twisting in space. With the 60-inch reflector at the Bloemfontein Station of the Harvard Observatory, Dr. Paraskevopoulos has photographed in red light the giant gaseous nebula, 30 Doradus, in the Large Cloud of Magellan. From photographs with this instrument it now appears that this famous nebula, sometimes called The Tarantula, has in its center a rich cluster of supergiant stars, each ten or twenty thousand times the luminosity of the sun.

(7) Announcement is made of the discovery in our own galaxy of about seven hundred new variable stars, the study of which contributes slowly to our increasing knowledge of galactic dimensions as well as to the central problem of the evolution of stars and of the stellar universe.

(8) In the nearest of external galaxies, the Large Cloud of Magellan, periods of pulsation have been measured on Harvard plates for many of the supergiant variables of the Cepheid class. These stars are important in the improvement of the period-luminosity law, which is fundamental in the measurement of the distances of galaxies.

(9) In the Small Cloud of Magellan, which is also a relatively near external galaxy, a thousand new variable stars have been found within the past few months through an examination of new photographs made at the Bloemfontein Station of the observatory.

(10) An indication of development throughout the Metagalaxy is found in the peculiarities of the distribution of galaxies throughout the enormous spaces covered by the surveys carried on at Mount Wilson and at Harvard. The Harvard census of new faint galaxies has now gone beyond 125,000. About a third of the sky has been covered in this survey; the discovered irregularities prove important for considerations of expanding regions, collapsing regions and places where the Metagalactic developments appear to be at a standstill. One of these apparently non-expanding regions is the Twin Supergalaxies in Hercules, a double group that contains several hundred individual galaxies, and extends over a region more than three million light years in diameter at a distance from the sun of about a hundred million light years.

ABSTRACTS OF PAPERS PRESENTED AT THE AUTUMN MEETING OF THE NATIONAL ACADEMY OF SCIENCES[1]

An x-ray study of grain-growth in metals produced by heat treatment: CHRISTIAN NUSBAUM (introduced by Dayton C. Miller).

The measurement of the absorption coefficients of x-rays of very short wave-length: F. K. RICHTMYER, T. R. CUYKENDALL and M. T. JONES. Almost no measurements have been previously made of the absorption of monochromatic x-rays of wave-length less than 100 x-units. The present program of investigation was undertaken in order to obtain such measurements, partly because of their importance in connection with current theories of physics; partly because such data are needed in high-voltage roentgenology. The high-voltage generating plant is capable of producing 600 K.V. The two-crystal spectrometer is of the direct-reading type, the x-rays passing *through* the crystals and being reflected from internal planes, instead of from crystal surfaces, as is usual at longer wave-lengths. A resolving power of 30 at 50 x.u. and of 160 at 200 x.u. is obtained. The ionization chamber contains argon at a pressure of 80 atmospheres. The ionization current is amplified by an FP54 tube. Measurements are now being made on various elements in the wave-length range $30 < \lambda < 150$ x-units with a precision of the order of 1 to 2 per cent. Sample data on the mass absorption coefficient, μ/ρ for carbon and for lead, are as follows:

	Wave-length	μ/ρ
Carbon	100 x.u.	0.142
	60	0.121
Lead	30	0.22
	60	0.90
	100	3.30
	135	7.15
	145	2.03

Evaporated surfaces on gratings for the vacuum ultraviolet: R. C. GIBBS and H. M. O'BRYAN (introduced by Ernest Merritt). On account of the greater permanence of its reflecting power, the glass grating has found general acceptance over the speculum metal grating for spectral studies involving wave-lengths less than 2,000 Å. However, the reflecting power of glass is small for wave-lengths less than 1,000 Å and falls to less than 1 per cent. below 400 Å. Recent progress in the technique of preparing evaporated metal surfaces has made it possible to apply these metal films to already ruled glass gratings without loss of definition in the spectral lines. By suitably choosing the metal for the desired spectral region a greatly increased reflecting power of considerable permanence can be secured, thus reducing the time of exposure several fold. In most cases these films can be removed by chemical treatment without injury to the quality of the grating, thus making it possible readily to renew the surface with a film of the same or another metal. For stability and permanence of reflecting power

[1] Cleveland, November 19, 20 and 21.

platinum has been found to be most generally satisfactory over an extended spectral region. A fresh aluminum film yields a greater reflecting power than platinum for the longer wave-lengths in this region but shows a marked falling off in its reflecting quality with use, especially in the presence of moisture. No such effect is observed for aluminum in the visible or near ultraviolet regions. At 500 Å platinum has a reflecting power about 10 times that of glass. For various reasons it was found advantageous first to apply a thin film of chromium to the grating before depositing the platinum. Other metals, such as chromium, germanium, tungsten and palladium, as well as antimony sulfide, were found to be useful for certain spectral regions.

A special theory of cathode sputtering: EDWARD S. LAMAR and KARL T. COMPTON. It has long been known that metals disintegrate under the influence of bombardment by fast-moving positive ions. This was first noted at the cathodes of gaseous discharge tubes and the process is commonly known as "cathode sputtering." Two principal theories have been advanced to account for this disintegration: one, that it is thermal evaporation from the regions of local high temperature produced by the impinging ions in the brief interval before this energy is dissipated into the body of the metal through thermal conductive processes. The other theory ascribes the sputtering to the mechanical "bumping off" of surface atoms by ions which have penetrated below the surface and rebounded so as to transfer a part of their outward momentum to the surface atoms which they strike from behind. Langmuir has shown that the latter process is consistent with the minimum kinetic energy with which impinging ions will produce sputtering in the case of several gases and metals. Others, and I believe Langmuir also, believe that the former process may be the predominating influence in many cases. Our earlier work on the "accommodation coefficient" of ions impinging on metal surfaces has thrown light on the conditions of energy and momentum transfer at impact. This work has also given evidence that small, light ions, such as hydrogen and helium, are far more likely to penetrate the surface of the metal and deliver energy and momentum to underlying metallic atoms than are the larger and heavier ions. This observation immediately suggests that the "bumping off" process may predominate in the sputtering of metals by small ions, and the evaporation process may predominate in the case of large ions. The present paper is an attempt to extend Langmuir's original theory, which predicted the minimum energies required for sputtering, so as to account also for the rate of sputtering produced by small ions on their rebound from metallic atoms lying below the surface. To make this calculation, three quantities need to be known: First, the mean free path of the ion as it penetrates the metal previous to its first collision with an atom; second, the average normal component of the mean free path of this ion as it moves back toward the surface after its first collision; and third, the law of angular scattering and momentum transfer at a collision. Our previous work has shown that, for high-speed ions of the type here considered, the third function is represented with considerable accuracy by the laws of impact between elastic spheres. There is some experimental evidence regarding the first two quantities which may at any rate be given values of the right order of magnitude by making the assumption that here again the collision processes are, to a first approximation, those between elastic spheres. In terms of these quantities, a calculation is made of the number of surface atoms in the metal which are struck from behind by ions coming after one or more collisions from the various layers of atoms beneath the surface, and imparting to the surface atom an outward momentum sufficient to overcome its attachment to the surface as expressed by its atomic heat of evaporation. This calculation has made possible the setting, with some confidence, of upper and lower limits to the rate of evaporation of a metal bombarded by any given number of penetrating ions. Within these limits the theory permits an estimate of the actual rate of sputtering with a somewhat less degree of certainty. The calculated values appear to be reasonable, but no existing experimental data have been secured under sufficiently well-controlled conditions to permit of an actual comparison between theoretically predicted and experimentally observed rates of sputtering.

Measurement of the velocity of light in a partial vacuum: A. A. MICHELSON, F. G. PEASE and F. PEARSON. To be published later.

The temperature of the copper arc: C. G. SUITS (introduced by Albert W. Hull). New measurements of the velocity of sound in the copper arc (6 amperes) in air at atmospheric pressure have yielded velocities somewhat higher than the preliminary values previously reported (*Phys. Rev.*, 46, 339, 1934). The new velocities are 1.42×10^5 cms sec.$^{-1}$ for arcs up to 8 cms in length, decreasing to 1.36×10^5 cms sec.$^{-1}$ for arcs of 15 cms length. The temperatures, uncorrected for dissociation, are 5,000° K. and 4,600° K., respectively. When account is taken of the dissociation of the oxygen, which is nearly complete, the partial dissociation of the nitrogen (3 per cent.) and the change in specific heat with excitation, the corrected temperatures are found to be 4,200° K. and 4,000° K. For an arc temperature of 4,000° K., the electron density n_I in the arc may be calculated from the observed gradient of 16.5 volts cms^{-1} and current density of 10 amperes cms^{-2} by assuming all the current to be carried by electrons. The kinetic theory value of mobility at the observed temperature is used. A second value of current density n_{II} may be calculated from the thermal ionization equilibrium equation. To bring n_{II} into agreement with n_I it is necessary to assume a partial pressure of copper vapor of 7.5×10^{-5} atmospheres.

A new isotope of nitrogen, artificial radioactivity and the emission of gamma-rays which accompanies the disintegration by capture of atomic nuclei: WILLIAM D. HARKINS. With the collaboration of D. M. Gans and H. W. Newson a new isotope of nitrogen of mass 16 has been discovered. It was assumed that this nucleus would be unstable, so that it would exhibit the phenomenon of

induced radioactivity, and would disintegrate, with the emission of a negative electron, and change into the nucleus of an atom of oxygen of mass 16. This is the ordinary oxygen of the atmosphere. This has been confirmed by Fermi. Neutrons of extremely high velocity, 35,000 miles per second, have been found, and have been shown to give rise to gamma-rays, analogous to those emitted by ordinary radioactive substances, but seemingly of much higher energy. Thus this energy rises as high as twelve million electron volts when nitrogen is converted into boron and helium by the action of neutrons. Contrary to what has been heretofore believed, it is found that atomic nuclei have in no case been disintegrated unless the high-speed projectile which causes the disintegration is captured by the nucleus which it hits. In this sense the synthesis or building of an atomic nucleus is a much more fundamental process than its disintegration. It is found that the gamma-rays emitted during such a disintegrative synthesis excited by neutron bombardment increase rapidly in energy as the energy of the neutron increases. An interesting feature of all the disintegrations thus far effected is that during the process kinetic energy always disappears (or very rarely is conserved) but never increases. The atomic nucleus is found to be a remarkably efficient machine for the conversion of kinetic into gamma-ray energy.

Biographical memoir of Edward Bennett Rosa: W. W. COBLENTZ.

Biographical memoir of Thomas Corwin Mendenhall: HENRY CREW.

Biographical memoir of Ernest Julius Wilczinski: ERNEST P. LANE.

On the equivalence of quadrics in m-affine n-space and its relation to the equivalence of 2m-pole networks: RICHARD STEVENS BURINGTON (introduced by Arthur B. Coble). The work of Cauer (*Göttinger Nachrichten,* 1934) and others on the equivalence of $2m$-pole electrical networks indicates the importance of the matric study of quadratic forms under m-affine non-singular transformations, $x_i = x_i'$, $i = 1, \cdots, m$; $\chi_j = \sum_{k=1}^{n} t_{jk} \cdot \chi_k'$, $j = m+1, \cdots, n$, of matrix T. Two symmetric matrices, A and B, are said to be *m-affine congruent* if there exists a T such that $A = T' \cdot B \cdot T$. The elements of A, B and T are assumed to belong to a field. It is shown that matrix H, where H is A with rows $r_1 \cdots r_t$ and columns $s_1 \cdots s_t$ deleted ($r_i, s_i \leqq m$), is an *invariant matrix* of A under T; that is, $\overline{H}$ can be found (i) either by transforming and then deleting the rows $r_1 \cdots r_t$ and columns $s_1 \cdots s_t$, or (ii) by deleting the rows and columns indicated, in A and T, and then transforming. The determinants $d(H)$ are relative invariants, their various ratios absolute invariants (parameters) and the ranks of the various H's integer invariants. If the field is ordered, the signatures are integer invariants. Every matrix A can be reduced to one of the canonical forms C_1, C_2, $\cdots$ indicated, according to the ranks (and signatures if the field is ordered) of the invariant matrices of A. A necessary and sufficient condition for the m-affine congruence of two matrices, whose elements belong to an algebraically closed (real) field, is that their invariant matrices have the same ranks (and signatures) and that their parameters, in case they appear in form C_i under consideration, be identical. Two quadratic forms are m-affine equivalent if and only if their matrices are m-affine congruent in the field. A detailed reduction is given for the $m = 2$ (four-pole) case; $m = 0$ yields the projective theory; $m = 1$, the affine case. (R. S. Burington, *American Math. Monthly,* xxxix: 527–532, 1932; *Phys. Rev.,* 45: 429, March 15, 1934). The relation of this work with that of Cauer is discussed. It is believed that this study will not only be of interest from a mathematical point of view, but that it will also throw more light upon the theory of linear networks.

On certain types of hexagons: J. R. MUSSELMAN (introduced by Arthur B. Coble). The expression $V_1 = \sum_{k=0}^{n-1} \varepsilon_k \chi_k$, where ε is a primitive n^{th} root of unity, was introduced by Lagrange in his memoirs, published in 1769, devoted to the fundamental principles of the solution of the cubic and quartic equations. However, their entrance into the field of geometry is very recent. If we think of the χ_k ($k = 0, 1, \cdots n-1$) as complex numbers representing n points in the plane, then $V_1 = 0$ for $n = 3$ is an equilateral triangle and for $n = 4$ is a pseudosquare. The writer has discussed previously two geometrical figures in which the general n-gon $V_1 = 0$ will arise. Since under homologies the n-1 Lagrange resolvents of an n-point form a complete system of relative invariants, they are used in this paper to study some hexagons connected with the figure of any triangle and its Fermat points. Secondly, the hexagon for which the Lagrange resolvents V_1 and V_2 vanish is discussed in some detail; as it is through the intermediation of a symmetrical hexagon of this type that the writer shows that associated with every positively-ordered six-point is a rectangular hyperbola. Just as for an ordered four-point there are two circumscribed squares whose vertices lie obviously on circles, so for an ordered six-point there are two circumscribed hexagons whose opposite sides are parallel and whose six vertices lie on a rectangular hyperbola.

Investigations of variable stars: HARLOW SHAPLEY. A large proportion of the research work at the Harvard Observatory bears on the numerous problems of variable stars. It is recognized that such stars stand first in importance in measurement of the universe and in the analysis of stellar evolution. Seven special researches will be summarized. (1) One of the first investigations completed with the new 61-inch reflecting telescope at the Oak Ridge Station of the Harvard Observatory has been the determination with a photo-electric photometer by Dr. W. A. Calder of the light curve of the important eclipsing system of u Herculis. The high accuracy of the work permits a study of changes in the light curve during the past few years, especially in the shift of the secon-

dary minimum, which indicates the motion of a somewhat elongated orbit in space. Dr. Calder's observations have permitted a redetermination of orbital elements. (2) A study, extending over several years, of those eclipsing binaries that show evidence of rotating elliptical orbits gives fuller results than heretofore available in this interesting and important phase of the evolution of binary systems. With the assistance of Miss Henrietta Swope several thousand observations have been obtained from the Harvard plates on half a dozen of these relatively rare binaries. The results show the high concentration of matter in the centers of these stars. (3) The complex, very peculiar variable star, R Aquarii, has been studied throughout the interval of nearly fifty years for which the Observatory now has systematic series of photographs. The observations give a fairly full history of the amplitude of variation of this system, which appears to consist of a long period red variable and a hot blue companion that is possibly a planetary nebula. The work is done in cooperation with Dr. Merrill's spectroscopic analyses at Mt. Wilson. (4) Two hundred and eighty new variable stars have been found and studied in several fields in the southern Milky Way in the course of the Harvard systematic survey over the whole sky. Material is now available for an examination of the distribution of period-length among long period variable stars; these faint new long period variables are found to be speedier, on the average, than brighter variables of the same class—about 240 days against 280 days. (5) A study of faint variable stars, mostly of the eclipsing type and Cepheid type, in latitudes far from the Milky Way has contributed useful data in estimating the diameter of the Milky Way system. A large number of new variable stars have been found in the course of this work, and a new long-term program of variable star study has been inaugurated. The preliminary results indicate a thickness of the Milky Way not less than 20 kiloparsecs (65,000 light years), but the population is very scarce at such great distances from the plane. It appears possible that our own galaxy, like the Andromeda system, may be nearly spherical in form when the outlying variables and other stars are taken into account, although the main body of stars in each system forms a highly flattened discoid. (6) To gain further knowledge of super-giant stars we have continued the study of brighter Cepheids in the two nearest external galaxies—the Clouds of Magellan. The periods and light curves have been determined for about fifty stars in the Large Cloud, all of absolute magnitude −1.0 or brighter. These periods furnish a check on the period-luminosity curve, both in its brighter portion and also for the faintest Cepheids. Light curves have been derived for a few of those remarkable and rare Cepheid variables with periods greater than forty days (luminosities 1,500 times that of the sun). (7) Supplementing earlier investigations at the Harvard Observatory, we have now used a series of new plates of the South African Station in the discovery of variable stars in the Small Cloud of Magellan. Six hundred new variables were added a year ago to those already known for the Large Magellanic Cloud, and now in the Small Cloud approximately one thousand have been found to supplement the 900 previously known in that system. Probably more than 90 per cent. of the 3,200 variable stars now known in both clouds belong to the Cepheid class, and the study of their distribution throughout the systems should help in the interpretation of the gravitational organization of the galaxy.

Energy spectrum measurements of the hotter stars: C. G. ABBOT. Author recalled that in 1922, 1923 and 1928 he had observed the spectra of a few of the stars in the constant temperature room of the 100-inch telescope at Mount Wilson Observatory which was used for the purpose in the coudé manner. In the experiments of 1928 a special radiometer was constructed using vanes of fragments of house flies' wings and an atmosphere of low pressure hydrogen. The measurements were mainly confined to the cooler stars as the wide dispersion of prisms, the diminished reflectivity of mirrors and other causes combined to weaken the spectra of the hotter stars intrinsically strongest in the ultra-violet. Development of Christiansen filters for use in the division of radiation and organisms of the Smithsonian Institution suggested using a battery of them for the stellar energy spectrum measurements, each selecting a narrow wave-length region within the range 3,300 to 10,000 angstroms. Author is indebted to Messrs. E. D. McAlister, L. B. Clark and A. N. Finn for their preparation. It was hoped to use with this outfit a thermoelectric equipment which had been employed by Pettit and Nicholson for measuring the total heat of the stars, but this apparatus had been dismantled. Fortunately, Dr. Joel Stebbins consented to cooperate with his photoelectric cell apparatus. Observations made on September 2 and 3, 1934, at the coudé focus of the 100-inch telescope on Mount Wilson included a program of 19 stars beside the sun, about equally divided in numbers between types O, B, A, F and G. The photoelectric cell was used between wave-lengths 3,300 and 6,400, but was relatively very weak for the shorter and the longer wave-lengths within this range. While the observations are, on the whole, very consistent and apparently of small accidental error, it is suspected that the photoelectric cell was affected by influences akin to fatigue which made the measurements in the yellow, the red and the ultra-violet not exactly comparable with those in the green and the blue where the instrument is most sensitive. Perhaps more prejudicial may have been the disproportionately extreme sensitiveness of the cell to the trifling amounts of stray light scattered by the filters from the blue regions of the spectrum. It is hoped to repeat the observations at some future time with a receiver of the black type, preferably a thermoelectric couple. The Christiansen filters seem very convenient for stellar spectrum energy observations.

The excitation of spectral lines in expanding nebular shells: OTTO STRUVE (introduced by Edwin B. Frost). This paper deals with the star P Cygni, a "nova" which first appeared in 1600 as a third-magnitude object and which is now of magnitude 5. Its spectrum consists of bright and dark lines, similar to those of other "novae." Measurements of 110 absorption lines and of 49 emission

lines lead to the following tentative picture of this star. The nucleus is a star of effective temperature 20,000° K, situated at a distance of approximately 3000 light years from the sun. Due to its great distance the interstellar calcium line is exceptionally strong. The absolute magnitude is –5, in fair agreement with the average absolute magnitude –6 found for P Cygni stars in the Magellanic Clouds. Selective interstellar absorption reduces the color temperature to about 6,000°. There is no line spectrum belonging to a stationary reversing layer: presumably the absorption lines are hidden by the bright lines. These, together with the violet absorption lines, originate in an expanding nebular shell. The velocity of this shell is accelerated outward, being approximately 200 km/sec in the region of formation of the hydrogen lines, and approximately 50 km/sec in the inner region where Si IV and N III are formed. The stronger absorption lines originate at lesser depths than the weaker lines. The lines of higher ionization potential originate at greater depths than those of lower potential. The radius of the shell is not known, but it is certainly very much less than that of a planetary nebula or of a nova. Departure in the mechanism of line-absorption and emission from that of ordinary thermal excitation is attributed to the low density of the shell, which precludes an active part of collisions. The remaining processes of photoelectric ionization with subsequent recombination, and of monochromatic absorption of radiation with subsequent fluorescence, under the influence of a diluted field of radiation, must lead to the observed departures from the Boltzmann law. There is some indication that the state of ionization in the shell decreases outward, and that consequently the density of the nebula decreases outward slower than $1/R^2$. The latter law would hold in an isothermal nebula.

The Ursa Major Group: J. J. NASSAU and LOUIS G. HENYEY (introduced by Ambrose Swasey). An expedient method is developed for finding stars which have a given common motion. It is essentially based on the stereographic projection of the circles of equal radial velocity and equal cross-motion in declination. The method is applied in an examination of all the 2,900 stars in the Yale Bright Star Catalogue having complete data (radial velocity, proper motion and parallax) for possible membership in the Ursa Major group. In 1921, N. Rasmuson, summarizing the work of all previous investigators, assigned 28 stars to the Ursa Major group. His study included the five Dipper stars, Sirius, α Coronae Borealis and β Aurigae. Ch. Bertaud in 1932 enlarged the group. Of the 79 stars given in his list all are of type A with the exception of 3, which are F. Our examination yielded 126 stars, each of which differed from the assumed velocity of the group by a vector whose magnitude was less than 9.5 km/sec. The mean velocity of the group in galactic coordinates, with solar motion excluded, was found to be $l = 1°.4$, $b = -6°.0$, $V = 29.5$ km/sec. The stars are moving approximately in the plane of the galaxy and in a direction about 36° from the galactic center. The space distribution of the stars is more or less spherical, with an approximate diameter for the group of 150 parsecs. A study of the spectral and parallactic distribution shows that the selection is not at random. As compared with the spectral frequency of stars having complete data, the Ursa Major stars exhibit a gradual increase in number from M to A with half of them A types, and a complete absence of B-type stars. The Russell diagram shows all the characteristics of a type 2a open cluster in Trumpler's classification. The stars in space are divided into two groups by a gap 18 parsecs wide passing through the sun. There is no marked difference in spectral distribution or in absolute magnitude between the two groups. Their difference of velocity is 1.7 km/sec. and it is parallel to the gap. One of the boundaries of the gap is a plane marked by 33 stars. Professor H. H. Turner in 1911, utilizing all the then known stars in the Ursa Major cluster, obtained practically the same plane. This paper appears in the *Astrophysical Journal*, Vol. 80, p. 282, 1934.

Fundamental geodetic surveys in the United States nearing completion: WILLIAM BOWIE. Geodetic surveys in the form of triangulation and leveling, started during the last century as a framework for topographic maps and for use in many other engineering operations, and which have assumed marked scientific importance, are being rapidly extended over the area of this country. Marked progress has been made in these surveys during the past few years as a result of the allotment of funds to relieve unemployment. While a number of agencies, federal and others, have engaged on geodetic surveys in this country, the greater part of the work has been done by the U. S. Coast and Geodetic Survey. The plans followed on the fundamental geodetic surveys call for lines of leveling and arcs of triangulation spaced at intervals of about 25 miles over the entire area of the United States. There are now 172,000 miles of lines of levels with only 28,000 miles remaining to be done. There are 55,000 miles of arcs of triangulation and there remain 61,400 miles to complete the net. It is expected that the leveling net will be finished during the coming winter, while at the present rate of progress, the triangulation net will be finished within three or four years. During the past few years the number of surveying parties in the field and the mathematicians and computers in the office have been greatly increased, but in spite of this increase the high accuracy of the geodetic surveys has been maintained. They are at least equal to the standards adopted by the International Geodetic Association. In 1927 the triangulation net as it existed at that time was readjusted by a new method, which proved very effective. In 1929 the adjustment of the combined leveling nets of the United States and Canada was made, which furnishes the fundamental elevations for tens of hundreds of bench marks. Canada and Mexico have joined their triangulation systems to that of this country, and in consequence we have a unified triangulation net for North America. This is the only continent in which this condition obtains. Already the triangulation, with connected astronomical observations in the United States, has been used in determining the figure of the earth and that figure has been adopted as an interna-

tional one by the International Geodetic Association. With the vast increase in the amount of triangulation in North America, it will be possible to derive a new figure of the earth which should be superior to any previous ones. The first comprehensive test of isostasy was made by the use of triangulation. The adjustment of the leveling net indicates that mean sea-level as determined by tidal observations on the coasts deviates from a level or equipotential surface. Mean sea-level at Portland, Maine, is 0.39 meter higher than at St. Augustine, Florida. Ft. Stevens at the mouth of the Columbia River in Oregon is 0.86 meter higher than at St. Augustine. These values are subject to some uncertainty due to accidental errors, but they are of the right order of magnitude. Geodetic surveys have been and will be used in the future in determining the extent of the deformation of the surface of the earth in the vicinity of earthquake epicenters. The triangulation and connected astronomical observations combined with the data secured from gravity surveys will furnish information for making further tests of isostasy and in enabling geologists and geophysicists to interpret more accurately buried geological structures.

Solar prominences recorded by the motion picture method: ROBERT R. MCMATH and ROBERT M. PETRIE (introduced by Heber D. Curtis). This film shows some of the results that are being secured with the spectro-heliokinematograph at the McMath-Hulbert Observatory of the University of Michigan. This is the first time that the growth, motion and change of solar prominences have been depicted in a continuous record by the motion picture method. Of especial interest is the record of a solar bomb, or very short-lived prominence, whose total life was of the order of ten minutes. In this, a cloud of dark hydrogen gas was suddenly ejected from a previously quiescent sun-spot. The cloud was about $40{,}000 \times 19{,}000$ miles in size; the component of its velocity of ejection across the line of sight was 42 miles per second. However, as the sun-spot was only about ten degrees from the line of sight, the actual velocity of ejection outward must have been of the order of 240 miles per second. After the disappearance of this bomb a long faint stream of gas, either from the outburst or of other material, was sucked back into the spot with a rapidly accelerating velocity. The method has great potentialities in the study of the rapidly changing phenomena of the solar surface, and should produce results of high scientific value and educational interest.

Variation and evolution among the stars: HARLOW SHAPLEY. Published in this issue of SCIENCE.

The presence of creatinine in blood plasma: JOSEPH M. HAYMAN (introduced by A. N. Richards). Indirect evidence indicates the presence of creatinine in normal and pathological human blood serum. This is based on acceptances of Gaebler's conclusion that all the material absorbed from a blood filtrate by Lloyd's reagent and eluted can be identified as creatinine. Trichloracetic acid filtrates were found more satisfactory than picric acid filtrates, since shaking picric acid with either kaolin or Lloyd's reagent leads to the development of a deeper color on addition of alkali or creatinine and alkali. The rate of color development in solutions of the material eluted from Lloyd's reagent is the same as that in creatinine solutions, while the rate in serum filtrates before and after shaking with Lloyd's reagent differs from pure creatinine solutions. Trichloracetic acid filtrates of both normal and pathologic sera show a decided reduction in the intensity of the Jaffe reaction after shaking with Lloyd's reagent. The sum of the remaining color and that obtained from material eluted from Lloyd's reagent agree with that in the original filtrate within the limits of the method. The relation between the two factions is the same, whether the increase in apparent creatinine is due to disease or ingestion of creatinine.

Further observations on systolic and diastolic coronary flow under natural conditions: CARL J. WIGGERS (introduced by Joseph Erlanger). The question whether coronary flow is retarded or even stopped during ventricular contraction, or, on the other hand, undergoes a decided acceleration during systole is still in dispute. Records obtained by flow recorders of different design give quite different answers. This is occasioned by the fact that the theoretical physical principles according to which such instruments can be designed and by which their efficiency can be evaluated have not been as clearly or comprehensively formulated as in the case of pressure recorders. Consequently, their construction is guided too largely by empirical trials, while judgment as to their efficiency becomes essentially a matter of opinion. Since consecutive changes in flow are the resultant of differences in pressure which exist from moment to moment in the peripheral and central ends of a coronary ramus, and since the pressure variations in the central end correspond to those in the aorta (Wiggers and Cotton, 1933), the variations of flow through intramural vessels should be determinable by simultaneous calibrated records of aortic and peripheral coronary pressures. Such recordings by use of optical manometers of adequate frequency were made in conjunction with my associates, Drs. Donald Gregg and Harold Green. It was soon realized that the physical limitations for our plan of deductions are that the pressure pulses recorded from the peripheral end of a coronary ramus represent effects produced by contractile stress and not transference of pressure through collateral channels. Although this appeared to be precluded by the discovery that the predominant and brusque increase in peripheral coronary pressure occurs before the rise of pressure in the aorta, additional confirmatory evidence was obtained by temporarily occluding the other coronary branches. The limiting physiological conditions for such tests were set by the immediate changes in the character and force of ventricular contractions and further by the short time that the heart survives with multiple branches occluded. Time is inadequate to detail the clever expedients through which Drs. Gregg and Green were able to circumvent these difficulties; the graphic lantern slide records attest to its accomplishment. By utilizing the calibrated pressure pulses presented, enlarging them and retracing them by means

of optical projection, the algebraic difference of pressures could easily be plotted. As shown by curves presented, it appears that under natural pressure variations in the aorta, the coronary flow is neither stopped nor retarded, as claimed by Anrep and associates; on the contrary, it undergoes first a systolic acceleration and then another acceleration early in diastole, as first postulated by Rebatel (1872). By drawing an arbitrary base line and determining the surface area beneath such curves, the relative volume flows during systole and equal intervals of diastole can be estimated. We found that the flow is smallest during systole and greatest during an equal interval of early diastole.

Criteria of acute alcohol intoxication: A. J. CARLSON. We studied the acute effects of alcohol in 3.2 per cent. beer on 150 persons, men and women, ranging from 20 to 60 years in age, and including teetotalers, moderate and heavy consumers of alcoholic drinks, primarily for the purpose of determining whether alcohol in this dilution is or is not intoxicating to an average normal adult. The beer was consumed in varying quantities and rates. The minimum alcohol intake was 27.3 cc, the maximum 208.4 cc. The rate varied from one to eight bottles of beer per hour, and the drinking time from 15 minutes to 16 hours. As control on the possible effects on liquid volume near beer was consumed in corresponding quantities and rates. It is well established that the acute effects of alcohol on the animal organism depend on the quantity, concentration and rate of consumption of the alcohol. In addition to observations of the general behavior of the subjects, determinations were made on the alcohol concentration in the blood, and in the urine, standing steadiness, hand steadiness, visual and auditory reaction time, cutaneous sensibility to pain and such mental factors as are involved in the speed and accuracy of card sorting and color naming. (1) There was no change induced in skin sensitivity to pain. (2) Consumption of from 8 to 14 bottles of beer (117 to 191 cc alcohol) in three hours induced some impairment in steadiness, reaction time, card sorting and color naming. The average maximum blood alcohol reached 1.17 mgr per cc. No consistent impairment occurred below this alcohol intake. (3) There is a fair parallel between the rate and concentration of the alcohol consumption, the concentration of alcohol in the blood and urine, the degree of impairment of performance, and the deviations from ordinary behavior, although the latter varies greatly with the individual and the kind of environment at the time of observation. (4) There is no single test or criterion for the degree of alcohol intoxication that has the social and legal implication of drunkenness. The blood alcohol concentration is significant, because none of our subjects showed "drunkenness" until the blood alcohol exceeded 1 mgr per cc. (5) The present confusion in the scientific, social and legal aspects of acute alcohol intoxication might be clarified by limiting the term "alcohol intoxication" to any and all immediate effects of alcohol, and define "drunkenness" as that degree of alcohol intoxication at which the individual becomes a nuisance or a danger to his fellow men. In our subjects the degree of alcohol intoxication that we might call drunkenness appeared, varying with the individual, at a blood alcohol concentration between 1 and 2 mgr per cc.

The temperature of the expired air, a hitherto unused physiological and clinical measure: FRANCIS G. BENEDICT and CORNELIA GOLAY BENEDICT. The mouth and rectum as body cavities for temperature measurements have long been used. By measuring the temperature of the expired air lung temperature may be obtained. A respiratory cycle lasting but four seconds calls for a thermal junction measurement of the temperature. An extremely fine wire, copper-constantan thermal junction with thermostat and galvanometer gives an instantaneous measurement of the complete respiratory cycle. The temperature of the expired air varies with the phase of the cycle and is highest toward the end of an exhalation. With a forced inspiration and exhalation a somewhat higher temperature is obtained. This is essentially that of mouth temperature with the clinical thermometer, but is several tenths of a degree below that of the rectal temperature. For physiological purposes, school surveys, examination of recruits, etc., the body temperatures can be measured with one expiratory blast, lasting three or four seconds, as rapidly as the subjects can be handled. In the clinic the significance of true deep lung temperatures may be of great value in respiratory affections.

Energetics of growth and metabolism in the chick embryo and a calculation of the developmental efficiency of these processes: NORMAN C. WETZEL (introduced by A. J. Carlson). The general equations previously found by the author to hold between growth and heat production in the human being and in other forms have now been applied to the entire life cycle of the chicken, that is, from the first day following fertilization throughout incubation of the egg, to full-fledged maturity. The equations of growth, for example, show satisfactory agreement with the data of Byerly, Murray and Needham over the range in weight from 0.7 mg at the first day of incubation to 2 kg at maturity. Equally good agreement has been obtained for the period of embryogenesis between the calculated values on coincidental heat production and the quantity of heat actually measured by Bohr and Hasselbalch, as well as that estimated from oxygen consumption by Murray. It is of interest that the negative values for heat output (absorption) which Bohr and Hasselbalch had originally described during the first 2 or 3 days of incubation are perfectly consistent with the present calculations which also show heat absorption in contrast to heat output during the first 3 days of incubation. A balance sheet can now be drawn up to show the relations between the quantity of energy originally present in the egg and the energy comprising the various products which have been generated, namely, the chick, the heat output due to growth and the heat output due to maintenance. These results stand opposed to the idea that there is no work involved in growth. It is, in fact, possible to compute the actual quantity of work done, as well as the quantity of energy lost by dissipation, and thus to estimate the efficiency of the growth process as such. This is surprisingly high,

reaching a value of 99.67 per cent. for the entire period of incubation; for, of an original 59,208 gram-calories used in the process, only 198 are dissipated. The entire remainder is disbursed between the chick itself (37,500 gram-calories), synthesis (882 gram-calories), maintenance of embryonic tissues (18,748 gram-calories) and in the formation of the extra-embryonic membranes (1,880 gram-calories).

Rate of growth and length of life: H. C. SHERMAN and H. L. CAMPBELL. The subjects of the experiments were rats bred in our own laboratory for over 30 generations, of which several generations were included in the present study. Females grow more slowly and live longer than males. Systems of feeding which influence the rate of growth may influence the length of life in either direction: the effects of different concentrations of different chemical factors of the diet upon rate of growth and length of life are still being studied. For animals on some diets, however, sufficient data are now in hand to permit statistical study of individual variations. Here it is found that among individuals of the same heredity and sex, living in the same environment and eating *ad libitum* of the same food, rate of growth and length of life vary independently of each other.

The relative growth function applied to white-eyed mosaics of the bar series of Drosophila: A. H. HERSH (introduced by E. G. Conklin). The detailed knowledge available on the genetics of *Drosophila melanogaster* allows for a degree of experimental control which makes it possible to obtain information on the chain of reactions leading from the genes of the fertilized egg to their effects on the characters of the adult. One method available is to have the egg begin its development in the presence of a known genetic constitution and then during the course of development to have the genetic constitution changed in a definitely known manner. In this way a different expression of the genes may occur in that part of the body of the adult where the controlled genes produce their main effects. Such experiments were undertaken involving the following sex-linked genes: Bar, a dominant reducer of eye size; w, a recessive gene for white eye color; Minute-n, a dominant reducer of bristle size which occasionally brings about the elimination of the chromosome that carries it. Fertilized eggs were made up containing the B- and the Mn-gene in one of the X-chromosomes and the recessive w-gene in the other of the X-chromosomes. The overwhelming number of females which develop from such eggs have a red eye somewhat larger than homozygous bar but smaller than the wild-type eye. For a small percentage of such eggs, however, the BMn-chromosome is eliminated from some cell in the optic disk during the course of larval development. Such a cell and its subsequent descendants possess the single X-chromosome, containing the w-gene, and so have the genetic constitution for the production of white facets. A fertilized egg with the same genetic constitution present from the beginning of its development would produce a white-eyed male with the characteristic large eye of the wild type (about 750 facets). An elimination of the BMn-chromosome from a cell at a suitable time and place in the optic disk of the larva results in a female fly with a mosaic eye, having some red and some white facets. The earlier the elimination occurs, the larger is the patch of white facets in the mosaic eye. The data obtained were seriated on the basis of the total number of facets in the eye. For the mosaics involving the B-gene, it is found that when the entire eye (x) contains 141, 164, 189, 206, 267, 288 and 306 facets, then the number of white facets (y) is, respectively, 6.3, 9, 30.5, 24, 60, 84 and 113. These data and similar data for mosaics involving ultra-bar show that the quantitative relation closely conforms to the relative growth function, $y = bx^k$, in which x and y have the meaning indicated above, and b and k are constants. For both sets of data the value of k is about 5, indicating that the white facets increase in number about 5 times faster than total facet number. b, however, is quite different for the two sets of data; it is lower for the mosaics involving a bar gene than for those involving an ultrabar gene. Some indication of the difference can be obtained from the graph, which leads us to expect an eye with about 105 facets, if one of them only is white. A similar figure for the ultrabar mosaics is about 65 facets. Furthermore, in the case of bar, if the same relation may be extended to somewhat larger eyes than were actually obtained, then an eye with about 380 white facets would be expected to be entirely white. In the case of ultrabar mosaics, the corresponding figure is about 150 facets. Finally, on the basis of these quantitative relations it seems justifiable to conclude that in such eyes with about 380 facets, all of which are white, the elimination of the BMn-chromosome occurs not later than the very first cell whose subsequent descendants enter into the formation of the eye. But if the same genetic constitution, *i.e.*, a single X-chromosome carrying the w-gene, is present from the beginning of development, the eye likewise will be all white, but it will contain about 750 facets. The further conclusion seems unavoidable that the B-gene in its rôle as a reducer of facet number exerts in some way an effect before the appearance of this first cell in the optic disk.

Arteriolar changes in essential hypertension: ALAN R. MORITZ (introduced by H. Gideon Wells). The contradictory character of published opinions as to the significance and even the presence of generalized thickening of the walls of small arteries and arterioles, in association with arterial hypertension in man, invites further study of the problem. Researches into the ultimate cause or causes of hypertension could be directed and executed with greater precision if it were known whether the thickening of arteriolar walls is the cause or the result of elevated blood pressure. Preliminary to any comparative study of the vessels of persons with and without a record of hypertension, it was necessary to determine if variations in the technical procedures involved in fixing, dehydrating and embedding tissues preliminary to microscopic examination might account for variations in the relative thickness of vessel walls. Such observations were made and no significant alterations in the ratios of

internal to external diameters of vessels could be related to variations in laboratory methods. Next it seemed advisable to learn if the physiological contraction or dilatation of vessels at the time of death might be rendered permanent by fixation of the tissue so that the observed differences in wall to lumen ratios could be the result of physiologic rather than anatomic change. By the repeated sampling of skeletal muscle of dogs before and after the administration of vaso-constricting and vaso-dilating drugs, it was found that neither vaso-dilatation nor vaso-constriction persisted through the process of preparing the tissue for microscopic examination. Having learned, then, that no significant alteration in the ratio of internal to external diameter of arteriolar walls could be related to artefact or to the physiological state of the vessel, it was concluded that observed differences must be regarded as significant. To determine if the walls of arterioles in persons having persistent arterial hypertension are thicker than those in persons known not to have had hypertension, two groups of cases were selected for study. The mean ratio of internal to external diameter of 75 arterioles in the skeletal muscle and 75 arterioles in the gastro-intestinal tract from each of 36 individuals known to have had persistent arterial hypertension was compared with similar ratios in a group of 36 individuals who did not have elevation in blood pressure. The populations of both groups were similar in regard to age distribution and sex. The first group was comprised of individuals on whom repeated observations of the blood pressure showed the systolic to be over 150 and the diastolic over 100, and who at death were found to have cardiac hypertrophy in excess of 400 grams and chronic renal disease. The normal group included persons who had no known elevation of blood pressure and no cardiac hypertrophy or chronic renal disease. Viewed as a group, the walls of arterioles appeared to be definitely thicker in persons having persistent hypertension than in those of the control group. Although the thickening of the arterioles was a group characteristic it was not present in all individuals who were known to have had long-standing elevation of blood pressure. This would indicate that thickening of arterioles was not a necessary or constant antecedent of hypertension, but rather that it develops in a large proportion of persons who have persistently elevated blood pressure. A study of the structural changes in these thickened arterioles revealed that the lesser degrees of thickening were the result of hyperplasia of the smooth muscle cells of the media, and that the more advanced thickening was characterized by degeneration and thickening of media and intima. These observations also support the view that the arteriolar changes were secondary to the hypertension. The measurements upon which the foregoing deductions were made have not been subjected to statistical analysis. This will be done at a later date.

On the evolution of the skulls of vertebrates with special reference to heritable changes in proportional diameters (anisomerism): WILLIAM K. GREGORY. In earlier papers the author has directed attention to the fact that during the course of evolution of any series of organisms two opposite but often simultaneous morphological processes may be observed. In the first (named polyisomerism) there is a budding or multiplication of some given part or parts, such as the teeth of sharks or the joints of the backbone in eels. In the second or opposite process (anisomerism) there is some emphasis or selective increase or decrease among the polyisomeres, resulting either in lop-sidedness or in the diminution of certain units even to the point of disappearance. Such local differences in rates of growth have doubtless produced the observed contrasts in general appearance between the skulls of "dolichocephalic" and "brachycephalic" types of man and other mammals. In the present paper it is shown that analogous changes in the proportions of the front part of the body were already at work in the oldest known forerunners of the vertebrates, namely, the ostracoderms or pre-fishes of the Silurian and Devonian periods. The publication of important recent memoirs on these forms by Kiaer, Stensiö, Bryant and others, together with the study of original material, leads to the following conclusions: (1) The most primitive known ostracoderms were probably members of the Heterostraci, not unlike *Poraspis*. These were anisomerous in the dorso-ventral plane and bilaterally polyisomerous in the horizontal plane. (2) The head shield, composed of a many-layered shell, was divided into five primary plates. During divergent evolution both the head shield as a whole and the individual plates were subject to progressive anisomerism resulting at one extreme in the "brachycephalic" shield of *Protaspis perlatus* Bryant and at the other in the very "dolichocephalic" shield of *Podalaspis*. (3) Extreme widening of a *Poraspis*-like head shield, together with fragmentation or secondary polyisomerism of the five primary plates, would give rise to the flat shield of the drepanaspids, thelodonts and coelolepids. (4) Among the cephalaspid ostracoderms a radial expansion of the so-called upper lip or posthypophysial fold caused the displacement of the naso-hypophysial tube to the upper surface of the shield, as suggested by Stensiö; an indication of this process of expansion is seen in the many primary and secondary branches of the canals of the so-called "electric nerves," as preserved in Stensiö's material. Anisomerous expansion of the shield then produced on the one hand the extremely wide shield of *Bennevias-pis* and on the other hand the long narrow shield of *Hemicyclaspis*. (5) Stensiö and Kiaer agree that the anaspid ostracoderms have been derived from the cephalaspid stem. Such derivation implies a marked secondary polyisomerism of the body segments, resulting in a long sinuous body, and a negative anisomerism of the dorsal plates of the head shield, which is reduced to a small area between the eyes, concomitant with a fragmentation or secondary polyisomerism of the rest of the head shield, the general exoskeletal pattern of the flanks tending to spread over the sides of the head and throat. (6) The existing lampreys and hag fishes, as shown by Stensiö and Kiaer, retain many deep-seated morphological characters from ancestral ostracoderms.

By secondary polyisomerism of segments the body may be more than twelve times as long as the head. By negative anisomerism the head shield is reduced and represented by the muco-cartilage plates of the larval *Petromyzon* (Gaskell). The myxinoids exhibit further degeneration of the head shield with extreme hypertrophy of the rasping apparatus, the endoskeleton of which was doubtless derived from the ventral portion of some of the visceral arches. (7) *Amphioxus* may be a greatly degraded ostracoderm which has completely lost its head shield and enjoyed enormous hypertrophy and secondary polyisomerism of the branchial apparatus, together with extreme negative anisomerism of the brain. Its nakedness is to be expected in a specialized derivative of primitively armored forms.

Post-natal growth patterns of the primate brain: T. WINGATE TODD (introduced by Aleš Hrdlička). Studies of post-natal growth in mammalian crania made in the laboratory by Schweikher, Cooke, Wharton and myself show that adult cranial capacity is very rapidly reached in non-Primate skulls. Perrine, Tracy, Krogman and I have shown that this is true also of the lower Primate cranium, but the rate of increase is not quite so great as in the non-Primate cranium. In anthropoids the rapidity of cranial growth checked against body growth is much less rapid and in man adult cranial capacity is approximately reached only at about six years. The detailed studies made in living children by Broadbent, Bolton, Richardson and myself demonstrate the local and irregular character of the cranial growth pattern. This is evident during the first year of life successively in occipital, parietal and frontal areas. The observations on children's brains made by Loo indicate that the cranial growth pattern, while not recording in detail the growth pattern of the brain, is nevertheless closely linked therewith in providing accommodation for the unequally expanding cerebral cortex. Investigations of the growing macaque brain made by Turner and myself show that the individual patterns seen in this Primate are less a problem of variation than of growth which affects more particularly the parietal area. Observations on anthropoid brains by Loo, Turner and myself present a very definite pattern of growth, expressed in post-natal life, more particularly in parietal and frontal areas. Our study of the human cortical patterns in children shows that the anthropoid growth features are reproduced and extended, the parietal and frontal areas again accounting for the bulk of the cortical expansion. Brains of subnormal and superior children point to the conclusion that individual variations are produced by interruption, aberrancy or unusual progress in the human growth pattern. These studies suggest that the cortical patterns recorded by Elliot Smith, Shellshear and Kappers on so-called primitive brains and on human paleolithic endocranial casts also represent stages in the unfolding of the human cortical growth pattern.

The fate of mercury in acute bichloride poisoning: TORALD SOLLMANN and NORA E. SCHREIBER (introduced by Dayton C. Miller). (1) The *elimination of mercury* was studied on two patients, with fatal, and two patients with light mercuric chloride poisoning. Only the early vomiting expelled any notable quantities of the mercury. After the patients reached the hospital, only insignificant quantities, equivalent to 1½ to 3 per cent. of the amount taken, were removed by extensive gastric and colonic lavage, feces and urine. (2) The organ distribution of mercury was studied in three typical cases of fatal mercuric chloride poisoning. The results agree with the scanty data in the literature. They show a surprising quantitative uniformity, although the dosage has some effect. The highest concentration occurs in the kidneys. It averages ca. 3.8 per 100 gm of moist tissue. The liver has about ½ to 2/3 of the kidney concentration, the intestines 1/9, the blood 1/40. The mercury content of the body at large could be estimated as about 240 mg.

Preliminary tests with sodium rhodanate on rabbits and chickens: WILDER D. BANCROFT, ESTHER C. FARNHAM and JOHN E. RUTZLER, JR. In order to determine the effect of continuous dosing, rabbits and chickens were given dilute solutions of sodium rhodanate instead of water. In one run five out of seven water rabbits died of coccidiosis as against two out of seven rhodanate rabbits. In another run two out of three water rabbits died and none of the three rhodanate rabbits. The absolute figures mean nothing and the rhodanate does not prevent coccidiosis. It seems to give increased resistance to disease. The second generation of rhodanate rabbits appears healthy. Two hundred and fifty-six twelve-weeks old chickens in poor health, all from one badly affected farm, were divided into four groups. In two months time 21 of 64 water chickens had died from infectious leukemia and coccidiosis, and 11, 11 and 7, respectively, of the three groups of rhodanate chickens. These chickens were a cross between Rhode Island and Plymouth Rocks. Three groups, 100 in each, of healthy, 10-day old, New Hampshire Red chicks from another farm are now being tested. So far, six out of one hundred water chickens have died from coccidiosis and infectious leukemia. Two of the 200 rhodanate chickens have died, one of them from an infected leg.

Present status of the adrenal cortex problem: J. M. ROGOFF (introduced by A. J. Carlson). The function of neither medulla or cortex of the adrenal gland can be satisfactorily explained. The medulla can be eliminated or its epinephrine secretion suppressed without apparent effect on life or health. The cortex (or interrenal gland tissue) is indispensable. Suppression of adrenal cortical function by excision of both glands in dogs or cats (free from accessory cortical bodies) is followed by death in one to two weeks. Survival can be prolonged, considerably, by administration of potent extracts of adrenal cortex. Such extracts often contain not only the indispensable hormone of the cortex (interrenalin) but other physiologically active substances. Therefore, aside from their capacity to prolong life of adrenalectomized animals, the use of cortical extracts in metabolic or other physiological studies may yield spurious results. Purified extracts are difficult to obtain and a definite chemical hormone has not yet been isolated. Commercially available adrenal cortical extract

has not proven satisfactory for physiological studies or for clinical use. Such extracts have been shown to contain significant amounts of protein, choline and histamine. In acute adrenal cortical insufficiency the following physiological consequences have been well established: (A) gastro-intestinal disturbances (aversion to fats, anorexia, bilious vomiting, diarrhoea, congestion and hemorrhages in the alimentary canal, congestion of the pancreas, ulcers in the stomach and duodenum); (B) circulatory and muscular asthenia; (C) nervous system disturbances (hallucinations, mania, muscular twitchings and spasms, convulsions, coma); (D) blood changes (increase in total NPN and urea N, especially with increase in the "undetermined fraction of the NPN," increase in Ca, diminished Cl, usually a moderate diminution in dextrose, increase in relative volume of corpuscles to plasma). Whether all these physiological changes are the direct result of loss of adrenal cortical function or are, in part at least, due to probable disturbed relations with other endocrine organs is under investigation. Evidence suggests involvement of the parathyroid and pancreas and probably other glands. More information might be obtained from studies upon animals in which sub-acute or chronic insufficiency of the adrenal cortex is induced. In a preliminary series of experiments upon such animals (prepared by sub-total ligations of adrenal blood vessels) the same general physiological changes were observed, but varying in degree with the degree and duration of cortical insufficiency obtained. The results in these animals afford more reliable information, on the physiology of the adrenal cortex, than comparable results obtained in human patients with chronic adrenal insufficiency (Addison's disease), since in the latter case they are confused by the presence of underlying or associated disease (usually tuberculosis). The problem at present calls for further information on the function of the adrenal cortex and its hormone, interrenalin. Recognition of insufficiency, earlier than the acute manifestations, is essential. Disturbed functional relations with other endocrine organs may yield significant information. These are the directions of our present investigations.

Current and voltage loci of polyphase circuits: A. C. SELETZKY (introduced by John B. Whitehead). The solution of unbalanced polyphase circuits by application of the classical method entails such cumbersome forms involving complex quantities as to make it impractical for engineering purposes. Various methods have been devised to shorten the labor of such computations. These are valid for a fixed condition of the network, thereby necessitating a point-by-point solution if it is desired to express any quantity as a function of some circuit parameter. Since all power systems operate at constant frequency, any current or voltage existing in a polyphase circuit, composed of bilateral linear impedances and constant electromotive forces, can be expressed as a function of any impedance element in the form of a linear fractional transformation. The variable impedance element may vary: (a) along its resistive component with fixed quadrature component; (b) along its quadrature component with fixed resistive component; and (c) in magnitude at constant phase angle. With any impedence element considered as a variable, the most general form of locus of current or voltage is a circle, degenerating in certain cases into a straight line. The same holds true for symmetrical components of all voltages and currents and unbalance factors thereof. Thus by resolution of the desired quantity into a linear fractional transformation, the solution is reduced to determining three points on the circular locus, two of which may be invariant points, thereby simplifying the computation. With the position of the circular locus determined, a linear scale line may be drawn which enables one to read off directly from the plot the magnitude and phase of the desired quantity for any value of the variable impedance. The paper gives detailed analytical solutions of the Y-Y and $\triangle$-$\triangle$ systems and a numerical solution of a typical Y-Y circuit.

Variations in tilt lines in the Huron-Erie district: FRANK LEVERETT and DONALD C. MACLACHLAN. The shores of glacial lakes in the Huron-Erie district show a notable difference in the trend of tilt lines in lakes of different age and also in different parts of the shore of a given lake. In the district west of Lake Huron the tilt line of Lake Arkona bears but a few degrees east of north while that of Lake Warren, a later body of water, bears about NNE. This seems to show that the area of uplift was shifted eastward at the time of the later lake. The tilt line of the Lake Warren shore changes from NNE on the borders of the Huron Basin to about NE on the peninsula between the Huron and Erie basins, but takes a NNE trend on the borders of the Erie Basin. It is thought that relief from ice weighting, which came earlier on the high land between the basins than it did in the basins, may have allowed it to be uplifted somewhat in advance of the uplift within the basins, and thus have induced the peculiar trend. The rate of uplift of the Lake Warren shore is not uniform, nor does it show a progressive increase from south to north. On the east side of the Huron Basin its profile shows changes from a rate of several feet per mile to a much lower rate in the general direction of the tilt line. Variations of this kind in the shores of Lake Algonquin on the borders of Lake Simcoe were brought to notice by W. A. Johnston in 1916, and tentatively connected with a fault that appears to have been developed there in late Pleistocene time. Whether the variations noted in the Warren shore are to be thus explained is not yet known.

Nature and extent of Tertiary formations immediately following the Columbia lava flows of the northwest: JOHN C. MERRIAM. In description of the series of formations in the John Day valley of eastern Oregon, published in 1901, the writer described under the name of the Mascall Formation a series of deposits in a depression formed by the down-folded Columbia lavas. It was noted that the dip of the lower Mascall is approximately the same as that of the lavas upon which it rests. Reference was made to the fact that the Ellensburg beds of central Washington are probably in part of the same age

as the Mascall, and that a similar formation occurs in the Crooked River region to the south. There has been question as to the original extent of the Mascall and discussion of its possible extension over a considerable part of the Columbia lava region east of the Cascades in Oregon and Washington. The purpose of the present note is to call attention to the fact that as studies have been extended by geologists and paleontologists in eastern Oregon and Washington the number of localities representing beds of the Mascall type has gradually increased. It is now important to have a study of the whole area with mapping of the beds of the Mascall stage and careful paleontological determination of the horizons. There is reason to believe that beds of the type of the Mascall may have existed over a considerable part of the Columbia lava region in the latter part of Miocene time. The present occurrences of Mascall may be due to post-Mascall depressions through which certain areas have been subject to relatively less intensive erosion, leaving relics of this formation to be covered in part by later accumulations.

Recent developments in Diesel engines: CHARLES F. KETTERING.

Some notes on the aging of metals: HERBERT M. BOYLSTON (introduced by Albert Sauveur). After an introductory historical sketch of the discovery and development of the phenomenon known as "The Aging of Metals" the important work of Merica, Waltenberg and Scott is reviewed briefly, while the later writings of Jeffries and Archer, Sauveur and W. P. Sykes are reviewed. Some results obtained in the Metallurgical Laboratories of Case School of Applied Science by M. Charlton and E. S. Steigner are then described. Their work included the study of the effect of cobalt additions on the age-hardening properties of iron plus 20 per cent. molybdenum and the age-hardening properties of iron plus 15 per cent. molybdenum. It is shown that these workers were able to increase the Brinell hardness of certain of these alloys by age-hardening from a hardness after quenching of approximately 15 to 43 Rockwell C. (179–352 Brinell) depending on the temperature from which the alloy was quenched and the amount of cobalt in the alloy to a hardness from 46 Rockwell C. (388 Brinell), where the hardness after quenching but before aging was approximately 16 Rockwell C. (183 Brinell), to a Rockwell hardness of C–68 (712 Brinell) in the case of an alloy containing 30 per cent. cobalt, 15 per cent. molybdenum, the balance iron where the hardness after quenching was about 49 Rockwell C (429 Brinell). Steigner, working with an alloy containing 20 per cent. molybdenum and 25 per cent. cobalt, balance iron, was able to increase the hardness from Rockwell C–46.5 (394 Brinell) in the quenched condition to 68.6 Rockwell C. (723 Brinell) when age-hardened. It is also shown that with copper containing approximately 2½ per cent. beryllium the hardness was increased from the as-rolled condition of C–20 (197 Brinell) and the hardness after quenching of C–12 (167 Brinell) to C–40 to 42 (331–346) after quenching from 1,450 deg. Fahrenheit and aging for one hour at 570 deg. Fahrenheit.

The significance of the persistence of the crystalline state above the melting point: ROBERT E. BURK (introduced by E. P. Kohler). To be published later.

The thermal decomposition of ammonia on metallic surfaces: ERIC A. ARNOLD (introduced by Roger Adams). The thermal decomposition of ammonia has been investigated on the surface of ruthenium. It was found that nitrogen as a product had no effect on the speed of the reaction, but the hydrogen had a marked retarding effect. By assuming that the seat of the reaction is the absorbed film of gas on the surface of the metal and further postulating a monomolecular film, an equation has been developed which quite satisfactorily expresses the experimentally observed rates of decomposition. From the assumptions set up, the mechanism of the decomposition of ammonia on ruthenium may be inferred. Similar work is now in progress using rhenium as the metallic surface.

The present status of studies on photosynthesis: O. L. INMAN (introduced by Charles F. Kettering). In recent years investigators in this field have come to realize more and more that the process of photosynthesis is one of the borderlands where radiant energy and chemical synthesis meet. Many chemical reactions in the living organism are brought about by energy derived from the oxidation of some carbon compound, which in turn originated by the reduction of some other carbon compound. However, in the process of photosynthesis, the carbon dioxide is reduced not by energy from some simultaneous oxidation, but by the energy from the sun. Since the living cell of the green plant is the place for this reduction, one is always faced with the problem of analyzing physico-chemical processes taking place in protoplasm. This does not lighten the burden of obtaining a satisfactory understanding of the reactions involved. Workers in this field have found much difficulty in trying to strike an energy balance between the visible light absorbed and the carbohydrates manufactured. Warburg and Negelein made considerable progress in this direction when they found that in the cells of *Chlorella pyrenoides* one molecule of carbon dioxide was reduced for every four quanta of light absorbed. Noack has reported the probability of surface reactions on the chloroplasts with iron acting as a catalyst. Other workers consider magnesium in the chlorophyll molecule as directly linked with the chemical reactions between carbon dioxide and water. One must also bear in mind that diffusion through semi-permeable membranes can not be neglected in dealing with reactions within the living organism. The recent chemical studies of the chlorophyll molecule by Hans Fischer, Conant and others have begun to indicate new lines of attack on the problems of photosynthesis, but much still remains to be done in applying these chemical studies to the mechanism of photosynthesis. Many investigators have been interested in the possibility of a chlorophyll-carbon dioxide compound. Evidence is accumulating that some such chemical combination takes place. The work of Emerson and Arnold, Padoa and Vita and others, as well as our own

experiments, strongly suggest this. Some of our results also point to a definite probability that chlorophyll as a functioning molecule in the chloroplast may be bound to a certain class of proteins. Acetylene has recently been proposed as a possible intermediate compound in the formation of carbohydrates. Artificial photosynthesis or the duplication of the work of the green plant in the laboratory seems rather remote at the present time.

Chlorophyll and the protochlorophyll problem: PAUL ROTHEMUND (introduced by Charles F. Kettering). With the increasing knowledge about the reactions and the structure of chlorophyll the problem of chlorophyll formation becomes important. Some investigators believe that chlorophyll is formed from a colorless precursor, protochlorophyll, chlorophyllogen or leucophyll by oxidation, in general in sunlight. Noack states that Monteverde's protochlorophyll, which occurs in small quantities in plants grown in the dark, is a reduced magnesium containing substance of porphyrin character. On the other hand, the suggestion has been made that protochlorophyll is not the precursor of chlorophyll but rather a decomposition product formed due to special environmental conditions of the plant. In our experimental studies we are considering both of these theoretical interpretations. White and yellow corn was grown in absolute darkness for about two weeks and worked up by a special technique to prevent the material from changing its protochlorophyll into chlorophyll, a change which would occur under the influence of light. Extraction with acetone and transfer into ether yielded a yellow solution exhibiting red fluorescence and a typical absorption spectrum. By using chromatographic adsorption analysis a solution free from yellow plant pigments was obtained. Crystallized material is not available yet. Chlorophyll and pheophytin were reduced according to Noack with iron in 80 per cent. formic acid. The 18 per cent. hydrochloric fraction of the reaction mixture in ether yielded crystals of m.p. 246° containing methoxyl, but no magnesium. The hydrolized product was also prepared. Noack reported mixtures of substances resulting from this experiment. The reduction of chlorophyll or chlorophyll derivatives in pyridine solution with zinc dust and acetic acid was performed in nitrogen and in carbon dioxide atmosphere. The resulting colorless solutions were reoxidized by the oxygen of the air whereby the green color came back. The absorption and fluorescence spectra of the original, the reduced and the reoxidized solutions were studied. Reoxidation causes the formation of several substances; the separation of this mixture is under way. The reduction products obtained by the two methods are different from each other and are also different from protochlorophyll prepared from etiolated plants. Absorption and fluorescence spectra also reveal that the products from the reduction with zinc dust in carbon dioxide are not identical with those formed in nitrogen atmosphere. Details of these investigations will be published elsewhere.

Elements and general Jupiter perturbations of ten Watson planets: A. O. LEUSCHNER. To be published later.

SCIENTIFIC EVENTS

THE RANGE OF THE JAPANESE BEETLE

THE U. S. Department of Agriculture, in its annual survey of the spread of the Japanese beetle, found a well-established infestation at St. Louis, Mo.; a less extensive one at Indianapolis, Ind., and another at Charlottesville, Va. According to Lee A. Strong, chief of the Bureau of Entomology and Plant Quarantine, with these three exceptions, no real infestation came to light outside the beetle's established range in Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, New Jersey, Pennsylvania, Rhode Island, Vermont, West Virginia, Virginia and the District of Columbia.

Through the instrumentality of plants or other materials, Japanese beetles are likely to establish themselves at points remote from the area along the Atlantic seaboard where they are firmly entrenched. To delay long-distance advances, the Department of Agriculture, through the federal plant quarantine, seeks to keep all products that might harbor the beetle from being shipped from infested to non-infested territory.

The largest control program so far undertaken against the Japanese beetle at an isolated infestation is now under way at St. Louis. Lead arsenate provided by the Federal Government is being applied to the soil in the 117 city blocks. The local relief administration is supplying laborers to assist in applying the material and the city fire department is lending hose lines. Similar measures, though on a smaller scale, will go into effect in the limited sections found to be infested in Indianapolis and Charlottesville.

Owing to a curtailment in funds, only 31,000 of the 56,000 traps owned by the Department of Agriculture were used this year. These traps were operated from Virginia to Maine. New catches were recorded in 5 cities in Maine; in 58 Maryland communities, both inside and outside the regulated zone; in Detroit, Mich., where a few beetles have been trapped each year since 1932; in 9 New York cities; in 6 localities in Ohio; at Erie, Pa., where an infestation was discovered in 1931; in 6 cities in Virginia, and at 7 points in West Virginia. In none of these places is the beetle well established. Either the numbers found were too small to constitute real infestations or the beetles present were the survivors of incipient infestations that are not increasing.

The results of the survey are said to show no need for changing the existing quarantine or for bringing