The reasons for this misuse of terms are probably that many who use electrodes for physiological or medical purposes are so untrained in physics and chemistry that they do not know the true meaning of the word, and that frequent use of a device which facilitates the application of a pair of electrodes to a nerve or other tissue, as a single unit, leads them to form the habit of thinking of it in the singular.

These reasons do not justify the practice. The word "electrode" has a definite physical meaning and should be used with respect to that meaning. This use of the singular where the plural is meant is analogous to calling a pair of boots a boot, or a pair of gloves a glove. The difference between a pair of eyeglasses and a monocle should serve to stress the point.

The misuse of the singular can not be excused on the ground that in practice one always uses a pair of electrodes, for there are cases in which an electrode may be applied singly, and the singular is needed to designate such a case. Often a diffuse electrode (usually grounded) is applied to one part of the preparation, while a small localizing electrode is applied to the particular structure being studied. This applies both to stimulation and to leading off of electric responses. If the word "electrode" is habitually used to denote a pair of electrodes, no suitable term is left for the single electrode. In short, the use of a word with a definite physical meaning in an improper sense opens the way to endless confusion, and should be heartily condemned.

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Transformations of differential elements: EDWARD KASNER. The simplest type of differential element is a lineal element (x, y, y') defined as a point with an associated direction. General element transformations, studied by the author, carry a curve, not into a curve, but into a *series* of ∞^1 elements, not in united position. A simple example of a series is a *turbine*, obtained from the elements of a circle by applying a turn T (through a fixed angle) or a slide S (through a fixed distance). All turns and slides generate a 3-parameter group G_3. This is a subgroup of the general group G_{15} which converts turbines into turbines. We next study general isogonal series and equitangential series obtained by applying T and S to general curves. The largest group converting isogonal series into such is shown to be the product of the conformal group and the turn group. The dual theorem gives the product of the equilong group and slide group. Transformation theories are obtained for velocity and natural families in dynamics and also for the dual types. The general transformation of normal congruences has application to optics. Finally, the osculating turbines of general series are studied, giving a wide generalization of the classic theory of evolutes which had its origin in Huyghens's wave theory.

Analysis of 18,000 proper motions derived at the Leander McCormick Observatory: P. VAN DE KAMP and A. N. VYSSOTSKY (introduced by S. A. Mitchell). Proper motions of 18,000 stars between magnitudes 7½ and 14 have been derived photographically in 341 regions. These regions, forming a sample of about one half of one per cent. of the total area of the sky, are representatively distributed north of Declination $-30°$. The motions have been made absolute by means of the motions of 574 bright stars kindly furnished by the Dudley Observatory in advance of publication. In addition, spectra for 5,200 of these faint stars were secured at the Harvard College Observatory. The more important results are: (1) Corrections to Newcomb's precession constants were found with high precision, due to the large number of faint stars with small motions which constitute an almost ideal "fixed" reference system. (2) The direction to the center of the rotation of the galaxy and the constants of the differential galactic rotation were found practically identical with corresponding figures previously derived by various investigators from the motions of the bright stars. Thus, it is shown that the phenomenon of galactic rotation is not limited to restricted groups of high luminosity stars, but is shared by the general population of the galaxy. The galactic longitude of the center was found to be 321°, in the constellation of Scorpius. (3) The position of the Solar Apex, at right ascension, 19.0 hours and declination, $+36°$, was found to differ by 15° from the Apex derived with respect to the bright stars. This is thought to indicate a higher percentage of high velocity stars among the apparently faint stars. The results given under (1) (2) and (3) were obtained from one simultaneous solution for the 8 unknowns involved; they are therefore independent of any outside data, except the system of the new "Boss" catalogue. (4) In general, the secular parallaxes are somewhat larger in northern galactic latitudes than in the corresponding southern latitudes, the smallest parallaxes being found not in the Milky Way as might be expected but about 15° away from it, north and south. Furthermore, the parallaxes of the groups of fainter stars in the Milky Way are much larger than had previously been supposed. These all indicate heavy obscuration near the plane of the Milky Way. The results given under (3) and (4) were confirmed in a general way from a discussion of the proper motions in right ascension of some 9,000 faint stars used in parallax determinations at the Allegheny, Johannesburg and McCormick Observatories. (5) A study of the ellipsoidal distribution of motions revealed a clear dependence of the position of the Vertex on absolute magnitude. Thus the stars of large proper motion (predominantly

[1] Continued from page 426.

dwarfs) have their Vertex at galactic longitude 330°, *i.e.*, close to the galactic center. Again, the Vertex found from stars in low galactic latitudes is at 347°, whereas from stars in high galactic latitudes where the proportion of dwarfs is larger, the vertex is found to be at 337°. This same dependence appears clearly in the works of Wilson and Raymond, of Jones and of Hufnagel, although none of them attached great weight to it. Furthermore, a re-analysis of the Radcliffe proper motions of faint stars shows the same effect. Thus, the dwarf stars conform to the simple theory of galactic rotation and only the behavior of the giants, which constitute a relatively unimportant part of the mass of the galaxy, remains to be explained.

Recent advances in our knowledge of the solar chromosphere: DONALD H. MENZEL (introduced by Harlow Shapley). Spectra of the chromosphere, secured by Lick Observatory at the eclipses of 1930 and 1932, have yielded a wealth of new data concerning physical conditions in the solar atmosphere. The spectrograms were calibrated photometrically, and relative intensities of emission lines at various levels have been obtained. Dr. Joseph H. Moore, of Lick Observatory, and I have measured the 1930 moving-plate spectra, and have evaluated the intensity gradients of numerous important lines. Dr. G. G. Cillie, Mr. H. H. Lane and I have investigated the 1932 spectrograms. The following conclusions are based on the best available data from all eclipses, including those of 1905 and 1908. The intensity gradient is logarithmic, *i.e.*, the intensities I at height x cms above the base may be represented in terms of the intensity I_o at the base by the following formula: $I = I_o e^{-ax}$, where a is the decrement constant. a appears to have practically the same value for all lines of a given atom in a particular stage of excitation, irrespective of the magnitude of I_o, which indicates that self-absorption is negligible. Lines of high excitation potential have higher values of a than lines of low excitation potential. For a given element, a is greater for the neutral than for the ionized atom, a result to be expected from ionization theory. a shows a tendency to increase with atomic weight, as if the heavier atoms were "settling out." Of particular significance are the ultimate lines of Ca^+, Sr^+ and Ba^+, for which the respective a values are, within experimental error, directly proportional to the molecular weights. Marked variations in a are shown to exist from eclipse to eclipse and at different points around the sun at a given time. These changes are especially pronounced for the lines of He and He^+. The observed a's for H are from three to five times less than would be expected in an atmosphere of pure H in gravitational equilibrium at 6,000°. The whole character of the chromospheric spectrum bears out an earlier conclusion, *viz.*, that the chromosphere is a hot-spot phenomenon. It appears to be impossible to account for the nature of the spectrum without postulating either (1) the existence of ultra-violet radiation ($\lambda\lambda$ 1,000 – 100) in excess of that to be expected from a black-body at temperature 6,000°, or (2) the presence of high-velocity electrons ejected from the sun.

The shape of the corona and its relation to the sun-spot cycle: S. A. MITCHELL. Measurements of the coronas of 1932 and 1934 have given the surprising result that the 1932 corona 1¼ years before minimum of sun-spots is more elongated than the corona of 1934, which took place almost exactly at the time of spot minimum. A total of 18 coronas beginning in 1893 have been measured and their ellipticities determined on a uniform plan. A close correlation is found to exist between the shape of the corona and sun-spot data. For many years the coronas with long equatorial extensions and pronounced polar rays have been called the "sun-spot minimum type," while the circular corona has been called the "maximum type." All the graphs, no matter what spot or prominence numbers are plotted, without exception tell the same story, namely, that the most pronounced minimum type of corona does not take place exactly at sun-spot minimum nor does the maximum type of corona occur at the time of maximum of spots. As long as 2½ years before spot minimum the corona is quite as elongated as it is at the time of minimum of spots. The most elongated corona is found 1¼ years before minimum of spots and likewise the corona closest in shape to a circle takes place 1¼ years before spot maximum. The corona of 1934 had lost its pronounced "minimum type" characteristics.

Some rare amphibians and reptiles of the United States: A. H. WRIGHT (introduced by L. Stejneger). Our project for the last ten years has been to photograph and to describe live representatives of every form of amphibian and reptile of the United States. Some 10,000 photos have accumulated. In our search, notes on living representatives of rare, recently described or little known forms have amassed, and we present herewith remarks on the following twenty forms: *Amphibians: Ambystoma cingulatum* Cope; *Ambystoma mabeei* Bishop; *Gyrinophilus porphyriticus duryi* (Weller); *Aneides aeneus* (Cope); *Leptodactylus albilabris* (Günther); *Rana heckscheri* Wright.

Reptiles: Crotaphytus reticulatus Baird; *Sceloporus disparilis* Stejneger; *Sceloporus torquatus cyanogenys* Cope; *Neoseps reynoldsii* Stejneger; *Coluber stejnegerianus (conirostris)* (Cope); *Elaphe rosacea* (Cope); *Elaphe subocularis* (Brown); *Lampropeltis alterna* (Brown); *Lampropeltis getulus brooksii* Barbour; *Stilosoma extenuatum* Brown; *Ficimia streckeri* Taylor; *Coniophanes imperialis* (Baird); *Kinosternon bauri palmarum* Stejneger. In addition, some 90 plates of the snakes east of the Rockies are exhibited.

A type in Datura with extra-chromosomal material which in inheritance resembles a recessive: A. F. BLAKESLEE, A. G. AVERY and A. D. BERGNER. A chromosomal type in Datura has been synthesized by replacing a 23·24 chromosome by the modified chromosome 23·14 and the chromosomal fragment ·24, which together compensate for the missing 23.24 chromosome. These chromosomes have been rendered homozygous to form a pure-breeding type $\left(\frac{\cdot 24}{23\cdot 14}\right)_2$ in which the 23·24 chromosome is lack-

ing and in which there is a double dose of extra ·14 material. The plant resembles the secondary 2n + 14·14 type called "Mealy," which also has two doses of extra ·14 material but which does not breed true. The addition of extra ·14 material has relatively little influence upon the appearance of the plant affected. In consequence, plants heterozygous for extra ·14 material can be distinguished from normals only by those skilled in recognition of slight differences among Daturas and then only under exceptionally favorable conditions of growth. The $\left(\frac{\cdot 24}{23 \cdot 14}\right)_2$ type, however, which has two doses of extra ·14 material, is readily recognized. This latter type, if its chromosomal constitution were not known, might be classified as a recessive so far as its breeding behavior is concerned. If crossed either way with a normal, the F_1 appears normal and the type is recovered in the F_2 generation. Most pure-breeding types with extra chromosomal material resemble dominant gene mutants in inheritance. Thus the type $(2n + 2 \cdot \cdot)_2$, in which a ·2 half chromosome is translocated to the 11·12 chromosome, is readily recognized when heterozygous as well as when homozygous for the extra ·2 material. Under certain conditions the dominance appears to be complete, since heterozygous can not be distinguished from the homozygous individuals.

Old and new criteria for determining the relationships of higher plants: WALTER T. SWINGLE. The phylogenetic taxonomy of the higher plants has proved extraordinarily difficult to work out. None of the criteria used for determining phylogenetic relationships are infallible, characters that have high classificatory value in one group may have little or no value in another group. Every new criterion helps to indicate relationships. *Criteria classified into Categories.*—A. Morphological (Categories I. to IV.), B. Physiological (Categories V. to VII.) and C. Genetical (VIII.). Category I. *General Morphology,* covers criterion 1, General Appearance of Plant, Gross Morphology and Color of Organs. Category II. *Special Morphology,* covers criterion 2, Flowers and Fruits; 3. Inflorescences, Branches and Metamers; 4, Leaves; 5, Seeds, Fruits and Pollen Grains; 6, Leaf Traces and Stelar Structures, and 7, Embryo Sac, Endosperm and Young Embryo. Category III. *Anatomy and Cytology,* covers 8, Anatomy of Plant Organs, and 9, Number, Size and Shape of Chromosomes and other Cell Structures. Category IV. *Ontogeny,* covers 10, Germination of Seed, Development of Young Plant, and 11, Teratology, Abnormal Development of Plant Structures. Category V. *Physiology and Chemistry,* covers 12, Serological Diagnosis, and 13, Chemical Composition. Category VI. *Compatibility and Susceptibility,* covers 14, Tissue Compatibilities in Grafts and other Tissue Transplants, and 15, Host-Susceptibility to Parasites. Category VII. *Ecology,* covers 16, General Environmental Relations of Plants; 17, Physical Life History Requirements and Limitations; 18, Nutritional Requirements and Limitations, and 19, Special Adaptations of Plants to Environment. Category VIII. *Genetics,* covers 20, Cross Breeding Capabilities; 21, Cytogenetic Characters of Chromosomes and Grouping into Genoms; 22, Cytonomic States of Nuclear Association; 23, Effects of Pollen Parent on Endosperm (Xenia); and 24, Effects of Pollen Parent on Maternal Tissues (Metaxenia). Some of these criteria have been in use since the dawn of human history; several have come into use during the present century and two or three have been discovered during the last decade. Studies of the higher plants made by using many or all of these criteria will undoubtedly lead to a much clearer picture than we now have as to their phylogeny. Such studies will also be of great help in making use of remote relatives of our cultivated plants in creating hybrids of the newly discovered allopolyploid type. These hybrids in many cases show superior vigor, hardiness and disease resistance.

A simple factor affecting the velocity of ionic oxidation-reduction reactions in aqueous solutions: Equivalence of valence change: PHILIP A. SHAFFER. Among the most elusive and obscure problems of chemistry are those concerning the specific velocity of reactions. Modern theory of the subject, although elaborate, is inadequate. Based chiefly on the concept of activation energy, it deals only with physical quantities which so far do not describe fully the characteristic *chemical* properties of atoms and molecules on which both reactions and their rates presumably depend. It is therefore not surprising that present theory is able to predict the velocity of a given reaction only by interpolation from values determined by experiment; without experiment no prediction is possible. Although to this extent apparently successful with many reactions, it seems doubtful whether the concept of activation energy alone, however elaborately treated, can account for the wide differences in velocity found among a large group of supposedly similar reactions of a simpler sort, namely, ionic oxidation-reduction reactions in aqueous solution. While many ionic reactions are immeasurably rapid and are therefore said to require only little energy for activation, others involving the same reactants with different partners may be immeasurably slow. There are many cases where ionic substances, both demonstrably "active," refuse to react (or react slowly) in the same solution, but react rapidly when separated in the form of an electrolytic cell or in the presence of suitable catalysts. To account for this rather surprising behavior some other ideas beside that of activation energy appear to be necessary. In seeking for an explanation, a number of oxidation-reduction reactions between both inorganic and some organic substances have been roughly surveyed as to their relative rates. It appears to be a somewhat general, although not universal rule, that where the "permissible" (and dynamically possible) valence-change of oxidant and reductant is equal—bimolecular reaction being therefore possible—the reaction is relatively rapid, while for cases in which the valence-changes are unequal the reaction rates are much slower, apparently for the reason that reaction must await for the proper three-body collision—a much less frequent event. Support for this simple interpretation is afforded by the fact that certain catalysts

of the latter class of reactions are capable of mediating the oddness of valence-change by undergoing both, thus permitting reaction to occur by a sequence of bimolecular steps. In several cases observed catalytic activity of the substance has led to the discovery of an additional valence state not previously suspected. It seems probable that mediation of an odd valence-change is a common mechanism for the action of catalysts in oxidation-reduction reactions. It is thought that this idea may account for the necessity for certain catalysts in biological oxidations; it appears to give new significance to the property of "two-step" oxidation-reduction possessed by various respiratory pigments, the theoretical analysis of which has been given by Michaelis.

Solutions of the wave equation in spheroidal coordinates: J. A. STRATTON (introduced by John C. Slater). It has been shown that the Schrödinger equation, including the wave equation as a special case, is separable in eleven systems of coordinates only. Of these eleven systems, three alone have been investigated with a thoroughness sufficient to meet all the demands of physical problems. Of those remaining, three more are of outstanding practical importance. The functions of the elliptic cylinder, the prolate spheroid and the oblate spheroid include as special cases the functions of the sphere and the circular cylinder, and are adapted to problems involving slits and flat strips, circular disks and rods of finite length. It is the object of the present investigation to establish the properties of these functions in a detail approaching that known for the Bessel and Legendre functions. On separation of the wave equation in any of the three coordinate systems named it appears that both angular and radial functions satisfy a differential equation of the type $(1-z^2)\,w'' - 2(a+1)\,zw' + (b - c^2z^2)\,w = 0$, wherein the separation constant b is restricted to characteristic values such that one particular solution exists which is finite at the regular points $z = \pm 1$. Asymptotic solutions appropriate to the region of large values of z are defined and normalized in the manner most convenient for physical problems. In diffraction problems, an expansion of a plane wave in terms of the functions of the elliptic cylinder or spheroid is required, and this, as well as the nature of the usual boundary conditions, necessitates a knowledge of the behavior of the functions of both the first and second kind in the neighborhood of $z = 0$. The analytic continuation of both asymptotic solutions into the origin is attained by means of contour integrals and thus expansions of the two independent solutions appropriate to all regions of the z-plane are available, together with their analytic connections.

Arc spectra of hydrogen and deuterium: R. W. WOOD and G. H. DIEKE. It was shown many years ago by Kiuti that in the secondary or molecular spectrum of a hydrogen arc between tungsten electrodes, many of the strong lines obtained with the hydrogen vacuum tube were missing, and others were relatively strong. The matter has now been more fully investigated with higher dispersion, and is discussed from the theoretical standpoint.

Remarks on the measurement of the magnetic moment of the proton: OTTO STERN (by invitation). *Spectroscopic method.* By measuring the frequency change of a spectral line in the magnetic field, the energy change of the atom $\Delta E = \mu H = h\Delta\nu$ is determined. In fact, only the difference in the energy changes of two states of the atom can be measured in this way. At least one of the two states must be an excited one. The *molecular ray method,* on the contrary, allows the measurement of the magnetic moment of a single state, the normal state of the atom. This is valuable not only for the treatment of some fundamental problems (space quantization, etc.), but also for the problem of measuring very small moments. Therefore, it is possible to measure the magnetic moment of the proton ($\mu \approx 10^{-23}$ e.s.u.), a problem not yet solved by the spectroscopic method. The reason for this is a fundamental one, the uncertainty principle of the wave mechanics.[1] This principle stipulates that the uncertainty δE of the measurement of the energy is connected with the length of time of the measurement δt by the relation $\delta E.\ \delta t \approx h$. Since the lifetime of an excited state of the H-atom is less than 10^{-8} seconds, the uncertainty of the energy measurement is $\delta E \approx \frac{6.10^{-27}}{10^{-8}} = 6.10^{-19}$ erg. The energy change in the magnetic field, due to the magnetic moment of the proton, is $\Delta E = \mu H \approx 10^{-23}.\ 6.10^4 = 6.10^{-19}$ erg in a field of 6.10^4 gauss. This means that even in such a strong field $\Delta E \approx \delta E$, or the uncertainty in the measurement is as large as the quantity to be measured. Under the conditions of the molecular ray method, δt corresponds to the time during which the atom is in the magnetic field, at least 10^{-4} seconds under the usual conditions. This means that in this case the uncertainty of the measurement δE is only 10^{-4} of the quantity itself ΔE. The actual measurements, carried out first in the Hamburg Institute of Physical Chemistry, fell very much short of this limit of error. Nevertheless, the measurements gave a very interesting result, about $2\frac{1}{2}$ nuclear magnetons. Dirac's theory, very well confirmed in the case of the electron, predicts a value of 1 nuclear magneton for the proton.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

SIMPLIFIED EQUIPMENT OF SMOKING KYMOGRAPH DRUMS

WHERE no separate room can be set aside for smoking kymograph drums, both the experimenter and the instructor is confronted with the necessity of smearing the paint and equipment of the laboratory as well as the clothing of the students with the excess soot. The former difficulty is also one of the frequent and serious

[1] For the spectroscopic problem, *cf.* W. V. Houston and Y. M. Hsieh, *Phys. Rev.*, 45: 263, 1934.