develop in the scutellum, the fundamental aleurone factors *A, C, R,* and *i* must be present. The *Pr pr* factor pair which differentiates purple and red aleurone has a similar effect on scutellum color. The scutellum is, of course, a product of the fusion of one sperm and the egg, whereas the aleurone (endosperm) results from the fusion of the second sperm with the polar nuclei.

Ordinarily, kernels with white aleurone have no scutellum color and, when their progeny are selfed, produce either white aleurone kernels or kernels segregating for aleurone color in ratios characteristic of the action of an inhibitory factor. Many aberrant kernels which possessed white aleurone and colored scutellums have been found and tested for breeding behavior. In spite of the colorless aleurone of the parent kernels, the progeny segregated for aleurone color in ratios characteristic of those generally obtained only from hybrid kernels with colored aleurone. This points clearly to a difference in genotype between endosperm (aleurone) and embryo (scutellum).

The term hetero-fertilization has been applied by the writer to the process resulting in those exceptional cases in which the endosperm and embryo differ genetically. These may occur because (a) the egg and polar nuclei are of different genetic constitution and fuse with identical sperms or, conversely, (b) the egg and polar nuclei have the same genotype but fuse with sperms having unlike genotypes during syngamy. Either of these phenomena would give rise to hetero-fertilized kernels.

It is obvious that hetero-fertilized kernels may be produced and escape detection because of phenotypical identity with their normal sibs. Hetero-fertilized kernels of this kind undoubtedly occur unnoticed in much maize material. For the ready identification of hetero-fertilized kernels, the embryo and endosperm must be of different phenotypes. The relation of aleurone and scutellum factors provides an ideal combination for detecting hetero-fertilization. The ease of identifying a particular kind of hetero-fertilized kernel, namely, those having a colorless aleurone and colored scutellum, has been taken advantage of in studying this phenomenon genetically. There is some evidence that hetero-fertilization may occur only in the presence of a certain gene or complex of genes. Some strains show no hetero-fertilization among several thousand kernels, whereas other strains show as many as 10 per cent. of hetero-fertilized kernels, and individual ears have shown much higher percentages of this anomaly.

It is conceivable that hetero-fertilization may be brought about in various ways. Dispermy, non-disjunction of one or more chromosome pairs when the generative nucleus divides to form the sperms, the persistence and functioning of the four megaspores, or mutation of one of the aleurone or scutellum factors might result in hetero-fertilized kernels. The genetic tests applied have failed so far to distinguish with certainty between the possible causes of hetero-fertilization. The occurrence of the phenomenon, however, is abundantly proved.

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Production of X-rays according to wave mechanics: A. SOMMERFELD (by invitation). Twenty years ago the author published a paper on the production of X-rays, especially on the angular distribution of X-rays, produced by high speed cathode rays. This work was done entirely on the basis of classical electrodynamics. New experiments taken with very thin anti-cathode by Kulenkampff and D. L. Webster make it desirable to treat the same question from the standpoint of wave mechanics. The general radiation emitted by the cathode particles in the process of stopping is computed from the matrix element of the coordinates. The initial and final state of cathode particles are treated as plane electronic waves. The forward shift of the maximum of the emitted intensity is calculated from a factor depending on the arithmetical mean of the initial and final velocity of the electron. The use of parabolic coordinates is proved to be convenient for expressing the distribution of the incident as well as the emergent electronic wave.

New studies of X-ray spectra from ruled gratings: J. A. BEARDEN and C. E. HOWE (introduced by Arthur H. Compton). One of us (J. A. B.) has been making precision measurements of the X-ray spectrum lines from copper (K series), trying to establish a more reliable standard of X-ray wave-lengths than that resulting from crystal measurements. A glass grating of 600 lines per millimeter and a glass and a speculum metal grating, each with 50 lines per millimeter, were kindly ruled for this work by Professor Michelson. Every one of the thirty-one plates obtained from these three gratings gave wave-lengths greater than those calculated from crystal diffraction data. The weighted mean value of the wave-length for the Kα line of copper is 1.5439 $\pm$ .0002 A, and for the Kβ line, 1.3940 $\pm$ .0002 A. These values are .35 per cent. higher than the wave-lengths of these lines given by Siegbahn from crystal measurements. Using these wave-lengths, the grating space of calcite is calculated to be 3.039 A, Avogadro's number as 5.999×10^{23} per gram molecule, and the electronic charge as $e = 4.825 \pm .005 \times 10^{-10}$ e.s.u. The last result differs so greatly from the usually accepted value, $4.774 \pm .005 \times 10^{-10}$ e.s.u. as to suggest a hidden error. The other one of us (C. E. H.) has been studying the spectra of very soft X-rays, especially the L series, whose wave-lengths lie between 10 and

40 A. Some of these spectra have been investigated by Thoraeus using crystal methods. His results agree well with the present ones, except that our wave-lengths are uniformly about 0.6 per cent. greater than those of Thoraeus. This is perhaps a difference of the same kind as that which J. A. B. finds with the Kα line of copper. The Lα line appears to be present for all the elements within this range. The Lα line seems to appear for elements of atomic number as low as 22, whereas Foote's extension of Stoner's table would predict its absence for atomic numbers lower than 24.

Two-electron jumps in X-ray spectra: F. K. RICHTMYER (introduced by Ernest Merritt). The several theories which have been previously proposed to explain the origin of X-ray satellites ("non-diagram" lines) involve a single-electron jump between two ionized states. An alternative theory, which in many respects agrees better with the experimental facts, is that satellites are produced by the simultaneous jumping of two electrons into the vacant orbits of a doubly ionized atom, both jumps cooperating to emit a *single* quantum. In support of this theory are the following facts: (1) K-satellites seem to occur only for those elements, Na to Zn, for which the third (or M) "shell" is increasing from one (for Na) to 18 (for Zn) electrons. Similarly, L-satellites occur only for the elements from Cu to Sn, over which range the fourth (or N) shell is increasing from one to eighteen electrons. This suggests that the second electron-jump is into a vacant place in an outer, incomplete shell. (2) Many of the plates show a continuous spectrum extending for some distance (toward short wave-length) from the satellite structure. This might be due to electrons, coming from outside the atom and possessing kinetic energy, jumping into the vacant orbit in the outside shell. (3) A Mosely graph is obtained when the square root of the frequence difference between a satellite and the parent line is plotted as a function of atomic number. This frequency difference is proportional to the energy which the second (*i.e.*, outer) electron jump adds to that corresponding to the parent line to give the satellite. Over the range of atomic numbers for which class of satellites are found, one would therefore expect a Mosely graph from the above plot.

Hyper-fine structure in spectral lines—especially those of singly ionized praseodymium: R. C. GIBBS and H. E. WHITE. Dr. King, of the Mount Wilson Laboratory, has recently published his temperature classification of the lines of praseodymium obtained from both the furnace and the arc and has indicated which of these lines probably arise from the singly ionized state. He has also noted the number of components into which some of these lines appear to be split up. These components for complex lines range in number from two to six with many in doubt because of the lack of sufficient dispersion to separate the components distinctly. Last summer photographs of the emission lines from a carbon arc cored with praseodymium oxalate, most of the strong lines of which according to King's classification are those from singly ionized atoms, were made over the region 3,900 to 5,000 Ångstroms using the fourth order spectrum of the 75-foot solar spectrograph on Mount Wilson. A dispersion of nearly an Ångstrom per centimeter was obtained and the complex structures of many lines were clearly resolved. Within the region studied all the completely resolved fine structures consist of six components. The frequency intervals between the components of any one line follow very closely the Landé interval rule, and the relative intensities of the components decrease with the interval. The components of some lines show decreasing intervals and intensities toward longer wave-lengths while others are similarly degraded toward shorter wave-lengths. Practically all the lines thus resolved are listed by King as belonging to the spectrum of the singly ionized atom. A study of the Zeeman patterns of some of these complex structures will doubtless help to classify these complex lines and possibly to identify the change in atomic configuration that is responsible for this unusual uniformity in the number of fine structure components. It will also be interesting to determine whether other elements, especially those among the rare earths, possess a similar complexity of structure.

Some new features of the band spectrum of oxygen, and the relative abundance of the isotopes O^{16}, O^{18}: HAROLD D. BABCOCK (introduced by C. E. St. John). Data derived from a band spectrum are here applied to the problem of the structure of molecules, somewhat analogously to the explanation of atomic features by the data of line spectra. Each absorption band produced by the symmetrical molecule of atmospheric oxygen shows a sequence of pairs of lines corresponding to successive increments of one unit to the rotational energy of the molecule. The absorption produced by about 30 kilometers of air, when examined by a powerful spectrograph, shows the presence of extremely faint doublets falling half way between the strong ones. These "missing doublets," now shown to exist with an intensity of the order of one ten thousandth of the strong ones, indicate a slight dissymmetry in the oxygen molecule hitherto unknown. In a description of the oxygen bands given two years ago accurate values were found for certain constants of the molecule, and a faint band was analyzed for the first time. Recently Giauque and Johnston have shown that this new band is due to a molecule in which one of the ordinary atoms of oxygen is replaced by an atom chemically the same but of mass 18 instead of 16, *i.e.*, an isotope. Further measurements are now presented in support of their conclusion, and still another faint band is discovered, but it does not appear to be due to the isotopic molecule. From measurements of the relative intensity of the bands due to ordinary oxygen and to the isotopic molecule it is found that in our atmosphere there are 1,250 ordinary oxygen atoms of mass 16 for every one of mass 18.

On the use of the electrodeless ring discharge to excite extreme ultra-violet spectra: K. T. COMPTON and J. C. BOYCE. A quartz tube sealed to the front of a vacuum

spectrograph and wound externally with twelve turns of heavy wire served as the discharge vessel. Purified gas was slowly admitted to this tube through an adjustable capillary leak, pumped out of the spectrograph by fast pumps, and returned to the purifying system, thus giving a continuous circulation of purified gas. The gas in the tube was electrically excited by high frequency currents through the surrounding coil, produced by either of two outfits, one giving up to 3.5 K. W. at 300,000 cycles and the other up to 0.75 K. W. at 800,000 cycles. Gas pressures between 0.001 and 0.15 mm were used. With large power and low gas pressure extremely high stages of ionization were attained. For example, in argon the strongest lines in the spectrum belong to A III and A IV. A V is found. A II is quite strong but A I is very weak. Similar results obtain with the other gases used, *viz.*, neon, nitrogen and oxygen. Other experiments suggest nearly 100 per cent. ionization of the gas, so that these high states of ionization may be due to ionization in successive stages. However, the voltages induced may suffice to produce this multiple ionization by single electron impacts, since the voltage at the terminals of the coil may reach values as high as 30,000 volts. Direct tests, necessarily conducted at much lower voltages, failed to show more than double ionization by single impacts. An interesting feature of this type of discharge is the extent to which gas, probably in the form of ions, is driven so firmly into the walls of the tube that ordinary heating will not dislodge much of it. For this reason we use a quartz tube to permit intense heating in order to purge the apparatus of one gas before admitting another. Otherwise each photographic exposure shows spectrum lines of all the gases which have previously been in the apparatus. We have analyzed the main spectral structure of Ne III in the region 200 to 1,300 A, and have made some progress with Ne IV, A III, A IV and A V. The ionization potential of Ne III is 63.2 volts and that of A III is 40.7 volts. Study of relative intensities with varied power input aids in the classification of the lines.

On the arc spectrum of nickel: HENRY NORRIS RUSSELL.

The absolute value of the international ohm: HARVEY L. CURTIS, CHARLES MOON and C. MATILDA SPARKS (introduced by George K. Burgess).

Scattered light (illustrated): R. W. WOOD.

Hot springs of Yellowstone Park: ARTHUR L. DAY.

Reconciliation of binocular and monocular fusion: CHRISTINE LADD-FRANKLIN. Binocular fusion of colored lights (red plus green into yellow—yellow plus blue into white) certainly takes place in some nervous center higher than the retina. Does it follow from this that the same event when the lights are thrown together upon *one* eye (monocular fusion) also can not take place in the retina? This has been maintained by G. E. Müller (*Z. f. Psychol.* Vols. 10 and 14) and quite lately by Hecht (*Proc.* Nat. Acad. Sciences, 1928), and the latter maintains that this works against the Hering theory and also against the development theory which I have defended. But Hering has always affirmed that *he does not state* where he supposes his antagonistic processes to take place, and his present chief defenders (Tschermak and Müller) assume that it takes place in nerve fibers, or in nerve centers. I have been less prudent myself, but the processes that I assume may also take place higher up (as Troland has shown). But the situation is not so simple as it seems. There must be *some* marked difference between the two events, for fusion is only one of *four* different events that may take place when the two eyes are stimulated severally: We may have: (1) dominance of one eye over the other; (2) rivalry; (3) transparence of one color through the other; or (4) fusion—and the latter only under very special conditions (Kuroda). If we take good, well-saturated, spectral colors (Trendelenburg), the field must be very small (only ½ to 1 degree in diameter); with very unsaturated colors (such as Hecht makes use of) it is easy to get. We have to explain, therefore, why *binocular* fusion is so hard to obtain. It may be that the physiological process in question may take place at more than one level (after-images must take place in the very highest centers, but surely not only there). But it may also be that reflex currents (Frank Allen, Kappers) secure a necessary participation of retinal processes even in the case of binocular fusion. The case against retinal processes is thus not so strong as it might seem to be at the first glance.

Further remarks concerning thermionic "A" and "b": EDWIN H. HALL. For metals in which the photoelectric work function, represented by b_o, is independent of temperature the expanded form of the thermionic emission equation should be $I = Fe \cdot \varepsilon^{az} T^q \cdot T^{0.5}\, \varepsilon^{-b_o/T}$ (1), where Fe is a universal constant, while a, z and q are constants, or near constants. If A' is put for $Fe \cdot \varepsilon^{az}$, this equation becomes $I = A' T^q \cdot T^{0.5} \varepsilon^{-b_o/T}$ (2). It is shown that $A'\ T^q$ is the same for all metals. If we choose to give A such a value that $AT^{1.5} = A' T^q$ (3), then A, though its physical meaning will be less definite than that of A', will be the same for all metals. Thus we get from (2) and (3) the familiar Richardson equation, $I = AT^2 \varepsilon^{-b_o/T}$ (4), with A a "universal constant." If the photoelectric work function is not a constant but is properly represented by $(b_o - \gamma T)$, where b_o and γ are constants, the emission equation becomes, from (2), $I = \varepsilon^{\gamma} \cdot A' T^q \cdot T^{0.5} \varepsilon^{-b_o/T}$ (5), or from (4), $I = \varepsilon^{\gamma} \cdot AT^2\ \varepsilon^{-b_o/T}$ (6). Then A remains a universal constant, but $\varepsilon^{\gamma} A$ is not such a constant. The factor ε^{γ} corresponds to the factor ε^{a} used by Du Bridge in a recent paper. The factor ε^{a} of equation (1) is taken by Du Bridge to be 1, a being treated as zero.

Biharmonic functions and generalizations: EDWARD KASNER. The author showed that if a function $F(xy\ x_1\ y_1)$ is converted by every *conformal* substitution $x_1 = \alpha\ (xy)$, $y_1 = \beta\ (xy)$ into a *harmonic* function $K(xy)$, then F must be *biharmonic* in the sense of Poincaré, that is, the real part of an analytic function $f(z_1\ z_1)$ of two complex variables. This is also true if we merely use the similitude group. It is not true if we use, for example,

the translation group or certain sets of symmetries and so larger classes of functions F are obtained. The most interesting generalization is for the group of rigid motions. The transformations associated with an arbitrary function $F(xy\,x_1\,y_1)$ do not usually constitute a group, and examples of this kind are also studied. Extensions to any number of variables are obtained.

Potential energy functions of diatomic molecules: PHILIP M. MORSE and E. C. G. STUECKELBERG (introduced by K. T. Compton). The problem of the determination of the potential energy of a diatomic molecule as a function of the nuclear separation is of importance in several fields of physics and chemistry, for from this energy can be obtained the valence forces and heats of dissociation of the molecules and their spectroscopic behavior. This problem has been attacked from two different approaches: (1) The potential energy for the simplest molecule, the hydrogen molecular ion, has been calculated by means of the wave mechanics for the first ten states of electronic excitation. This provides a basis from which approximate formulas might be obtained, *ab initio,* for the potential energies of the molecules. (2) A formula has been derived by wave mechanical means whereby a close approximation to the potential energy function of any diatomic molecule can be obtained by analysis of the band structure of the molecular vibration spectrum. By means of a discovered empirical rule, $r^3_0\omega_0 = K$, the normal nuclear separation r_0 can be obtained without analysis of the rotation bands. This method provides a basis whereby approximate formulas can be obtained empirically for the potential energy functions of molecules. The two methods check satisfactorily in the cases where curves by both methods have been calculated. Curves calculated by the second method have been successfully applied in the explanation of the critical potential and band intensities of the oxygen molecule.

Alternating-current three-terminal electrically conducting nets: A. E. KENNELLY. It is known that an electrically conducting network or net, carrying steadily sustained alternating currents from a pair of input terminals AG, to a pair of output terminals BH, offers a certain hyperbolic angle which is, in general, complex or has a real component associated with a real hyperbolic angle and an imaginary component associated with a real circular angle. When the terminals G and H are united on the net, the system becomes a three-terminal net. There are evidently three ways in which the A, B and GH leads can be applied to the net in rotation, and these may be called the three aspects of the net with respect to the three terminals. It is known that when the net carries steady continuous currents, the three real hyperbolic angles of the net θ_{AB}, θ_{AG}, θ_{BG}, in the three aspects, have corresponding gudermannian circular angles β_{AB}, β_{AG}, β_{BG}, which sum up to just π radians or 180°, and so may be regarded as defining a family of plane triangles. It has recently been ascertained, however, that the proposition extends to alternating-current nets, for which both the hyperbolic angles θ_{AB}, θ_{AG}, θ_{BG}, and their respective gudermannians β_{AB}, β_{AG}, β_{BG} are complex. In such an alternating-current case, the three real components of the β's add up to 180°, and the three imaginary components of the β's cancel, or add up to zero. The original continuous-current proposition thus extends to alternating-current nets.

The monophone—a one-way telephone for program service: GEORGE O. SQUIER. What we now call broadcasting by space-radio has already reached the "saturation point" in its assigned band of frequencies. The new fields for the use of this young art which now appear regularly clearly show that there is little chance of overtaking them with adequate channels for years to come. The monophone, therefore, proposes to put the telephone wires now leading into millions of homes to work sixteen hours a day in providing multiple program service. It must and does accomplish this without interfering with the regular point to point telephone service or changing its present equipment in any way. To indicate the electrical efficiency of this form of wired-radio, as compared with present space-radio, it may be stated that fifty watts of energy has been found adequate to saturate satisfactorily approximately 500 cable-pairs. A small and compact 5-watt transmitting unit for Army Signal Corps uses and for demonstration purposes throughout the country has been constructed. These units are capable of supplying about 200 receiving sets. The best minds from our state universities and colleges and the departments at Washington must be added to the teaching staff of our high schools through the development and perfection of chain broadcasting as a national educational function. This will result in elimination of waste in the present duplication of teaching staff, and reduce rather than increase the annual educational budget by dispensing with the inefficient teacher and raising the standard of the smaller staff then required. The needs for new channels of communication require that ultimately both the telephone wires and the power wires into the home should be utilized in competition or cooperation. The super-university of the United States, for both youth and adults, can become in the era ahead the greatest educational and cultural institution in all history. Radio is the new agency by which alone this is possible.

A new microphone: ARTHUR L. FOLEY (introduced by Dayton C. Miller). The author has devised a microphone which is essentially a multiple fixed-plate air condenser. The action of the condenser depends upon the fact that the compressions and rarefactions of the sound waves passing between the condenser plates change the dielectric value of the air between the plates and therefore the capacity of the condenser itself. The variations in the density of the air may be increased, and therefore the sensitivity of the microphone will be increased, by placing an ebonite (or other non-conducting) plate in contact with the rear surface of the condenser so as to reflect the waves back between the condenser plates. Being free from diaphragms or other movable mechanical parts, the new microphone is wholly independent of frequency.