the Uranyl Salts under X-Ray Excitation. FRANCES G. WICK.

The Efficiency of Energy Transformation in the Corona Method of Precipitating Fumes. W. W. STRONG.

Leakage of Gases Through Quartz Tubes. (By title.) E. C. MAYER.

A New Method for Measuring Gravity at Sea, with Some Trans-Pacific Observations. LYMAN J. BRIGGS.

The Oxidation of Nitrogen. W. W. STRONG.

The Alleged Dissymmetrical Broadening of the D Lines of Sodium. E. A. ECKHARDT.

Exhibit of Mechanical Models Illustrating (*a*) Subdivision of Alternating Current Between Two Branches in Parallel, (*b*) The Alternating Current Transformer, (*c*) Coupled Circuits in Wireless Telegraphy. W. S. FRANKLIN.

Some Causes of Variation in the Sensitivity of Moving Coil Galvanometers. PAUL E. KLOPSTEG (presented by A. ZELENY).

A New Standard Phone and Phonometer for any Pitch. A. G. WEBSTER.

A New Form of Radiation Pyrometer. (By title.) S. LEROY BROWN.

The Doppler Effect in X-Ray Spectra and Application to the Kinetic Theory of Solids. L. GILCHRIST AND D. A. KEYS.

On Acoustic Impedance, and an Approximate Theory of Conical Horns. A. G. WEBSTER.

Vapors with Positive Specific Heat in Energy Conversion. (By title.) J. E. SIEBEL.

Progress of B-Particles through Matter. A. F. KOVARIK AND L. W. MCKEEHAN.

A Thirty-two Element Harmonic Synthesizer. DAYTON C. MILLER.

The Result of Plotting the Separation of Homologous Pairs against Atomic Numbers instead of Atomic Weights. HERBERT E. IVES AND OTTO STUHLMANN.

Beaded Lightning. W. J. HUMPHREYS.

A Practical Measurement of Colors. H. E. WETHERILL.

Preliminary Note on a Mercury-vapor Tube Oscillator. B. LIEBOWITZ, introduced by M. I. PUPIN.

On Tuesday evening a public lecture, complimentary to the citizens of Philadelphia and illustrated by experiments and the lantern, was given by

Dayton C. Miller. On Wednesday evening a successful dinner for Physicists was arranged by Professor H. C. Richards at a hotel near the University. This was enjoyed by about seventy members. The members of the Society were the guests of the University of Pennsylvania at lunch each day of the meeting. The registration of the meeting was one hundred and seventeen. The attendance at the various sessions was exceptionally uniform and varied between one hundred and one hundred and fifty.

The result of the mail ballot for officers for 1915 was announced at the meeting as follows: For President Ernest Merritt, vice-president K. E. Guthe, secretary A. D. Cole, treasurer J. S. Ames; for members of Council (three years) C. E. Mendenhall and G. W. Stewart, and for Editorial Board J. S. Ames, A. A. Michelson and E. Buckingham. The reports of the managing editor of the PHYSICAL REVIEW was presented by the editor. It was approved and that of the treasurer reported in the hands of the President, duly audited. Both were ordered printed, to be sent to each member with the announcement of next meeting.

A. D. COLE,
Secretary.

A METHOD OF DETERMINING WHETHER OR NOT THE VELOCITY OF LIGHT DEPENDS UPON THE VELOCITY OF THE SOURCE, BY THE USE OF CANAL RAYS.[1]

BY GORDON S. FULCHER.

LET a source of light, a canal ray for instance, move toward an observer, that is a spectrograph, with a speed v with reference to a system in which the speed of light is c, while the observer is moving toward the source with a speed u with reference to the same system so that the relative speed is $v + u = V$. If the source s and observer o are at a distance apart equal to l at the instant $t = 0$, the 1st and the $(n+1)$th waves will reach the observer at instants $l/(c + u)$ and $1 + (l - u - v)/(c + u)$, if the source sends out n waves per second. The observer receives n waves in the time

$$1 + \frac{l - u - v}{c + u} - \frac{l}{c + u} = \frac{c - v}{c + u}$$

or at the rate of $n[(c + u)/(c - v)] = n'$, per second. The resulting doppler effect would be

$$n' - n = n\frac{v + u}{c - v} = n\frac{V}{c - V + u}.$$

Now suppose the apparatus rotated through 180° so that the relative speed of the source with reference to the observer is the same as before, but the speed with reference to the fixed system is greater. The number of waves received per second by the observer now is

$$n'' = n\left(\frac{c - u}{c - v}\right);$$

[1] Abstract of a paper presented at the Chicago meeting of the Physical Society, November 28, 1914.

the doppler effect would be

$$n'' - n = n\left(\frac{uv -,}{c - v}\right) = n\frac{V}{c - V - u}.$$

Supposing the two spectrograms are taken one immediately above the other the shift in the doppler effect which should be observed if, as we have assumed, the velocity of light in the fixed medium is independent of the velocity of the source, is

$$n'' - n' = n\cdot\frac{2uV}{(c - V)^2 - u^2};$$

or, approximately,

$$\Delta\lambda = \frac{\lambda_1^2}{\bar{\lambda}}\cdot\frac{2uV}{(c - V)^2} = \lambda\cdot\frac{2uV}{c^2}.$$

If $u/c = 10^{-4}$ (earth); $V/c = 10^{-2}$ (fastest canal rays); $\lambda = 4861$ Å (H_β); then $\Delta\lambda = 2 \times 10^{-6}\,\lambda = .0097$ Å. To measure this, we should require very homogeneous, parallel, canal rays whose high speed must be maintained constant within one part in 10,000 during the experiment. While the experimental difficulties would be very great, they do not seem insurmountable.

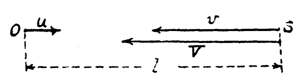

Fig. 1.

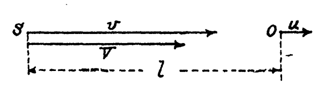

Fig. 2.

It is to be noted that the shift is a first order change of the doppler effect and can not be accounted for, if it is found by experiment to exist, by any second order change of V or l. The wave-lengths are measured in all cases by a spectrometer moving with the same speed with reference to the fixed system.

University of Wisconsin.

Note on Thermo E.M.F.'s in Which the Resultant Peltier E.M.F. is Zero.[1]

By H. C. Barker.

TAIT and others have noted that couples having two or more neutral points would give thermoelectric currents maintained by the Thomson effect alone, if the junctions were at the temperatures of the neutral points.

In this case the resultant Peltier E.M.F. is zero as the component Peltier E.M.F.'s are each equal to zero.

The writer has been led to question whether it is generally recognized that the Thomson thermodynamic theory leads to the conclusion that large thermo E.M.F.'s in which the resultant Peltier E.M.F. is zero, are obtainable with couples for which there exists only one neutral point.

[1] Abstract of a paper presented at the Philadelphia meeting of the Physical Society, December 29–31, 1914.

The condition is easily shown to be that the sum of the junction temperatures be equal to the neutral temperature. The Peltier E.M.F.'s are then equal, and their difference, the resultant Peltier E.M.F., is zero. Thus the current may be said to be maintained by the Thomson effect alone.

It is plain that two temperatures meeting this condition may be so chosen that the thermo E.M.F. is relatively large.

The appended curves exhibit the essential relations.

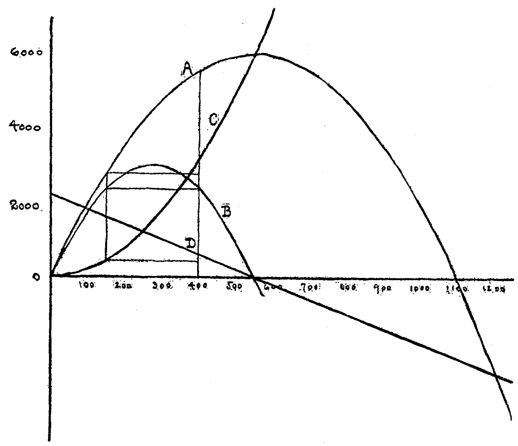

Fig. 1.

Abscissæ represent absolute temperature. Ordinates for curves A, B and C represent E.M.F. in microvolts. Ordinates for Curve D represent microvolts per degree, $\times$ 100.

Curve A. $E = 22\theta - .02\theta^2$. Thermo E.M.F. is given by difference in ordinates.

Curve B. $e_p = \theta \dfrac{\partial E}{\partial \theta} = 22\theta - .04\theta^2$. Resultant Peltier E.M.F. given by difference in ordinates.

Curve C. $e_T = -\displaystyle\int_0^\theta \theta \frac{\partial^2 E}{\partial \theta^2}\, d\theta = .02\theta^2$. Resultant Thomson E.M.F. given by difference in ordinates.

Curve D. $P = \dfrac{\partial E}{\partial \theta} = 22 - .04\theta$. Thermoelectric power.

UNIVERSITY OF PENNSYLVANIA,
PHILADELPHIA, PA.

LINEAR RESISTANCE CHANGE WITH TEMPERATURE OF CERTAIN MOLTEN METALS.[1]

BY EDWIN F. NORTHRUP.

COPPER and tin have been studied to 1680° C., lead to over 1600° C., gold to 1500° C., silver to 1340° C., bismuth to 750° C. and their change of resistance with temperature when molten has been found, within the limits

[1] Abstract of a paper presented at the Philadelphia meeting of the Physical Society, December 29–31, 1914.

of accuracy of the measurements, to be linear. Lead and tin, particularly the latter, are shown to constitute excellent thermometric materials for the accurate measurement of high temperatures which may be read with apparatus that reads on a uniformly spaced scale directly in degrees centigrade. Several features and relations of interest respecting the resistivities of the above metals are pointed out.

Palmer Physical Laboratory,
Princeton, N. J.

Influence of Concentration of Electrolyte upon Electrode Potentials.[1]

By Arthur W. Ewell.

According to Nernst's formula, the potential of an electrode dipping into an electrolyte increases as the concentration of the electrolyte is increased. At ordinary temperatures the amount of increase is $.058/N \log c_2/c_1$ where N is the valency and c_2/c_1 is the ratio of the concentrations. This law has often been closely verified by well-known electrochemical methods, both when the electrode dips in the electrolyte and when the two are separated by ionized air.

A year ago Borelius showed that when single electrode potentials were studied electrostatically the potential decreased as the concentration was increased, the rate of decrease being approximately equal to the rate of increase hitherto observed.

The writer has studied the influence of concentration, employing a modification of the apparatus recently used for determining absolute single potentials.[2] The two electrolytes of different concentrations were contained in two similar glass flasks. The silver film on the outside of each was connected to a pair of quadrants of a Dolezalek electrometer and the deflections of the latter were observed when earthed electrodes were dipped into the electrolytes. The observations gave values for the numerical factor (.058 in Nernst's equation) between .037 and .053 and all negative, thus confirming Borelius's results with a type of apparatus which, unlike Borelius's apparatus, gave absolute potentials independent of Volta effects.

Worcester Polytechnic Institute.

The Alleged Dissymmetrical Broadening of the D Lines of Sodium.[1]

By E. A. Eckhardt.

H. KAYSER in his Handbuch der Spectroscopie[3] refers to the dissymmetrical broadening of the D lines in an emission spectrum. Bro-

[1] Abstract of a paper presented at the Philadelphia meeting of the Physical Society, December 29–31, 1914.

[2] This Journal, Vol. IV, No. 6, p. 547.

[3] H. Kayser, Handbuch der Spectroscopie, Vol. II, p. 365.

therus[1] and Iwanow[2] as well as others appear to have subsequently observed the same phenomenon. The present investigation had for its program first the reproduction of this dissymmetrical broadening and then by measurably controlling the factors which are responsible for the broadening to find if possible in what manner the dissymmetry is introduced.

Since the dissymmetries seem always to have been observed in emission spectra it seemed pertinent to investigate whether they exist also in the corresponding absorption spectra. Consequently the light of an arc lamp was made to pass through a strongly absorbing sodium flame and was then focused on the slit of a grating spectroscope. The absorption of the sodium flame was under control within very wide limits. The spectrum was photographed and the distribution of intensity across the spectrum lines was determined by means of a Hartmann photometer.

Although the D lines were broadened much more than they had been in the experiments of Brotherus and Iwanow no dissymmetries of any kind were discovered. The results of the present work indicate strongly that there are no dissymmetries in the absorption spectrum obtained under conditions which are comparable to those in which the dissymmetry has actually been observed in the emission spectrum. If the dissymmetries really exist in the emission spectrum, they appear to have no counterpart in the corresponding absorption spectrum. The work could not be completed because the Hartmann photometer which had been borrowed ceased to be available. It is hoped that the original program may be carried to its conclusion in the near future.

UNIVERSITY OF PENNSYLVANIA,
PHILADELPHIA.

IONIZATION AT METALLIC SURFACES.[1]

BY G. W. STEWART.

WE have much evidence that suggests ionized layers of gas at metallic surfaces at atmospheric pressures, but only the experiments of Anderson and Anderson and Morrison furnish direct evidence.

The apparatus consisted of two polished surfaces, one silver and one german silver, .35 cm. and .50 cm. in diameter respectively. These are plane to within one half wave-length of light. They are approached by an interferometer carriage. Distances were measured by electrical capacity method and by the screw of instrument.

The experiments argue in favor of an ionized layer of gas because of the following points:

1. The minimum distance of approach without apparent conduction was four wave-lengths. Without an ionized layer this distance would have been one wave-length.

[1] Abstract of a paper presented at the Philadelphia meeting of the Physical Society, December 29–31, 1914.

[1] Hj. V. Brotherus, Ann. d. Phys., Ser. 4, 38, 1912, p. 416.

[2] K. Iwanow, Phys. Z., XIII, 1912, p. 1118.

2. With air, oxygen and hydrogen, the presence of water vapor extends the layer ten to forty wave-lengths.

3. Effect of the three gases named and carbon dioxide is similar, but probably not the same. The influence of water vapor in the case of the latter is less distinct and may not exist at all.

4. Current-voltage curves taken of necessity without the existence of steady states, indicate either ionization by collision or the dragging of additional ions from near the surface by the increased voltage.

5. An approximate value of the contact potential difference is obtained by virtue of the ionized layer.

6. The current-voltage curves shift with direction of field in accord with the contact potential difference value.

The surface layer is found in both of the metals used. Moreover, this layer explains well-known facts with insulators. The origin of the ionization is not clear. It is improbable that it is due to the electrons from within or to a radioactive impurity now known. More probable causes would be the intrinsic radiation of the metal, an unknown radioactive impurity, and chemical action.

The presence of ionized layers of gas is important in the study of coherer action, carbon transmitter action, double layer electrification at low pressures, and the ionization supposed to be due to a penetrating radiation.

THE STATE UNIVERSITY OF IOWA,
IOWA CITY, IA.

LIGHT PRODUCED BY RECOMBINATION OF IONS.[1]

BY C. D. CHILD.

CERTAIN phenomena connected with the luminosity of the light rising from the mercury arc indicate that this light is produced by the recombination of ions.[2] If this explanation is correct, the light must continue for a time after the current through the arc has been stopped. This can be tested by observing the light from an alternating current arc at different phases of the current. Such observations have already been made for the carbon arc in air by Fleming and Petavel[3] who found that the light from the gas between the carbons does not disappear entirely at the time when the current is zero.

Since the phenomena with the carbon arc in air is complicated by the oxidation of the carbon and by the high temperature of the gas, it seemed desirable to repeat their experiment substituting mercury terminals in a vacuum for carbon terminals in the air. This has been done and it has been found that in this case also the light continues to exist for an appreciable length of time after the current has ceased flowing. Such light can not be due to ionization and is in all probability due to recombination of the ions.

[1] Abstract of a paper presented at the Philadelphia meeting of the Physical Society. December 29–31, 1914.

[2] Phil. Mag. (6), 26, 906, 1914.

[3] Phil. Mag. (5), 41, 339, 1896.

Measurements are now being made for the purpose of learning the length of time that the light continues after the current ceases and the rate at which the light dies away.

COLGATE UNIVERSITY,
HAMILTON, N. Y.

A NEW METHOD FOR MEASURING GRAVITY AT SEA, WITH SOME TRANS-PACIFIC OBSERVATIONS.[1]

BY LYMAN J. BRIGGS.

THE apparatus used was in principle similar to a closed barometer. The air-chamber consisted of a closed glass tube 3 cm. in diameter and 60 cm. long. A capillary tube was sealed into the upper end of the air-chamber and extended nearly to the bottom of the latter, the lower end opening beneath a mercury surface. The capillary above the air-chamber was bent into a zigzag glass spring and ended in a spherical bulb 3 cm. in diameter. This bulb contained a fixed ground glass point extending to the center of the bulb with its axis forming an extension of the axis of the air-chamber. The bulb was mounted in a light carriage sliding on rods clamped to the air-chamber. A micrometer-screw mounted on the rods above the carriage controlled the position of the carriage and bulb. The bulb was highly evacuated and sealed off. The whole apparatus was then packed in crushed natural ice, and the air-pressure in the chamber adjusted until the mercury stood in contact with the glass point. The air-chamber was then sealed off.

As long as the apparatus is vertical and is surrounded by and in equilibrium with pure melting ice, a change in the height of the column is theoretically dependent only on a change in the force of gravity, provided the apparatus is assumed to be free from volume-changes due to external pressure. The height of the bulb is so adjusted by means of the screw that at the time the final reading is made the mercury surface is barely in contact with the glass point. Under these conditions the quantity of mercury remaining in the air-chamber is always the same. The apparatus is, therefore, of the constant-volume type, and the height of the mercury column at two stations is inversely proportional to the force of gravity.

The length of the column is such that when the apparatus is removed from the ice tank, the upper bulb becomes completely filled with mercury. The apparatus may then be tipped in any position and is perfectly transportable. On board ship, the cork-covered ice tank containing the apparatus was swung from gimbals, the latter being suspended from spiral springs.

In the laboratory, a series of readings made on different days agreed to within less than 1 part in 200,000. On board ship, however, things happen that the writer at least did not anticipate, and which combine to reduce the accuracy to 1 part in 50,000, or even less, depending on the weather and the ship. The

[1] Abstract of a paper presented at the Philadelphia meeting of the Physical Society, December 29–31, 1914.

apparatus is now being modified with the hope of increasing the accuracy of measurements at sea.

U. S. Bureau of Plant Industry,
Washington, D. C.

Leakage of Gases Through Quartz Tubes.[1]

By E. C. Mayer.

A CYLINDRICAL tube of quartz closed at one end of approximately 51 cu. cm. volume and 111 sq. cm. internal superficial area, was found to be pervious to hydrogen at temperatures ranging from 330° C. to 710° C., and at pressures varying from 20 cm. below to 20 cm. above atmospheric pressure. The quartz was of the transparent variety. The curve indicates the general character of the results. Time in minutes is plotted as abscissas, and lengths proportional to volume of gas reduced to 15° C. and 76 cm. pressure as ordinates. Each unit of the ordinate scale corresponds to a volume of 0.217 cu. cm. In the case of oxygen and nitrogen, no leakage could be de-

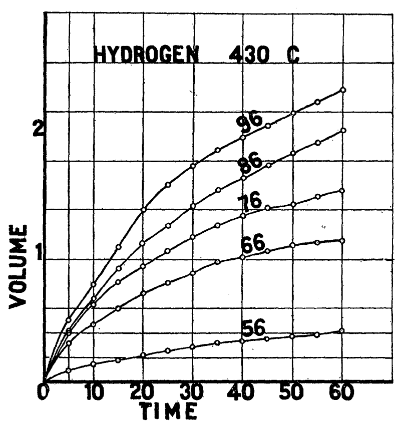

Fig. 1.

tected for pressures less than one atmosphere. Nitrogen did not seem to escape until a temperature of about 430° C. was obtained. At constant temperature the results for all gases showed a considerable increase in leakage with increasing pressures. Under approximately like conditions hydrogen leaks most rapidly and nitrogen least.

Heating was obtained by means of an electric furnace. Temperature was measured by an iron-advance thermocouple.

Cornell University,
Ithaca, N. Y.

[1] Abstract of a paper presented at the Philadelphia meeting of the Physical Society, December 29–31, 1914.