of the analyses, and Dr. E. B. Renaud for some of the literature references.

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THE NATIONAL ACADEMY OF SCIENCES

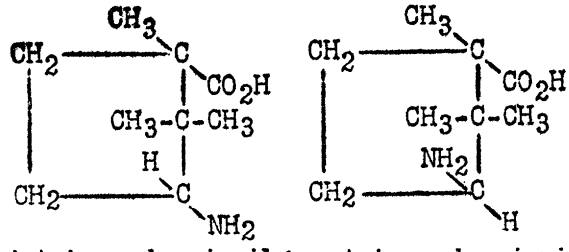
AT the annual meeting of the National Academy of Sciences held in Washington, on April 26, 27 and 28, the following papers were presented:

A crystalline-diazo compound of the camphor series: WILLIAM A. NOYES and FORREST E. KENDALL.

Chiles and Noyes (*J. Amer. Chem. Soc., 44,* 1798 (1922)) succeeded in preparing six optically active, aliphatic diazo compounds in which the only asymmetric carbon atom was that connected with the diazo group. Levene and Mikeska (*J. Biol. Chem., 55,* 595 (1923)) have also obtained optically active diazo compounds, though they failed to confirm some of the work of Noyes and Chiles.

The diazo compounds prepared were all liquids and had small rotatory power. It seems very desirable to prepare crystalline compounds, if possible, and also compounds giving a greater rotation.

It seemed possible to realize these conditions by the preparation of diazo compounds from *cis-* and *trans-*aminocamphonanic acids, which have the following configurations:



cis-Aminocamphonanic acid *trans*-Aminocamphonanic acid

The diazo compound of the methyl ester of the *cis* acid has been obtained by treating an etherial solution of the anhydride of the acid with sodium methylate, washing the solution of the diazo compound with water, freezing out the water at $-80°$, concentrating in a current of dry, carbon dioxide-free air at a low temperature and crystallizing from ether at $-80°$. So far as we have been able to learn, this is the first diazo compound having the group in the gamma position with reference to an ester group. The compound has a rotation of approximately 410.

To demonstrate the asymmetry of the diazo group in this compound it will be necessary to prepare the corresponding compound from the *trans* isomer. The work on this is not yet complete.

Atomic formation and disintegration, and separation of isotopes: PROFESSOR W. D. HARKINS.

The synthesis of 2-phenyl-benzoselenazole-4'-arsonic acid and of some other benzoselenazoles: PROFESSOR MARSTON TAYLOR BOGERT and ARTHUR STULL.

o-Chloronitrobenzene is converted into the o-nitrophenyl diselenide and the latter reduced to the zinc salt of o-aminophenyl selenophenol. By the action of aldehydes or acid halides upon this amino selenophenol, benzoselenazoles are obtained in excellent yield. When nitrobenzaldehydes or nitrobenzoyl chlorides are employed, 2-nitrophenyl-benzoselenazoles result, which can be readily reduced to the corresponding amino derivatives. Application of the Bart reaction to these amines gives the corresponding arsonic acids, the alkaline salts of which are freely soluble in water and are now being tested pharmacologically.

The products are therefore water-soluble organic arsenicals containing selenium as part of the molecule, and represent one phase of the exploratory work now being conducted at Columbia University to determine the therapeutic value of organic selenium derivatives as well as to gain additional knowledge concerning the chemistry of this group.

The alleged constancy of our physico-chemical constants; the metastability of naphthalene: ERNST COHEN, GEORGE HENRY BRANDES and JOHN CALVIN KELLER (by invitation).

New evidence in favor of a dual theory of metallic conduction: PROFESSOR EDWIN H. HALL.

Professor Bridgman has recently discovered a development of Peltier effect heat where an electric current changes direction within a metal crystal, and he has expressed the opinion that none of the well-known theories of electric conduction would lead us to expect such an effect. The dual theory, by means of a formula published several years ago, readily explains this phenomenon, as Professor Bridgman at once admitted when this formula was brought anew to his attention.

Professor Millikan has still more recently announced that, by experiments and reasoning of his own, he has been led to the conclusion that most of the electrons which maintain an electric current within a metal do not share the energy of thermal agitation, while the thermions, which he thinks responsible for thermoelectric action, do share this energy. This evidence appears to give strong support to conceptions which have long been held and repeatedly expressed in the development of the dual theory.

Applied to the results of Bridgman's experiments on the electrical and thermal behavior of metals under high pressure, the dual theory appears to be helpful in establishing a rational relation between the various effects observed.

Determination of excitation potentials of soft X-rays: K. T. COMPTON and C. H. THOMAS, Princeton University.

By soft X-rays we refer to radiation emitted from solids when bombarded by electrons whose energies correspond to a fall through potential differences from 5

to 2,000 volts and which may be expected to have wave lengths between 2,000 and 5A. This is the largest spectral region which is almost unexplored, but overlaps the extreme ultraviolet region at one end and the known X-ray region at the other. The non-penetrating and nearly non-reflecting character of this radiation has prevented its study by spectroscopic methods. It may be detected, however, by its photoelectric action in causing the emission of electrons from a neighboring electrode. If this photoelectric current is plotted as a function of the voltage at which the radiation is excited, there are discontinuities in the curve which probably are to be explained as minium voltages at which particular parts of the radiation can be excited. These critical voltages V lead to an estimate of the wave lengths of the radiation λ by the substitution in Einstein's photoelectric equation $V = \frac{300\ hc}{e\lambda} - \phi$, which has been verified for radiation of both longer and shorter wave length than that in this soft X-ray range. A method of spectroscopy in this region consists therefore in an accurate determination of the critical voltages V.

Unfortunately this determination is difficult. There are several causes of spurious discontinuities in the curves, leading to false values of V. Also these discontinuities are generally so slight as to escape detection or to be masked by the errors due to the limited accuracy of observations. Thus the only consistent agreement in previous work has been in connection with the few most prominent discontinuities.

We have made a study of the causes of spurious discontinuities and especially of methods for increasing the precision and sensitivity of this method. By special design to make the currents as large as possible, by unusual precautions to insure steadiness in the electrical circuits, by a balancing method of measuring galvanometer currents and by a new method of using an electrometer we have been able to measure the currents involved in the experiment accurately to 1 part in 10,000 and to secure absolute steadiness at this sensitivity. This has enabled us to plot the first or the second derivatives of the original curves, making calculations by a computing machine, and thus so to magnify discontinuities in the current-voltage curves as to make the method one of real precision.

By this method numerous elements of the soft X-ray spectrum have been discovered which were incapable of detection by the former methods. The soft X-ray spectra of Fe, Co, Ni, Cu, C and W are shown to be rich in lines and to raise interesting problems of interpretation and classification. Slides are shown to explain the method and illustrate the results.

Links connecting fluorescence and the luminescence of incandescent solids: PROFESSOR E. L. NICHOLS.

Various white and refractory solids—particularly oxides—at certain stages of incandescence have been shown to greatly exceed in brightness a black body of the same temperature and have therefore been described as *luminescent.*

In addition to the criteria justifying the term, which were noted at the time of the original experiments (1922), new facts connecting the phenomenon intimately with fluorescence have recently been discovered. These are:

(1) That traces of an activating element in solid solution in the incandescent material will enhance the brightness of luminescence many fold.

(2) That the luminescence of these activated solids occurs at a transformation temperature which is characteristic of the activator and independent of the solvent.

(3) The intimate relation between the emission spectrum of the incandescent body and the fluorescence spectrum of a solid containing the same activator.

Some thermionic experiments with a new source of positive ions: C. H. KUNSMAN (introduced by K. T. Compton).

Fused mixtures of very pure artificial magnetite and about 1 per cent. of an alkali or alkaline earth oxide furnish a very good source of positive ions when used as a hot anode in a vacuum. This source compares favorably with the present thermionic sources of electrons in ease of operation and control. The advantage of this source over that of a hot platinum strip is shown. The effect of reducing the mixture in hydrogen was to increase the positive emission about ten fold. Barton and Harnwell, of Princeton, have shown conclusively by a mass spectrograph analysis of this emission that the positive current consists only of singly charged particles of the alkali metal or alkaline earth metal which was introduced in the original mixture in the form of a salt.

Since, for a considerable range of temperature, this emission obeyed Richardson's equation, $I_+ = A\,T^{\frac{1}{2}}\,\epsilon^{-\phi e/kT}$, definite and reproducible values of φ_+, the equivalent work function in volts for the alkali or alkaline earth metal ions were obtained. The value of φ_+ for K ions vaporizing from an Fe–K mixture was 2.10 volts and for Cs ions vaporizing from an Fe, Al, Cs mixture was 2.37 volts. In the case of an Fe–Ba mixture, the Ba ion emission was quite constant at sufficiently high temperatures where appreciable electron currents were also obtained. φ_+ was 2.01 volts for Ba when φ_- for the reduced surface was 3.60 volts, where both ion and electron currents were measured for a given temperature throughout a range of from 1075 to 1300° Kelvin. The electron affinity, φ_-, of the surface is larger than φ_+, therefore the Ba atom is robbed of one of its outer electrons on vaporizing from the surface. However, φ_- is not large enough to remove both outer electrons, as no doubly charged Ba ions were observed in the mass spectrograph studies.

Capillary condensation and adsorption: PROFESSOR WILLIAM C. BRAY and HAL. D. DRAPER.

There are presented typical results of measurements of the sorption of water vapor at 25 per cent. on the partially hydrated oxides, copper oxide, manganese dioxide, and mixtures of these oxides, in the form of porous granules. In every case, 85–90 per cent. of the

sorption took place at pressures greater than half the vapor pressure of pure water. Other examples of this type of sorption isotherm are cited, and it is pointed out that earlier investigators have demonstrated that the sorption at the higher pressures is due to condensation of liquid in capillaries. In the case of copper oxide, the radii of the capillaries range from 15 Ångstrom units to about 150.

Evidence is presented that the true adsorption at lower pressures in an entirely different phenomenon from capillary condensation, and is a necessary precursor to it. The latter will occur only when the surface (covered with the adsorbed monomolecular layer) is sufficiently curved. It is suggested by J. W. McBain and the writers that, for materials which are highly adsorbent at low pressures such as charcoal or partially dehydrated hydroxides, the structure is a very open or incomplete lattice or lattices *into the spaces of which the individual adsorbed molecules penetrate.*

Changes in the rate of rotation of the earth and their geophysical consequences: PROFESSOR ERNEST W. BROWN.

The first part of this paper is a summary of our knowledge of the apparent deviations of the moon from its gravitational orbit, including in the latter the effects of tidal friction. The oscillatory and other characteristics of these deviations are again discussed. The second part is a similar discussion for the motion of the earth round the sun. In both cases an attempt is made to separate out the portions which are due to errors of observation. It is concluded that the remaining deviations give good evidence of the hypothesis originally made by Simon Newcomb when he discovered the lunar deviations, namely, that both sets of variations are due to variations in the rate of rotation of the earth. It is shown that the strongest part of this evidence has only been available within the past ten years.

Granting that the rate of rotation of the earth is variable it is next shown that the only hypothesis which can account for it with any semblance of probability is a variability in the earth's moment of inertia and that this must involve changes in the external radius. The extreme limits of these changes are 5 inches to 12 feet according to the hypothesis made as to the depth of the source from which the changes originate. The former corresponds to uniform changes of radius throughout the whole mass of the earth; the latter to forces at a depth of 50 miles which merely raise or lower the crust of the earth.

Geophysical evidences of such oscillations are next considered. The inequalities of the crust will necessarily require that seismic effects of all kinds appear. Some further evidence of a correlation between earthquake periodicities and the variation of the earth's rate of rotation is given, in addition to evidence of a similar character brought out by Professor H. H. Turner, of Oxford, some years ago. It is pointed out that many other geodynamical effects such as mountain building, the maintenance of isostasy, tidal waves, are much simplified by the hypothesis. These oscillations taking place in periods of the order of a few years to a century or two are compared with oscillations taking place in geological periods hypothecated by Professor Joly a short time ago. The latter assumed them as the supposed thermal effects of radium in the interior of the earth. No hypothesis as to the chemical or physical cause of the short period oscillation, deduced by astronomical and mechanical arguments in the present paper, is put forward.

The elasticity of dunite and its bearing on the composition of the earth: L. H. ADAMS and R. E. GIBSON (introduced by Arthur L. Day).

The significance of volcanic gases found in hot springs: DR. ARTHUR L. DAY (illustrated).

The Californian Orogenic Period: PROFESSOR BAILEY WILLIS.

The central fact of the Californian orogenic period is the great batholith of the Sierra. Its known superficial area is 25,000 square miles, its probable area is three times that figure, and its volume presumably several hundred thousand cubic miles. The rock, so far exposed, is granodiorite with some more acid facies. Although large, this mass is not the largest among similar batholiths, it being exceeded by that of Lower California and that of British Columbia. The date of intrusion of the batholith in California was Upper Jurassic. The epoch of the gestation of the magma preceded that time. The effects as manifested in the uplift of successive mountain masses extend down to the present and have not yet come to an end. The Californian orogenic period thus covers geologic time since the Triassic.

The existence of the batholith raises a number of questions: what was its origin and manner of intrusion; what have been the mechanical effects of the presence of so large and so rigid a mass in the outer earth's crust upon the character of the deformation which the latter could undergo; what metamorphic changes might develop in the deeper portions of the batholith and what would be their effect in developing compressive stresses; what relation would such effects have to the great difference of elevation which actually exists between the Pacific deep and the Sierra summits; what force may be inferred to have acted to produce the orogenic developments and what variations of conditions may be postulated to account for their mode of action in this particular case.

The paper presented alternative answers to some of these problems and pointed out the direction of a reasonable hypothesis.

Studies of Pleistocene phenomena of Ohio River basin: FRANK LEVERETT (introduced by T. C. Chamberlin).

Studies in Ohio and West Virginia in 1925, toward which a grant of $500 was made from the Joseph Henry Fund, are a continuation of studies begun in 1924 in Indiana and Kentucky, which have for their main object the clearing up of the early Pleistocene history of the district tributary to Ohio River. This involves not only a mapping of the extent of each of the drift sheets, but

also the determination of the extent to which a ponding of water outside the ice border was produced, and the effect of such ponding in developing the present system of drainage, which is widely different from the preglacial drainage. Attention was also given to the amount of work done by the Ohio and some of its tributaries since each of the glacial stages. This throws light upon the relative dates of the different glacial stages. The studies in 1925 have shown that it was at the earliest stage of glaciation, known as the Jerseyan, that the main filling of the old north flowing drainage lines took place, the clay deposits in some of them being more than 100 feet thick. Since that time the streams have removed much of this clay, and have cut down 150 to 200 feet or more into the underlying rock formations. Much of this excavation was over with by the time of the third or Illinoian glacial stage, but the part of the Ohio above Wheeling seems not to have been fully excavated at that time. It reached its full depth, however, before the last or Wisconsin stage of glaciation.

It was probably at the Jerseyan stage that the ice-sheet reached its greatest extent in the Ohio drainage basin, though its limits were not greatly different from those of the third, or Illinoian, drift, and the general direction of ice movement seems to have been about the same in both stages, a southwestward movement from the Labrador peninsula. The drift of the second, or Kansan, glacial stage may be represented in the old drift of northwestern Pennsylvania, and in copper, and copper bearing rocks, brought into Ohio and Indiana by a southward ice movement from the Superior basin, which is out of harmony with the Jerseyan and the Illinoian ice movements.

Two new faunas in the marine Upper Triassic of Nevada: TIMOTHY W. STANTON (introduced by David White).

In the Triassic of the Tonopah and Hawthorne quadranges, Nevada, two faunas of Noric age have recently been discovered, both of which are later than the *Tropites subbullatus* fauna. The older of these consists chiefly of pelecypods, especially *Myophoria, Ostrea* and *Pinnigena,* and the other contains many ammonoids, including *Cladiscites* aff. *tornatus, Rhabdoceras* and *Rhacophyllites.*

Relations of European and American lower Paleozoic systems (illustrated): E. O. ULRICH.

Criteria in stratigraphic correlation: E. O. ULRICH.

Some phases of evolution in microfossils: R. S. BASSLER (introduced by E. O. Ulrich).

Some features of the structure of southeastern Idaho (illustrated): G. R. MANSFIELD (introduced by David White).

Physical and biological effects of high-frequency sound-waves in water: PROFESSOR R. A. WOOD and ALFRED L. LOOMIS.

High-frequency sound waves, of periods from 100,000 to 400,000 generated by a piezo-electric plate of quartz excited at 60,000 volts by an electrical oscillator of 2,000 watts output. The wave-length in water varies from a centimeter to a few millimeters, and small fish, worms and paramecia are killed in less than a minute by the sound-waves. If the beam of sound is directed towards the surface of the water, the surface is heaped up in a mound. The vibrations heat the water, a rise of 5° C. in one minute having been recorded.

Objectives of a fundamental study of Middle American civilization (illustrated): JOHN C. MERRIAM and SYLVANUS G. MORLEY.

The structure of living cells (film by Heinz Rosenberger): ALEXIS CARREL and ALBERT H. EBELING (introduced by Victor C. Vaughan).

The interpretation of the Michelson-Morley experiment in the light of the observations of the years 1925 and 1926: DAYTON C. MILLER, Case School of Applied Science, Cleveland, Ohio.

A complete study of the ether-drift experiments for 1925 and 1926 leads to the conclusion that there is a systematic displacement of the interference fringes of the interferometer corresponding to a constant relative motion of the earth and the ether of ten kilometers per second; and that the variations in the direction and magnitude of the indicated motion are exactly such as would be produced by a constant motion of the solar system in space, with a velocity of 200 kilometers, or more, per second, towards an apex in the constellation DRACO, near the pole of the ecliptic, which has a right ascension of 262° and a declination of +65°. In order to account for these effects as the result of an ether drift, it seems necessary to assume that, in effect, the earth drags the ether so that the apparent relative motion at the point of observation is reduced from two hundred, or more, to ten kilometers per second, and further that this drag also displaces the apparent azimuth of the motion about 45° to the west of north.

A recalculation of the earlier experiments by Michelson and Morley in 1887, and by Morley and Miller in 1904, has been made showing that they are entirely consistent with the present result. The question then arises, "Why is the magnitude of the effect less than would be expected on the stagnant ether and why is the direction of the effect at Mount Wilson deflected to the westward?" It seems necessary to reconsider the Stokes theory of the ether or the Lorentz-FitzGerald theory of contraction.

The present state of the problem of stellar evolution: PROFESSOR HENRY NORRIS RUSSELL.

Recent advances in atomic physics have led to a great increase in our understanding of internal conditions in the stars. We now know that, inside a star, the atoms have their outer parts knocked off, but retain their individuality, and it is possible to calculate at what rate heat should escape from the interior to the surface, and,

therefore, how bright the stars should be, if we know how large and massive a star is and how much denser it is in the interior than at the surface. It is well known that stars of the same mass are all about equally bright, no matter of what size they may be. It may be shown that this is a necessary consequence of the known general laws of ionization and opacity—considerable difference in the distribution of internal density affecting very little the amount of heat which escapes from the surface. The outstanding problem is to find where the heat radiated by the stars comes from, and in what manner it is liberated inside them. The existing evidence indicates that the heat is probably produced by a slow transformation of matter into energy after the manner first suggested by Einstein. The laws governing this process can at present be investigated only by a study of the stars themselves. It can be shown that, if all the stars were of exactly the same composition, stars of the same mass would be not merely similar in brightness, but also similar in size, color and temperature. This is not the fact, and it follows that some stars must contain more than others of the "active material," which is the source of heat.

It appears that the observed facts can be accounted for by assuming that there are two kinds of active material, both of which are transformed more rapidly the higher the temperature. For the first, the rate of transformation is nearly the same at all pressures. For the second, low pressure, as well as high temperature, favors the production of heat.

It can be shown that a star of given mass will automatically adjust its diameter and internal temperature until the rate of production of heat from one or other of these active substances is just sufficient to balance the radiation from the surface. If a large number of stars of different masses should come into existence in any manner, they would adjust themselves, probably within a few millions of years, so as to exhibit just such relations between mass, brightness and color, as are actually found in star clusters and among double stars. It is therefore no longer necessary to assume that different stars in the same cluster are of very different ages, as had to be done on the earlier theories.

What the life-history of a star would be depends upon the proportion of active material in its composition. If, as seems probable on the whole, this originally forms the larger part of the star's mass, a star of large mass will start as a red giant, gradually become hotter and whiter, and finally cool down and end as a faint dwarf star. Stars of smaller mass may begin their careers as dwarf stars without ever passing through the giant stage. White dwarf stars, like the companion of Sirius, may be accounted for as cases in which one of the two kinds of active material has been completely used up; and stars of all known types appear to find a place in the scheme. These conclusions differ from those reached recently by Dr. Jeans. The writer believes that certain of Dr. Jeans's conclusions, while mathematically sound, on the assumptions which he has made, do not correspond with the conditions that are actually met with in the stars.

Barro Colorado Island as a station for the study of tropical life (illustrated): FRANK M. CHAPMAN.

On painting eclipses and lunar landscapes (illustrated): HOWARD RUSSELL BUTLER (introduced by H. N. Russell).

Designs of a building devoted to general education in astronomy and related sciences (illustrated): HOWARD RUSSELL BUTLER (introduced by Henry Fairfield Osborn).

Orbit of a minor planet (100) Hekate: A. O. LEUSCHNER and H. THIELE.

The discovery of eclipsing stars: PROFESSOR JOEL STEBBINS.

Observations with the spectroscope reveal motions of certain stars which can be explained by their having large companions or planets. The periods of revolution of many of these attendant bodies are very short, even as small as one or two days. By choosing the proper time for light measurements, it is found that among the cases known in advance to be favorable fully one half of these double systems present eclipses as viewed from the earth. A study of the variation of the light of a star during an eclipse makes it possible to calculate the diameter of both the bright star and its dark or faint companion. As an illustration, it is noted that two stars moving in space parallel to the stars of the Big Dipper, and presumably belonging to that system, have each been found to have satellites. It is shown that each of the bright bodies is twice as heavy and gives one hundred times as much light as the sun, so that the latter would make only a mediocre planet for any star of the Big Dipper.

These observations are taken with the photo-electric cell, the same instrument that is used for transmission of pictures over telephone wires. The observer measures the light of stars by timing their effect on a delicate electrometer, attached at the eye-end of the telescope, and it is literally true that it is possible to measure and weigh a star by means of a stop-watch.

On the frequency of parallel proper motions among the stars: PROFESSOR FRANK SCHLESINGER.

Yale Observatory has recently issued a catalogue of the positions and proper motions of more than 8,000 faint stars between declinations 50° and 55° north. A discussion of these proper motions reveals many cases of stars separated by several degrees of arc whose proper motions across the sky are sensibly parallel and equal in amount. To make certain in any particular pair or group of cases that the motions are parallel in space, we should have to know the radial velocities, and these in general are not at present forthcoming. But the frequency with which the proper motions come out the same is much greater than can be due to chance and indicates that most of these cases represent true equality and parallelism of motion. If this view is correct it implies that star streaming is a common phenomenon.

(To be concluded)