photosphere is examined, and evidence is brought forward from recent direct visual observations (Howlett, Sidgreaves, Spoerer), from the rate of solar rotation deduced from faculæ, spots, and surface (Dunér), and from the thermal absorption over spots, to support the view that spots may be masses of absorbing gases above rather than below the photosphere. The paper will be published in the *Astrophysical Journal*.

Sedenions: By JAMES B. SHAW; presented in outline by Prof. E. W. Hyde.

If q be any quaternion, Φ the operator on q such that if

$$q = w + xi + yj + zk,$$
$$\Phi q = (a^i w + b^i x + c^i y + d^i z)$$
$$+ (a^{ii} w + b^{ii} x + c^{ii} y + d^{ii} z)i$$
$$+ (a^{iii} w + b^{iii} x + c^{iii} y + d^{iii} z)j$$
$$+ (a^{iv} w + b^{iv} x + c^{iv} y + d^{iv} z)k.$$

Φ is called a *Sedenion.* The paper (offered for publication in the *Bulletin of the American Mathematical Society*) is a development of the elementary formulæ of *Sedenions* considered as an algebra of sixteen units. These formulæ are developed by the aid of Quaternions.

On the Distribution and the Secular Variation of Terrestrial Magnetism, No. IV: On the Component Fields of the Earth's Magnetism: By L. A. BAUER.

This paper, to appear in *Terrestrial Magnetism*, continues the researches hitherto published by the author, and is an attempt to resolve the prevailing magnetic field of the earth into its components. The paper was illustrated by maps and diagrams.

Determination of the Weights of Observations: By J. R. EASTMAN.

A brief account was given of a method of determining the weights to be used in combining the results of observations made in a series of years with the same instrument (meridian circle). The results also showed the futility of excessive repetition of an observation with a view to increased accuracy.

On the Composition of Simultaneous and Successive Vectors: By ALEXANDER MACFARLANE.

Vector Algebra is commonly founded partly on physical ideas, partly on arbitrary formal laws. The author prefers to give it a purely geometrical or physical basis. The sum of simultaneous vectors is commutative, because they have no real order; the sum of successive vectors is not commutative, because they have a real order. The square of a sum of successive vectors differs from the square of a sum of simultaneous vectors by a set of terms depending on the order of the succession. This was illustrated by the generalized form of the Exponential Theorem for space.

All the papers on the program having been read, at the conclusion of the session on Wednesday afternoon, August 26th, Section A adjourned.

<div align="right">EDWIN B. FROST,</div>

DARTMOUTH COLLEGE.   *Secretary.*

SECTION B—PHYSICS.

THE address of the Vice-President, Carl Leo Mees, upon *Electrolysis and some Outstanding Problems in Molecular Dynamics,* will be printed in this JOURNAL.

The meetings of the section were full and interesting. One of the sessions was interrupted by the introduction of Dr. Chas. E. West, of Brooklyn, a founder of the Association, who gave reminiscences of Joseph Henry and exhibited a small helix made by Prof. Henry and used by him in conjunction with Dr. West on July 10, 1842, to magnetize needles during a thunder storm. Dr. West also exhibited a fragment of wood from the ship of Captain Cook, given him by the elder Silliman sixty years ago. The remarks of Dr. West were listened to with profound interest and the section tendered to him a vote of thanks.

The section enjoyed a visit to the home of Mr. Edgar B. Stevens, a manufacturer

of Buffalo, who has a large collection of Crookes' tubes with accessory apparatus for the exhibition of the Röntgen rays.

On Friday afternoon the section made a special excursion to Niagara Falls, and the members were courteously received at the large Power House, at the Carborundum Factory and at other places of interest.

During the seven working sessions of the section twenty-nine papers were read in full and two by title.

Polarization and Internal Resistance of a Galvanic Cell: By B. E. MOORE.

The E. M. F. between each electrode of a cell of the Leclanché type, without depolarizer, and an auxiliary carbon electrode was determined during the polarization of the cell and during its subsequent recovery.

The Lead Storage Cell: By B. E. MOORE.

The author explained from Nerst's theory the character of the curves of charge and discharge of a lead storage cell.

A Theory of Galvanic Polarization: By W. S. FRANKLIN and L. B. SPINNEY.

The authors pointed out the existence of a term in the energy equation of the electrolytic cell depending upon an irreversible or sweeping process at each electrode. Experiments were described showing that the coefficients of these terms do not in general vanish with the current.

On the Counter Electromotive Force of the Electric Arc: By W. S. FRANKLIN.

The author attempted the experimental determination of the decay of E. M. F. between the carbons of the electric arc after the circuit is broken. It was pointed out by G. W. Patterson that the results were entirely ambiguous.

On the Element of Diffraction in Fresnel's Experiments with two Mirrors and with the Bi-prism: By ERNEST R. VON NARDROFF.

The author discussed in detail the coloring by diffraction of the central band obtained by Fresnel's mirrors and Fresnel's bi-prism.

Segmental Vibrations in Aluminum Violins: By ALFRED SPRINGER.

Five years ago the author pointed out that the acoustical properties of aluminum are approximate to those of wood. Continued experiments made with aluminum sound boards have verified this earlier conclusion. The author exhibited several aluminum violins, together with a device, called a bass bar, by means of which the quality of the tone produced by the instrument can be controlled.

Preliminary Note on a proposed new Standard of Light: By CLAYTON A. SHARP.

It is proposed to define a standard of light as a flame of definite size produced by a gas of definite composition burning in a continuously renewed atmosphere of definite composition. Experiments have been made with a mixture of equal parts of acetylene and hydrogen burning in an atmosphere of pure oxygen. The mixture of acetylene and hydrogen issues from a small tube, surrounding which is a larger tube supplying oxygen. The importance of using dry gases was pointed out.

A Photographic Study of the Röntgen Rays: By W. A. ROGERS.

Note on the Duration of the X-Ray Discharge in Crookes' Tubes: By BENJAMIN F. THOMAS.

It has been found that slow make and break in the primary of an induction coil produces almost as strong effect on a Crookes' tube as very rapid make and break. This seems to indicate the long duration of activity of the tube at each discharge. The author has shown, however, that the duration of the acting discharge is as short as $\frac{1}{5000}$ second and probably as short as $\frac{1}{50000}$ second.

Preliminary Communication concerning the Anomalous Dispersion of Quartz for Infra-

red Rays of Great Wave-length: By ERNEST F. NICHOLS.

In the absence of the author this paper was presented in abstract by Prof. E. L. Nichols. The author has investigated the optical (?) properties of quartz for waves greater than 4 μ.

The reflection from a surface cut perpendicular to the optic axis was found to decrease steadily from $3\frac{1}{2}$ % at wave-length, 4.5 μ to a minimum of 0.29 % at 7.4 μ. From this point the reflection increases rapidly to 14 % at 8 μ, 36 % at 8.1 μ, reaching a maximum of 76 % at 8.4 μ. A second minimum of 51 % was found at 8.6 μ and a second maximum of 65 % at 8.8 μ; beyond which the reflection falls to 50 % at 9 μ.

The transmission through a quartz plate 18 μ in thickness cut perpendicular to the optic axis shows three pronounced minimum and four maximum values between 4 μ and 7 μ. The last maximum is at 7 μ. The transmission at this point is 80 % From this point the transmission falls to 51 % at 7.6 μ, 36 % at 7.7 μ, 12 % at 7.9 μ, and to a value less than 1% at 8.1 μ. Beyond 8.1 μ the transmission is imperceptible.

A computation of the indices of refraction from observed reflection and transmissions by the Cauchy formula has given results which agree with the Ketteler-Helmholtz dispersion formula, which, according to Rubens' constants, requires rays in the region of 8 μ to be bent towards the apex rather than towards the base of a quartz prism.

The reflection and transmission measurements were made with a Torsion Radiometer. The radiations pass through a fluorite window into a vacuum chamber and fall upon a blackened vane of mica, 2x15 mm., which is carried by a light arm at a distance of 2 mm. to one side of a quartz fibre. The deflection of the vane is observed by means of a mirror, telescope and scale. The sensitiveness of the instrument, with a full vibration period of 12 seconds, was such that the rays from a candle at a distance of six meters gave a deflection of 61 divisions on a scale distant 1 meter from the instrument. When properly protected the instrument is absolutely without 'drift,' and the zero point remains constant within a centimeter for days at a time.

An Experimental Study of the Charging and Discharging of Condensers: By F. E. MILLIS.

In the absence of the author this paper was presented by Ernest Merritt, who exhibited a number of very fine photographic tracings of alternate current curves and of curves obtained by the charge and discharge of condensers. The instrument used was essentially a tangent galvanometer with a miscroscopic soft iron magnet and mirror placed in an intense magnetic field and having about 17,000 free half-vibrations per second.

Notes on certain Physical Difficulties in the Construction of Modern Large Guns: By W. LECONTE STEVENS.

The author related some experiences in connection with the manufacture of a large gun at the Watervliet arsenal, on the Hudson river.

On the Photographic Trace of the Curves described by the Gyroscopic Pendulum: By ERNEST MERRITT.

The author exhibited a number of the curves.

On the Distribution of High Frequency Alternating Currents throughout the Cross-Section of a Wire: By ERNEST MERRITT.

The author exhibited, by platted curves, the results of extensive calculations from the formulæ of Lord Kelvin and Heaviside.

On the Compactness of a Beam of Light: By ERNEST R. VON NARDROFF.

The author calls the solid angle subtended by the extreme rays of a beam of light at a

point the *vergency* of the beam. Assuming the luminous source to be of uniform brightness, he shows that the quotient—intensity of beam divided by vergency—is a constant; this he calls the compactness of the beam. He applies this conception to the discussion of various theorems in connection with optical instruments.

Some Points in the Mechanical Conception of the Electro-magnetic Field: By W. S. FRANKLIN.

The author pointed out the importance of applying the conceptions of Maxwell and Lodge directly to the explanation of fundamental principles instead of to special cases. In addition to the explanation of the two laws of induction he applied the conceptions of Maxwell to the explanation of the energy stream and to the explanation of electro-magnetic waves.

Mechanical Models of the Circuit: By BROWN AYRES.

The author exhibited a model consisting of a number of fly-wheels arranged in a circuit with spring connections. The model represented in a striking manner nearly all of the fundamental phenomena of the electric circuit, particularly the phenomena of electrical oscillation and resonance.

Graphical Treatment of Alternating Currents in Branching Circuits: By HENRY T. EDDY.

The author gave an elegant treatment of the general problem of branched circuits containing resistance, inductance and capacity, showing the construction of the locus of the resultant current vector for varying frequency.

Description and Exhibition of a Convenient Form of the ' Interferential Comparer,' and of an Interferential Caliper Attachment for Use in Physical Laboratories: By W. A. ROGERS.

Description and Exhibition of a Bench Comparator for General Use in Physical Laboratories: By W. A. ROGERS.

On the Rule for the Dynamo and Motor: By ALEXANDER MACFARLANE.

In the discussion of this paper Prof. S. T. Moreland gave a mnemonic rule, not generally known, associating the directions of the electric current and of the magnetic field with the hand in such a way that the force is in the direction one would naturally push.

Note on the Effect of Odd Harmonics upon the Virtual Values of periodically varying Quantities: By FREDERICK BEDELL and JAMES E. BOYD.

The authors showed that the virtual value of a periodic E. M. F. is independent of the phase relations of its odd harmonics, but dependent only upon their amplitudes.

Experimental Determination of the Relative Amounts of Work Done in changing the Lengths of two metal Bars under the same Thermal Conditions, by an Envelope of Heated Air, and by Pure Radiations in a Vacuum: By W. A. ROGERS.

The author explained the difference in the behavior of a metal bar in an air bath and in a vacuum.

An Experimental Method of Finding the Value of a Unit of Force in Any System Whatever: By W. A. ROGERS.

A new Alternating Current Curve-tracer: By EDWARD B. ROSA.

The author described an apparatus by means of which the successive points in an alternate current or E. M. F. curve are platted directly, avoiding the necessity of taking and entering numerical observations. He exhibited a large number of curves, originals and enlargements.

Visible Electric Waves: By B. E. MOORE.

The author described an arrangement in which stationary electric waves on a wire are rendered visible by the brush discharge from the various portions of the wire.

Electrical Waves in Long Parallel Wires: By A. D. COLE.

The author described some preliminary work carried out in connection with the determination of the dielectric constants of liquids.

The Influence of a Static Charge of Electricity on the Surface Tension of Water: By ED-WARD L. NICHOLS and JOHN ANSON CLARK.

The authors used a dropping apparatus for determining the surface tension, and a novel electrometer for measuring E. M. F. This electrometer consisted of a light conducting sphere suspended by a long conducting fibre near a large plane plate. The movement of the sphere was observed by means of a telescope.

Determination of the Specific Heats of Nitrogen by Adiabatic Expansion: By W. S. FRANKLIN and L. B. SPINNEY.

The authors pointed out the fact that of the four quantities R (in the equation $pv = Rt$), K, C_p and C_v associated with a gas only two are independent; and they described some incomplete experiments for the indirect determination of C_v.

The Analysis of Vowel-sounds, by Means of the Sympathetic Vibrations of a Rigid Body: By L. B. SPINNEY.

The author described the manner of mounting a light mirror so as to vibrate with sound waves impinging upon it, and exhibited a number of photographic tracings.

Polar and Interpolar Effects of the Galvanic Current on Living Animal Tissues: By C. P. HART.

Description and Exhibition of a Portable Apparatus for Recording Curves of Alternating Currents and Electro-motive force: By H. J. HOTCHKISS.

The author exhibited the apparatus, and also, some photographic tracings taken by means of it.

The discussion of Nomenclature and Units was made a special order for the last Sectional meeting, but on account of lack of time it was deferred and made a special order for the meeting of next year.

IOWA STATE COLLEGE.   W. S. FRANKLIN.

THE PHYSIOLOGY OF COLOR IN PLANTS.

SINCE the preparation of my recent summary of the uses of color in plants[*] the work of Stahl in the botanic garden at Buitenzorg has been published,[†] by which some of the current conclusions are seriously modified.

I have pointed out in the paper cited above that the theories concerning the relations of plant colors to animals are by no means on a secure basis, and Stahl by a large number of experiments in which red and green leaves were fed to snails, rabbits, antelopes, etc., finds that the choice of food depends on the degree of hunger of the animal to a much greater extent than on the color of the plants eaten. He concludes that in no instance is it placed beyond doubt that color areas have been developed as a 'warning' to serve as a protection against animals, but is disposed to regard the so-called warning devices as accidental.

Because of the prevailing acid reaction of red leaves, this author uses the term 'Erythrophyll' to denote the reddish coloring matter, instead of 'Anthocyan.' So far as its physical qualities are concerned, he confirms the view of Engelmann that its spectrum is complementary to that of chlorophyll. He does not, therefore, agree with the theory of Kerner that color layers may serve as a protection of the chlorophyll against intense sunlight,[‡] but formulates an extended and modified statement of Pick's conclusions,[§] in which he sug-

[*] MacDougal: Physiology of Color in Plants. Pop. Sci. Monthly, May, 1896.

[†] Ueber bunte Laubblätter. Ann. d. Jard. Bot. Buitenzorg, 13: 137–216. 1896.

[‡] Pflanzenleben, 1: 364. 1890.

[§] Bot. Centralblatt, 16: 1883.