

ABSTRACTS OF PAPERS PRESENTED AT THE CHICAGO MEETING OF THE NATIONAL ACADEMY OF SCIENCES

Some recent advances in the theory of the calculus of variations: G. A. BLISS. Problems of the calculus of variations with variable end-points were considered early in the history of the subject. One of the first was that of finding, among the arcs joining two fixed curves, one down which a particle starting with a given initial velocity will fall in the shortest time under the action of gravity from one curve to the other. When the two fixed curves are replaced by two fixed points the problem is said to have fixed end-points. The case when both end-points are variable was studied by Lagrange in 1762. He made an error which he corrected in a paper of 1770, where he also formulated a much more general problem of the calculus of variations with variable end-points. Since that time the theory of problems with fixed end-points has been highly developed, but the theory of problems with variable end-points has lagged behind. In 1913 Bolza formulated a problem of the latter type which at present seems the most widely applicable. Recent papers by M. Morse and myself have brought the theory of this problem to a stage comparable with that of the theory of problems with fixed end-points. Important improvements were added by M. R. Hestenes while he was my research assistant and in later papers, and by L. M. Graves. Their results afford significant advances for the theory of problems with fixed end-points also, since they are deduced without the assumption of normality on sub-intervals customarily made by preceding writers, and apparently also without any assumptions of normality whatsoever. I have recently discovered, however, that on the basis of their hypotheses one can construct a problem for which the arc considered is normal, though not necessarily normal on sub-intervals, and by means of which the sufficiency theorems of Hestenes can be attained. Thus the normal case still appears to be the most important one. This is the result which I emphasize especially in this paper.

Remarkable results in additive number theory: L. E. DICKSON.

Polynomial approximation on a curve of the fourth degree: DUNHAM JACKSON. At a recent meeting of the American Mathematical Society the writer discussed the formal properties of polynomials in two real variables which are orthogonal on a curve in the plane of the variables. In the simplest cases, when the curve is a line segment or a circle, the resulting series developments reduce essentially to Legendre and Fourier series, respectively, so that in those cases new problems of convergence do not arise. The present paper is concerned with questions of the convergence of polynomial approximation on a particular curve of the fourth degree, for which the results are new in substance as well as in form.

Photoelectric guiding of astronomical telescopes: A. E. WHITFORD and G. E. KRON (introduced by Joel Stebbins). During long photographic exposures the astronomer must

have his eye fixed at the eyepiece of a telescope in order to keep the instrument centered exactly on the object being photographed. The "automatic guider" in this paper delegates this tedious and exacting task to a photoelectric cell. The principal difficulty is the extremely small amount of light available to actuate the mechanism, so that the feeble impulse from a star must be amplified as much as a billion billion times. The use of the new Zworykin electron multiplier has made it possible to extend the working limit somewhat beyond that attainable by conventional methods of amplification. The control is exercised entirely through electron tubes, without mechanical relays. Preliminary tests on the 60-inch telescope of the Mount Wilson Observatory show that the device performs satisfactorily on stars down to about the eighth magnitude. The development of the new instrument is part of a program of research in connection with the 200-inch telescope of the California Institute of Technology.

The colors of stars in a region in Sagittarius: JOEL STEBBINS and ALBERT E. WHITFORD. With a photoelectric amplifier attached to the 60-inch telescope at Mount Wilson, measures of the brightness and color of seventy-five stars were made in a region about five degrees square in the constellation Sagittarius. Most of the stars are in a bright star cloud of the Milky Way, which is bordered by dark areas having the appearance of absorbing clouds of dust in space. Stars which shine through dense portions of the dust are found to be redder than stars out in the clear; the degree of reddening indicates the amount of dust between us and a star. The distances of stars can be measured by triangulation to two or three hundred light-years; farther than that the distances can be estimated by the apparent brightness of the stars. The stars here studied are two thousand light-years away. The region is toward the center of the galaxy, but the center is much farther, about 30,000 light-years, and no telescope will reach the center because of the obscuring dust. Even though this star cloud and others in the neighborhood appear as the brightest parts of the Milky Way, the measured reddening of stars shows that there is a thin veil of dust over this entire region of the sky, while in the opposite direction, away from the center of the galaxy, stars like those in Orion are white because we see them through much less dust.

The empirical mass luminosity relation: G. P. KUIPER (introduced by F. R. Moulton).

The 82-inch reflector of the McDonald Observatory: GEORGE W. MOFFITT (introduced by F. R. Moulton).

Solar activity recorded by the motion-picture method at the McMath-Hulbert Observatory of the University of Michigan: ROBERT R. MCMATH and EDISON PETTIT (introduced by Heber D. Curtis.) The new solar tower of the McMath-Hulbert Observatory of the University of Michigan is located at Lake Angelus, near Pontiac, Michi-

gan. It was completed on the first of July of the present year and is the sixth solar tower in the world in point of time. In certain elements of design, however, it is believed to be the most efficient in existence, and is also certainly the most convenient in use. The paper presented consisted essentially of a motion picture film showing a general view of the new tower telescope of the McMath-Hulbert Observatory and certain important constituent parts of the special mechanisms contained therein. Following the above, the prominences were displayed in motion in sequence according to the classification of Dr. Edison Pettit, of the Mount Wilson Observatory. As far as is known, these pictures are the first continuous large scale records of solar prominences, although in point of time the first successful continuous record of solar phenomena were pictures taken at this observatory on a smaller instrument in June, 1934. Preliminary measurements indicate motions varying from 30 kilometers per second to 150 kilometers per second. The motions of the various types of solar prominences are very well shown by these pictures and afford an astronomer his first opportunity of actually reviewing with his own eyes these motions. We see no evidence that light pressure alone will, in any way, satisfactorily explain the activity of these prominences and all appearances favor an electrical theory of prominence formation, motion and destruction. Also it is apparent that a substantial portion of the material in motion travels towards the sun-spot area. We are indebted to H. E. Sawyer, J. T. Brodie and R. C. Williams, who have acted as solar research assistants during the entire period covered by this film.

A projection method for ascertaining the heights, shapes and dimensions of the surface features of the moon: F. E. WRIGHT. The moon is so nearly spherical in shape that, for local measurements, it may be considered to be spherical without sensible error. A photograph of the moon is a perspective projection of its surface on the diametral plane of the sphere normal to the line of sight. For each lunar photograph the exact time at which the exposure was made is recorded; hence the phase angle (angle at the moon's center between the directions to the centers of the sun and the earth, respectively) is known. If, therefore, an accurate lunar polar perspective projection plot be prepared and superimposed on a given lunar photograph of the same diameter the elevation angle (complement of the angle of incidence) of the sun's rays at any point on the moon's surface can be read off in the projection. If, for example, the angle of elevation of the sun's rays is less than the angle of slope of an inner crater wall, the wall casts a shadow; if the elevation is greater, the slope is illuminated; when elevation and slope angles are equal, grazing incidence is observed. Distances are read off directly on the projection in angular measures, and these in turn are reduced to linear measures by use of a conversion table. The height of a given feature is determined from measured data of measurement on slope angles and distances. This method enables the geologist to ascertain relative heights, depths, shapes and dimensions of lunar surface features with a satisfactory degree of accuracy and with little computation. The measurements are all made with the aid of accurate polar and

meridian perspective projection charts superimposed, usually by optical projection, on lunar photographs. Preliminary measures on photographs taken with the 100-inch telescope at Mt. Wilson Observatory show that the inner slopes of small craters (craterlets) are in general steeper than those of larger craters and walled plains; their slope angles may reach 50° to 55° . The committee of the Carnegie Institution of Washington on study of the surface features of the moon is applying this method to study of the physiography of the moon's surface. To facilitate this study a large series of photographs of the moon during an entire lunation is to be taken in the near future with the 100-inch telescope equipped with a special three-element Ross corrector lens at the Newtonian focus.

The pituitary gland of whales: E. M. K. GEILING. The pituitary gland of whales, which had hitherto not been studied except for the porpoise (Wislocki), offered promise of being suitable material for answering the following question: Where are the active components responsible for the multiple properties of so-called posterior lobe extracts elaborated? Are these principles formed in the pars intermedia, in the pars nervosa or in both? The more detailed anatomy of the hypophysis of whales has just been published by Wislocki and myself. To date four species have been or are being studied by us—the sperm (*Physeter megalocephalus*), the finback (*Balaenoptera physalis*), the blue or sulfur bottom (*Balaenoptera sibbaldii*) and the humpback (*Megaptera nodosa*). In all these species the adult gland is made up of a large, flattened anterior lobe and a smaller neural lobe; the latter is surrounded by a capsule derived from the leptomeninges, as well as by dura and subdural space, and is consequently entirely separated from the anterior lobe. The anterior lobe is embedded directly in the thick dural pad lining the floor of the whale's cranial cavity. There is no pars intermedia or a residual lumen present. The anterior lobe is relatively homogenous in character and is composed of acini of acidophil, basophil and chromophobe cells. With the techniques employed, the neural process is composed of a fibrillar substance containing relatively few well-defined cells and abundant blood vessels. No nerve cells are visible in any part of the neural hypophysis. Hyaline bodies of Herring are present in the neural lobe. Because of the anatomical separation of epithelial and neural lobes, these bodies can not be regarded as a product of any portion of the epithelial hypophysis, but must arise *in situ*. Furthermore, Gersh and Tarr have recently reported experiments indicating that the Herring bodies are artifacts and are not precursors of the pressor, antidiuretic and oxytocic principles. Extracts of the acetone-desiccated posterior lobe powder possess pressor, antidiuretic and oxytocic activity. The pressor and antidiuretic principle is present in the same concentrations as in the standard powder (beef), but the oxytocic principle is present in a much smaller concentration; in the finback and humpback whale there is about 40 per cent., in the blue whale 30 per cent., while in the sperm whale only 8 per cent. of the activity found in an equal weight of the standard powder (McClosky, Miller and LeMessurier). The melanophore principle is not in the posterior lobe, but in the anterior lobe. It is

concluded that the pressor and oxytocic components are elaborated in the neural lobe, and are not derived from the pars intermedia. The anterior lobe has the gonadotropic (follicle-ripening and luteinizing) hormones (the luteinizing principle in relatively smaller concentration, however, than in the sheep anterior lobe), and also the thyrotropic and adrenotropic principles (Lawrence). The prolactin content of the anterior lobe is very low; a good yield of follicle-stimulating hormone was obtained; and the presence of the thyrotropic factor was demonstrated (Riddle and Bates).

The effect of cortin upon the renal excretion and balance of electrolytes in the human being: F. A. HARTMAN, G. W. THORN, HELEN R. GARBUTT and F. A. HITCHCOCK (introduced by C. M. Child). Previous attempts to show a positive effect of cortin in normal subjects have met with little success. It has been found in our experiments that large doses of cortin injected intravenously produce a prompt effect on the kidney of a normal human being. Eighty cat units (three to four times the daily requirement for a patient with severe Addison's disease) administered over a period of four hours caused an average reduction of 42 per cent. in the sodium excretion. Potassium excretion was increased 30 per cent. In balance studies with subcutaneous daily injections of 12 to 30 cat units of cortin (the daily requirement of a severe case of Addison's disease) there was no effect on the electrolytes in eight normal subjects. The amount of hormone was sufficient to cause marked retention of sodium and chloride in patients with Addison's disease. Therefore it seems that there is a normal limit of cortin action beyond which a considerable increase is required to produce further effect.

The adrenal glands in diabetes: J. M. ROGOFF. For nearly thirty years an idea has prevailed that the function of the adrenal medulla plays an important rôle in pancreatic diabetes. In 1907, Zuelzer proposed the view that glycosuria following pancreatectomy is due to diabetogenic action of epinephrine secretion from the adrenals in the absence of antagonistic action of internal secretion of the pancreas. Since then evidence has been offered by various workers to support this view. It has been alleged: *a*, that pancreatic diabetes does not develop in the absence of epinephrine secretion and that interference with epinephrine secretion ameliorates the diabetic condition if present; *b*, that insulin requirement to control pancreatic diabetes is reduced if epinephrine secretion is reduced or suppressed; *c*, that reduction or suppression of epinephrine secretion increases sensitivity to insulin; *d*, that human diabetes is ameliorated or cured by roentgen irradiation of the adrenals or by surgical intervention with the glands to reduce epinephrine secretion. We have found that the development and course of experimental pancreatic diabetes is not modified by reduction or suppression of epinephrine secretion from the adrenals. The range of insulin dosage required to control glycosuria in depancreatized animals with reduced or suppressed epinephrine output is the same as in depancreatized animals not subjected to interference with epinephrine secretion. Sensitivity to insulin does not differ in these two groups. Furthermore, we observed

that liberation of epinephrine sooner or later becomes reduced or suppressed in diabetic animals that have not been subjected to interference with the adrenals. This appears to be due primarily to the diabetic state of the animal, since it was found to occur in depancreatized dogs not treated with insulin as well as the treated animals. Indeed, marked reduction in liberation of epinephrine was found in control, unoperated dogs maintained for some weeks on a diet to which was added 100 grams of sugar daily, with or without administration of insulin. Liberation of epinephrine from the adrenals can be increased by electrical stimulation of the splanchnic nerve, up to or above the normal level, in those animals that show a marked reduction in output. In view of these observations, based upon quantitative investigations of epinephrine secretion from the adrenals in relation to diabetes, we consider the evidence for the conclusions stated by Zuelzer, and supported by others, untenable. Obviously, treatment of diabetes by roentgen irradiation of the adrenals or by surgical intervention with the glands or their nerves is not fundamentally sound. Such practices involve danger of irreparable damage to the indispensable adrenal cortex.

The character of the estrus-inhibiting substance in testis-tissue extracts: D. R. L. DUNCAN, T. F. GALLIGHER and F. C. KOCH (introduced by F. R. Lillie). Crude male-hormone preparations from testis tissue inhibit the normal estrus cycle in adult rats. Some investigators have interpreted this physiological response as due to the inhibiting action of the male hormone on the hypophysis. Our studies show that further fractionation of the testis male-hormone preparations involving the purification of the male-hormone fraction shows that the estrus-inhibiting activity is concentrated in the lipin fraction free from male hormone and particularly in the phospholipin fraction, but that the male-hormone activity does not parallel the inhibiting action. Lecithin and cephalin obtained from these products produce the same inhibition in doses equivalent to the original crude product. Crude choline and choline obtained by hydrolyzing these phospholipins or pure choline and choline prepared synthetically produce the same inhibition. Pure testosterone in doses twenty times those found in our crude testis-tissue concentrate do not inhibit the estrous cycle. We conclude that the estrus-inhibiting action in crude testis-tissue male-hormone concentrates is due to the phospholipins and not to the male hormone.

Enterogastrone: Proof of the existence and methods of assay: A. C. IVY (introduced by Ludvig Hektoen). Enterogastrone is a chalone which is produced by the intestinal mucosa, when an adequate amount of fat or sugar and possibly other substances enter the intestine, and which acts to reduce the motility and secretion of the stomach. The observations upon which the existence of enterogastrone is based are: (1) The introduction of fat or sugar into the intestine inhibits the motility and secretion of an autotransplanted pouch of the stomach or of a stomach whose intrinsic nerves have been sectioned. This unequivocally establishes the existence of a humoral or blood-borne agency. (2) The injection of dextrose, fatty chyle or the products of the digestion of sugar and

fat intravenously does not inhibit motility or secretion. This shows that the inhibition is not due to the absorption of the products of digestion of fat and sugar. (3) Appropriately made extracts of the mucosa of the upper intestine yield a substance which, when injected intravenously or subcutaneously, inhibit gastric secretion and motility, and which possess a number of the aspects of specificity. The steps in the proof remaining to be supplied are the chemical isolation of the substance and its identification in the blood or lymph. The substance has not been sufficiently concentrated to warrant its parenteral injection into a human subject. A unit of enterogastrone is that quantity, which when injected intravenously in a 12 to 14 kg dog with a pouch of the entire stomach and receiving sufficient histamine subcutaneously at 10-minute intervals to maintain a uniform flow of 1 cc of gastric juice (5 mg HCl) per minute, causes a 50 per cent. reduction in the secretion of hydrochloric acid during two hours following the injection of enterogastrone. Five one-hundredths of a unit will inhibit the movements of a stomach distended by a balloon containing 100 cc of air for about six minutes; one unit for about fifty minutes.

Mode of action of parathyroid extract on bone: FRANKLIN C. MCLEAN and WILLIAM BLOOM (introduced by A. J. Carlson). Very large doses (1,000 units) of parathyroid extract were administered to growing rats. Within six hours many of the osteoblasts died; the majority, however, changed into fibroblasts or osteoclasts, or became phagocytic. Within twelve hours a large proportion of the bone cells were necrotic, especially in the rapidly growing spongiosa of the long bones, and the number of osteoclasts had greatly increased by development from osteoblasts and reticular cells. Within twenty-four hours the necrotic bone tissue had been largely resorbed and replaced by scar tissue, containing a large number of osteoclasts, thus producing the typical picture of osteitis fibrosa generalisata. Recovery occurred by extensive intramembranous formation of new bone, accompanied by development of large numbers of active osteoblasts from the fibroblasts of the scar. These observations throw new light on the pathogenesis of experimental osteitis fibrosa, which appears to develop, in part at least, as a reaction to the death or injury of the cellular elements of bone. Of more general biological interest is the evidence that osteoblasts are not permanently differentiated cells, for they have been seen to change into phagocytes, osteoclasts and fibroblasts; further, fibroblasts have been seen to develop into osteoblasts which were then associated with the formation of new bone. This, then, is an example of controlled reversible cellular differentiation.

The mechanical efficiency of the heart as a measure of its fitness: M. B. VISSCHER (introduced by F. R. Lillie). In these studies, the oxygen consumption of the heart and the work performed by it were measured as described by Peters and Visser. The dog's heart in the Starling Heart-Lung preparation was employed. Previous work, particularly by Starling and collaborators, has shown that the energy liberation with variations in load on the heart is determined by the length of the muscle fiber at the

beginning of contraction. The fiber length is obviously determined by the volume of the ventricles of the heart, so it can be stated that volume of size of the heart at the end of diastole is the factor determining the liberation of energy in the succeeding contraction. Hearts were made to work for periods long enough to permit them to undergo acute failure and the quantities of energy liberated and work performed measured. The hearts were made to work at constant diastolic volume, that is, initial fiber length. Two important interrelated facts became apparent. First, as the heart became less able to perform work the energy output per contraction at uniform initial fiber length remained virtually constant. Obviously in this type of heart failure the defect is not a progressive inability of the muscle to liberate a normal quota of energy upon contraction. There is rather a failure on the part of the muscle in its ability to convert as large a fraction to useful work. Thus there was found to be an important decrease in the efficiency of heart muscle in the process of failure. The fact previously referred to, namely, that the heart automatically adapts itself to its load by increasing its volume and thus its energy liberation when it is unable to eject as much fluid per unit of time as enters it, necessitates that in order for a failing heart to carry a uniform load it must dilate. Thus a heart which must dilate greatly to perform a small load of work is an inefficient machine. In clinical terms such a heart is ordinarily described as having poor tone. In physical terms the tone of the heart muscle is shown by these studies to be in reality synonymous with its mechanical efficiency or its fitness to carry its load. In a further series of experiments the mechanism of action of certain cardiac drugs was investigated in relation to this question. It was found that the most useful glucosides of the digitalis series, employed in therapeutic doses (about 0.1 mgm per liter of blood) showed a prompt and large effect in restoring the efficiency of failing hearts toward the normal. It seems likely that these agents have their beneficial action through this mechanism. A new experimental criterion for the evaluation of cardiac drugs is available by the use of these methods.

The regulation of body temperature by the hypothalamus: S. W. RANSON (introduced by C. J. Herrick).

The rôle of stimulative and inhibitive induction in the development of primary and secondary sex characters: EMIL WITSCHI (introduced by F. R. Lillie). Previous studies showed that in the development of the vertebrate gonad the cortex acts as an inductor of ovarian differentiation and the medulla as an inductor of testicular differentiation. Thus sex is determined on the basis of a competition between two inductors, each of which stimulates differentiation of one sex and tends to prevent development of the other. New experiments on the nature of the inductors are presented which support the following conclusions: (1) Each inductor has a double function, stimulative and inhibitive. (2) Stimulative induction is transmitted from the inductor to the reacting tissues mainly by direct contact and therefore spreads only over a narrowly limited district. (3) Inhibitive induction has always a

wider range and in the extreme assumes the character of a typical hormonal reaction, transmitted by the blood stream. (4) It appears therefore that each inductor produces and releases at least two different inductive substances which are designated as *cortexin* + and *cortexin* - in the case of cortical products and *medullarin* + and *medullarin* - in the case of medullary products. (5) These inductive substances are not identical with the sex hormones of the mature sex glands which control the functional development of secondary sex characters.

Effect of galactic rotation on cosmic rays: ARTHUR H. COMPTON. Because of the rotation of the galaxy, the earth moves at about 300 km per second toward R.A. 20 h 40 m and declination 47° N. As a result of this motion, Dr. Gettling and the author predicted a variation with sidereal time of about 0.1 per cent. (within a factor of 2) at 45° latitude and a difference of intensity between 45° N and 45° S latitude of about 0.5 per cent. During the past year the existence of a sidereal variation of the predicted amplitude and phase has been reported in the northern hemisphere by W. Illing, and in the southern hemisphere by B. F. J. Schonland and his collaborators. New measurements by R. N. Turner and the author provisionally confirm likewise the predicted difference between the northern and southern hemispheres. This quantitative confirmation of the predictions implies: (1) The astronomer's estimate of the rate and direction of galactic rotation is roughly confirmed, and no indication appears of a motion of the Milky Way as a unit relative to the source of cosmic rays. (2) The source of most of the cosmic rays is beyond our galaxy. (3) The agreement with prediction is satisfactory only if the cosmic rays are electrically charged particles.

Approximately relativistic equations for nuclear particles: G. BREIT (introduced by A. H. Compton). Cosmic ray showers indicate that at high energies the forces between protons and neutrons are intimately concerned with the creation and destruction of matter. Complete theories of the nucleus will, therefore, probably contain these phenomena as an integral part, and a full inclusion of the principle of relativity in the theory of the nucleus is presumably impossible without bringing in the electro-neutrino field or its equivalent. At present no satisfactory view of this kind is available. For most practical purposes it is nevertheless possible to form much simpler theories, including the effects of relativity and allowing one to compute the interactions between orbits and spins of nuclear particles. In this paper possible forms of such theories are enumerated. By means of them the fine structure of energy levels in the nucleus can be calculated. Comparison with experiment is made and is found to be satisfactory.

The intermediate product in nuclear reactions and disintegration in steps: WILLIAM D. HARKINS. (Read by title.)

Anisotropy in the atomic vibrations of zinc crystals as revealed by the scattering of x-rays: G. E. M. JAUNCEY (introduced by Joseph Erlanger). About a year ago

Brindley and Spiers reported anomalous intensities for certain x-ray reflections at room temperature from powdered zinc crystals. These anomalous intensities indicated that the thermal vibrations of the atoms in a zinc crystal have larger amplitudes in the direction of the c-axis than in a direction perpendicular to this axis. Somewhat later Zener derived a theoretical formula for the mean square displacement in a direction ψ with the c-axis of a hexagonal crystal like zinc. This formula was immediately put to test in the author's laboratory. The method used was that of the diffuse scattering of x-rays from single large crystals. This method has the great advantage in this type of investigation that the mean displacement can be measured at a given angle of scattering for as many values of ψ as one desires. On the other hand, the powdered crystal method gives the mean displacement at a given angle of scattering for only one value of the angle ψ . We used Cinnamon's method for growing single crystals of zinc with different respective orientations ψ . We found that the root mean square displacements for liquid air and room temperatures are as shown in the table

ψ	100°K	298°K
0°	.103 Å	.172 Å
90°	.054 Å	.093 Å

These values are considerably larger than Zener's theoretical values. However, when Brindley and Spiers's anomalous reflection values are corrected for these thermal displacements they give values for the atomic structure factors of zinc which are those required by wave-mechanics when dispersion is taken into account.

The constitution of the borates: W. H. ZACHARIASEN (introduced by A. H. Compton). Through crystal structure determinations of several borates it has become possible to state some of the principles which govern the constitution of this class of substances: (1) Boron is either tetrahedrally surrounded by four oxygen atoms or triangularly by three oxygen atoms. (2) No oxygen atom is bonded to more than two boron atoms. (3) Not more than one oxygen atom is bonded to the same two boron atoms. Furthermore, the experimental work has led to accurate values for the interatomic distances and for the bond angles involved. A criterion can also be given which to some extent enables one to predict whether the coordination number for boron in a given case is three or four. The constitution of borates, particularly with reference to the polyborates, will be discussed on the basis of these principles. It will be shown how the glass-forming tendency of many borates can be explained from their constitution.

The ruling and testing of diffraction gratings: HENRY G. GALE (introduced by A. H. Compton). By greatly reducing friction in the new ruling engine at the Ryerson Physical Laboratory, we have succeeded in making diffraction gratings of very uniform spacing. It is now possible to study the effect of errors introduced automatically and to compare the resulting effects with those predicted by theory. A grating ruled with perfectly uniform spacing, a_0 , will give in any order, N , a single sharp image of a monochromatic spectrum

line. If, however, the spacings, instead of being constant, vary sinusoidally with an amplitude a_1 , and with a fixed period, false images appear on each side of the parent spectrum line. These false lines are called Rowland ghosts. Professor Rowland showed that the intensities of the parent line and of the 1st, 2nd, 3rd, etc., ghosts may be calculated from the Bessel functions of $(2\pi N \frac{a_1}{a_0})$ of order zero, 1, 2, 3, etc., respectively. The new ruling engine performs so consistently that it has been possible to confirm Rowland's theory experimentally. An experimental comparison has also been made of the relative sensitiveness of knife-edge and interference tests of optical surfaces, and they have been found to be about equally sensitive. Both methods have been applied in testing concave and plane diffraction gratings. Knife-edge tests are very convenient and sensitive for testing the error of run in concave gratings, and interferometer tests are simple and convenient in testing the periodic error in plane gratings. Knife-edge tests may be used to detect departures from straightness in the rulings, when these departures are too minute to affect the definition. In ruling gratings on speculum metal, minute particles of speculum sometimes stick to the diamond point and cause it to fail to rule, often for a good many lines. This difficulty has been overcome for several years by covering the surface with a layer of oil a few millimeters thick. The oil keeps the diamond point washed clear of speculum particles.

Absorption spectra of the rare earths in crystals: SIMON FREED and RAYMOND J. MESIROW (introduced by W. D. Harkins). The absorption spectra of salts of ytterbium (the chloride $\text{YbCl}_3 \cdot 6\text{H}_2\text{O}$, the acetate $\text{Yb}(\text{C}_2\text{H}_3\text{O}_2)_3 \cdot 4\text{H}_2\text{O}$ and the ethylsulfate $\text{Yb}(\text{C}_2\text{H}_5\text{SO}_4)_3 \cdot 9\text{H}_2\text{O}$) were found to resemble those of cerium very closely, especially in their diffuseness even at low temperatures. This is in marked contrast with the sharp spectra of the other rare earths. The resemblance was anticipated on the supposition that the 13 electrons in the 4f shell of Yb^{++} , one short of the maximum the shell can hold, would give rise to but one term 2F , the same term as the electron of Ce^{++} in the same shell gives rise to. That is, activations aside from fine structure are impossible when the 13 electrons remain in the 4f shell. This prohibition is derived from the Pauli exclusion principle as it is applied to gases. The lattice, however, may possibly modify the application of this principle. It was thought likely that the activated states of these ions in crystals would respond to any change in the application of the principle the lattice might impose. The spectra show that the principle holds for these ions in crystals in exactly the same way as it does in gases. Strong confirmation is obtained that the sharp spectra of the other rare earths consist of "forbidden transitions," arising from a change in coupling among the electrons of the 4f shell.

Electronic structures of molecules: ROBERT S. MULLIKEN. Work of the writer on the electronic structures and spectra of molecules is illustrated by some examples. Comparing isoelectronic molecules, analogous energy lev-

els and spectra can be traced, but the energy order and degree of degeneracy of the levels, and the locations of corresponding spectra, vary greatly with the symmetry and the chemical constitution. Among isoelectronic sets which have been studied are: N_2 , CO , C_2H_2 , HCN ; B_2H_4 , O_2 , C_2H_4 , CH_2O ; F_2 , H_2O_2 , NH_2OH , N_2H_4 , CH_3OH , CH_3NH_2 , C_2H_6 ; CH_3 , NH_2^+ , NH_3 , H_2O^+ , OH ; BeF_2 , BOF , BO_2^- , NCF , NCO^- , CO_2 , N_2O , N_3^+ . Another type of comparison is between a molecule and its chemical homologues (e.g., O_2 , SO , S_2 ; or H_2CO , H_2CS); or between a molecule and its chemical derivatives (e.g., C_2H_4 , $\text{C}_2\text{H}_5\text{Cl}$, $\text{C}_2\text{H}_5\text{Cl}_2$, etc.; CH_4 , CH_3Cl , CH_3Br , CH_3I , CH_2Cl_2 , etc.; H_2CO , Cl_2CO , etc.). By making comparisons of these various kinds, including cross-comparisons, and trying to fit the available data into a (qualitative or partially quantitative) theoretical framework based on quantum mechanics, it has been possible to arrive at rather definite conclusions in many cases as to the natures of the electronic structures, energy levels and spectra, including continuous spectra. The results can be rather well expressed by assigning electron configurations to the various molecules and molecular states, and giving ionization energies for the various types of orbital (i.e., one-electron orbital wave function) which appear in these configurations. Also, comparison of molecular ionization potentials with one another and with related atomic potentials gives information about charge-distribution or polarity in molecules (example, the $p\pi$ potential in I, HI, CH_3I , $\text{C}_2\text{H}_5\text{I}$, etc.).

(To be continued)

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