JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOLUME II, 1912

PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST AND SEPTEMBER, WHEN MONTHLY,

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
THE WAVERLY PRESS
BALTIMORE, MD.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. II, JANUARY 4, 1912. No. 1.

PHYSICS.—*Wave lengths of Neon.* IRWIN G. PRIEST. Communicated by S. W. Stratton. To appear in the Bulletin of the Bureau of Standards, **8**: No. 4. 1912.

Ten wave-lengths in the spectrum of neon have been determined by the method of flexure with reflection fringes previously described.[1]

The following values result from a long series of determinations.

TABLE

5852.4862 I.A.	±0.0003
5881.8958	±0.0005
5944.8344	±0.0003
6074.3383	±0.0004
6096.1608	±0.0004
6143.0600	±0.0006
6266.4948	±0.0005
6304.7929	±0.0005
6382.9882	±0.0005
6402.2392	±0.0003

The probable errors are in every case less than one part in 10,000,000. Confirmatory results and counter checks indicate that the values given are accurate within about one or two thousandths of an Ångström unit. A detailed discussion of the accuracy will appear in the complete paper.

PHYSICAL CHEMISTRY.—*The hydrolysis of sodium oxalate and its influence upon the test for neutrality.* WILLIAM BLUM, Bureau of Standards. Communicated by C. E. Waters. To appear in the Bulletin of the Bureau of Standards (Reprint No. 178) and in the Journal of the American Chemical Society.

In connection with the testing of sodium oxalate for use as a primary standard in acidimetry and oxidimetry, a knowledge

[1] Bulletin Bureau of Standards, **6**: 573. 1911.

of its normal alkalinity is essential. Calculations based on the generally accepted theory of hydrolysis, using the most probable values of the dissociation constants, indicate, that in a decimolar solution of sodium oxalate, $[H^+]_{18°} = 2.0 \cdot 10^{-9}$. In such a solution phenolphthalein should be converted into its pink salt to the extent of 7.8 per cent, if we accept the simple theory of indicators, and employ the value $1.7 \cdot 10^{-10}$ as the dissociation constant of phenolphthalein. Pure sodium oxalate was prepared by recrystallization in platinum of two samples, containing respectively slight excess of acid and alkali. After two crystallizations, products of uniform and constant alkalinity were obtained; which was accepted as the criterion of purity. This material was found to produce a color equal to only 4 per cent transfromation of phenolphthalein instead of the calculated 7.8 per cent. Calorimetric comparisons with solutions based based upon Sörensen's E.M.F. measurements indicate that $[H^+]_{18°}$ for 0.1 M sodium oxalate is $2.5 \cdot 10^{-9}$, and that the salt is hydrolyzed at 18° to the extent of 0.0024 per cent. The error involved in a titration for neutrality, if this "normal alkalinity" is neglected, is only about 0.02 per cent, which is practically negligible in all analytical work. It was found that, contrary to statements of Sörensen, sodium oxalate solutions do not decompose on boiling, but that in glass they do become more alkaline, due to the attack of the vessel. Of various kinds of glass tested, "Durax" was found to be most resistant to such solutions. It was also found that commercial samples of sodium oxalate may contain "excess CO_2," either as $NaHCO_3$ or as occluded CO_2; which is not readily expelled at 240°C. Before testing the neutrality of sodium oxalate it is therefore necessary to boil the solutions in quartz or Durax to expel such CO_2.

EVOLUTION.—*Evolution in discontinuous systems.*[1] I. ALFRED J. LOTKA. Communicated by J. A. Fleming.

In the minds of most of us the term "evolution" is associated probably more closely with the biological than with the physical

[1] Paper read before the Philosophical Society of Washington on November 11, 1911.

sciences. Yet the concept is essentially physical in character, and is definable in exact terms probably only in the language of physics. For in its last analysis we may define evolution as *the history of a material system undergoing irreversible transformation.* To the physicist, therefore, the study of evolution is essentially the study of irreversible changes, and the law of evolution is the law of increasing entropy, or, more generally, of the increasing probability of the successive states of any real material system.

Now among the infinite variety of changes of which matter is susceptible, there is a certain class which stands in a measure apart—the so-called "changes of state" in the narrower sense.

If an iron rod is placed in the fire, its temperature rises gradually, and finally the rod may become incandescent. In a perfectly general sense we might speak of this as a "change of state." It is customary, however, to restrict the use of this term to denote such changes as that from ice to water, from water to steam, and so forth. What distinguishes these changes, and places them in a class by themselves, is their discontinuity.

In general the state of a material system may be defined by indicating the values of a number of suitably chosen variables $x_1, x_2. \quad . \quad . \quad ,$ and changes in the state of the system then naturally find expression in terms of the changes in the values of these variables. Now in the case of "change of state" in the narrower sense certain of these variables are masses $M_1 M_2. \quad . \quad . \quad ,$ for the system is composed of a number of separate portions $A_1 A_2 \quad . \quad . \quad . \quad ,$ differing from one another in their properties in a discontinuous manner. The mass M_i of any one A_i of these separate portions is in general susceptible of change by the transformation of matter of the species A_i into other forms A_j, $A_k \quad . \quad . \quad .$ It is this passage of matter from one such portion of the system into another or into others, which constitutes "change of state" in the narrower sense.

If, as we noted above, the separate portions $A_1 \, A_2 \quad . \quad . \quad .$ of which the system is composed, differ from one another in a discontinuous manner, implicitly this conveys the idea, that each portion for itself is in some sense continuous (not necessarily as regards distribution in space). In the realm of physical chemis-

try this continuity shows itself on the one hand in the so-called "phases," on the other hand, in a somewhat different form, in the "chemical individuals," i.e., elements, compounds, dissociates, associates, etc. Quite generally such a continuous portion of a discontinuous system shall be called a "continuum."

Now, aside from the continua known to us in the field of physical chemistry, there are other material aggregates of a very different kind, which display the same continuity, each within itself, while each is fenced off from the others of the same system by a discontinuity: the biological species are of this character.

The term "species" is here used provisionally, as being the word in our existing vocabulary which most nearly expresses my meaning. For the sake of exactitude and to avoid conflict with biometricians, who have appropriated the term "species" for use in a more restricted sense, it will be preferable to employ some other phrase, such as "kindred-group," to denote a group of organisms that stand in blood-relationship to one another, either actually or potentially.[2]

It is worth while to note in passing, that the cause of the continuity within a kindred-group lies in its mode of growth: A germ of the parent-substance serves as the nucleus for the formation of the young individual, which, by heredity, resembles its parent. This is what Wo. Ostwald[3] has called "autocatakinetic growth," in analogy with the autocatalytic growth of the solid phase upon a crystal germ introduced into a supersaturated solution.

Two other types of aggregates deserve brief mention. In the beehive, the anthill, or a human community we have instances of a "social continuum." Such a continuum comprises a number of different social elements joined together in a definite, though not invariable proportion, a proportion essential for the proper functioning and life of the continuum. Such an aggregate also

[2] Barren hybrids, such as the mule, are here to be left out of account; in nature they will presumably never number more than a small proportion of the total of the crossed groups.

[3] Über die zeitlichen Eigenschaften der Entwickelungsvorgänge; published by W. Engelmann, Leipsic 1908, in the series "Vorträge und Aufsätze über Entwickelungsmechanik der Organismen," edited by W. Roux; p. 36.

grows by autocatakinesis, each new portion added resembling in general character the original stock.

The third and last type of biological aggregate which we shall note here is seen in its fullest development in connection with the human race. From the moment when man learnt to till the soil, to raise cattle, and so forth, when therefore the crop in the field, the herd upon the pasture grew in synchronism and in *controlled proportion* with the human population, from that moment man, together with the plant and animal stock raised and nurtured by him, formed one "economic continuum." This again grows by autocatakinesis, and is seen in its most highly developed type in modern civilized man and his agricultural, industrial, commercial and political equipment.

To recapitulate, we have noted the following types of continua:

1. Physical continua—Phases.

2. Chemical continua—Elements, Compounds, Associates, Dissociates.

3. Biological continua—(a) Physiological: Kindred-Groups (Species). (b) Sociological: Societies. (c) Economical: Economic systems.

A complete discussion of the subject of "Evolution in Discontinuous Systems" should, then, cover all those "changes of state," in which any of the types of continua noted in our table are suffering changes in *character* or in *mass*. It would therefore include the physics of change of state, the whole of physical chemistry, the study of radioactive transformations, and the discussion of certain biological, sociological, and economic questions.[4] I propose to restrict myself here on the one hand to considerations relating to the subject as a whole, as embodied in this introduction, and on the other hand to the treatment of one or two specific examples which have not hitherto received much attention from this point of view.

A point has just been touched, which requires our more detailed consideration: the dual character of the changes to which a continuum is subject, namely changes in character and changes

[4] Compare A. J. Lotka, Am. Jl. Sci. 24: 216, 1907, the first paragraph of the summary.

in mass. The simplest example in point comes to us from physical chemistry. In general a change of state, such as crystallisation from a supersaturated solution, involves a change in composition, as well as in mass, of one or more phases.

When we turn to biological systems, composed of a number of "kindred-groups," we observe an analogous state of affairs. In general the individuals comprised within a kindred-group are not all precisely similar. Thus, expressing the matter analytically, out of a total N_1 of individuals of some group A_1, a certain fraction

$$N_1 C_1 (p, q, r, \quad . \quad . \quad . \quad) \, dp \, dq \, dr \, . \quad . \quad .$$

will have the values of certain characteristic features P, Q, R, . . . comprised between the limits

$$\begin{array}{l} p \text{ and } (p + dp) \\ q \text{ and } (q + dq) \\ r \text{ and } (r + dr) \\ \quad . \quad . \quad . \quad . \quad . \quad . \end{array}$$

A similar statement holds for each of the other groups A_2, A_3, . . .

As time goes on both the values of N_1, N_2, . . . will in general change, and also the form of the frequency functions C_1, C_2, . . . In other words, the matter of the system undergoes a change in distribution: (1) among the several kindred-groups; (2) among the several types of individuals of which each group is composed. The former change may be spoken of as "Inter-Group Evolution," the latter as "Intra-Group Evolution."[5]

It is intra-group evolution, the change in time of the character of a species, with the possibility of the origin of a new species as its outcome, which has hitherto mainly engaged the attention of the biologist.

We, on the contrary, will here turn our attention chiefly to certain aspects of inter-group evolution.

[5] Annalen der Naturphilosophie, p. 69. 1911.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

PHYSICS.—*The density and thermal expansion of linseed oil and turpentine.* H. W. BEARCE. Bulletin of the Bureau of Standards. 1912.

Sixteen samples of linseed oil and twelve samples of turpentine were examined with a view to determining their physical and chemical characteristics; special attention was given to the density and thermal expansion. Tables have been prepared for obtaining the densities of these substances at temperatures between 10° and 40° C. from their densities at a single temperature; also conversion tables for changing pounds to gallons and gallons to pounds. H W. B.

PHYSICAL CHEMISTRY.—*Preliminary report on the ternary system* $CaO-Al_2O-Si_3O_2$. *A study of the constitution of Portland cement clinker.* E. S. SHEPHERD and G. A. RANKIN, with optical study by FRED. E. WRIGHT, Geophysical Laboratory. Journal Industrial Engineering Chemistry, **3**: 1. 1911.

In the earlier work with mixtures of pure lime and silica, two compounds, the metasilicate ($CaO.SiO_2$) and the orthosilicate ($2CaO.SiO_2$), were definitely established, but no trace of the hitherto generally accepted tricalcic silicate ($3CaO.SiO_2$) could be found in mixtures of pure lime and pure silica. In the three-component system, on the other hand, the tricalcic silicate appears promptly with the addition of alumina to mixtures of appropriate lime-silica concentration, and after a long and difficult experimental investigation, involving the study of about 1,000 heat treatments of various compositions, many of which required to be studied at temperatures between 1800° and 1900° C., it has finally been prepared pure, excepting for a small excess (between 1 and 2 per cent) of orthosilicate or lime or both.

Tricalcic silicate appears to be unstable at its melting temperature, and so does not form from a melt of this composition. For the same reason, it does not form eutectics with the adjacent compounds, calcium

orthosilicate and lime. Neither is there any evidence that the tricalcic silicate takes up calcium orthosilicate or lime in solid solution.

In addition to the tricalcic silicate, a new and probably unstable form of the orthosilicate has been discovered which may prove to be of importance in Portland cement.

The general boundaries of the different phases occurring throughout the entire diagram of the ternary system $CaO-Al_2O_3-SiO_2$, have been established, together with the course of the boundary curves. From these it is possible to predict the compounds which will crystallize out of a lime-silica-alumina cement of any composition, provided only that the compounds are intimately mixed and the heat is sufficient to bring the mixture to equilibrium during formation. The exact location of the quintuple points, with the exception of points 13 to 17, and the isotherms remains to be established. The location of these quintuple points is as follows:

POINT	17	16	15	14	13
CaO	59.5	58.5	52.8	49.2	48.5
Al_2O_3	32.5	33.0	40.5	44.0	42.0
SiO_2	8.0	8.5	6.7	6.8	9.5

Portland-cement clinker within the concentration limits set by Richardson, *when in equilibrium*, may exist in the following combinations, depending primarily upon relatively small changes in the quantity of lime present:

I	II	III	IV	V
CaO	$3CaO.SiO$	$2CaO.SiO$	$2CaO.SiO_2$	$2CaO.SiO_2$
$3CaO.SiO_2$	$2CaO.SiO_2$	$3CaO.Al_2O_3$	$5CaO.3Al_2O_3$	$2CaO.Al_2O_3SiO_2$
$3CaO.Al_2O_3$	$3CaO.Al_2O_3$	$5CaO.3Al_2O_3$	$CaO.Al_2O_3$	$CaO.Al_2O_3$

Richardson's typical cement corresponds to class II. The relative cement-forming value of the above mixtures has yet to be determined. The more intimate the mixture of the raw material, and the more uniform the heat treatment, the closer will be the approach to equilibrium and therefore to constant relations and the more uniform the behavior of the final product. Classes III and IV are predicted from the general direction of the boundary curves and the quintuple points 14 and 15. Class V will occur in cements low in lime and will differ only in the relative amounts of the different phases from pure slag cements whose compositions lie below the line joining the calcium orthosilicate and

$2CaO.Al_2O_3.SiO_2$ compositions. Type V is dependent on the nature and location of point 13 and is to be regarded as tentative.

If solid solutions are formed they are very limited in extent and are not sufficient to affect the optical properties of either silicate, the lime or the aluminate. This fact serves to give greater definiteness to the problem and an unexpectedly clear field for studies of the cement-forming quality of clinkers of nearly related composition but different chemical constitution. It therefore seems inevitable that such studies will lead to more reliable standards in cement practice.

The diagram indicates that the constitution of slag cement will be seriously affected by relatively small differences of composition in the neighborhood of the line joining the compounds calcium orthosilicate and $2CaO.Al_2O_3.SiO_2$. It is, however, unwise to draw positive conclusions about the character of this portion of the diagram until it has been more carefully studied.

Incidentally, it has been observed that Fe_2O_3 appears *not* to form solid solutions with CaO, $2CaO.SiO_2$, or $3CaO.Al_2O_3$. It does appear to react in some way with $5CaO.3Al_2O_3$, but the nature of this reaction has not yet been studied. Attention should also be called in passing to the important fact that Fe_2O_3 dissociates at about 1400° with the formation of Fe_3O_4.

Finally, too great importance can not be given to the constant use of the microscope in cement study and practice. It is not improbable that microscopic examination will eventually provide much of the information desired about the constitution of test samples, with the advantage over chemical methods of giving immediate results.

It remains to determine the isotherms of the diagram and to determine whether or not the five typical "clinkers" possess any differences in properties when hydrated to form cement. The work on the isotherms is well under way. E. S. S. and G. A. R.

MINERALOGICAL CHEMISTRY.—*The mineral sulphides of iron.* E. T. Allen, J. L. Crenshaw, and John Johnston; with Crystallographic Study by E. S. Larsen. Am. J. Sci. (In press.)

The formation of iron disulphide was accomplished (1) by the action of hydrogen sulphide on ferric salts, or the action of sulphur and hydrogen sulphide on ferrous salts; (2) by the addition of sulphur from solution to amorphous ferrous sulphide or pyrrhotite; (3) by the action of soluble polysulphides on ferrous salts; (4) by the action of soluble thiosulphates on ferrous salts according to the equation $4M_2S_2O_3 + Fex_2 = 3M_2SO_4$

$+ FeS_2 + 2Mx + 3S$. The first three methods may be generalized as *the action of sulphur on ferrous sulphide:* (1) in acid solutions; (2) in nearly neutral solutions; and (3) in alkaline solutions, since in (1) we may assume that ferrous sulphide first forms by the action of hydrogen sulphide on the ferrous salt, and in (3) we know that polysulphides first precipitate a mixture of ferrous sulphide and sulphur. Marcasite was obtained with certainty only by method (1); low temperatures and free acid favor its formation. A solution containing about 1 per cent of free sulphuric acid at 100° gives pure marcasite. Less acid solutions at higher temperatures give mixtures of marcasite and pyrite. The other methods give pyrite, which, under certain conditions, may be mixed with amorphous disulphide. It is possible that some marcasite may be formed by method (4).

Marcasite and pyrite were identified in the above products: (1) by microscopic examination and crystallographic measurement. Marcasite crystals with the proper axial ratio were prepared for the first time; (2) by Stokes's oxidation method. This method serves also for the analysis of mixtures of the two minerals.

Marcasite changes to pyrite with evolution of heat. The change proceeds very slowly at 450° and is not accelerated by pressures even of 10,000 atmospheres. Marcasite is monotropic toward pyrite. This is in accord with the greater inclination of marcasite to oxidize, its assumed greater solubility, and the fact that its formation is conditioned by the composition of the solution from which it crystallizes.

The fact that marcasite never occurs as a primary constituent of magmas, while pyrite sometimes does, is explained by the fact that marcasite can not exist above 450°. The formation of pyrite in deep veins and hot springs is explained by the fact that the waters from which it came contained no strong acid. The marcasite of surface veins was probably formed from cold acid solutions, while mixtures of marcasite with pyrite were probably conditioned by higher temperature (up to 300° or 400°), or the presence of less acid, or both. Micro-organisms may have been active in the formation of pyrite and marcasite by giving rise to hydrogen sulphide.

Pyrrhotite was formed by the decomposition of pyrite or by heating marcasite, or by heating iron with excess of sulphur. The dissociation of pyrite into pyrrhotite and sulphur is readily reversible. At 565° (about) pyrite and pyrrhotite are in equilibrium with the partial pressure of sulphur in H_2S, which here amounts to about 5 mm. (data of Preunner and Schupp); at 550° in hydrogen sulphide, the pyrrhotite

passes into pyrite, and at 575° the reverse action proceeds. At about 665° the evolution of sulphur from pyrite becomes rapid and a marked absorption of heat results. The pressure of the sulphur-vapor here reaches one atmosphere.

Pyrrhotite is of variable composition. Its composition at any temperature depends on the pressure of sulphur-vapor in which it is heated. Tho it has not been found feasible to vary the temperature and pressure independently, a series of products were prepared by first decomposing pyrite and then reheating the resulting material to various measured temperatures in hydrogen sulphide and then chilling in the same or cooling in nitrogen. The products lowest in sulphur were obtained in the latter way. These products all resemble natural pyrrhotite in physical and chemical properties. Their specific volumes vary continuously with composition and pyrrhotite is therefore to be regarded as a solid solution of sulphur in ferrous sulphide. The maximum percentage of dissolved sulphur in synthetic pyrrhotite was 6.04 per cent at 600°. By extrapolation the saturated solution at 565°, below which point pyrite forms, was estimated to be 6.5 per cent. This corresponds closely to the maximum percentage of sulphur reported in natural pyrrhotite.

Equilibria between pyrrhotite and the partial pressure of sulphur in dissociated hydrogen sulphide were determined at different temperatures, by sufficiently long heating and then rapid cooling. The dissolved sulphur varied under these conditions from 6.0 per cent at 600° to 2.0 per cent at 1300°. The curve shows a discontinuity at the melting temperature, at the beginning of which there is a sudden decrease in the percentage of sulphur.

The melting-point of pure ferrous sulphide could not be exactly determined, because the compound dissociates at high temperatures into its elements. By heating it in a vacuum this dissociation was placed beyond doubt, though the dissociation was so slow that the melting-point could be located approximately. It may safely be put at 1170° ± 5°. In hydrogen sulphide, the melting temperature is raised because the solid solution thus formed contains more sulphur than the first portion of liquid to which it melts. The limits of the melting interval can not be determined as yet, but the maximum heat absorption falls at 1183°. In one atmosphere of sulphur-vapor this temperature rises to 1187°.

Crystals of pyrrhotite, the measurements of which are recorded under the crystallographic study, were repeatedly formed at various temperatures between 80° and 225° by the action of hydrogen sulphide on slightly

acid solutions of ferrous salt containing some ferric salt. The product usually contained some crystals of disulphide.

Troilite is only the end-member of the pyrrhotite series and not a distinct mineral species. Thus far it has not been prepared free from metallic iron. E. T. A.

PHYTOPATHOLOGY.—*The control of the chestnut bark disease.* HAVEN METCALF and J. FRANKLIN COLLINS. Farmers' Bulletin U. S. Department Agriculture No. 467. Pp. 24, figs. 4. 1911.

This bulletin describes the chestnut bark disease and recommends methods for its control. This disease, caused by the fungus *Diaporthe parasitica* Murrill, first came prominently to the public attention in 1904, and since that time has proved itself perhaps the most serious tree disease known to science. First noted in the general vicinity of New York City, it has now spread into at least ten States. It attacks the American chestnut, the European chestnut, the chinquapin, and, rarely, the Japanese chestnut; but so far has not been found growing parasitically outside of the genus *Castanea*. The total financial loss is now estimated at $25,000,000. If the disease is not controlled thru human agency, there appears to be no reason to doubt that the chestnut tree will become largely extinct in North America within the next ten years. The fungus gains entrance at any point where the bark is broken, borers' tunnels forming the most common means of entrance. From the point of entrance, the disease spreads primarily in the inner bark and produces characteristic lesions which girdle the tree at the point attacked.

Conspicuous symptoms are the development of bunches of sprouts below the girdling lesions; the half-formed yellowish leaves in the spring on the previously girdled branches; the reddish-brown leaves on branches girdled in summer, and the yellow, orange, or reddish-brown pustules of the fruiting fungus on the bark. It is practically useless to attempt systematic location of the disease from October to April, inclusive.

The spores may be carried considerable distances on chestnut nursery stock, tan bark, and unbarked timber; also by birds, insects, squirrels, etc., which have come in contact with the sticky spore masses. Water quickly dissolves these spore masses and the minute spores are in this way carried along with water, as, for instance, with rain water running down a tree.

The only known practical way of controlling the disease in a forest is to locate and destroy the advance infections as soon as possible after they appear and, if the disease is well established near by, to separate

the area of complete infection from the comparatively uninfected area by an immune zone. Advance infections should be located by trained observers and destroyed by cutting and burning. As the disease develops almost entirely in the bark, this must be completely destroyed (burned).

In order to carry out the above methods it is essential that the several States concerned secure necessary legislation and appropriations, following the example of Pennsylvania, as no law exists whereby the federal government can undertake such work and coöperation among private owners without State supervision is impracticable.

Chestnut nursery stock should be rigidly inspected for the disease and only perfectly healthy plants passed.

The life of valuable ornamental trees may be greatly prolonged by promptly cutting out all diseased areas and removing all disease-girdled branches and then covering the cuts with tar. Spraying is of no use in stopping the fungus after it has once started growth in the bark.

It is recommended that owners of infected woodland cut down and utilize the diseased chestnut timber as soon as possible.

For the present the planting of chestnuts anywhere east of Ohio is not advised, but there is no apparent reason why chestnut orchards west of Ohio may not be kept free from the disease. H. M

PHYTOPATHOLOGY.—*Root knot and its control.* Ernst A. Bessey, Bureau of Plant Industry. Bulletin No. 217, pp. 89, 3 pl., 3 figs. 1911.

The disease known as root knot is abundant in sandy soils thruout the warmer parts of the United States and more sporadically in other regions. It is due to the attack of a nematode, *Heterodera radicicola* (Greef) Müller, a near relative of the European sugar beet nematode, *H. schachtii.* The disease was first recognized in Europe in 1855. Its first mention in print in this country seems to be in the latter part of the eighties altho it had been observed by florists in greenhouses as early as 1876. It has been found to be present in North and South America, West Indies, Europe, Asia, Africa, East Indies, Australia and Hawaiian Islands. It seems to be tropical in its origin, probably having been native to the Old World. A list of plants susceptible to root knot is given, including 480 species, on 291 of which the author observed the parasite himself, the highest previous list including only 235 host plants. The plants included represent almost all of the more important families of dicotyledons and monocotyledons as well as one gymnosperm and one

fern. They include both herbaceous and woody plants and annual, biennial and perennials. The anatomy and development of the parasite is discussed, followed by a comparison between this nematode and the one causing the disease of the sugar beet in Europe, they having been shown to be decidedly distinct as long ago as 1890 by Voigt. It is shown that the chief method of introducing the pest into a new location is by means of live plants, especially nursery stock, and when once introduced, it spreads from place to place in the soil adhering to tools, hoofs of animals, wagons, etc. The presence of the nematode within the roots causes hypertrophy of the tissue resulting in a gall. These galls are usually confined to the roots but in some cases were seen to occur on the stems, leaves and fruits where these have come in contact with infested ground. The water-conducting tissues within these galls are very much twisted and dislocated so that when the galls are abundant, the plants are subject to wilting much more easily than the uninfected plants. These fleshy galls also form the center of infection for various parasitic fungi. Conditions favoring root knot are high temperature and sandy soil with plenty of moisture altho the soil must not be entirely saturated. This pest is practically inactive at a temperature lower than 10° C., but is able to survive in unprotected soils at −35° C. The control of root knot is discussed under the following headings: Greenhouses, seed beds, etc.; in the field with no crop present; and in the field occupied by perennial crops. In the first, live steam is most satisfactory altho fresh soil can be used if obtainable nematode free, and formaldehyde, one part of 40 per cent solution to 100 parts of water, is successful under certain conditions. In the field with perennial crops, practically no treatment is satisfactory except the stimulating of the plants to abundant growth by the use of extra amounts of fertilizers. For exterminating the pest in fields not occupied by perennial crops, rotation methods with non-susceptible crops were the most successful. Those that were most successful in the South were the use of Cowpeas ((*Vigna unguiculata*), Velvet Bean (*Stizolobium deeringianum*), Florida Beggar weed (*Meibomia mollis*). Only the non-susceptible varieties of the first can be used, for example, the variety known as Iron. These are grown as summer crops and in the fall rye or oats is sown. Two years of each crop is necessary to free the field and in some cases perhaps three would be more successful. There seems to be considerable promise in breeding varieties that are non-susceptible to the trouble. E. A. B.

FORESTRY.—*Reforestation on the national forests.* WILLIAM T. COX. Bulletin Forest Service, No. 98. 1911.

Next to the importance of protecting the national forests from fire and disposing of the mature timber to secure good natural reproduction is the task of starting forest growth upon the vast areas of untillable mountain lands which have been rendered unproductive by fires, insects, and other agencies. Of this class of land within the national forests there are approximately 7,500,000 acres which must be artificially sown or planted. The policy of the Forest Service in artificial reforestation on the national forests is first, to conduct experiments to find out what can be done, and what is the best way to do it; second, to reforest by direct seeding where this is possible; and third, to plant nursery seedlings where direct seeding is too uncertain. In selecting sites for artificial reforestation preference is usually given in the following order: First, watersheds of streams important for irrigation or municipal water supply; second, lands which produce heavy stands of quick-growing trees; third, lands suitable for the production of especially valuable species, or where conditions are favorable for improving the character of the forest; fourth, sites which offer good opportunities for object lessons to the public in the practice of forestry; and fifth, denuded lands which have no special claim for attention except that they will grow some kind of trees. The Forest Service itself collects most of the seed of native tree species needed for planting on the national forests. This is done usually for considerably less than the seed would cost if purchased from regular collectors of seed growers. During the autumn of 1910 it collected 107,780 pounds of native tree seed, and purchased 54,100 pounds of the seed of European species, a total of 161,780 pounds. There are three methods of collecting cones; from felled trees, from standing trees, and from squirrel hordes. The cones are dried and the seed extracted promptly after collection. Some cones can be opened by spreading them on canvas sheets to dry in the sun. Other species must be taken to the drying house and opened by artificial heat.

Of the two methods of artificial reforestation—direct seeding and planting—the first offers for certain species on many of the national forests by far the greater promise of success. In general, hardy trees, the seed of which is easily and cheaply obtained, can be reproduced satisfactorily by direct seeding, while species like red pine, which bear small crops of seed that are difficult to collect, can be reproduced more cheaply by planting. W. T. C.

FORESTRY.—*Columbian mahogany: Its characteristics and use as a substitute for true mahogany.* GEORGE B. SUDWORTH and CLAYTON D. MELL. *With a description of the botanical characters of Cariniana pyriformis.* HENRY PITTIER. Circular Forest Service, No. 185. 1911.

One of the best imitation mahoganies now marketed is the so-called Columbian mahogany *Cariniana pyriformis*, Miers. It is not true mahogany, but belongs to an entirely different family of trees, the monkey-pod family, *Lecythidaceae*. The true mahogany, *Swietenia mahagoni*, Jacq., is a member of the family *Meliaceae*, to which the well known China tree belongs. Tho the consumption of material passing in the markets as mahogany amounts annually to about 40,000,000 feet, the cut of real mahogany is only about 18,000,000 feet. How long the wood of *Cariniana pyriformis* has been used in the United States for mahogany is not known. It has been exported from Cartagena, Columbia, to Havre, France, for more than thirty years, and there sold in immense cargoes as genuine mahogany. Practically all of the "Columbian mahogany" now marketed is cut at points from 100 to 200 miles inland, and shipped from Cartagena. Columbian mahogany and true mahogany are as botanically unlike as an oak and a maple, but a superficial resemblance in the grain and color of their woods has made it possible to substitute the Columbian wood for the other. It seems possible now when the demand for mahogany is greater than the supply that there could be accepted use for such woods as *Cariniana pyriformis*, acknowledged not to be mahogany, but which are so similar to it in color, grain effects, and working qualities, as to serve for the rarer wood. There should be no objection to calling such woods by their proper names.

Cariniana pyriformis first became known botanically in 1874, while true mahogany was first described in 1760. Adequate information regarding the botanical characteristics of *Cariniana pyriformis* and of the structural nature of the wood has never before been published.

G. B. S.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 41st annual (701 regular) meeting was held on December 9, 1911, President Day in the chair. The meeting was devoted to hearing the annual reports of the secretaries and the treasurer, and to the election of officers for 1912. The following were chosen:

President: E. B. Rosa. Vice-Presidents: C. G. Abbot, G. K. Burgess, W. S. Eichelberger, L. A. Fischer. Treasurer: L. J. Briggs. Secretaries: W. J. Humphreys, R. L. Faris. General Committee: Wm. Bowie, E. Buckingham. E. G. Fischer, J. A. Fleming, B. R. Green, D. L. Hazard, R. S. Harris, P. G. Nutting, F. A. Wolff.

R. L. Faris, *Secretary.*

THE BOTANICAL SOCIETY OF WASHINGTON

The 76th regular meeting of the Society was held at the Cosmos Club, Tuesday, December 5, 1911. President W. A. Orton presided. Thirty-three members were present.

The following papers were read:

Thrips as pollinators of beets. Harry B. Shaw.

Thrips tabaci were observed to be numerous on seed beets in Utah. They were always abundant on flowering racemes, as many as 190 being collected from one small branched raceme. They were not observed to interfere with seed production. On the contrary, it appeared more probable that they acted as agents of pollination. An examination showed them to bear numerous pollen grains scattered about their bodies. As many as 140 beet pollen grains being counted on one adult thrips. An experiment, started August 7 and 8, 1911, under carefully arranged isolation conditions on emasculated beet flowers, resulted in 17.2 per cent of the flowers to which thrips had been introduced being fertilized and producing seed. All the controls remained sterile. The conclusions are that thrips are probably important beet pollinators; that they may act similarly with other plants; that their absence or too small number may account for the non-fertilization of flowers in some localities and seasons; that they may fertilize flowers under supposedly isolation conditions and may even cross plants not regarded as capable of being crossed by insects, e.g., barley; and that they may also spread fungus spores and bacteria.

Forest types. Raphael Zon.

An ecological survey of the forests of western Idaho, in connection with the preparation of yield tables, revealed three main forest types, or, in the terminology of ecologists, "formations." Two of these are final or

climax and one an intermediate or transitory type. The climax types are yellow pine-Douglas fir and cedar-hemlock. The transitory type is white pine-larch. The yellow pine-Douglas fir is both a pioneer and climax type. When burned or cut over it invariably succeeds itself. The cedar-hemlock type is a climax type preceded by the larch-white pine. The order of succession from the pioneer to the climax forest is as follows:

First the larch (*Larix occidentalis*) comes in as the pioneer, shading the ground and offering the protection necessary in order that the white pine (*Pinus monticola*) might establish itself. The white pine, soon after becoming established, begins to crowd the larch, overtopping and exterminating gradually all but the most vigorous specimens. Under the shading of the white pine and larch cedar (*Thuja plicata*), hemlock (*Tsuga heterophylla*), and white fir (*Abies concolor*), begin to come up, crowd out the white pine and finally become the sole occupants of the ground.

This ecological study had a practical bearing upon the management of the forest as it pointed out the possibility of leaving larch and selling the white pine, which alone at present commands any price, without danger of eliminating it from the future stands. This study furnishes a concrete example of the value of ecological studies as a basis for forest management.

Phytochemical Studies on Cyanogen. Dr. C. L. Alsberg and O. F. Black (by invitation).

W. W. Stockberger, *Corresponding Secretary.*

PROGRAMS AND ANNOUNCEMENTS

PHILOSOPHICAL SOCIETY

702nd Meeting, January 6, 1912. Cosmos Club at 8.15. R. A. Harris: *Krümmel's Handbuch der Ozeanographie, Vol. II.* J. M. Miller: *The Determination of the Pole Distance of a very Small Magnet.*

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCE

VOL. II, JANUARY 19, 1912. No. 2.

GEOLOGY.—*Applied geology.*[1] ALFRED H. BROOKS.

The science of geology, generally regarded as having originated in the vague speculations of the cosmogonists hardly two centuries ago, has today become of great practical utility. During the past decade all geologic investigations have shown a marked tendency toward material problems, which is in contrast with the previous decade, when the interests of pure science were much more strongly emphasized. No one will deny that economic, or as I prefer to call it, applied geology is attracting more and more attention from professional geologists. It is appropriate that the members of this Society should take cognizance of this trend in geologic thought, analyze the conditions which have brought it about, and decide, it may be, whether it makes for the good or the evil of the science.

Before discussing this subject it will be well to attempt a definition of the term "applied geology." Some appear to believe that when the geologist emerges from the tunnel's mouth he is at once transplanted into the realm of pure science, and that the miner's candle illuminates only the so-called practical or even commercial problems. I submit that such opinions are not justified. The surveys made as a basis for geologic maps and structure sections, usually classed as belonging to the realm of pure seicnce, often yield results which are the most concrete examples of applied geology. On the other hand, the exhaustive study of mineral deposits is essential to the solution of many fundamental geologic

[1] Published by permission of the Director of the United States Geological Survey.

Presidential address delivered before the Geological Society of Washington, December 13, 1911.

problems. A close analysis will make it evident that the line of demarcation between the fields of pure and applied geology is in a large measure arbitrary. The collection today of a new group of facts or the determination of new principles relating to pure science, may result to morrow in their application to industrial problems. Mr. Gilbert has recognized two fields of geologic research, the one embracing the study of local problems of stratigraphy, structure, etc., the other, the general problems of geo-

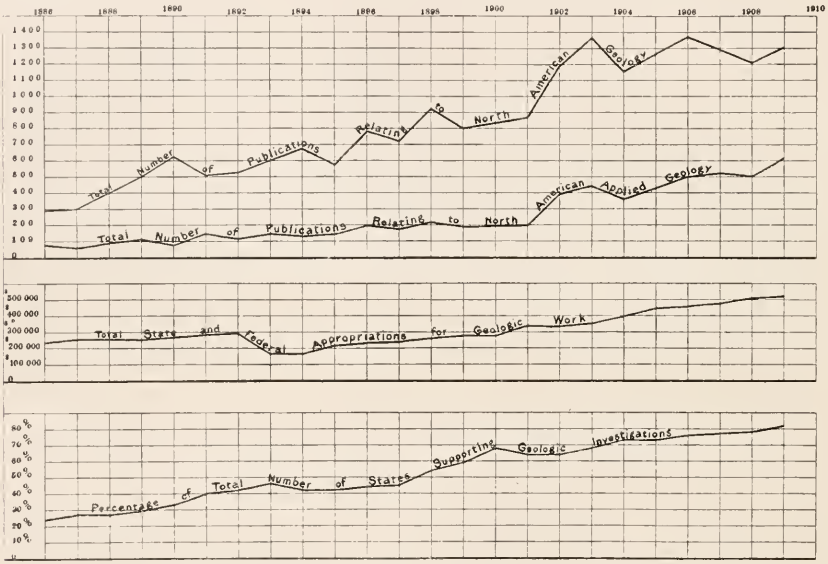


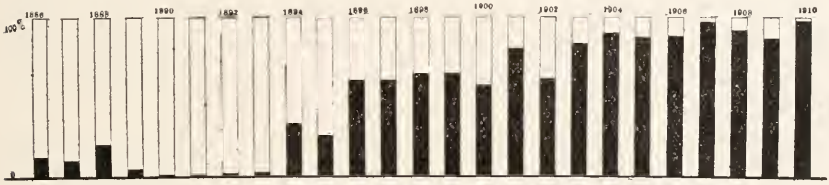
Fig. 1. Geologic publications, state and federal appropriations for geologic work, and percentage of total number of states supporting geologic work for the years 1886 to 1909

logic philosophy, and has shown that both may yield results of the highest industrial importance. As David Paige has expressed it:

> There indeed can be no antagonism between science and art, between theoretical knowledge and its economic application. The practical expression of a truth can never be divorced from its theoretic conception.

If, in spite of what has been said, the two fields of science are to be differentiated, applied geology may be defined as the science which utilizes the methods and principles of pure geology to supply the material needs of man.

While the present tendency of geologic science toward the investigation of problems of everyday life is patent to all, yet it is desirable to express this tendency quantitatively. For this purpose, I have determined the percentage of geologic publications issued annually during the last quarter of a century devoted in part or entirely to applied geology. The result of this analysis is graphically presented in the diagram (Fig. 1) in which the one curve represents the total number of publications; another, those classed as bearing upon applied geology. This diagram is based on an actual count, judging by the titles, of the publications included in the annual bibliography of North American geology. It is conceded, of course, that a mere enumeration of titles is, at best, but a crude method, which neither takes into account the extent of the individual publications nor attempts to



Percentage of Total Publications of U.S. Geological Survey Relating to Applied Geology

Fig. 2

appraise their value to science. However, I trust it will serve as a rough measure of the activities of North American geologists. On this basis, the diagram clearly records a very rapid increase during the past decade in the ratio of publications dealing with applied geology to the total of geologic literature.

The figures show that applied geology was at its lowest ebb in 1890, when only 12 per cent, and at its highest flood in 1909, when 47 per cent of the total publications related to this subject. To consider the percentage of economic papers by decades: In the ten years ending in 1895 the average was 22 per cent; for the following decade, 30 per cent; and for the last five years, 44 per cent.

Another measure of this trend in geology has been obtained by a similar classification of the publications of the United States Geological Survey. The result of this enumeration is shown in a

second diagram (Fig. 2). In this, it will be seen that in 1890 less than 1 per cent of the publications issued by the federal survey treated of applied geology, and in 1910 the percentage was 98. Considering it by decades: For the ten years ending in 1895 the average of economic papers was 11 per cent of the total number of publications; in the following decade, 71 per cent; and in the last five years, 92 per cent.

These figures are not to be interpreted as evidence that pure science has not been recognized in these publications of the federal survey. I have classed with the applied geology group all publications which treat in any measure of this subject, though many of them deal chiefly with problems of more purely scientific interest. For example , the geologic folios, which include some of the most notable contributions to pure science, are here included in the literature of applied geology. To me it is less surprising that nearly all the recent publications contain some practical deductions than that most of those of twenty years ago omitted all data of this kind.

The marked tendency toward practical problems, as indicated by these figures, is by no means confined to one organization, for it is exhibited in the same degree by state surveys and is also reflected in the work of the universities. Nor is it limited to this continent, for countries as widely separated geographically and in scientific traditions as South America, Japan, and Germany show similar signs. Everywhere geologic research of practical problems is receiving more and more support, both publicly and privately.

It is pertinent to consider the attitude of the public at large toward this economic tendency. There are undoubtedly those who believe that the direction of scientific work should rest entirely with the investigator and not with the people. Let them bear in mind that geologic investigations, since they involve heavy expenditures and trespass on private property, can, for the most part be properly carried on only through government agencies, in this differing from such sciences as chemistry, physics, or biology, which can be furthered by private means. If geologic surveys are properly a function of the state, in the last analysis the people

must be the final arbiters as to what phase of the science is to be emphasized. In our democracy the citizen has a right to inquire what he, as a member of the body politic, is gaining by expenditures from the public purse.

It is estimated, on the best data available, that during the past quarter century the total grants for geologic work made by state and federal governments aggregate over eight million dollars. This may be regarded as evidence of public confidence. More significant to the present discussion is the annual grant of funds during this interval, and this is illustrated by a curve on the same diagram with those showing character of publications (Fig. 1). This curve is in part based on estimates, but these are without doubt sufficiently accurate to indicate that the total annual appropriations of state and federal governments for geology have been augmented at a rate which proves that they are affected by some other factor than that of increase of population. The annual grant of funds is now more than double that of twenty-five years ago. It is probably safe to interpret this as indicating that the present economic tendency in geology is approved by the people of the United States. The close parallelism between the lines marking the publications relating to applied geology and the annual allotments of public funds for geologic surveys is probably not entirely fortuitous.

Perhaps the best measure of popular confidence in the results of geologic research is the number of different geologic organizations supported by public funds. We are apt to credit the obtaining of government support for this or that research entirely to some individual or organization, forgetting that, until the general public has in a measure been persuaded of its value, all efforts would be useless. Therefore, when we find geologic surveys thruout the country supported by commonwealths having widely different social and industrial conditions, it is fair to presume that the average citizen has acquired the belief that these are attaining results beneficial to the community. The numerical increase of state geologic surveys during the last twenty-five years is illustrated by the curve on the diagram before you which marks the percentage of total number of states supporting geo-

logic work (Fig. 1). In 1886 24 per cent of the states had geologic surveys; in 1895 the percentage was 42, and in 1910, 80.

This growing public interest is also manifested by the increase in geologic teaching at colleges and universities. I interpret the statistics published by Prof. T. C. Hopkins as indicating that in 1886 there were about 220 of the higher institutions of learning in which geology was taught, while in 1894, there were 378. Of these, 51 had geology organized as a separate department. I have been unable to find any more recent data on geologic education, but that it has made great strides in the last seventeen years will be conceded by all. It will also be generally admitted that the teaching of economic geology is receiving constantly greater attention in the colleges and technical schools. More significant evidence of the present status of geology among the people is the fact of the large number of geologists now in private employment. There are many professional geologists who are engaged in consulting practice. Nearly every large mining company and many railways include in their personnel one or more geologists. In a commercial directory of mining experts recently published fully 10 per cent classed themselves as geologists, while an edition of the same directory issued ten years ago included only one who claimed to be a geologist. While at that time, as now, many mining engineers were in fact professional geologists, they did not care to advertise the fact.

All this indicates that applied geology has during the last two decades become a dominating element in our geologic work; also that this tendency toward industrial problems pervades all geologic investigations, whether under federal, state, or private auspices. Furthermore it has been made evident that this trend is not limited to the North American continent, but is world-wide. It is clear, also, that since emphasis has been laid upon the economic side there has been a marked increase in the support given to geologic work, from which fact may be drawn the logical conclusion that the public endorses this policy. It does not necessarily follow that this dominating practical note in geology has made for the advancement of the science. Before discussing this important question it will be well to trace briefly the origin of geology as an applied science.

It seems to be generally assumed that the application of geology to industry was not attempted until after its development into a more or less complete rational science. It can not be denied that the application of the principles of a science must await the establishment of those principles through scientific inquiries. It is true, however, that long before geology had developed as a science men observed the geologic phenomena that bore on certain vocations and often correctly interpreted such observations.

The science of applied geology, therefore, had its origin among those who, like the miners, were by vocation brought into intimate contact with natural phenomena. Many of the elementary facts relating to mineral deposits were forced on the attention of the miner, and as the correct interpretation of these facts added to his material welfare, some deductive reasoning was undoubtedly applied. The rudimentary conceptions thus formed were more likely to be correct than those of the early closest academician, whose science for generations began and ended in pure speculation.

Therefore, to trace the origin of applied geology the oldest archives treating of mining, quarrying, agriculture, engineering, and mineralogy must be searched—a task which has been quite beyond me. And reaching far back of any written record was the traditional lore bearing on geologic phenomena of countless generations of miners and husbandmen. Even the man of the stone age must have subconsciously acquired knowledge of the distribution of the materials which he fashioned into implements of the chase and war. If we are to allow our imagination full scope, we can conceive of some primitive economic geologist who, by finding a deposit of copper and revealing the superiority of the new material for weapons, became the hero of his tribe.

While our Aryan ancestors appear to have been ignorant of the use of metals when they first invaded the Mediterranean countries, yet they acquired a knowledge of them from the Semitic races long before the dawn of history. In winning these metals primitive man used methods which required neither any high degree of technical skill nor a knowledge of the form of their occurrence. Mining, being second only to agriculture in its

importance to the human race, became more systematized with the progress of civilization. By the time historical records began the recovery of metals and the quarrying of building stones were well-developed arts, and there is no reason to suppose that the mode of occurrence of the deposits exploited were ignored by those whose livelihood was involved.

The rulers of this early period, keenly alive to the value of the metals, undoubtedly caused this source of wealth and power to be investigated by able men. It is recorded that Philip of Macedon evinced his interest in mining by examining in person some underground workings in Thrace. Jason's search for the golden fleece pictures the prospector of those days as a national hero. In any event, it is certain that millions of ounces of gold and silver and many tons of copper, as well as tin and iron, had been produced centuries before the Christian era. We must believe that this production indicates a sufficiently developed industry to employ not only skilled artisans but also those who delved deeper into the problems of mining. The ancient Egyptians were eminently practical and developed a high degree of skill in certain branches of engineering. Undoubtedly the Egyptian engineers paid some heed to the distribution of building stones as well as to methods of quarrying, while among other peoples who excelled in metal mining it is presumed there were engineers who specialized in mining matters, as do their successors of today.

It is far easier to speculate on the knowledge the ancients may have had of some of the principles of applied geology than to trace the actual extent of this knowledge. Ancient Hebrew literature abounds in references to the metals and their utilization, but furnishes little clew as to what was known of them. The same is true of the records of ancient Egypt, in which both placer and lode gold are mentioned. One document that has come down to us shows that location of mineral wealth was considered worthy of note. An ancient papyrus, dating about 1350 B.C., displays a crude map for the purpose of locating Nubian gold mines. It is one of the oldest maps in existence and the first which can be said to impart geologic information. The oldest written record of geology or allied subjects is Theophrastus' descriptions of

metals, stones, and earths, dating back to 315 B.C. Pliny's work of four centuries later seems to have been the first attempt at a complete treatise on minerals of economic importance, but he was more concerned in the utilization of the metals than in their mode of occurrence. Other of the ancient writers, notably Aristotle, touched on geologic subjects, but rather from the standpoint of speculative philosophy than of interest in material problems. Some of the early geographers and historians, like Strabo and Herodotus, discussed the geographical distribution or the exploittation of metals. Another field of applied geology is found in treatises on agriculture containing references to character and distribution of soils. Even Virgil in his Bucolics attempts a practical classification of soils. As this dwells on the physical rather than the chemical properties of soil, it would seem to have at least the merit of being in accord with some of the latest scientific maxims.

I have dealt with this subject as if the nations of Europe and western Asia had alone made advances in technology. Mining and metallurgy, even in very early times, were important industries in both India and China, and it is not unlikely that there may be in those countries a literature of practical geology which antedates our own.

The meager records of the early period of mining give no clew to the knowledge of applied geology held by the ancients. But that they were not entirely ignorant of its principles is to be presumed from the importance of the mining industry, and the absence of written records does not argue against this theory. The same is true of other arts. We do not assume, for example, that the principles of mechanics applied to structures were not understood because there were no written treatises on architecture until centuries after many periods of architecture had successively developed and declined.

Scant as is the literature of mineralogy and mining up to the early part of the Christian era, the succeeding ten or twelve centuries are almost entirely without records. This was the medieval period of intellectual stagnation—the eclipse of scientific and critical thought. The Arabs, who alone preserved the traditions

of antiquity during this lapse, made considerable contributions to scientific knowledge, not neglecting mineralogy. Aside from this, there are only a few minor references to the subject in the chronicles of that time.

While science was neglected in the middle ages, the arts continued to progress, and among these mining was important. It is recorded that in Charlemagne's time thousands of miners were employed in the metal industry of northern Tyrol, and many other countries made notable contributions to the metallic wealth of the world. Coal mining began in England and Germany in the twelfth century. In fact, the mining industry assumed an importance which attests a high degree of administrative and technical skill.

With the revival of learning in the fourteenth and fifteenth centuries, scholars began again to turn their attention to the natural sciences. At first they labored solely to verify and amplify the theories of the ancient writers, never doubting that the classical philosophers had encompassed the entire realm of human thought. Generations of scholars sought their science in the Greek and Roman literature. But with the renaissance scholastic thought was freed, and then the first epoch of scientific geology began.

The wide chasm which separated the academician from the technician at that time prevented any utilization of the great store of geologic facts accumulated by miners. The miner had neither education nor incentive to record the facts so laboriously collected; the scholar had yet to realize that nature must be studied by observation and deduction, not by speculation alone. The cosmogonist wrote his treatises on the origin of the world with his vision limited by academic walls, while the miner held his knowledge as important only for his need.

Agricola was one of the first scholars to consider the practical problems of the miner. His works, published in the middle of the sixteenth century, show both keen observation and realization of the importance of applied geology. The German mining industry had at that time advanced sufficiently to have a large technical vocabulary of its own. But as Agricola wrote in Latin, he

was forced to translate these technical terms as best he could. German mining methods and terminology must then have found wide acceptance in Europe, for Pierre Belon, the French naturalist recorded that in 1546 they were in use in the Thracian gold fields—then as now a part of the Ottoman Empire.

In Agricola's day there appeared a number of other treatises dealing with some phase of applied geology. These were mostly devoted to mineralogy, which was destined to become a science long before geology had passed beyond the speculative stage. Most of this early literature was in Latin and therefore calculated to have little influence on mining practice. It did, however, bring the scholar into closer touch with the phenomena of nature and thus pave the way for a rational science of geology.

In the early history of the science pure and applied geology can be compared with two confluent rivers having widely separated sources—the one springing from the high realm of speculative philosophy, the other having a more lowly subterranean origin. These two streams of thought gradually drew together, for a space flowing side by side, and finally merged into one great stream.

The following passage, written by Peter Martyr, in 1516, while describing the golden wealth of Hispaniola, reflects something of the status of geology in his day:

> They have found by experience that the Vein of gold is a living tree, and that the same by all ways spreadeth and springeth from the root, by the soft pores and passages of the Earth, putteth forth branches, even to the uppermost part of the Earth; and ceaseth not until it discover itself unto the open air; at which time it sheweth forth certain beautiful colours in the stead of flowers, round stones of golden Earth in the stead of fruits, and thin plates in stead of leaves. . . . . For they think such grains are not engendered where they are gathered, especially on the dry land, but otherwise in the Rivers. They say that the root of the golden Tree extendeth to the center of the Earth, and there taketh nourishment of increase: for the deeper that they dig, they find the trunks thereof to be so much the greater, as far as they may follow it, for abundance of water springing in the Mountains.

This fantastic account of gold deposits contains a sufficient kernel of truth to indicate that the writer had at least some comprehension of the form of auriferous veins and their relation to gold placers.

One of the earliest recorded attempts of a practical application of geology is that of George Owen, a country squire of Wales, who about 1600 prepared a lengthy description of Pembrokeshire in which he discussed the occurrence of limestones and coal. He appears to have been the first to note the change of bituminous coal to anthracite. Owen's practical purpose is made clear by the following quotation from his writing:

> . . . . it may be a guide to some parties to seek the lymestone where it yet lieth hidden and may save labours to others in seeking it where there is no possibility to find it.

While men of the Agricola type were assembling and classifying observations on minerals and ore bodies, another group of scientists was engaged in wordy wars about such problems as to whether fossils had been formed by the influence of stars or were the remnants of former living organisms. It is noteworthy that among the most rational contributions to this discussion, which continued over a century, were those of Leonardo da Vinci and Nicholas Steno, the first of whom based his arguments on his own observations as an engineer, while the second had some practical experience in the study of ore bodies. These two belonged to the class of scientists designated by John Webster in his *History of Metals*, published in 1671, as "experimental observers," of whom he says:

> For either they were such as attended the mines, or went thither to converse with the workmen to inform themselves, or bore some office about those places, or were those that either for curiosities sake, or to enrich their knowledge, did gather together all the minerals they could, or used the most of all these ways to gain understanding. And therefore I commend these above all the rest before named, to be read and studied of all officers and men belonging to any mineral or metallick works; and of all young students and beginners that seek after mineral knowledge: because these authors speak not altogether by opinion, fancie, and conjecture; but forth of their own experience, and the experience of those that were conversant about the mines, and getting of ore, and purifying and refining of them; and therefore more certain to be relyed upon for leaders and teachers. And more, because they have written what they knew, openly and plainly as the subject would bear; and not in parables, and ænigmatical expressions.

This treatise contains, amid much that now appears childish, some practical hints for the discovery of ore bodies. Webster

laments the almost universal ignorance of this subject, which he accounts for as follows:

> That the way and means to discover the nature of minerals, is not onely difficult and dangerous, but in itself is so sordid, base and troublesome, that the most men of parts, will hardly adventure themselves into the pits or shafts where ores are usually gotten; nor can indure to stay so long, that they can rightly inform themselves of anything that may be satisfactory to their inquiries. And the Miners or Workmen (for the most part) being but people of the most indigent sort, and such as whose knowledge and aims reach no higher than to get a poor living by that slavish labour, regard to inform themselves of no more then what may conduce to such a poor and servile kind of living; by which means they are little able to give any learned man satisfaction to those necessary inquiries that might tend to enable him to judge rightly of the nature of the things in that subterraneous kingdom.

The prejudice of the scholar against learning from the miner, so quaintly described by Webster, gradually died out in the eighteenth century. Thereby the science profited much, through acquiring a better ground-work of fact, while, on the other hand, technology derived assistance from applied science. Even before Werner's day a number of mining officials discussed in print the occurrence of mineral deposits. As a result of this better understanding between the scientist and the practical man geology developed from a condition of pure speculation into a science which approached the rational and concrete. It need hardly be added that the advances made in chemistry, physics, and biology, were essential to this progress.

By the latter part of the eighteenth century conceptions of stratigraphy began to take definite form. In this field, again, the miner to a certain extent forestalled the scholar, for he had recognized that locally, at least, the earth crust was built up of superimposed strata having a definite order. He had also noted that this order was sometimes interrrupted by breaks and in the underground workings had opportunity to grasp some details of tectonic geology.

The advancement of science and arts toward the end of the eighteenth century had been such as to create a demand for trained engineers. In the field of technical education mining was given the first recognition, for the school at Freiberg was established in

1765, twenty years before the existence of any other school of engineering, except those devoted to military science. This school was to have a world-wide effect on geology, through the influence of Werner, the first great teacher of the science. The founding of other mining schools followed rapidly, indicating a need throughout continental Europe for trained mining engineers. With the exception of Freiberg none of these schools gave special heed to science, but their establishment was of great importance to applied geology, as it gave definite recognition to the fact that mining was to be directed by engineers and not by artisans. The advent of the trained mining engineer was of first importance, for on him was to fall much of the work of advancing the new science.

On the continent mining was chiefly carried on by or under the direct supervision of the state, and the need of properly trained engineers was probably the chief reason why technical mining education began before other branches of engineering. In England, on the other hand, mining was mostly a matter of private enterprise, and technical education lagged far behind the continent. The men entrusted with the direction of mining affairs seem to have been drawn from the practical school of experience and were known as mineral surveyors. To this class belonged William Smith, the founder of stratigraphic geology.

Worthy of note also is John Williams, a mineral surveyor, who preceded Smith by one generation. Williams was a Welshman, who was bred as a miner, served as a soldier under the Dutch flag, and held various responsible positions in the coal and lead-mining industries. In 1789 he published a Natural History of the Mineral Kingdom, which is remarkable for expressing some of the modern views on applied geology. It contain a large number of accurate observations, notably on coal and lead deposits. In discussing ore deposits Williams suggests a probable genetic relation between intrusive dikes and mineral veins. Unfortunately for Williams' standing as a scientist, he considered it necessary to present a theory accounting for all geologic phenomena and to show the errors in Hutton's conclusions, which had then just appeared.

Inasmuch as Williams treated coal deposits quantitatively he was far ahead of his generation. He pointed out that coal beds

are definitely limited, and this at about the time that Werner was preparing to launch his theory of "Universal formations." A few quotations from his book will serve to illustrate Williams' attitude:

> The result of his investigation refutes by inference another erroneous opinion concerning coal, which I have often heard asserted with great confidence, viz., that coal is inexhaustible. That the fund of coal treasured up in the superfices of the globe, for the accommodation of society, is very great, I readily acknowledge; but that it is inexhaustible, in the proper sense of the word, I deny.
>
> If our coals really are not inexhaustible, the rapid and lavish consumpt of them calls aloud for the attention of the Legislature, because the very existence of the metropolis depends upon the continued abundance of this precious fossil, and not only the metropolis, but also the existence of the other cities and great towns, and of the most fertile countries in the three kingdoms, depend upon the abundance of this valuable article; and moreover, most of our valuable manufactures are in the same predicament, and, therefore, if our coal mines are not inexhaustible, it is high time to look into the real state of our collieries.
>
> I feel in myself a strong reluctance against sounding the alarm to my country in a matter of so much importance. I am but an obscure individual of very little consequence in the world, and I have not the least doubt that I shall be severely censured by many for my presumption, and therefore I proceed with sensible remorse; but it is not guilty remorse; on the contrary, my heart tells me, that were I to temporize with my own feelings of reluctance, and to conceal a truth which so nearly concerns the welfare of the community, for fear of incurring censure, my silence would be unpardonable.
>
> The present rage for exporting coals to other nations may aptly be compared to a careless spendthrift, who wastes all in his youth, and then heavily drags on a wretched life to miserable old age, and leaves nothing for his heirs.

While Williams' dire prophesies, made a century and quarter ago, of the early exhaustion of England's coal have not been justified, yet he seems to have been one of the first to urge upon public attention the close relation between the prosperity of a nation and its fuel supply. He was also a pioneer in recommending governmental surveys and investigations of mineral resources. After pointing out the value of the Cape Breton and other coals in the British North American possessions and recommending their development, he goes on to say:

In discussing this topic, we presume to suggest, that, in the first place, it is necessary for Government to explore and discover these coals, and lay them bare for the inspection of British coal masters or companies, and with this view, the first thing to be done, is to employ a prudent man of abilities and skill in the theory and practice of the coal business; to survey the West India coals and coal fields; to make such trials upon the coals already discovered, and those he may discover, as may be necessary to ascertain the thickness, quality, and situation of each stratum of coal that may be judged worth attention; and to make out a full and substantial report of all the material circumstances relating to each coal, for the information and use of Government, and of such gentlemen and companies as may wish to look into this interesting subject.

These recommendations for governmental surveys of mineral resources were made a generation before they were followed and fully a half century before the nations of the world were generally to accept the principle. Williams also touches on some of the problems which absorb us today. After advocating the investigation of the colonial coal fields, he says, in words which have a familiar ring:

When this report is made and considered by Government, suitable encouragement should be offered to gentlemen and to companies of character, stock, and abilities for such undertakings, to open and work some of these coals. . . . .

The first undertakers should be allowed a sufficiently extensive coal-field, and every reasonable privilege and indulgence; but they should not have a monopoly. Other adventurers should have room to employ their skill and capitals in this line of business in the west as well as in Britain. Monopolies seldom do much good. The views of monopolists are always too selfish and confined to be of extensive utility and public benefit.

While Williams was among the first to recommend governmental mineral surveys, the idea of showing mineral deposits on maps appears to have been part of a plan for soil maps conceived by Martin Lister a century before, and put into practice by Guettard in 1746. Sir Archibald Geikie has credited the first geologic map to this eminent French naturalist, but has not sufficiently emphasized the fact that Guettard's map also showed the distribution of mines and mineral deposits. Others followed his example, and before the close of the eighteenth century the cartographic representation of geology and mineral deposits had become well established.

The nineteenth century opened during the epoch of intellectual freedom which followed the turmoil of the French Revolution. The time was favorable to the progress of science. The scholar felt free to follow scientific inquiries to their logical conclusions untrammeled by the interdict of authority. Nowhere was this more true than in the field of geology, for, notwithstanding the efforts of dogmatic theology for upwards of half a century to dominate geologic thought, its edicts could hamper the growth of the science but little.

Further incentive sprang from the development of new political ideals. As the nation began to concern itself with the needs of the individual citizen the application of science to human needs was encouraged. Under the old regime, so long as the wants of the ruling classes were supplied no thought was given to the wants of the masses. When this attitude was changed it was natural to seek the aid of the scientist in ameliorating conditions. Therefore, the dawn of the new century was propitious not only to the advancement of pure science, but also to a general appreciation of applied science.

Nowhere were conditions for the evolution of geologic science better than in our own land. Being far removed from the controversies which occupied the sole attention of many European geologists we could accept or reject without prejudice this or that theory. Our people had entered upon the exploitation of a new land, with boundless possibilities of natural wealth, and pioneer conditions brought most of them into intimate contact with natural phenomenon. Books of travel written in the early part of the century bear witness that a close observation of geologic facts was forced upon every traveller.

A general interest in science and its application was prevalent in America, even in colonial times. This was reflected in the scientific and practical character of educational ideals. In its first advertisement, issued in 1754, Columbia College (then called King's) provided for the instruction of youths—

"in the arts of numbering and measuring; of surveying and navigation; of geography and history; of husbandry, commerce, and government, and in the knowledge of all nature in the heavens above us and in the air, water, and earth around us, and in the various kinds of meteors, stones,

mines, and minerals, plants and animals, and everything useful for the comfort, the convenience and elegance of life; and in the chief manufactures of these things."

This was half a century before the idea of scientific and technical instruction had taken root in European countries. In the period extending from 1768 to 1811 chairs of chemistry were established in eleven colleges of the United States. In 1824 the Rensselaer Polytechnic Institute was founded—the first school of applied science in any English-speaking country. The avowed aim of this school was to apply "sciences to the common purposes of life." Van Rensselaer, who founded it, was a patron of geologic science, and Eaton, the geologist, its first president.

Geology had, however, received recognition in several American colleges long before the founding of the Rensselaer Institute. According to Professor Hopkins there were 31 American colleges which offered courses in geology previous to 1845. Of these, one began teaching geology in 1804, one in 1807, one in 1819, and one in each of the years from 1820 to 1845. The large number of scientific societies founded at this time shows the widespread interest of the people in science. Nearly every town had its lyceum of natural history, while the larger cities boasted of academies of science and similar associations, of which several have survived to the present day. In 1819 the American Geological Society was organized—only twelve years after the founding of the Geological Society of London and nearly thirty years before that of the Deutsch Geologische Gesellschaft.

Numerous journals devoted to science and art were established during the period under discussion. While some of these were only short lived they attest the interest in science of the American people. Another example of this interest is found in the course of lectures on natural history which, according to Dr. Merrill were delivered before the New York State Legislature by Amos Eaton in 1818. This is probably the only instance in our history where a body of law makers have welcomed serious instruction in scientific matters.

Most of the collegiate instruction and the scientific societies had for their purpose the promoting of knowledge in pure rather

than applied geology, but it was in the latter that geology really had the support of the American people. One far-reaching influence on the development of applied geology in the early part of the last century was the scarcity of mining engineers or experienced operators, while the vocation of prospecting was almost non-existent. Our mining industry was in the early stages and there were almost no engineers and but few so-called practical men to whom the people could turn for information. In European countries, on the other hand, centuries of mining had developed a class of professional men other than geologists who were considered authorities on mineral wealth. But in our own country it was the scientist rather than the engineer or the practical miner who was called upon for information. This not only led to the utilization of science in the preliminary work of seeking mineral deposits, but also had the effect of forcing the scientists to give their investigations a practical turn.

Either from choice or necessity, the early American geologists, like their successors of today, always emphasized in their work the needs of the community. McClure devoted much of the brief text which accompanied his geologic map of the eastern United States to the relation of geology to agriculture. Eaton's first work bore on the resources of the region adjacent to the Erie Canal. Rodgers elucidated the structure of the coal fields, while Jackson attempted a classification of the public lands of the State of Maine.

I venture the opinion that one reason why the investigators of this continent have accomplished so much for the advancement of geology is that their research has never been entirely divorced from the field of applied science. We have had no distinct schools of pure and applied geology, as there were until recently in other lands. In Europe there was the practical school of the miner, whose scientific conception seldom reached beyond his immediate environment; and there was the school of the scholar, whose angle of vision was apt to be too wide to focus on facts near at hand. There were, indeed, some exceptions, for the scholar Agricola learned from the miner; Werner's teaching was, in theory at least, an application of geology to the mineral industry; and

William Smith used his knowledge of stratigraphy in the practice of his engineering profession. Even in Europe the distinction between the work of these two schools has now almost disappeared.

The general interest and faith in science during the early history of our country is well exemplified in the attitude of public men. Our first two presidents, in spite of the fact that they differed greatly in temperament and experience, showed more interest in scientific work than almost any of their successors. Washington's training as an explorer, surveyor, and planter and his close connection with the beginnings of the iron industry is perhaps sufficient to account for his attitude toward science. He is probably the only president who, by his own efforts, attempted to advance applied science. While president he started an investigation of the soils of the eastern states through personal correspondence. More important, however, was the work of Jefferson, in bringing about the establishment of the chair of chemistry at the University of Virginia, thereby introducing scientific teaching into this country. He also discussed the mineral resources of Virginia in his book on that commonwealth, wrote, while vice-president, geologic paper, and above all inaugurated that system of exploration and investigation of the trans-Mississippian region which was to yield such fruitful results in the century to follow. John Adams, while he took no personal part in promoting scientific research, manifested interest in it by helping to establish the American Academy of Arts and Sciences.

A review of the conditions which brought about the rapid growth of geologic work in this country during the first decades of the nineteenth century cannot fail to consider the political and industrial situation. The war of 1812 had united as one nation the commonwealths which up to that time, in spite of the federation, had strong centrifugal tendencies. Duing the war with Great Britain New England had been on the verge of rebellion, while the Trans-Appalachian region was not held to the East by any strong bonds. The country, rent by domestic quarrels and the turmoil of opposing political factions, paid small heed to the problems of industry and commerce.

After the war the people thought less about state rights and more about industrial prosperity. There was no longer a French party or an English party, but men of all political faiths had come to the conclusion that we must work out our own salvation. We had learned to supply our own material needs during the war when English frigates, cut off European sources of supply. In short, the nation had found itself and was ready to begin to harvest the resources of the vast territory which the war had settled for all time was to be our own. Our people, while possessing the self-confidence of the pioneer, were facing new problems, and, guided by their scientific instincts, turned to the scientist for help.

In spite of the fact that the war had developed a relatively strongly-centralized federal government, yet our political theory

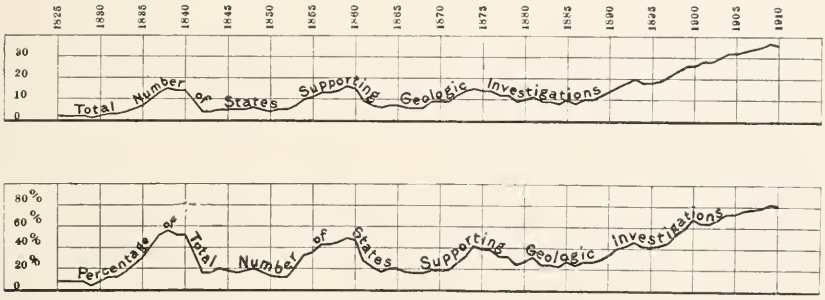


Fig. 3. Total number and percentage of total number of states supporting geologic work, 1825 to 1910

was still one of state rights. Moreover, the Republicans were in power, with a hopelessly small Federalist minority. It was natural, therefore, that the people, loyal to their political faith, should turn to the commonwealths for aid in developing the new land. This aid for the most part took the form of large grants for public improvement of transportation facilities—at first for canals and wagon roads, later for railways. During the period ending with 1838 the states borrowed sums aggregating over $160,000,000 for purposes of public improvement. Compared with this sum, the expenditures for geologic surveys were small. It is a significant fact, however, that in 1838, a larger percentage of the states supported geologic surveys than in any subsequent year until 1898. This is graphically illustrated in Fig. 3. The upper

curve shows the total number of states, and the lower the percentage of total number which supported geologic surveys between 1826 and 1910.

The very rapid increase in state surveys is all the more significant when compared with the status of governmental surveys in Europe. Though much geologic work was done in European countries during the early part of the century, it was not until about the middle, that the governments began organizing systematic surveys. England led by establishing her survey in 1832. Next came surveys of Austria-Hungary and Spain, organized in 1849, of Bavaria in 1851, and France in 1855. Most European countries did not undertake systematic geologic surveys until about 1860, or more than twenty years after our first maxima of state surveys had been reached.

As already indicated, the principal influence that led to this first era of state surveys, as Doctor Merrill has called it, was the wide-spread interest in scientific investigations and the great industrial advancement which created a demand for the practical results of such investigations. A good example of the faith the people had in applied geology is found in the first geological survey made in Georgia, which was paid for by land owners of two counties—a condition that has never been repeated until recently in some of the rich mining districts of the west.

Another reason for the large number of state grants for geologic work lay in the general westward movement of population from the Atlantic states. This had a two-fold effect on geologic surveys. First it gave rise to a demand for information about the new lands, and second, it put the older states on their mettle to hold their population. So rapid was the westward movement that the Atlantic states became alarmed for their future. In 1815 and 1816 the legislatures of both North Carolina and Virginia appointed committees to divise means for checking the drain on their population. This was unquestionably the motive in establishing many of the eastern state surveys, and in directing their activities toward agricultural problems.

Meanwhile the federal government had undertaken the investigation of the resources of the unorganized western Territories.

The chief purpose seems to have been a classification of the public lands—a work which was to be interrupted for over half a century and then resumed as the proper function of federal geologists.

According to Doctor Merrill[2] the first epoch of state surveys declined even more rapidly than it arose, due, largely to the financial crisis of 1837. An era of promotion, inflation, and straining of state credits to their uttermost, accompanied by a waste of the borrowed millions and the lack of any sound federal financial policy, resulted in a money panic, the collapse of many ill-advised enterprises, the repudiation of their public debts by several of the states, and a wide-spread commercial depression. It is no wonder that, under these conditions, geologic surveys were regarded as luxuries that might well be spared; particularly since these first governmental surveys, it must be admitted, hardly justified themselves from the standpoint of practical results. This fact does not detract from the credit due the pioneer geologists who carried on these surveys under almost insuperable difficulties. They learned much about real distribution of the larger geologic units, but most of the investigations were not detailed enough to yield results of practical value. Moreover, even in that day many geologists were still living in "flat land"—they considered formations in only the two horizontal dimensions; for while the vertical element was by no means ignored, it was not closely understood.

During the decade following the panic, few states had surveys and no great progress was made in the science, beyond the publication of results attained in the previous era. Though the contributions to geologic literature by the class of professional geologists—whose appearance was perhaps the most important result of the activity of the previous decade—were not unimportant, yet as a whole both pure and applied science were at a rather low ebb.

The panic was but a temporary check to the industries, however. The estimated production of pig iron was 347,000 tons in 1840, and 600,000 in 1850, while the coal production during the

[2] The extensive use I have made of "*Contributions to the History of American Geology*" by G. P. Merrill will be evident to all who have read that work.

same period increased from 2,000,000 to 7,000,000 tons, and the railway mileage from 2818 to 9021. These industrial advancements were accompanied by the rapid settlement of the middle west, by the beginnings of copper mining in Michigan in 1844, and of iron mining in Michigan and Missouri in 1853, and most important of all, the discovery of gold in California in 1848. All this activity gave a new impetus to geologic work, which is reflected in the revival of interest in state surveys. At this time, too, men began to dream of a trans-continental railway and therefore the federal government undertook a more systematic exploration of the western cordilleran region than had previously been made. The curve of state surveys, as seen in the diagram, continued to rise until the outbreak of the civil war. In this second epoch of geologic work the states of the middle west—then the frontier—led. This was but natural, because history has proved geology always appealed more strongly to the pioneer than to any other class of people.

It is difficult to measure the accomplishment of this second period of geologic activity under state and federal auspices, owing to its abrupt termination by the civil war, which interrupted many important investigations. One fact stands out clearly: that applied geology was the mainspring of most of the research, and the results indicate that pure science had not been the loser thereby.

The prosperous time following the civil war in the north and west, with its almost unique industrial advancement, again centered public interest on mineral resources. This caused the federal government to resume explorations in the west, which took the form of areal geologic surveys and in some cases detailed study of mineral deposits. Many states undertook similar work, and the curve of geologic surveys arose until the interruption by the panic of 1873.

The results thus attained proved a final justification of geology, not only as an intellectual pursuit, but also as a practical aid to mankind. While the immediate benefits of these investigations were large, they were not so important as the institution of geologic mapping, based on accurate mensuration. Crude as those

maps were compared with the present standards of refinement, they represent the earliest general attempt in this country to apply engineering methods to geologic problems. It was very unfortunate that this first epoch of engineering geology, as it might be called, was so soon interrupted and the work practically discontinued for over a decade. The people were, in fact, hardly educated up to an appreciation of its value; moreover, the natural resources that could be readily exploited without the aid of science were so extensive that the time was hardly ripe to make full use of this new geology.

We have seen that the period following the civil war was especially favorable to the development of applied geology. The same is true of pure science. This, in fact, has been the history of geology in this country—advances in pure science were always in more or less direct proportion to advances made in the applied science.

It has been shown that, in the early history of the nation, the genius of the American people was essentially scientific. A deep interest was felt both in the facts and deductions of science, and in the affairs of life deference was paid to the opinion of the investigator. Unfortunately, for reasons which are difficult to fathom, this scientific attitude gradually declined. At the beginning of our national existence we were in close contact with the intellectual life of Europe, which was then essentially scientific. This gave us our first intellectual stimulus and led us to do our full share of the work of advancing both pure and applied science. Then came an interim between the time when we forsook the intellectual standards of the old world and before we fully established those of our own. Meanwhile, the opening of a continent, with its unbounded resources, was calculated to bring out the characteristic efficiency and self-reliance of the average American. Then gradually developed what may be called the era of the "practical man"—an era characterized essentially by unscientific thought among the mass of the people. The "practical man" now became a national fetish, and the people, overlooking the fact that his success was due to energy and opportunity, attributed it rather to the absence of technical and scientific knowledge.

Nowhere was this national trait better shown than in the mineral industry, where the era of the "practical man" cost the nation untold millions. His distrust of applied science was deep-rooted. For a generation every mining community swarmed with these self-styled experts, whose technical and scientific limitations were only exceeded by their blatant self-assertion.

Unfortunately, at this time there also developed between the geologist and the mining engineer an antagonism, which was detrimental to the advance of the science. A school of geology arose which revived to a certain extent the ancient practice of speculation without observation and regarded itself as moving in a higher intellectual sphere than that of the engineer, who dealt with practical problems. On the other hand, many engineers came to regard all work of the geologist as either visionary or purely speculative.

Since the rise of the modern school of applied geology, which may be said to have begun in the eighties, this antagonism between the engineer and the geologist has gradually disappeared. The geologist has made his results of more value by adopting some of the methods of the engineer, while the engineer no longer hesitates to use geology in his own field. Both professions have been improved by this mutual help, and the geologist has by no means gained the least. The modern mining engineer now recognizes that, even in his own special field, scientific investigations are essential. This is evidenced by the general hearty support given by engineers to the new federal Bureau of Mines.

It is not necessary to describe in detail the recent progress in applied geology. While most of the countries of the world have taken part, it is a field that the American geologist has made peculiarly his own. Among our important contributions in this field is the geology of mineral oils, presented by Mr. Campbell to this Society last year. In this, as in the survey of coal deposits, stratigraphic and structural geology have almost come to be exact sciences. Equally important to the nation are the results achieved in underground water investigations. The tectonics of mineral veins now also approaches an exact science; while many of the conclusions on the genesis of ore bodies, notably that

of secondary enrichment, are among the triumphs of applied geology.

Moreover, the field is being extended. In Germany the work of the geologist is regarded almost as essential to railway or canal location as that of the engineer—a lesson we have only recently learned at Panama. The investigations of soils is now a distinct science, based largely on applied geology. Questions of public health, such as purity of water and sanitation problems, also in part fall in the domain of the geologist.

A significant phase of the new epoch in applied geology is its contributions to political economy. A striking example of this is the geologic survey of Korea, executed by the Japanese during their war with Russia. It need hardly be said that this was not made for the purpose of advancing geologic knowledge, but solely to gain a scientific valuation of the land which was costing so much blood and treasure. Though the present status of the science does not permit of a quantitative determination of resources which is more than approximate, yet the fact that geologists are being called upon by political economists for assistance indicates how fundamentally the science affects the welfare of the nation.

This historical survey of applied geology, in which special emphasis has been laid on its progress in this country, seems to point to several conclusions. First, that much of the modern science of geology originated in the field of applied science. It was the striving of mankind to solve problems of material welfare that gave the first impulse to geologic thought. Second, that, as a rule, the science has made most rapid strides at those times when its study was inspired by a desire to achieve some practical end. Whenever geology has become entirely divorced from industry, it has drifted towards pure speculation. The geologists of the past, like those of the present, received much of their inspiration from the fact that they were adding to the material welfare of mankind. Werner, Humboldt, von Buch, de la Beche, were not only trained as mining engineers, but continued for most of their careers to be intimately connected with the mining industry. William Smith was an engineer before he was a geologist, and even Hutton knew

from personal experience the value of applying the sciences of agriculture and chemistry. On this continent McClure, Eaton, Rodgers, Owen, Leslie, Logan, Whitney, Orton, Cook, Dawson, and King, with a host of others, were all identified with the industrial application of their science. The elder Silliman, in an account of his own training in geology, said: "I learned in the mining districts how and what to observe." The years that Dana spent on explorations may be counted in the field of applied geology. James Hall, for two generations the leader in American geology and the founder of that organization which for three-quarters of a century has preserved the highest scientific ideals, gained his early inspiration in studying practical problems. An enumeration of the leading geologists of the present generation will, I think, show that the larger part have given much attention to the material application of geology.

The recent economic trend of geology is only a counterpart of similar tendencies in most fields of scientific research. The introduction of science into practical affairs is a feature of the present age. It has come about not only because, as the sciences progressed, their results were more directly applicable to material problems, but more specially because of the gradually changing conditions throughout the world. With a sparse population and abundance of natural resources the need of applied science is never so evident as when the lands become crowded and the more readily accessible resources depleted. The people of a virgin land need pay small heed to exhaustion of soil or destruction of forests, and can carry on shallow mining operations with little recourse to science or technology. It is only when increasing population results in a demand for a greater food supply and makes sanitation important; when the depletion of timber becomes a factor in cost of structures; and the superficial deposits can no longer yield sufficient minerals, that the need of scientific knowledge becomes strongly emphasized. This stage has been reached in most of the civilized countries of the world to a greater or less extent, and the evils of relative over-population and depletion of nature's wealth are resulting in an appeal to applied science. China stands alone among the great nations of the world in not utilizing scientific

thought to better the conditions of her people. The present turmoil in China can probably be interpreted, in the last analysis as a protest against the affairs of state being guided by the classicist rather than by the scientist.

While we may criticise China for not accepting the dictum of science, we have only recently departed from a similar attitude, though our abundant resources have made our own faults less conspicuous. In this respect the present generation has made greater strides than all that preceded. We are now applying science to the affairs of the nation as never before. The old-fashioned publicist, with his classical education or, at least, traditions, is being shouldered out of the way by the man who analyzes the problems of public welfare on scientific principles. The trained investigator is being more and more appealed to in the affairs of the nation. In this we are following Germany, whose long leadership in pure science has now been overshadowed by her leadership in applied science. We have begun to realize, that it is one thing to win prosperity and happiness out of the bounty of a new land, another to gain it by utilizing resources which can only be made available by scientific genius.

Mr. Gilbert has said that "pure science is fundamentally the creature and servant of the material needs of mankind." Yet it is not uncommon to find the devotee of pure science assuming that his field is on a higher plane than that of those studying problems which involve the material welfare of the human race. This seems specially true in the field of geology. If a bacteriologist finds a new toxin for a disease germ, a botanist a new food plant, a sanitary engineer a measure for preserving human life, all unite in commending his work. Yet there are not a few geologists, though I believe a constantly decreasing number, who seem to view with suspicion any attempt to make the science of geology more useful. Those who are devoting themselves to economic geology are charged with commercializing the science, as if the applying of its principles to better the conditions of the people were not the highest use to which scientific research could be put. One reason for this attitude is because much which has been masquerading as applied geology is not science at all. The commer-

cial exploitation of natural resources under the cloak of geology is not to be confounded with geologic research, which has for its aims the application of scientific principles to the needs of man.

The geologist who is studying the resources of the public domain to the end that a sound policy may be adopted for their utilization, or he who is gaging the exhaustion of our mineral wealth by studying statistics of production, is doing his share of scientific work no less than he who is engaged in the more pleasing task of evolving new geologic principles. The masters of the science have not hesitated to turn their attention to economic problems. Clarence King deserves no less credit for his aid in opening up the west by economic investigations than for his contributions to knowledge on the age of the earth. We think of Major Powell as one of the founders of physiographic geology, but his memory will live rather for employing science to make available the latent fertility of the arid regions of the West. Surely no one will charge King or Powell with commercializing their science.

As I see it, there lies no danger in the present trend toward applied geology, provided our applied geology rests on a broad basis of scientific research. If the spring of pure science is cut off, the stream of applied geology must soon run dry. There is no field of pure geology which will not yield results applicable to questions of material welfare. On the other hand, any given investigation in applied geology may lead to problems of paleontology, petrography, geophysics, or other branches of pure science. In view of the pressing demand for results, we are justified in giving precedence to those fields of investigation which promise the earliest returns of material value. There is, however, grave danger that, carried away by the present furor for practical results, we may lose sight of our scientific ideals. Applied geology can only maintain its present high position of usefulness by continuing the researches which advance the knowledge of basic principles. Future progress in applied geology depends on progress in pure geology.

GEOLOGY.—*Note on the stratigraphy of east-central Idaho.* J. B. UMPLEBY, Geological Survey.

During recent field studies much additional information has been obtained concerning the stratigraphy of east-central Idaho. During September 1910 the writer examined the area about the head of Lemhi Valley, and a year later, in company with Dr. George H. Girty, revisited the locality about Gilmore and made a fairly complete collection of fossils.

The Paleozoic section at Gilmore is made up of a great succession of sedimentary rocks, striking north-south and usually dipping about 45° east. Cambrian, Ordovician, Silurian, Devonian (?) and Mississippian formations are present. At the base is a clear-white, fine-grained quartzite at least 2,000 feet thick. It is well exposed above Meadow Lake. Conformably above it is massive blue dolomitic limestone about 500 feet thick. This is assigned to the Richmond stage of the Ordovician. Then follows 300 feet of massive white dolomitic limestone of Silurian age. The formation next above comprises about 2,000 feet of thin-bedded blue and white dolomitic limestones, with occasionally a siliceous band. This formation is tentatively considered as Devonian. It is presumably conformable with the Mississippian, altho its upper contact was not seen. Only a portion of the latter formation is exposed, but from this it is known to be more than 300 feet thick.

The Paleozoic series rests upon intensely metamorphosed rocks of Algonkian age which outcrop along its western border. On the east it disappears beneath Miocene lake beds. Mesozoic formations are absent.

EVOLUTION.—*Evolution in discontinuous systems.* II[1]. ALFRED J. LOTKA. Communicated by J. A. Fleming.

One of the principal types of change of state with which we are concerned in discussing inter-group evolution in biological systems is the passage of matter from one kindred-group into another thru the process of "feeding," the one group serving as food for

[1] See this Journal 2: 2. 1912.

the other. Among the various possible cases of this kind we can distinguish the following:

1. A group A_i feeds on living portions of a group A_h, which are either

(a) expressly killed in the act of feeding, or

(b) continue to live, at least for a time, while A_i is parasitic upon them (parasites, disease germs).

2. The waste products A_H of a group A_h serve as food for A_i.

3. Several groups, such as A_i and A_j feed competitively on the same group A_h.

Schematically we may represent these three cases by the following diagram

(1) $$A_h \rightarrow A_i \rightarrow A_k$$

(2) $$A_h (\rightarrow A_H) \rightarrow A_i \rightarrow A_k$$

(3) $$A_h \begin{matrix} \nearrow A_i \rightarrow A_k \\ \searrow A_j \rightarrow A_l \end{matrix}$$

In the case of type (1) A_i will as a rule tend to exert a prejudicial influence upon the growth of A_h. An exception occurs where there is symbiosis with mutual benefit, the term being here used in a general sense, to include for example the relation between man and farm plants and animals.

In the case of type (2) the influence of A_i upon A_h will be rather beneficial than otherwise, since waste products are by the very nature of things more or less harmful to the group from which they originate. So long, however, as there is no undue crowding, so that the waste products are sufficiently spread out in space ("diluted"), this effect will as a rule be small, and may often be negligible.

Case (3) may be regarded as a special form of cases (1) and (2).

If we denote the mass of any given group by the letter M with the proper subscript, we may express in analytical form the statements made in the last three paragraphs. Arranging the facts in a table we have:

	$\frac{\partial}{\partial M_i}\left(\frac{dM_h}{dt}\right)$	
	COMMONLY	SPECIAL CASE
(1) $A_h \rightarrow A_i \rightarrow A_k$	$-$	0 or $+$
(2) $A_h (\rightarrow A_H) \rightarrow A_i \rightarrow A_k$	0 or $+$	

We now proceed to discuss in greater detail a case of the type (2) noted in our table:

$$A_h (\rightarrow A_H) \rightarrow A_i \rightarrow$$

that is to say a kindred-group A_i feeds on the waste products A_H of other groups which we denote collectively by A_h. Thus for example A_h may represent a number of carnivorous species, A_H the carbon dioxide and other matter excreted by them, and A_i some green plant which assimilates such waste products, but is not itself consumed by A_h.

Fixing our attention first on A_i we note that

$$\frac{dM_i}{dt} = B_i - Z_i \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where B_i is the total food consumed by A_i per unit of time, and Z_i is the total waste matter (including the bodies of dead individuals) discarded by A_i per unit of time.

We will write

$$\frac{dM_i}{dt} = (b_i - z_i) M_i = r_i M_i \quad \ldots\ldots\ldots\ldots\ldots (2)$$

Similarly we have for A_H

$$\frac{dM_H}{dt} = B_H - Z_H \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

We will suppose that the groups A_h have had time to arrive at a state of equilibrium with their environment, and that the waste products A_H exert at most a negligible influence on A_h. Then we have for the mass M_h of the groups A_h

$$M_h = \text{constant} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

This being so, the mass Z_h eliminated per unit of time by A_h will, under otherwise similar conditions, also be constant, so that

$$B_H = Z_h = \text{constant} \qquad (5)$$

Again, Z_H the rate of elimination of mass per unit of time from A_H, stands in a simple relation to the rate of formation B_l of A_l. If A_H lost mass only through A_l feeding upon it, while on the other hand A_l gained mass by feeding exclusively on A_H, we should have simply

$$Z_H = B_l \qquad (6)$$

In general we can not, however, suppose these conditions to be satisfied, so that we must introduce a coefficient θ, and write

$$Z_H = \theta B_l = \theta b_l M_l \qquad (7)$$

Substituting (7) in (3) we obtain

$$\frac{dM_H}{dt} = B_H - \theta b_l M_l \qquad (8)$$

We are supposing all other conditions constant, and only M_H and M_l changing. Under these circumstances b_l, r_l and θ will be functions of M_H and M_l alone

$$b_l = b_l(M_H, M_l) \quad r_l = r_l(M_H, M_l) \quad \theta = \theta(M_H, M_l) \qquad (9)$$

Our immediate problem is to find a general solution of the set of differential equations (2) and (8), expressing M_H and M_l as functions of t. For this purpose we will first of all simplify our notation by dropping all subscripts, and writing

$$M_H = X \qquad M_l = Y \qquad (10)$$

Equation (8) and (2) then assume the form

$$\frac{dX}{dt} = B - \theta b Y \qquad (11)$$

$$\frac{dY}{dt} = rY \qquad (12)$$

Let us expand the right hand member of (11) by Taylor's theorem in the neighborhood of the point X_∞ Y_∞ given by

$$\frac{dX}{dt} = B - \theta_\infty b_\infty Y_\infty = 0 \quad \ldots\ldots\ldots\ldots \quad (13)$$

$$\frac{dY}{dt} = r_\infty Y_\infty = 0 \quad \ldots\ldots\ldots\ldots \quad (14)$$

We thus obtain

$$\begin{aligned}(B - \theta b Y) = (B - \theta_\infty b_\infty Y_\infty) &- \left\{\frac{\partial \theta b}{\partial X} \cdot Y_\infty\right\}(X - X_\infty) \\ &- \left\{\frac{\partial \theta b}{\partial Y} Y_\infty + \theta_\infty b_\infty\right\}(Y - Y_\infty) - \frac{1}{2}\left\{\left(\frac{\partial^2 \theta b}{\partial X^2} Y_\infty\right)(X - X_\infty)^2\right. \\ &+ 2\left(\frac{\partial^2 \theta b}{\partial X \partial Y} Y_\infty + \frac{\partial \theta b}{\partial X}\right)(X - X_\infty)(Y - Y_\infty) \\ &\left. + \left(\frac{\partial^2 \theta b}{\partial Y^2} Y_\infty + 2\frac{\partial \theta b}{\partial Y}\right)(Y - Y_\infty)^2\right\} - \ldots\ldots\ldots\ldots \quad (15)\end{aligned}$$

or, in an obvious notation, and putting

$$(X - X_\infty) = x \quad \ldots\ldots\ldots\ldots \quad (16)$$

$$(Y - Y_\infty) = y \quad \ldots\ldots\ldots\ldots \quad (17)$$

$$\frac{dx}{dt} = \alpha x + \beta y + \gamma x^2 + \delta xy + \epsilon y^2 + \cdots \quad \ldots\ldots\ldots\ldots \quad (18)$$

Similarly

$$\frac{dy}{dt} = \alpha' x + \beta' y + \gamma' x^2 + \delta' xy + \epsilon' y^2 + \cdots \quad \ldots\ldots\ldots\ldots \quad (19)$$

The solution of the system of differential equations (18) (19) is

$$\begin{aligned}x = A_1 e^{-ht} + B_1 e^{-kt} + A_2 e^{-2ht} + B_2 e^{-(h+k)t} + C_2 e^{-2kt} \\ + A_3 e^{-3ht} + B_3 e^{-(2h+k)t} + C_3 e^{-(h+2k)t} + D_3 e^{-3kt} + \cdots \quad (20)\end{aligned}$$

$$y = a_1 e^{-ht} + b_1 e^{-kt} + \cdots \quad \ldots\ldots\ldots\ldots \quad (21)$$

The values of h, k, A_1, A_2, ... a_1, a_2, ... can be determined by substituting the solution in the original equation and equating the coefficients of homologous terms. It is unnec-

essary to carry this out in detail here; the expressions thus obtained for h and k are, however, of special interest

$$h = -\frac{1}{2}\left\{(\alpha+\beta') + \sqrt{(\alpha-\beta')^2+4\alpha'\beta}\right\} \quad \ldots\ldots\ldots (22)$$

$$k = -\frac{1}{2}\left\{(\alpha+\beta') - \sqrt{(\alpha-\beta')^2+4\alpha'\beta}\right\} \quad \ldots\ldots\ldots (23)$$

From these expressions it will be seen, that the solution becomes oscillatory as soon as

$$(\alpha-\beta')^2+4\alpha'\beta<0$$

It is then convenient to write the solution in trigonometric form, as follows

$$x=e^{-pt}\{A'_1\cos qt+B'_1\sin qt\}+e^{-2pt}\{A'_2\cos 2qt+B'_2\sin 2qt+C'_2\}$$
$$+e^{-3pt}\{A'_3\cos 3qt+B'_3\sin 3qt+C'_3\cos qt+D'_3\sin qt\} \ldots\ldots (24)$$

$$y=e^{-pt}\{a'_1\cos qt+b'_1\sin qt\}+\cdots\cdots\cdots\cdots (25)$$

where

$$p=-\frac{1}{2}(\alpha+\beta') \quad \text{and} \quad q=\frac{1}{2}\sqrt{-\{(\alpha-\beta')^2+4\alpha'\beta\}} \ldots (26)$$

For lack of numerical data we can not apply the solution thus found to a concrete example of the particular case here considered. However, for a certain type of reaction, which the writer has discussed elsewhere,[2] the laws of chemical dynamics lead to a set of equations

$$-\frac{dx}{dt}=Lx+Ky+xy \quad \ldots\ldots\ldots\ldots\ldots\ldots (\mathrm{I})$$

$$\frac{dy}{dt}=Lx+xy \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (\mathrm{II})$$

which will be recognized as a special case of (18) (19); their solution is, in point of fact, of the form (20) (21) (24) (25).

In order to illustrate the character of the function represented by the series (24), a concrete example of such a reaction has been

[2] Jl. Phys. Chem. **25**: 271. 1910. Zeitschr. phys. Chem. **72**: 508. 1910. Only the first two terms of the series are given in these publications.

worked out, arbitrarily assuming the following values for the constants occurring in equations (I) and (II)

$$K = 0.505 \qquad L = 0.2$$

whence follows

$$p = 0.1 \qquad q = 0.302$$

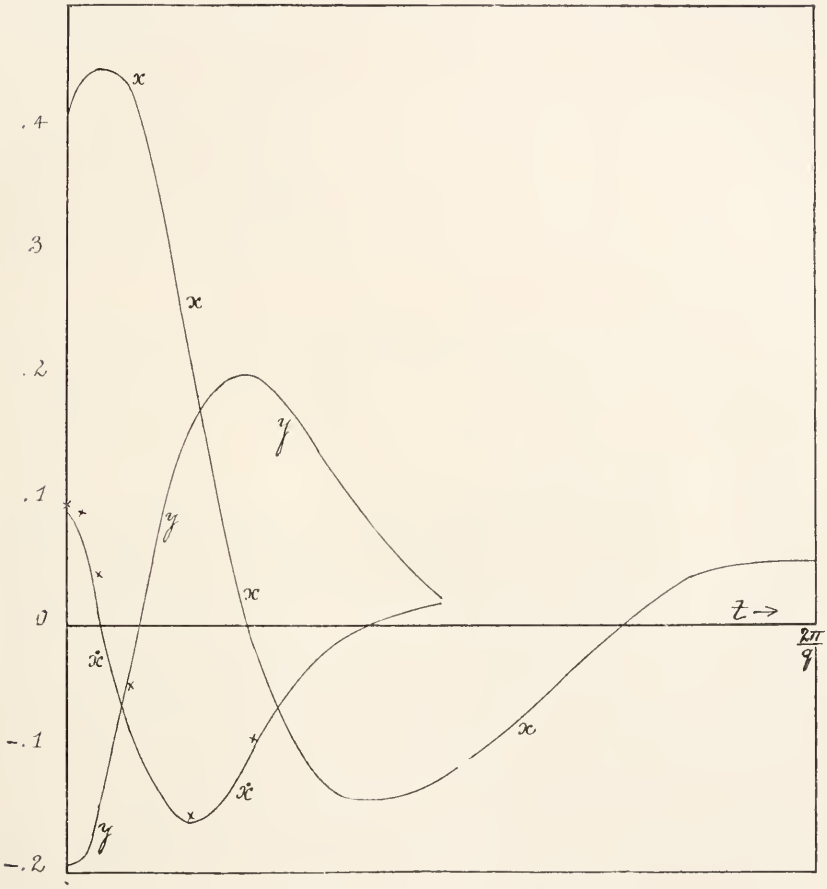


Fig. 1. Solution of Equations (24) and (25)

The first three terms of the solution were worked out. The constants thus obtained for x are tabulated below, together with the corresponding constants for y and $\dot{x}$.

	A_1	B_1	A_2	B_2	C_2	A_3	B_3	C_3	D_3
x.....	0.390	0.000	0.0385	0.1049	0.0454	—0.0611	0.0777	—0.00524	—0.0222
y.....	—0.077	.2329	—.0956	—.0438	.0298	— .0630	— .0780	.0118	— .00539
x.....	—0.039	— .1176	—.0556	—.0542	— .0091	.0886	.0320	— .00512	.00824

No attempt was made to investigate the convergence of the series, but the solution was tested by substituting it in the right hand member of (I) and comparing the values thus obtained with the corresponding values of $\frac{dx}{dt}$ obtained directly from the solution as tabulated above. These latter are shown as a continuous curve $\dot{x}$ in the accompanying diagram while the crosses indicate corresponding values obtained by substitution. Beyond the last cross shown the agreement was complete within the limits of plotting error.

While the curves shown in the diagram refer specifically to the reaction mentioned above, in their general appearance they are typical of the solution (25) of the general case, and we may here discuss them as if they related to the groups A_{II} and A_{I} which we have been considering.

We note, then, that at the start there is an abundance of the food material x, and accordingly the feeding group y increases rapidly, with the result that soon the increased consumption causes the total food supply to diminish, tho it is still for a time quite plentiful, and y accordingly continues to increase. After a certain time, however, when x, the food supply, has fallen below a certain value,[3] the feeding group y now also begins to diminish. This alternate rise and fall of the two curves, with a certain phase difference, would go on indefinitely if we extended our curves to infinity, for it can be seen by inspection of (24) (25), that for very large values of t the solution reduces simply to the form of damped harmonic oscillation. Actually the curve for x has been

[3] That this value happens to be zero is peculiar to the special case here considered, x being a factor of $\frac{dy}{dt}$ (see Equation II); in general this is not the case. To be precise, x represents not the food supply, but the excess of this over its equilibrium value. See Equation (16).

drawn for one entire fundamental period, and the curve for y for one-half-period.

The significance to a biological kindred-group of such alternating periods of prosperity and depression as are indicated in our oscillating curve, representing a function of the form (24) is so obvious as to call for no further comment. In particular, the question suggests itself to our minds, whether the curve of growth along which the human race is at present ascending, leads to a maximum, to be followed by a downward incline. That we have been living on our capital of natural resources is only too clear. But we are awakening to a realisation of this fact, and are taking stock, and looking ahead in preparation to meet such emergencies as may arise. Our reflections here lead us to the consideration of such topics as the preservation of our natural resources, the production of nitrogen compounds from the air, and the exploitation of the radiant energy received from the sun. These things have been discussed at length in the current scientific and technical literature, and their mere mention here in their logical place must suffice.

As an example of a case of the type (1. b) (page 50), we will consider a bacterial disease, such as pulmonary phthisis, which is more or less constantly present in the population (i.e., not epidemic in its occurrence). Brief reflection shows that we can apply to this case a mathematical treatment precisely analogous to that of the growth of a population. For we may think of the diseased part of the population as a separate aggregate, into which new individuals are recruited by fresh infection, just as new individuals enter an ordinary population by births. On the other hand members are continually eliminated from the aggregate, firstly by deaths, and secondly by recoveries. On the basis of these considerations formulae can without difficulty be established to express a relation between the total and the diseased population, which in this case is of more immediate interest than the ratio of the total mass of the population to that of the bacteria. Such general furmulæ however involve certain functions which are unknown, and whose determination by statistical methods would at best present great difficulties. The matter

assumes a somewhat more favorable aspect if we are satisfied with the discussion of the simple special case of a stationary population, in which the disease also is supposed to have reached equilibrium.

We may then proceed as follows:

Let N be the total number of the population, and

N_1 the number afflicted with the disease.

Let $S = Ns$ be the total number of deaths per unit of time, and let

$S_1 = N_1 s_1$ be the number of deaths per unit of time, due to the disease considered.

Let $N_1\sigma_1 = N_1 \frac{s_1}{\tau}$ be the total number of individuals eliminated from the aggregate of diseased persons per unit of time from all causes, including deaths by the disease under consideration, by other diseases, and also recoveries.

When a stationary condition is reached, σ_1 must be equal to the reciprocal of the mean duration L of the disease. In this case we have, then

$$N_1 s_1 = N_1 \frac{\tau}{L} \quad \ldots\ldots\ldots\ldots\ldots\ldots (27)$$

Furthermore, if γ is a factor indicating that fraction of the total deaths, which is due to the disease considered, then

$$N_1 s_1 = N_1 \frac{\tau}{L} = \gamma N s \quad \ldots\ldots\ldots\ldots\ldots\ldots (28)$$

Hence

$$\frac{N_1}{N} = \frac{\gamma L s}{\tau} \quad \ldots\ldots\ldots\ldots\ldots\ldots (29)$$

or, solving for L

$$L = \frac{N_1}{N} \frac{\tau}{\gamma s} \quad \ldots\ldots\ldots\ldots\ldots\ldots (30)$$

By the way of a numerical example, let us substitute in the formula thus obtained some data gathered from the statistics

for New York City. The supposition of a stationary population and an equilibrium condition of the disease is quite unwarranted here, but in the absence of more suitable material, and in view of the great uncertainty of the figures obtainable, we shall have to rest content with this very crude illustration.

In 1909 the total population of New York was about 4.5 millions. The total number of consumptives at the time has been estimated at about 45,000. Hence $\frac{N_1}{N} = 0.01$. The death rate per head, per annum, from all causes, was 0.016; that from tuberculosis alone 0.002. Hence

$$\begin{aligned} s &= 0.016 \\ \gamma s &= 0.002 \\ \gamma &= 0.125 \end{aligned}$$

The coefficient τ represents a measure of the "deadliness" of the disease, i.e., it expresses what fraction of the persons once struck with the disease untimately die therefrom. It is difficult to obtain any kind of estimate of the value of τ. We will assume that $\tau = 0.8$

We then have by (30)

$$L = \frac{0{,}01 \times 0{,}8}{0{,}002} = 4$$

In view of the crudity of the data on which it is based, this calculation must be regarded purely as an illustration of the principles involved, and not in any sense as an attempt to determine L, although the endeavor has been made to preserve at least the right order of magnitude in the example given.

The mathematical treatment of the phenomena presented by infectious diseases has been developed in some detail by Sir Ronald Ross, especially with respect to insect-carried diseases, in his book *The Prevention of Malaria*,[4] and, quite recently, in a paper published in *Nature*.[5]

[4] Published by Murray, 1910; Second Edition, 1911.

[5] "Some Quantitative Studies in Epidemiology," *Nature*, Oct. 5, p. 466. 1911.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 488th regular meeting was held at the Cosmos Club, November 18, 1911. Four new members were elected. The first communication was an illustrated paper on a *Study of distribution based upon the family Pyramidellidae*, by PAUL BARTSCH.

The second communication was entitled *The peculiar migration of the Evening Grosbeak*, by WELLS W. COOKE.

Most species of North American birds have migration routes that are approximately north and south, while the migration route of the Evening Grosbeak is nearly east and west.

The species is rather common in the mountainous parts of western North America from central Alberta to southern Mexico. It has been divided into three farms: *montana* includes all the breeding birds of the United States and southern British Columbia; *mexicana*, all the breeding birds of Mexico; and *vespertina*, the remainder of the breeding birds of Canada.

The species was originally described from migrants taken in April, 1823, at Sault Ste. Marie, Mich., but it was more than half a century later before the first eggs were found. The first published description of the eggs was by Bryant in 1887 of a set found May 10, 1886, in Yolo County, Calif. A set of eggs had been taken two years earlier at Springerville, Ariz., but an account of it was not published until 1888. Ten years elapsed before the next set was taken in 1896 near Lake Tahoe, Calif. There had been only three sets found, therefore, up to 1901, when Mr. F. J. Birtwell found at Willis, N. M., five nests in one small colony. He secured the eggs from two of the nests and lost his life by an accident in climbing after the third. Only a few nests have been found in the last ten years, so that there are scarcely a dozen sets of the eggs of the Evening Grosbeak in existence at the present time. All of these eggs belong to the subspecies *montana;* the eggs of the type species *vespertina* are still unknown to science, although young have been found in the nest.

The form *montana* is not migratory in the strict sense of the word. It nests in the mountains and spreads out in winter time into the valleys and the neighboring plains. The form *vespertina*, nesting entirely north of the United States in the mountains of Alberta, is strongly migratory, but instead of moving south in the fall, which would bring it into the district occupied throughout the year by *montana*, it journeys eastward and is a common winter visitant in Manitoba and Minnesota. Hence it spreads less commonly to Iowa, Wisconsin, Michigan and western Ontario. The species was scarcely known further east until the winter of 1889–90, when a remarkable invasion of the Evening Grosbeak was noted throughout much of the northeastern United States. So numerous were they that more than a thousand were killed in the vicinity of

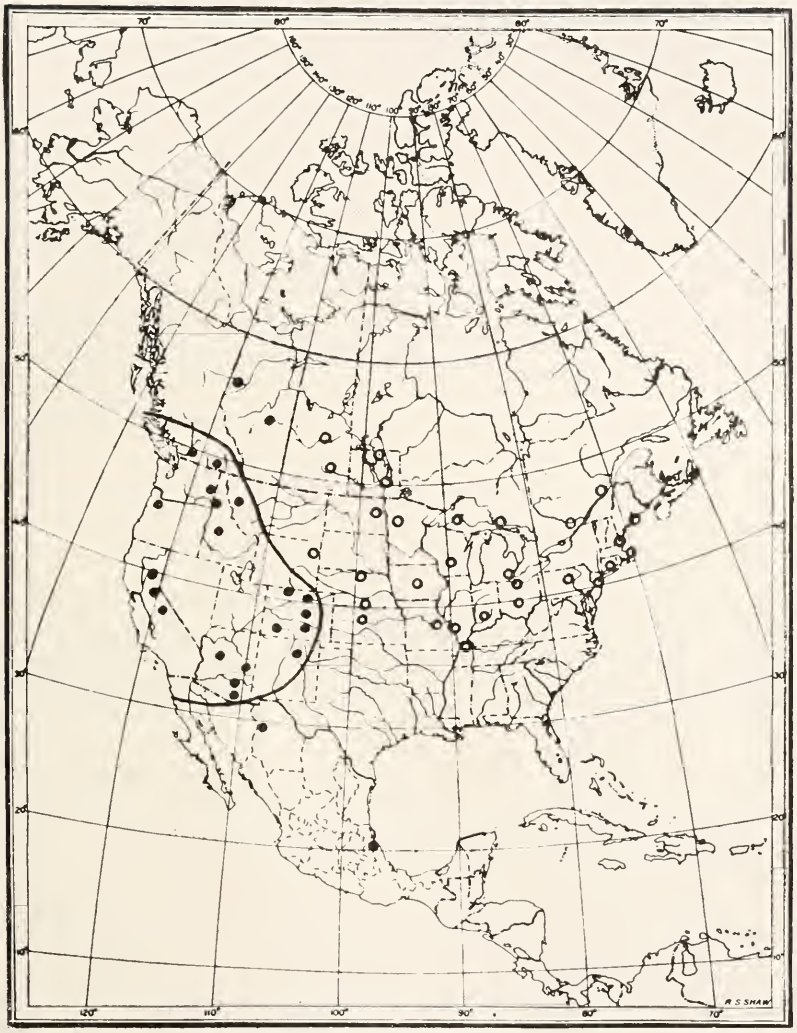


Fig. 1. Evening Grosbeak

● Breeding
○ Winter

Heavy line separates *montana* from *vespertina* on the north and *mexicana* on the south.

Toronto, Ontario, and the birds for the first time appeared in New England. Ten were seen in this part of the country for the next ten years, but during the last few years they have become increasingly common and the winters of 1909–1910 and 1910–11 witnessed the presence of almost as many individuals as had appeared twenty years earlier.

The species is known to have ranged east, southeast and south to the city of Quebec, Canada, Bucksport, Me., Seabrook, N. H., Cape Cod, Mass., Woonsocket, R. I., Portland, Conn., Fairhaven, N. J., Williamsport, Pa., Granville, O., Hickman, Ky., New Haven, Mo., Onaga, Kans., and Ellis, Kans.

During the invasion of 1889–90, the birds remained until May 1, the last being seen on that date at Henniker, N. H. During 1910–11, they remained until May 15 at Leominster, Mass.

Not all of the migrants go eastward, for the Evening Grosbeaks of Sundance, Wyo., belong to the Canadian farm, *vespertina*, and must have made a long migration from Alberta; though *montana* breeds but a short distance to the westward.

D. E. Lantz, *Recording Secretary.*

PROGRAMS AND ANNOUNCEMENTS

BIOLOGICAL SOCIETY OF WASHINGTON

The 492nd meeting will be held at the Cosmos Club at 8 p.m. Saturday, January 20, 1912. Program: Brief notes and exhibition of specimens. *Elk heads in Jackson Hole, Wyoming;* illustrated; E. A. Preble. *A naturalist among the Igerotes of the Philippine Islands;* illustrated; H. V. Harlan.

JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. II, FEBRUARY 4, 1912 No. 3

ELECTRICITY.—*The four-terminal conductor and the Thomson bridge.* FRANK WENNER. Communicated by E. B. Rosa. To appear in the Bulletin of the Bureau of Standards.

In the measurement of low resistances the resistances of connectors and contacts are often as large as the resistances with which we may be concerned. It is therefore necessary, if a high precision is desired, to use a method of measurement by which the effects of the resistance of the connecting leads and contacts are eliminated. That is the method must be such that we can limit the resistance measured to that of a part of a conductor which contains no variable connecting resistances. The first requisition then is that the conductor have four terminals suitable for making electrical connections to other conductors or leads. Usually two of the four terminals are designed for making connections to current leads while the other two are designed for making connections to the potential leads.

When a current enters through one of the current terminals and leaves through the other, there is a difference in potential between the potential terminals. The ratio of this potential difference to the current is the resistance of the four-terminal conductor.

When such a conductor is to carry a large current, as is often desired, the current terminals must be large so the current distributions in the conductor depends to some extent upon the way in which the current leads are connected. Where this is the case we are not surprised when we find the resistance of the conductor somewhat indefinite. Where, however, this matter is given due consideration in the design the resistance can be made definite within the limits of measurement, even where the conductor is made of sufficient section to carry 1000 amperes or more.

If the current leads are connected to the potential terminals there is, when a current is flowing, a difference in potential between the current terminals. The ratio of this potential difference to the current is the same as with the regular connections. If the current leads are connected to one of the current terminals and to a corresponding potential terminal, there may be a difference in potential between the other two terminals when a current flows. The ratio of the difference in potential to the current is what we may call the cross resistance.

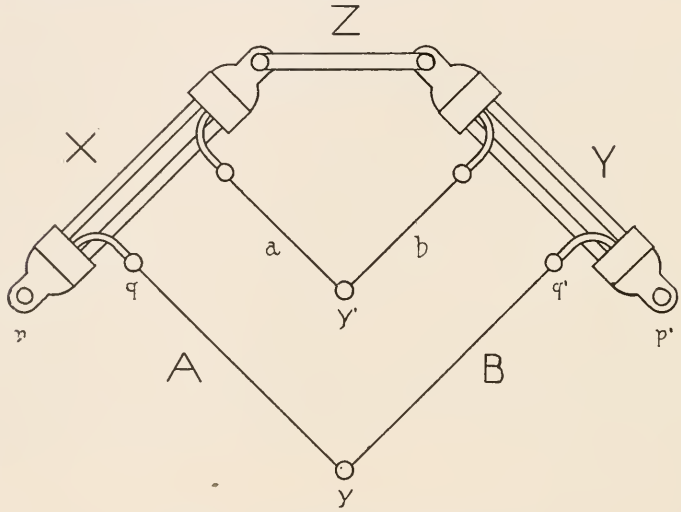


Fig. 1. Thomson Bridge Method

Where the cross resistance is appreciable, errors may be introduced unless the method of measurement is such as to eliminate its effect as well as the effect of the connecting resistances.

Of the different methods available for the comparison of low resistances, we shall consider here only the Thomson bridge method. This method has been in use for about a half century[1] and many of its advantages were pointed out in the original paper. The arrangement of the conductors in the bridge is shown in Fig. 1. Here X and Y designate the low resistance conductors to be compared and A and B the conductors of the main ratio set.

[1] Sir Wm. Thomson, Phil. Mag., **24**: 149. 1862.

Later we shall use X and Y to designate the values of the low resistances and A and B to designate the values of the resistances in the ratio set between p and y, and y and p'. We shall also use X_m and Y_m to designate the inductances of the low resistance conductors. The equations generally given for use with this method have been derived without taking into consideration the cross resistances of the four terminal conductors. The relations given by the equations are therefore not exact as has generally been supposed. Recently Prof. Searle has derived new equations[2] giving the relations between the various resistances including the cross resistances. These equations are necessarily somewhat complicated and in order to be able to use them in calculations, it is necessary to know the values of a large number of resistances. If, however, adjustments are made so that the bridge is in balance using alternately p and p', and q and q' as branch points and if the balance is not disturbed on removing the connector Z it can be shown that

$$X/Y = A/B \qquad (1)$$

Low resistance standards are sometimes used in alternating current measurements. In such cases it is generally necessary to know both the resistance and inductance or to know that the inductance is so small that at the frequency used, the phase angle may be considered zero. The Thomson bridge method may be used for measuring both the resistance and inductance.

A general equation, giving the relations between the resistances inductances and frequency of the alternating current necessary for a balance, would be very complicated. If however, adjustments are made so that, under the conditions given above, the bridge is balanced both when using direct current and when using alternating current the relations become much simpler and as a particular case it can be shown that

$$X_m/Y_m = X/Y = A/B \qquad (2)$$

Here it is assumed that the inductances of A and B are so small in comparison with their resistances that their time constants may be considered zero.

[2] Electrician, **67**: 57. 1911.

EVOLUTION.—*Evolution in discontinuous systems.* III.[1]
ALFRED J. LOTKA. Communicated by J. A. Fleming.

In our considerations so far we have supposed r_i, the fractional rate of increase of any group A_i, to be a given function of the general conditions of the system, and in particular of the masses M_h and M_i.

Let us now look a little more closely at this function r, and examine it in its relation to the physical properties of the living organism.

In the first place we note that

$$r = \frac{1}{M}\frac{dM}{dt} = \frac{1}{M}(B - Z) \quad \ldots\ldots\ldots\ldots\ldots (31)$$

If m is the average mass of one individual, we have

$$M = Nm \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (32)$$

For our present purpose it will be sufficiently near the truth to assume m to be constant. In that case

$$r = \frac{1}{M}\frac{dM}{dt} = \frac{1}{N}\frac{dN}{dt} = \frac{1}{N}(G - S) = (g - s) \quad \ldots\ldots\ldots (33)$$

where

G = total number of births per unit of time, and

S = total number of deaths per unit of time.

Our problem, then, is to investigate G and S, or g and s as functions of the physical properties of the organism.

It may appear at first sight the most logical procedure to discuss first of all B or G. On looking into the matter, however, we find that B can always be referred back to Z, and that the latter appears really more directly related to the physical properties of the system, so that its discussion naturally takes first place.

The statement has just been made, that B can always be referred back to Z. This is evidently true, for whatever material is gained by one group, must be lost by one or more other groups, or to express this in the form of an equation,

[1] See this Journal, 2: pp. 2 and 49, 1912.

$$B_1 = \sum_{v=1}^{v=\omega} \lambda_{1,v} Z_v \quad \ldots\ldots\ldots\ldots\ldots\ldots (34)$$

where the coefficients $\lambda_{1,v}$ have an obvious import.

But in many cases there is also a simple relation between g and s. Thus for a stationary condition we have

$$g = s \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (35)$$

while, under constant conditions, birth and deathrate tend to approach the relation

$$\frac{1}{g} = \int_0^\infty e^{-(g-s)a} p(a) da \quad \ldots\ldots\ldots\ldots\ldots (36)^2$$

where $p(a)$ is the probability, at birth, that an individual picked out at random from among newly born shall reach age a.

We obtain still another relation between g and s if we suppose that matters have so adjusted themselves, that the birthrate is the one that gives the maximum rate of increase for the population, a condition which is presumably approached in nature. In such a case we must have

$$\frac{dr}{dg} = \frac{d(g-s)}{dg} = 0 \quad \ldots\ldots\ldots\ldots\ldots\ldots (37)$$

or

$$\frac{ds}{dg} = 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (38)$$

Our immediate task, then, is to discuss the influences which determine the deathrate of a given group. Obviously such deathrate will depend (1) On external conditions; (2) On the the properties of the group.

As regards the first of these two factors, we note that in general the external influences to which the individual is exposed vary from point to point in space and from instant to instant at a given point. For the purposes of our present discussion we shall

[2] Lotka, Am. Jl. Sci., **24**: 201. 1907. Science, **26**: 22. 1907. Sharpe and Lotka, Phil. Mag., p. 437, April, 1911.

suppose that the mode of variation is given, so that we may restrict our discussion to the second factor, the dependence of the death rate, under given external conditions, on the properties of the group.

We noted at the outset, that the distinguishing characteristic of the kind of changes with which we are here concerned, is their discontinuity. Let us consider a little more in detail how this discontinuity enters into play in the case of an aggregate of living organisms. If we single out some one particular individual, and follow up its history, we shall see it exposed, in its travel through time and space, to fluctuating internal and external conditions. This will in general lead to changes in the distribution of energy both within the individual and between it and the environment. With regard to such redistribution of energy the following observation is to be made:

In general an infinitesimal change in the distribution of energy in a material system brings with it an infinitesimal change in the condition of the system. If, however, such change in distribution continues in a given direction, sooner or later a point will in general be reached, beyond which any further change, even if infinitesimal, will now cause a finite change in the condition of the system. Thus a discontinuous change takes place. Analytically we might express these facts somewhat as follows: Let P be some one of the parameters which serve to define the state of the system under consideration. Let the distribution of energy in the system suffer a change by the passage, in stated manner, of a quantity dQ_1 of some form of energy E_1 from one portion of the system into another, or from the surroundings into the system. Then in general $\frac{dP}{dQ_1}$ is a finite and continuous function of Q_1. After a certain quantity Q_c has been transferred, however, and the parameter P has reached a corresponding critical value P_c, any further increment dQ_1, however small, now causes a finite change in P—in other words the function $\frac{dP}{dQ_1}$ has a discontinuity at this point. We may speak of P_c as the "critical" or "limiting strain" of the system for the par-

ticular form of energy and mode of redistribution of the same. Each system has a definite set of such limiting strains, which represent characteristic properties, and which we may speak of collectively as the "passive resistance" of the system to impressed modifications.

If we turn our thoughts back now to the consideration of the individual organism whose history we were following up, we observe that in general, among the fluctuating influences to which it is subjected, there will sooner or later arise conditions in which a "limiting strain" is exceeded—the individual suffers a discontinuous change, which may be of such character as to kill it, *i. e.*, eliminate it from the aggregate.

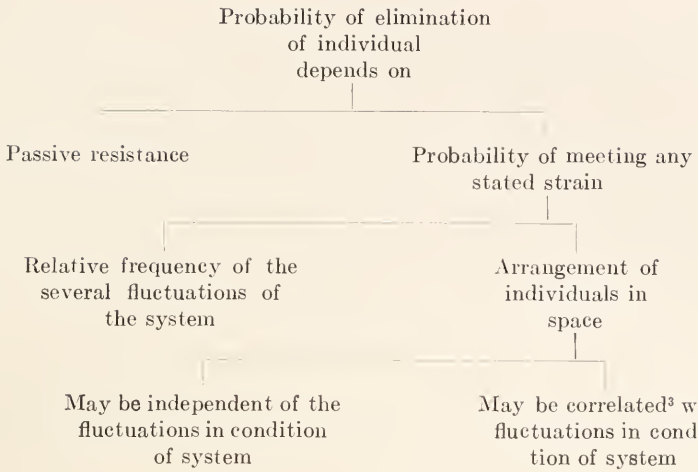
Under the conditions of the problem as it presents itself to us in nature we can not in general foretell when a particular individual will meet with the fatal variation. We may know, however, in a statistical way, what fraction $p(\mathrm{a})$ out of some large number of individuals, picked out at random and counted at the moment of their birth, will reach age a, or, what amounts to the same thing, what proportion $\mu(\mathrm{a})$ of individuals at age a are eliminated per unit of time. Our problem is to analyse $\mu(\mathrm{a})$ in its relation to the properties of the organism.

An analysis of the factors which determine $\mu(\mathrm{a})$ leads us first of all to a division of these into two classes. For the probability that a given individual shall be eliminated from its continuum, in a small interval of time dt say, depends on two kinds of conditions: Firstly on the "passive resistance" of the individual, as defined above, and as measured by the set of values of the several P_e; secondly on the probability that the individual shall be exposed to any stated strain during the interval dt. This latter probability itself in turn depends on two factors; firstly on the relative frequency of the several fluctuations in the conditions of the system; and secondly on the probability that a given fluctuation occur in such relation to time and space that the individual under consideration is affected thereby. Finally, this last probability depends on the distribution and disposition (arrangement) of the individuals in space. And in this respect there are two cases to be distinguished. On the one hand the

arrangement of the individuals in space may be independent of the distribution of the "fluctuations" in the system—at least so far as the critical limits are not exceeded—; thus, for example, according to the simpler form of the kinetic theory, which regards the molecules as elastic spheres, the probability of finding a molecule at the point x, y, z is independent of the coördinates and velocities of the other molecules, provided only that x, y, z does not fall within the radius of another molecule. If we suppose that chemical action takes place at the time of a collision between two molecules, then we see that in this case, the occurrence at a given point, of a fluctuation which would cause a molecule placed at that point to be eliminated from the aggregate (namely the presence there of another molecule with certain velocity components), has no influence upon the probability that some molecule or other shall be moving upon the point in question at the moment considered.

But in an important class of cases the arrangement of the individuals in space is not independent of the distribution of the fluctuations in space; on the contrary, there is a more or less close "correlation" between the occurrence of certain fluctuations in the general conditions of the system and the presence of an individual at the corresponding point of time and space. In fact, it is hardly too much to say, that the dominant tendency in the evolution of the highest types of living organisms, and of modern man in particular, is to make this correlation as close as possible.

Before we proceed to consider more in detail the manner and means by which this correlation is secured, it will be well to summarise in tabular form the essential points of our analysis. Expressing successive dependencies on the pattern of genealogical tables, we obtain the following picture:



Let us now briefly consider how this correlation between the conditions of the system from point to point and the disposition of the individuals in space is established. It will be useful to illustrate by means of a simile the phenomena here involved.

The individual in its struggle for existence may be likened to a fencer A, whose opponent B represents the external world. We will think of B as being immortal, a condition which might be realized for example by immediately replacing him by a substitute as soon as he received a serious injury. Then, however excellent A's fencing might be, short of absolute perfection, sooner or later he must succumb to the attack of his assailant. Now we may roughly represent the course of the combat as follows: B makes the attack. Let x' y' z' be the coördinates of the point of his sword. For the sake of simplicity we will suppose that these coördinates define B's position at every moment sufficiently for our purposes. A's task is to parry each of B's thrusts. In other words, if x y z are the coördinates of A's swordpoint, A's problem is to make x y z such functions of x' y' z', that the latter coördinates at no instant fall within the geometrical boundaries of his vital organs.

[3] Such correlation is probably possible only in a system having a fund of free energy. The phenomenon is closely related to "relay action," in which "action and reaction" are *not* equal.

Now A's success will evidently depend on two factors: Firstly on his determination and skill in the selection of a suitable function; and secondly on the precision with which he attains the functional relation aimed at. This precision in turn depends on two factors: on the one hand on the accuracy of his sense organs (receptors), as measured for example by the frequency curve of his observational errors; on the other hand the precision of A's fencing depends on the agility with which his body and limbs (effectors) carry out the actions aimed at, i.e., those corresponding to the function selected.

Leaving now our simile,[4] and considering the actual case of a living organism, such as man, we observe that thruout all his activities there runs the so-called "sensory-motor circuit," which comprises the following steps:

1. The external world is "represented" (in the mathematical sense)[5] in the individual. This is effected partly by the sense organs (receptors), and partly also with the assistance of the thinking organ, which, by logical argument, further develops the representation formed directly by the sense perceptions.

2. The representation of the external world so obtained calls out another representation of a "modified external world." (The modification may involve both the external world and the individual.) If this modified "representation" be a subject of consciousness in the individual, we recognise it as a "desire," "purpose," or "intention." If several alternatives of this kind are presented, in general one of these is selected. If this choice is made by a conscious process, it is determined by a faculty which may be termed the "judgment of value" of the individual.

3. The third and terminal step in the circuit is an "action" of the individual, whereby the external world is so modified as to correspond with greater or less accuracy to the "modified representation" of the external world, which we noted under (2). At this step also, as in (1), thought-processes may assist in

[4] This simile is of course incomplete in so far as we have supposed A to remain purely on the defensive, whereas the typical living organism must necessarily make active attack. This does not, however, materially affect the argument, since the same principles apply to its actions in either attitude.

[5] The German word "abgebildet" is particularly expressive.

the carrying out of the "purpose" in view, i. e., in impressing upon the external world the form corresponding to the modified representation just referred to.

Now the efficiency of the "receptor-effector system" depends on the perfection with which each of the steps of the sense-motor circuit is carried out. The investigation of the function r in its relation to the physical properties of an organism such as man for example therefore resolves itself into the discussion of the several sources of "error" in the working of the receptor-effector system, and the influence of such errors upon the rate of increase of the group. No attempt shall be made here to attack this problem, or even to put it in mathematical setting, tho this latter offers no difficulty, and might prove instructive. We will rest content on this occasion with a tabular synopsis of the principal sources thru which errors enter into the functioning of the receptor-effector system. Such a table appears as follows:

Synopsis of the Steps in the Sensory-Motor Circuit, with the Corresponding Sources of Error.

	1. *Representation of the external world in the individual*	
A.	Sense perceptions	Observational error
B.	Reasoning (as a step in the further development of the image formed by the senses)	Logical error
	2. *Determination of the "Modified Representation"*	
A.	Unconscious (Reflex)	Deviation from the "best adapted" modified representation[6]
B.	Conscious: "Valuation" of several possible "modified representations" and selection of one of them	Error of the "judgment of value"[7]
	3. *Action*	
A.	Actuation of limbs, etc.	Operational error
B.	Reasoning (as a step in the realisation of the "modified representation")	Logical error

[6] It is presumably by such a "false reflex" that a moth is drawn into the destroying flame.

[7] Flagrant errors of this kind are seen for example in the case of the drunkard, the gambler and so forth.

While this table must be regarded as more or less provisional, it represents perhaps a first step in that analysis of the phenomena involved, which must necessarily precede any quantitative treatment of the problem before us, namely the investigation of the rate of increase of a given type of organisms, as a function of their physical properties. So much, perhaps, has been made clear, that the subject is closely related, on the one hand to the theory of observational error, and on the other to the theory of value. This last point, on closer inspection, seems to offer some specially alluring prospects for further study. Mathematically the problem at this point takes the form typical of the calculus of variations: In an evoluting system of the kind considered, certain functions must tend to assume such form as to make the probabilities of a fatal encounter a minimum.

If on the other hand we contemplate the subject of our "judgment of value" in its philosophical relation to human life again we are met by a number of interesting suggestions.

But at this point my subject merges into the realm of sentiment, which one is reluctant to enter.

PHARMACOLOGY.—*Physiological studies in anaphylaxis. VI. The reaction of the opossum to horse serum.* W. H. SCHULTZ and H. E. JORDAN, Hygienic Laboratory. Communicated by J. W. Kerr. To appear in a Bulletin of the Hygienic Laboratory.

The intact non-sensitized opossum reacts only slightly to large intraperitoneal doses of horse serum, this action being evidenced chiefly by signs of abdominal cramps. The anesthetized non-sensitized animal records a temporary fall, and sometimes a slight rise of blood pressure and a change in the rate and force of respiration when injected intravenously with 0.0025 cc. of horse serum per gram body weight.

The intact opossum sensitized toward horse serum reacts very energetically to intraperitoneal and intravenous injections of serum, as is evidenced by the passage of urine and feces, the frequent yawning, the slowing and deepening of the respiration, vomiting, muscle weakness, and signs of abdominal cramps. The

animal may or may not recover, depending upon the gravity of the symptoms elicited by the toxic dose of serum. For example there was observed in one sensitized opossum, under ether anesthesia, a sharp fall of blood pressure from 122 to that of 20 mm. of mercury, at which latter level the pressure remained for three or more minutes. The respiration changed from a rate of 44 per minute, before the fall of blood pressure, to one of 54 during the fall, with a diminished respiratory output. As soon as the blood pressure reached its lowest level the respiration was greatly slowed and increased in force. The oscillation of the intrapleural pressure was also greatly increased and accompanied by a gradually increased inspriatory period until finally respiration ceased in the semi-inspiratory stage; whereupon the animal, after some minutes, gave a series of gasps and recovered, whereas in another animal the respiratory gasps were absent and the animal failed to recover.

The blood vessels of the opossum's lung react much as do those of the guinea-pig while the bronchi react more like those of the cat-lung.

One of the most interesting phenomena observed in one highly sensitized animal, but which may not prove to be characteristic of the anaphylactic opossum, is the reaction of the blood. In this animal the arterial blood became milk-red in appearance and upon bleeding the animal a milk-like layer floated to the surface and was pipetted off. If the horse serum was present in large quantities in a large blood vessel masses of the white material seemed present and in time became tough, but where the serum was more thoroughly mixed with large quantities of blood the particles as seen thru the microscope were extremely small. This very finely divided emulsion when dried as a film upon a cover slip revealed a rich supply of fat droplets after staining with Sudan III, or with osmic acid. There was also other material, the nature of which has not yet been determined, but which took Hasting's and also Wright's stain and appeared like cellular and protein débris. Animals that did not prove to be hypersensitive toward horse serum yielded a fat layer in the blood, to about the same extent as does cat-blood, but so far the phenomenon to which

we refer is, quantitatively at least, much more marked, and apparently different from the fat phenomenon in cats.

Large quantities of this material seemed distributed thruout the body so that the voluntary muscles of the chest, the surface of the right heart, the large veins up to the lungs, the diaphragm, and especially the upper portion of the alimentary tract, appeared whitish. The large blood vessels of the stomach and upper half of the intestines stood out in striking contrast as a white net-work. The large veins being at the same time greatly distended.

After a lethal dose of horse serum the heart continues to beat some time after cessation of respiratory movements, the ventricles contract with rapidly diminishing force and frequency until finally only occasional twitches are recorded, while the auricles beat quite vigorously for some time later. The heart muscle, however, even after ceasing to beat rhythmically responds to mechanical stimuli for some minutes thereafter.

The respiratory muscles of the chest, the diaphragm, as well as other voluntary muscles respond to mechanical stimuli after stoppage of the heart.

The appearance of the respiratory and circulatory phenomena in the anaphylactic opossum, therefore, lies between those described for the cat and those for the guinea-pig, and death probably ensues from asphyxia and low blood pressure. This low blood pressure being due to a weakening of the heart, increased pulmonary resistance and a consequent engorgement of the right heart and large veins, the primary cause of which is doubtless to be found in the chemical and physical changes in the blood and tissue cells after a toxic dose of serum.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

ASTRONOMY.—*Catalogue of 23521 stars between 13° 35′ and 45° 25′ south declination for the equinox 1850. From zone observations made at the United States Naval Observatory 1846–1852.* Compiled by W. S. Eichelberger and F. B. Littell. Publications of the United States Naval Observatory, Second Series, 7: Pp. XLVII + 558, 4°. 1911.

These observations were made in pursuance of an ambitious plan of the first superintendent of the observatory for "a regular and systematic exploration of the whole heavens from 45° South . . . . . with the intention of penetrating with the telescopes every point of space from that parallel of Declination up to the North Pole, and of assigning position to every star, down to the 10th magnitude." The plan was much too large for execution by the force available at the Observatory within any reasonable time, and after a desultory campaign extending over about six years, it was apparently abandoned. During that time the region of the sky from south declination 45° to south declination 10° was partially covered in an irregular way, some parts being covered repeatedly, some once, and some not at all.

Three instruments were used, the meridian circle, the mural circle adapted for right ascension work as well as its usual declination work, and the transit instrument adapted for declination work in addition to its usual right ascension work. All the work was strictly zone work, the instrument being clamped in a given position and stars being observed as they passed through the field of the telescope.

The journal publication of the bulk of the zones has already been issued. The first publication was issued in 1860 and contained the results of the Meridian Circle Zones observed in 1846, compiled by Assistant Astronomer James Ferguson. The completion of the reductions of the other zones was turned over to Dr. B. A. Gould in 1861, and in

1867 the results were sent to the Observatory ready for printing. In 1872 the Mural Zones were published with an introduction by Prof. Asaph Hall, U.S.N., and later in the same year the Meridian Transit Instrument Zones were similarly published, In 1873 the remaining Meridian Circle Zones were published and in closing the introduction Professor Hall says, "On account of the inexperience of some of the observers and the lack of good organization these observations contain many errors, and the whole work needs a careful revision. In order to facilitate this revision, and the final arrangement of the stars into a catalogue, a list of 415 stars has been selected from the Mural Zones, and these stars will be observed anew with the Pistor and Martins Meridian Circle. With this new data, combined with the results obtained from southern observatories, it is hoped that we may have the means of deriving from these zones a valuable catalogue of southern stars." This particular plan of reducing the zone observations, however, was never executed.

In 1892, as a preliminary step to the formation of a catalogue all the observations were copied on cards under the direction of Prof. J. R. Eastman, U.S.N.

In 1902, a considerable number of unreduced zone observations were found in the files of the observatory. They were reduced under the direction of Prof. F. B. Littell, U.S.N., and they furnish about 6000 of the 44900 observations in this volume. Nearly all of these observations were taken in 1851 and 1852 using the then newly introduced method of the electric chronograph for recording transits. It is interesting to note that the increase of accuracy due to this change was, as is generally conceded to be the case, not great for a transit over a single thread, the results of these observations indicating an advantage of about 6 per cent in accuracy for the chronographic method. However, as five threads could be observed by this method in the time taken to secure two threads by the eye and ear method, and as many of the earlier observations were restricted to but one or two threads on account of lack of time, the real gain from the introduction of the chronographic registration by which five threads were usually secured was much greater. Indeed for this particular work, as it was done, it is likely that the increase of accuracy due to the use of the chronographic method averaged nearly 75 per cent. With the transit instrument in 1851–52, the declinations were obtained by means of chronographic transits over sets of oblique threads inclined at an angle of 45° to the right ascension threads. From a comparison of the results however, no gain was shown by this method

over the more usual one employing a zenith distance micrometer which had been used with this instrument in the earlier observations. These observations have not been published in journal form.

In 1901, the demand for a catalogue of these observations for use in the preparation of the Geschichte des Fixsternhimmels became so insistent that Prof. W. S. Eichelberger, U.S.N., undertook the work of forming the catalogue, with such reduction as might be necessary. The plan adopted was to select a catalogue rich in stars in this region, and using its positions as standards, to reduce these zones to the system of the selected catalogue with the greatest rigor possible. The catalogue selected as the standard was the Cordoba General Catalogue. The work involved was very great, especially as there were an excessive number of blunders of record due to the inexperience of many of the observers. To the painstaking care with which this plan has been carried out must be ascribed the value of the resulting positions.

Without the Cordoba General Catalogue, it would have been impossible to have made a satisfactory discussion of these zones, as no other catalogue would have furnished a sufficient number of reference stars to determine the peculiar errors which affect many of the zones. Furthermore, without the assistance of the Cape Photographic Durchmusterung which was published 1896–97, it would have been impossible to have corrected many of the numerous errors of record of the stars too faint to be in other catalogues. The column of notes bears testimony to the necessity for such a check on the observations. While, therefore, the formation of a catalogue of these observations may be regarded as having been unduly delayed, it is in some respects fortunate that it was not done until these works were available for use in its formation.

The catalogue gives the separate positions resulting from each observation. The probable errors vary considerably for the three instruments, the average being about $\pm 0^{s}.07$ for a single observed right ascension and $\pm 1''.3$ for a single observed declination. For comparison it may be stated that the corresponding probable errors for the Astronomische Gesellschaft zone observed at this Observatory from 1894 to 1901 were $\pm 0^{s}.050$ in right ascension and $\pm 0''.53$ in declination. A considerable part of the excess in probable error of the earlier observations is undoubtedly due to the large zenith distance, averaging about 66°, at which the observations were made. All things considered, it appears that the right ascensions determined by the Transit Instrument and the Mural Circle, and the declinations determined by the Mural Circle are fairly satisfactory.

Inasmuch as one important use of this catalogue will be in the statistical study of proper motions, since for many of these stars these are the earliest observations ever made, it was highly desirable to determine corrections which would reduce the system of the catalogue of reference, the Cordoba General Catalogue of 1875, back to 1850 the epoch of this catalogue. This was done by making a comparison between the Cordoba General Catalogue and the Cape Catalogue of 1850, and the systematic corrections resulting from this investigation have been applied so that the positions in this catalogue are virtually those which would have been obtained by the use of a reference catalogue of its own epoch. The system of this catalogue is therefore that of the Cape Catalogue of 1850.

F. B. LITTELL.

NAVIGATION.—*Daylight observations on Venus.* J. P. AULT. Bulletin American Geographic Society. October, 1911.

The writer gives a summary of his experience in making daylight observations on Venus as navigating officer on board the *Carnegie*, the magnetic survey yacht of the Carnegie Institution of Washington, during her first cruise in the North Atlantic, 1909–1910. The usual instruments and methods used in making observations on the Sun were employed in observing on Venus. Tabulations of observations both for latitude and longitude are given. The observations for latitude were usually made by two and sometimes by three observers and the results never differed by more than 0.5 minute of arc and usually agreed within 0.1 minute. The observations for longitude also indicated that uniformly good results can be obtained. The novelty of observing a star by daylight adds enough interest to the work of the navigator to warrant undertaking the operation without any other inducement, but there is added to this at least two opportunities for an accurate determination of the ship's position entirely independent of the operation of dead reckoning.

J. A. FLEMING.

ATMOSPHERIC ELECTRICITY.—*Atmospheric electricity observations on the second cruise of the "Carnegie," from New York to Colombo.* EDWARD KIDSON. To appear in the Journal of Terrestrial Magnetism and Atmospheric Electricity.

This paper gives tabulations together with a synopsis of the observations taken for the specific conductivity of the atmosphere, radioactivity, and potential gradient of the atmosphere, as determined on board the *Carnegie* on her second cruise between New York and Colombo during

June 1910 to June 1911. As a rule the conductivity observations so far obtained by the Department of Terrestrial Magnetism seem to indicate a diminution of the conductivity in equatorial regions and, at any rate during the daytime, in the near neighborhood of land. At the same time the ratio of the conductivity of positive electricity to that for negative becomes smaller. The equatorial regions are perhaps regions of upward currents. Gerdien's apparatus was used for the determination of the specific conductivity of the atmosphere, the aluminum leaf electroscope, however, being replaced by a string electrometer as described by Lutz. The amount of radioactivity obtained varied in very irregular manner, but little activity was shown in midocean. The potential gradient observations indicate a low potential gradient, being associated in general with high conductivity and vice versa. Thus, when the conductivity was very low during a fog the potential gradient was high.

J. A. Fleming.

PHYSICS.—*The influence of pressure on the melting points of certain metals.* John Johnston and L. H. Adams, Geophysical Laboratory. American Journal of Science, (4) **31**: 501. 1911.

The authors have been engaged in developing methods and apparatus by means of which it will be possible to investigate the effects of high temperatures and pressures on certain systems and reactions, and especially those in which water plays an important part. The work has progressed until now we are able to introduce into the bomb current leads and thermo-element wires in such a manner that the wires are all thoroughly insulated electrically, and the joint remains absolutely pressure-tight. Thus, it is possible to heat a substance to somewhat over 400°, under pressures up to 2,000 atmospheres, and to measure both temperature and pressure with precision. Moreover, the whole system, by reason of the special methods of construction adopted, is absolutely free from pressure leaks, even when the bomb is repeatedly closed and opened, disconnected from, and reconnected with, the remainder of the high-pressure system. For instance, on one occasion heating was continued for 30 hours continuously at a pressure of 1800 atmospheres, without sensible loss of pressure in the whole interval.

With this apparatus, the melting-points of tin, bismuth, cadmium, and lead were determined, first at atmospheric pressure, and afterward with a gradual increase of the pressure up to 2,000 atmospheres. The change of melting temperature with pressure was found to be an accurately linear function of the pressure.

By substitution in the Clausius-Clapeyron equation of the data of Vicentini and Omodei on the volume-change at the melting-point, and of Person on the latent heat of fusion, dt/dp was calculated for each of the four metals. The calculated values are in satisfactory agreement with those observed. Incidentally, a convenient standard curve for the calibration of copper constantan thermo-elements at temperatures from 0 to 425° has also been computed and included in the paper.

L. J. and L. H. A.

CHEMISTRY.—*The phenomenon of occlusion in precipitates of barium sulphate and its relation to the exact determination of sulphate.* JOHN JOHNSTON and L. H. ADAMS. Journal American Chemical Society, **33**: 829. 1911.

The occlusion by barium sulphate of other sulphates is a general phenomenon. The amount of this occlusion depends upon (*a*) the composition of the original solution; (*b*) the fineness of the precipitate, which in turn is conditioned by the degree of solubility of barium sulphate in the particular medium, the rate of precipitation, and the time and manner of standing between precipitation and filtration. The phenomenon is therefore in all probability an absorption at the surface of the grains of the precipitate, since it is affected by the factors just mentioned.

On the basis of the knowledge gained in this way, attempts were made to find a direct method for the determination of sulphate which should be generally applicable, exact, and require only small and easily determined corrections. The following procedure is suggested: To the solution (300 cc. for a precipitate to weigh 2 grams) add 50 cc. of concentrated hydrochloric acid, heat to boiling, and precipitate, stirring constantly, with a 10 per cent solution of barium chloride. This should be added at such a rate that about four minutes is required in running in the 22 cc. necessary; the rate is best regulated by attaching a suitable capillary tip to the burette containing the barium chloride solution. Evaporate the whole to dryness on the steam-bath (this may be done immediately after precipitation), take up with hot water, filter thru paper, wash until the washings are free from chloride, ignite very carefully (so as to obviate reduction), and heat to constant weight over a Bunsen burner. The necessary correction is determined by a concurrent calibration of the method; that is, by dissolving an equivalent weighed amount of pure dry sodium (or potassium) sulphate in a medium such that the resulting solution is as nearly as may be of the same composition as the solution to be analyzed; the sulphate in this comparison solution is then

determined precisely as above. The difference between the calculated amount of barium sulphate and that actually found is the correction to be applied to the weight of the precipitate obtained in the actual analysis.

This procedure, as compared with that advocated by Allen and Johnston, is easier and much more rapid; it is, however, not so generally applicable, but may be used whenever the composition of the solution containing the sulphate to be determined is known approximately; and, we believe, will yield results, accurate to ± 0.05 per cent of the total sulphate present, in most cases likely to occur in general analytical work.

J. J. and L. H. A.

GEOCHEMISTRY.—*The data of geochemistry (second edition).* F. W. Clarke. Bulletin U. S. Geological Survey No. 491. Pp. 782. 1911.

This work was first published in 1908. The present volume has been revised and much enlarged. F. W. C.

PETROLOGY.—*The methods of petrographic-microscopic research: Their accuracy and range of application.* Fred. Eugene Wright. Publication No. 158, Carnegie Institution of Washington. (In press.)

During the past six years the work with artificial silicate preparations in the Geophysical Laboratory has imposed new and difficult problems to be solved by the microscope. Not only are such preparations very fine-grained, but the degree of accuracy of each measurement must be definitely known if it is to be applied without reserve to geophysical problems. To meet these new conditions, it has been necessary to devise new methods, involving extensive alterations in the microscope, and also to test the different methods available for the determination of the optical constants of minerals in the thin section and to ascertain their relative accuracy and general applicability. As a result of these tests, the methods best adapted for work with artificial and all fine-grained preparations are now fairly well established and their application has become in large measure a matter of routine.

The present publication aims to offer a connected presentation of the entire investigation of the petrographic microscope so far as it has been carried, in which the different methods are coördinated and the significance and usefulness of each particular method is made to appear in its proper relation. An effort has been made to establish the limits of accuracy of each method as ordinarily used, and also the limits of accuracy theoretically attainable in measurements of this kind.

It may be stated, as a result of experience, that on clear individual grains measuring from 0.01 to 0.03 mm. in diameter, all the optic properties ordinarily employed in the petrographic microscopic investigation of minerals in the thin section can now be determined with a satisfactory degree of accuracy.

The introductory chapter contains a statement of the general theory of the microscope and the uses of its individual parts and accessories. Chapter I includes the application of the microscope in the determination of properties of the first class (color, pleochroism, absorption, crystal habit, optical, character, dispersion, etc.), which do not admit of numerical measurement. The properties of the second class which admit of accurate determination and numerical expression are treated in the following chapters: Chapter II, Refractive indices; III, Birefringence; IV, Extinction angles; V, Optic axial angles. F. E. W.

GEOLOGY.—*Geology of the Berners Bay region, Alaska.* ADOLPH KNOPF. Bulletin U. S. Geological Survey No. 446. Pp. 58, with 2 maps. 1911.

Berners Bay is a broad and deep indentation from Lynn Canal, in latitude 58° 42′ north and longitude 135° west. The region under consideration, whose areal extent is 50 square miles, embraces the long, tapering peninsula and its mountainous background that lies between Berners Bay and Lynn Canal, and is at the northwestern extremity of the long zone of auriferous mineralization on the mainland of southeastern Alaska, known as the Juneau gold belt.

The Berners formation of slates and graywackes occupies the larger part of the area and is well exposed on both sides of Berners Bay. The strata show locally intense plication, but as a rule strike northwest and southeast and dip steeply northeast. Fossil plants, consisting chiefly of ferns, are indicative of Jurassic or Lower Cretaceous age. The older view that the rocks of the Juneau gold belt are Carboniferous therefore needs modification; it is probable that the rocks of the productive part of the velt are mainly late Mesozoic.

Northeast of the sedimentary rocks is a belt of much altered lavas, chiefly basaltic amygdaloids. Northeast of these is an intrusive quartz diorite gneiss, which constitutes the crushed and foliated margin of the granitoid core of the Coast Range.

The most important rock in the region from an economic point of view is the Jualin diorite, which invades both the sedimentary and volcanic rocks. The main ore bodies lie within its area. These are auriferous deposits of low grade, most of which are well-defined fissure veins or

irregular stockworks. The veins are up to 15 feet wide, but the average is 5 feet. The stockworks are up to 80 feet wide, averaging from $3 to $5 a ton in gold, and constitute the principal deposits. The gangue material of the ores is quartz with subordinate calcite, and the principal sulphide is pyrite with which are subordinate chalcoyprite, galena, and sphalerite. Free gold is rarely seen.

The wall rock of the ore bodies has been affected by locally intense hydrothermal metamorphism, characterized by the development of albite in small veinlets. This metamorphism is similar to that which has transformed the Treadwell albite-diorite dike into an auriferous lode. The ores are therefore of deep-seated and probably of magmatic origin.

The diorite rocks of the Berners Bay and Juneau regions are part of the great chain of batholithic Mesozoic intrusions that extends from the Sierra Nevada of California northward into Alaska. Here, as in California, the ascent of these magmas was accompanied by metallization of great economic importance. A. K.

GEOLOGY.—*Geology and mineral resources of parts of the Alaska Peninsula.* WALLACE W. ATWOOD. Bulletin U. S. Geological Survey No. 467. Pp. 137, with maps, sections, and views. 1911.

The Aleutian Range forms the axis of the Alaska Peninsula, which is the land mass separating the northern Pacific from Bering Sea. On the Pacific side the mountains lie close to the sea, and the shore line is broken by numerous embayments; on the Bering Sea side they are separated from tidewater by a coastal plain which is notched by several shallow bays and lagoons.

The geologic history of the Alaska Peninsula, so far as it has been determined, is limited to Mesozoic and Cenozoic times. Some granitic rocks in the northwestern portion of the province are known to be of pre-Upper Jurassic age, but no rocks on the peninsula are definitely known to be pre-Triassic. Since the opening of Mesozoic time sedimentation has been going on in some portion of the peninsula during each of the great geologic epochs, with the possible exception of the Pliocene and Oligocene. The Triassic is represented in at least one locality. Large areas of Jurassic sediments represent at least portions of the Middle Jurassic and the Upper Jurassic series. The Lower Cretaceous and the Upper Cretaceous are also present. There are also Eocene, possibly some Oligocene, and certainly some Miocene sediments in the province. From the Eocene epoch to the present time there have been numerous volcanic outbursts at various places on the peninsula, and a portion of the material ejected from the volcanoes is possibly of Pliocene age. The Pleisto-

cene or glacial epoch is represented by morainic deposits and some unconsolidated sands, clays, and gravels. Since the close of Pleistocene time there has been an accumulation of alluvial deposits in the valley bottoms, along the shores and at the heads of the bays.

The structure of the peninsula is that of an anticlinorium. Faulting has occurred as many places. In some faults the movement along a single plane was as much as 1000 feet, and in others systems of distributive faults developed, with movements ranging from a few inches to several rods along the separate fault planes. Much of the lava that rose beneath the peninsula during the periods of volcanism failed to reach the surface. Some of this remained in vertical or nearly vertical fissures as dikes, other masses spread out between sedimentary strata as intrusive sheets or sills, and some entered the sedimentary series as great laccoliths and lifted the overlying beds in large domes.

A. H. Brooks.

BACTERIOLOGY.—*XIV. The artificial cultivation of the bacillus of leprosy.* Donald H. Currie, Moses T. Clegg, and H. T. Hollmann, Public Health and Marine Hospital Service. Public Health Bulletin 47.

Lepri bacilli were first cultivated artificially in 1909 by Clegg, who grew them in symbiosis with amoebae and s. cholerae. The authors refer to the bearing of this epoch making discovery on subsequent studies of transmission and serum therapy of leprosy, present a review of the literature on the subject, and record the growth of nine strains of acid fast organisms, six being different strains of leprosy bacilli, one the grass bacillus of Moeller, one the bacillus Margarine, and one the Smegma bacillus. The investigations were made at the U. S. Leprosy Investigation Station, Hawaii. The cultural characteristics of the above mentioned organisms are described, and a summary of the results presented.

No appreciable difference was noted between the individual cultures of the six strains of lepri bacilli worked with. Only slight differences were noted in any of the organisms, and these are not regarded as being of practical importance as a means of differentiation. The serum of a horse that had been immunized to lepri bacilli strongly clumped all of the strains of this organism worked with, but failed entirely to clump the other three organisms. As a result of their work, the authors conclude that by the method of Clegg, it is frequently possible to grow an acid fast bacillus morphologically similar to the leprosy bacillus from the tissues and organs of lepers, and that it is possible to isolate this acid fast organism in pure culture. The acid fast organism thus isolated

resembles culturally other members of this group, but serum tests are capable of differentiating it from the other organisms worked with.

J. W. Kerr.

BACTERIOLOGY.—*XVII. Further observations in rat leprosy.* Donald H. Currie, and Harry T. Hollmann, Public Health and Marine Hospital Service, Honolulu, T. H. Public Health Bulletin 50.

The authors refer to a previous article ("A Contribution to the Study of Rat Leprosy," Public Health Bulletin No. 41, Public He lth and Marine-Hospital Service of the United States, Washington, D. C., November, 1910) in which they found that a broncho-pneumonia with septicemia, due to the bacillus of rat leprosy, often preceded the better known lesions of the disease. They further observed that a certain mite (Laelaps echidninus) when found on the bodies of infected animals, often contained the bacillus of rat leprosy.

In the present article, they record further observations of a similar character, and close by concluding as follows:

"*First:* In the disease that we are dealing with, whether the animal is inoculated by a laboratory method or simply allowed to develop the disease from coming into contact with infected rats (i.e., the natural mode of infection) the lesions met with are practically the same."

"*Second:* With the exception of the local lesion, occasionally produced at the site of artificial inoculation, infection of the viscera seems to usually precede the lesions of the skin."

"*Third:* Of the visceral lesions, a broncho-pneumonia is often the earliest, and the most constant. Infection of the spleen is also often an early event."

"*Fourth:* The heart blood of infected rats often contains the bacilli of rat leprosy, and no difficulty is experienced in demonstrating the presence of acid-fast bacilli in the mites, contained on the bodies of these animals, when the latter's heart blood contains the organism."

"*Fifth:* The fact that these mites contain the bacilli so frequently naturally leads one to suspect that they may be one of the means of transmitting the disease from rat to rat, but up to the present time we have no positive evidence that such is the case." Donald H. Currie.

EPIDEMIOLOGY.—*The Causation and prevention of typhoid fever, with special reference to conditions observed in Yakima County, Washington.* L. L. Lumsden, U. S. Public Health and Marine-Hospital Service. Public Health Bulletin 51.

The bulletin presents (1) a general consideration of the causation and prevention of typhoid fever with particular reference to conditions in

the United States; (2), a detailed discussion of the typhoid fever situation in Yakima County, taken as a somewhat typical instance of high typhoid fever prevalence in American communities; and (3) a report on an investigation of typhoid fever in North Yakima, Washington. Following the body of the report are two appendices. The first (A) being on the subject of the construction and maintenance of a sanitary privy and the second, (B) on the subject of measures to prevent the spread of infection from the bedside of a typhoid fever patient. The bulletin is well illustrated, and is written in semi-popular style so as to be readily intelligible to the lay reader.

The section on typhoid fever in North Yakima deals particularly with an outbreak of the disease in May and June, 1911, which was attributed to infection in water pumped into the city mains from a pond used as an auxiliary source of water for a large lumber mill on the edge of the city, and with a sanitary campaign carried out in the city in the summer of 1911. The author concludes that as a result of the campaign the rate of prevalence of typhoid fever in North Yakima for the summer and fall of 1911 was reduced by over 90 per cent. L. L. L.

PATHOLOGY.—*XVIII. A statistical study of the nasal lesions in leprosy.* HARRY T. HOLLMANN, U. S. Public Health and Marine Hospital Service, Honolulu, T. H. Public Health Bulletin 50.

This article gives the results of the examination of the nasal mucous membrane of 500 lepers, and shows that of these cases, 152 of the nodular type of this disease showed lesions of the nasal mucous membrane, while 19 of the same type showed no nasal lesions. Of the anaesthetic type, 174 presented nasal lesions, while in the case of 53 the nasal mucosa appeared normal. Of the mixed type of the disease, 84 presented nasal lesions, while 18 were free from them.

The nasal lesions mentioned included hypertrophic rhinitis, atrophic rhinitis, perforation of the nasal septum and absorption of cartilage. Of these several types of lesions, the latter was the one most commonly met with. DONALD H. CURRIE.

REFERENCES

AGRICULTURE.—Publications of the bureau of plant industry since January, 1911: Bulletin 198—*Dimorphic branches in tropical crop plants; cotton, coffee, cacao, the Central American rubber tree, and the banana,* O. F. COOK. Bulletin 192—*Drought resistance of the olive in the southwestern States,* SILAS C. MASON. Bulletin 203—*The importance and improvement of the grain sor-*

ghums, CARLETON R. BALL. Bulletin 194—*Summer apples in the Middle Atlantic States*, H. P. GOULD. Bulletin 213—*Crown-gall of plants: its cause and remedy*, SMITH, BROWN and TOWNSEND. Bulletin 202—*The seedling-inarch and nurse-plant methods of propagation*, GEORGE W. OLIVER. Bulletin 201—*Natural vegetation as an indicator of the capabilities of land for crop production in the great plains area*, H. L. SHANTZ. Bulletin 205—*Seeds and plants imported during the period from October 1 to December 31, 1909.* Inventory No. 21. DAVID FAIRCHILD. Bulletin 204—*Agricultural explorations in the fruit and nut orchards of China*, FRANK N. MEYER. Bulletin 211—*Bacteriological studies of the soils of the Truckee-Carson irrigation project*, KELLERMAN and ALLEN. Bulletin 208—*Seeds and plants imported during the period from April 1 to June 30, 1910;* Inventory No. 23. DAVID FAIRCHILD. Bulletin 207—*Seeds and plants imported during the period from January 1 to March 31, 1910;* Inventory No. 22. DAVID FAIRCHILD. Bulletin 210—*Hindi cotton in Egypt.* O. F. COOK. Bulletin 209—*Grimm alfalfa and its utilization in the Northwest.* CHARLES J. BRAND.

Farmers Bulletins: Bulletin 428—*Testing farm seeds in the home and in the rural school*, F. H. HILLMAN. Bulletin 431—*The peanut*, W. R. BEATTIE. Bulletin 432—*How a city family managed a farm*, J. H. ARNOLD. Bulletin 434—*The home production of onion seeds and sets*, W. R. BEATTIE. Bulletin 437—*A system of tenant farming and its results*, J. W. FROLEY and C. BEAMAN SMITH. Bulletin 433—*Cabbage*, L. C. CORBETT. Bulletin 436—*Winter oats for the South*, C. W. WARBURTON. Bulletin 446—*The choice of crops for alkali land*, THOMAS H. KEARNEY. Bulletin 443—*Barley: growing the crop*, H. B. DERR. Bulletin 448—*Better grain-sorghum crops*, CARLETON R. BALL.

Circulars: Circular 73—*The distinguishing characters of the seeds of quack-grass and of certain wheat-grasses*, F. H. HILLMAN. Circular 74—*The sulphur bleaching of commercial oats and barley*, LEROY M. SMITH. Circular 75—*Agricultural survey of four townships in Southern New Hampshire*, E. H. THOMSON. Circular 76—*The relation of crown-gall to legume inoculation*, KARL F. KELLERMAN. Circular 35 (Sec.)—*The adulteration and misbranding of the seeds of alfalfa, red clover, Kentucky bluegrass, orchard grass, and redtop*, WM. A. TAYLOR. Circular 78—*Agricultural observations on the Truckee-Carson irrigation project*, F. B. HEADLEY and VINCENT FULKERSON. Circular 77—*A study of the improvement of citrus fruits thru bud selection*, A. D. SHAMEL. Circular 81—*The shrinkage of corn in storage*, J. W. T. DUVEL and LAUREL DUVAL. Circular 85—*Crown-gall and sarcoma*, ERWIN F. SMITH. Circular 79—*Winter wheat in western South Dakota*, CECIL SALMON.

Documents: Document 633—*Distribution of cotton seed in 1911*, LEON M. ESTABROOK. Document 631—*Farm fertilizers*, S. A. KNAPP. Document 619—*The production of cotton under boll-weevil conditions*, S. A. KNAPP. Document 648—*The control of cotton wilt and root-knot*, W. A. ORTON. Document 644—*Boys' demonstration work; the corn clubs*, S. A. KNAPP and O. B. MARTIN. Document 647—*Results of boys' demonstration work in corn clubs in 1910*, S. A. KNAPP and O. B. MARTIN.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

WASHINGTON ACADEMY OF SCIENCES, PHILOSOPHICAL, AND BOTANICAL SOCIETIES

A joint meeting of the Philosophical Society with the Washington Academy of Sciences was held October 28, 1911. President Clarke of the Academy introduced Prof. ARTHUR SCHUSTER, who spoke on *The foundations of physics.*

This subject is one that affects the whole of physical science. There is at the present moment a general feeling of unrest which has definitely altered some of our scientific beliefs and shaken our belief in others. The great discoveries of recent years have revolutionized our ideas of matter and force which we had considered settled. We must often accept revolutions when they are accomplished, tho we may not like them, but we may also bear in mind the warning of Kepler, and in the words of a German proverb, be careful when emptying the bath-tub not to turn out the baby with the dirty water.

The science most of us have learned in our youth was based on the laws of motion, established by Galileo, Huygens and Newton. Its fundamental principles were: Constancy of Mass; Action and Reaction, involving Constancy of Momentum; to these was added later Conservation of Energy. The consideration of these together led to the view that they could explain all physical phenomena, giving the materialistic system of which we may take Kelvin as the most typical exponent. The phenomena of light added the ether as a definite substance being able to contain energy and therefore possessing mass. To Kelvin the ether could have no properties not inherent in ordinary matter. The third law of Newton in the past was true affecting matter only, but if necessary ether may contain momentum; this requires a revision of our ideas concerning the laws of motion.

There has always been a concurrent stream of metaphysics as illustrated in some of the writings of Kirchhoff, Hertz, Mach and others. But independently, the idea of the Conservation of Energy introduced quasi-metaphysical ideas such as Potential Energy, Energy Paths, and the Atomic Constitution of Energy. Physical science must get rid of the metaphysics, and a good deal of unnecessary trouble existing in our ideas on physics is due to the tendency to mix physics and metaphysics.

Concerning the question of cause and effect, the doctrine of Kirchhoff that in physical science it is only necessary to describe things as they are and not to explain them, is not sufficient nor is it physics.

The matters thus far spoken of really belong to the old physics. Maxwell's theory of light was the origin of the new. This theory requires the assumption of an ether with properties not hitherto known, an ether that would transmit electrical energy and also transmit light, and which need not have the properties of matter as we know it. When light is transmitted thru ether there is momentum, hence the concept of the pressure of light. The momentum in Maxwell's theory comes out just one-half that in the corpuscular theory of light.

Electricity is probably of an atomic nature, but we need not attach any idea of mass, in the old sense, to the atom of electricity, yet it possess energy and will behave as tho it had mass. Whether or not we may consider the mass of a body to vary with the surrounding energy, it is not legitimate to assume that the mass of an atom is the sum of the component electrons. There are many difficulties in satisfactorily accounting for the relations of mass to gravitation and at the same time reaching a satisfactory electron theory of matter.

The new idea of mass then, places it in the ether and involves the abolition of the constancy of mass: it must change with velocity and the addition theory does not hold. The expression "Ether *and* Matter" should be "Ether *no* Matter." From consideration of the instability of motion we are led also to postulate both a longitudinal and a transverse mass.

The really great revolution of modern physical science is based on a single experiment, that of Michelson and Morley who found the ether apparently had no velocity with respect to the earth's motion. No satisfactory explanation of this fact has been found which will also account for many other well known phenomena. Generalization to the principle of relativity sometimes leads to a denial of the ether, tho space carries energy and momentum. We are again in a quandary when we attempt to surmount the difficulties due to rotation. It is an interesting problem that of creation founded on the theory of relativity the expounders of which appear to postulate that we can never find any relations between ether and matter. Are we, then to reject all questions treating of the structure of the ether? Concerning the structure of matter, are really all intramolecular forces of electrical origin and are they the same for molecular and large distances? Do we know that magnetic fields can be calculated inside molecules in the same way as outside?

In conclusion, we must reject the purely materialistic views of Kelvin and must also resist the meta-mathematician who tempts us with a new apple of knowledge disposing of time as merely a fourth dimension of space and promising to unravel the mystery of creation with a formula.

In the discussion Mr. R. S. Woodward stated that the physics of today is yet untried, and that we must be patient and not be scared out of our ancient learning, and that the foundations of the older physics are yet quite unshaken. We should revise our earlier ideas about mass, but the certainty of the conservation of mass is strong. The law of gravitation is doubtful and the most in proof of it is yet to be done. Physics and mathematics are often not distinguished, physics is not

mathematics. Mathematics is only an instrument. Kelvin appealed to observation, some others used mathematics to reach their conclusions. We should cultivate the principle of relativity, and in doing this it was predicted that our earlier views would prove to be but first approximations. That matter is essentially atomic, and that ether can be placed in the same category, which was also Lord Kelvin's view, is the greatest advance in the last twenty years.

A joint meeting of the Botanical Society and the Washington Academy of Sciences was held on the evening of November 14. Prof. W. JOHANNSEN, of the University of Copenhagen, was introduced by President Clarke and spoke upon *Heterozygosis in pure lines of beans and barley.*

He began by stating that the title of the paper being technical might possibly not be understood by those unfamiliar with the nomenclature applied to cross-breeding in plants and animals. The essential sexual element of an individual is called a gamete. These unite forming zygotes. A zygote is therefore a dual being. When these zygotes are like the parent gamete they are called homozygotes, when different heterozygotes. Heterozygosis may therefore be defined as mixed interbreeding.

Two flowers may look alike but give rise to offspring quite different in appearance. These different forms serve to show the latent characters existing in the parent and inherited from previous ancestors. There appear to be influences at work here which resemble the affinities shown in some chemical compounds.

A pure line is one that produces homozygotes. There are apparently chemical laws at work here but what they are we at present but dimly surmise.

The lecturer illustrated his remarks by reference to diagrams showing the effect of crossing certain strains of beans, barley, snails, etc.

In commenting upon the lecture President CLARKE said that the question of the coloration of flowers was doubtless a chemical phenomenon and that the intimate study of the chemistry of these compounds will probably yield some results. As to how chemical substances or reactions can influence form we are at present almost entirely in the dark.

Mr. McDougal said that the work in a botanist's laboratory was necessarily limited, more definitely than actually occurred in nature as he could perform artificial selections at will. Doubtless mechanical as well as chemical factors are at work to produce the varied forms of offspring. These were the problems which the modern physiologist has to face.

FRANK BAKER, *Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 489th regular meeting was held at the Cosmos Club, December 2, 1911, with President DAVID WHITE in the chair.

Under the head of *Brief notes and exhibition of specimens,* GENERAL WILCOX told of finding many pieces of white quartz in the stomachs of the blue grouse.

Barton W. Evermann reported the arrival in the United States of ten more young fur seals from the Pribilof Islands. Two of them were left with Professor Trevor Kincaid of the University of Washington, at Seattle, two were sent to the New York Aquarium, four to the National Zoölogical Park, while two were retained at the Bureau of Fisheries building. Of ten brought last year, four escaped at Seattle, and the other six died. This leaves the two 2-year-old animals at the Fisheries building as the only specimens of the fur seal that have ever been kept in confinement for over a year. The male on November 20 weighs 64 pounds, the female, 43.

L. O. Howard reported that Mr. R. S. Woglum of the Bureau of Entomology had just arrived from Asia bringing with him from the Punjab, India, six cases of living parasites of white fly (*Aleyrodes citri*) now so destructive to citrus fruits in Florida. Much is expected as a result of this introduction.

The regular program consisted of three communications:

1. *The hooting of the Blue Grouse.* E. A. Preble.

During his stay in Jackson Hole, Wyoming, in the spring and early summer of 1911, the speaker had an opportunity to observe and photograph the blue grouse (*Dendragapus obscurus richardsoni*) in the act of hooting. The birds were quite tame and many characteristic attitudes were shown in the lantern slides presented.

2. *Notes on the fishes of the District of Columbia and vicinity.* Alfred C. Weed.

The waters of the region were divided into five classes, River, Lowland Streams, Creeks, Upland Brooks, and Pools, and some of the more prominent species in each environment were named with general notes on their habits, especially where these differ markedly from those of most other members of the same group, as in the case of the Catfish, *Schilbeodes insignis*, which lives under stones, etc., in the most rapid waters; and the Darter, *Boleosoma olmstedi*, which is found in all waters from the swiftest and coldest to the most stagnant.

In regard to the more prominent introduced species mention was made of their economic importance and of their relation to other species, both native and introduced. The speaker expressed himself as being firmly of the opinion that the German Carp does not destroy eggs and nests of the Black Bass to any appreciable extent, but that it does furnish an abundant food for this fish which could not be supplied by the native minnows. Several of the small native minnows destroy many more eggs and fry than the Carp.

Brief mention was made of some of the more recently discovered native fishes, with statement of the probable reasons for their having so long remained unnoticed.

The talk was illustrated by lantern slides of fishes and their habitats.

3. *On another supposed fruit-bearing fern-like plant of the American Permian.* David White.

The 490th regular, and 32nd annual meeting was held December 16 1910. The reports of the various officers were received.

The following were elected as officers for 1912: President: E. W. Nelson. Vice-Presidents: J. N. Rose, W. P. Hay, Paul Bartsch, A. D. Hopkins. Recording Secretary: D. E. Lantz. Corresponding Secretary: N. Hollister. Treasurer: J. W. Gidley.

Members of Council: Vernon Bailey, A. K. Fisher, A. B. Baker, Hugh M. Smith, Wm. Palmer.

D. E. Lantz, *Recording Secretary.*

PROGRAMS AND ANNOUNCEMENTS

PHILOSOPHICAL SOCIETY OF WASHINGTON

704th Meeting, Cosmos Club at 8.15 p. m., February 10. Program: Frank Wenner: *Constancy of wire resistance standards.* Arthur W. Gray: *Measurement of inaccessible displacements, production of temperature uniformity, and determination of expansion of gas-thermometer bulbs.* (Illustrated).

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. II, FEBRUARY 19, 1912 No. 4

PHYSICS.—*The density and thermal expansion of ethyl alcohol and its mixtures with water.* N. S. Osborne, E. C. McKelvy and H. W. Bearce. Communicated by L. A. Fischer. To appear in the Bulletin of the Bureau of Standards. 1912.

Part I. The preparation of pure ethyl alcohol. E. C. McKelvy. Ethyl alcohols from different sources were subjected to purification treatments. The lower boiling impurities were completely removed by heating the alcohol for a considerable time under a reflux condenser, the water of which was held at about 60° C. Dehydration was accomplished by means of lime, aluminium amalgam, and metallic calcium, giving an alcohol of nearly identical physical properties. The first two gave equally good results. The density values obtained with metallic calcium were somewhat higher. The physical properties used as criteria of purity were the density and the critical solution temperature of alcohol-kerosene mixtures (Crismer). These two methods are of approximately equal sensitiveness. An alcohol was obtained which when subjected to an additional dehydration and fractionation gave alcohol of the same density and with no separation into fractions of different densities. Dehydration and subsequent fractionation under reduced pressure gave alcohol of essentially the same density. These results indicate that the alcohol was pure within the limits set by the accuracy of determination of the physical constants used as criteria of purity. Dissolved acetic aldehyde increased the density while ethyl ether and air decreased it.

The low results obtained for the density of anhydrous ethyl alcohol by Messrs. Squibb could not be obtained by a repetition of their procedure. A repetition of the procedure of Mendeléef gave results closely agreeing with his. Tables are given showing the comparison of results with those of former investigators. The mean density of fifteen of the fractions regarded as the purest was found to be 0.78506, at 25° C.

Part II The thermal expansion of mixtures of ethyl alcohol and water. N. S. Osborne. Twelve mixtures of alcohol and water were prepared and their densities at 10°, 15°, 20°, 25°, 30°, 35°, and 40° C. determined by the method of hydrostatic weighing. The observations of density for each mixture were reduced by the method of least squares and the coefficients of the assumed equation

$$D_t = D_{25} + \alpha\,(t-25) + \beta\,(t-25)^2 + \gamma\,(t-25)^3$$

determined. The values of D_{25}, α, β and γ for the twelve mixtures are shown in Table I.

TABLE I

PERCENT ALCOHOL BY WEIGHT	DENSITY AT 25°C.			
	g/ml	$\alpha \times 10^7$	$\beta \times 10^8$	$\gamma \times 10^{10}$
0.000*	0.997077	−2565	−484	+319
4.907	0.988317	−2684	−502	+311
9.984	0.980461	−3119	−484	+258
19.122	0.967648	−4526	−393	+180
22.918	0.962133	−5224	−331	+100
30.086	0.950529	−6431	−226	+ 47
39.988	0.931507	−7488	−145	− 4
49.961	0.909937	−8033	−128	− 24
59.976	0.887051	−8358	−121	− 24
70.012	0.863380	−8581	−117	− 9
80.036	0.839031	−8714	−108	− 69
90.037	0.813516	−8746	− 93	− 51
99.913	0.785337	−8593	− 57	− 62

* Water according to Chappuis.

The values of α, β and γ for each integral per cent of alcohol between 0 and 100 were then obtained by interpolation.

Part III. The density of ethyl alcohol and its mixtures with water. N. S. Osborne. The mean of fifteen determinations of the density at 25° C. of the purest alcohol obtained was found to be 0.78506 gram per milliliter. A series of twenty-five mixtures of known percentages of alcohol and water were prepared as close as possible to integral per cents and their densities at 25° C. determined, partly by the method of hydrostatic weighing and partly by the use of special picnometers; the same constant temperature bath being used in both methods. The densities of the various mixtures, reduced to the nearest integral per cent, are shown in Table II. The values for 90 and 95 per cent are each the mean results of two mixtures.

TABLE II

PERCENT ALCOHOL BY WEIGHT	DENSITY (*) AT 25°C. *g/ml*	PERCENT ALCOHOL BY WEIGHT	DENSITY AT 25°C.
0	0.997077	55	0.898502
2	0.993359	60	0.886990
5	0.988166	65	0.875269
6	0.986563	70	0.863399
10	0.980434	75	0.851336
15	0.973345	80	0.839114
20	0.966392	85	0.826596
25	0.958946	90	0.813622
30	0.950672	95	0.799912
35	0.941459	98	0.791170
40	0.931483	99	0.788135
45	0.920850	100	0.785058
50	0.909852		

* These density values are for mixtures saturated with air.

Tables I and II permit the calculation of the density of any mixture of ethyl alcohol and water at any temperature between 10° and 40° C. (Circular No. 19, Bureau of Standards).

Part IV. The density and thermal expansion of ethyl alcohol and its mixtures with water. H. W. Bearce. A second and independent series of mixtures of known percentages of alcohol and water were prepared and their densities determined at 15° and 25° C., thus furnishing, at the same time, a check on both the

density at 25° and the change of density between 15° and 25°, as determined in Parts II and III. A comparison of the two series is given in Table III. The results obtained in Parts II and III are shown in the columns headed Osborne, those from Part IV in the columns headed Bearce.

TABLE III

PERCENT ALCOHOL BY WEIGHT	DENSITY AT 15°C. *g/ml*		DENSITY AT 25°C. *g/ml*	
	Osborne	Bearce	Osborne	Bearce
0	0.99913	0.99913	0.99708	0.99708
10	0.98304	0.98305	0.98043	0.98044
20	0.97069	0.97070	0.96639	0.96640
30	0.95686	0.95688	0.95067	0.95067
40	0.93883	0.93882	0.93148	0.93146
50	0.91776	0.91777	0.90985	0.90985
60	0.89523	0.89524	0.88699	0.88698
70	0.87187	0.87186	0.86340	0.86340
80	0.84772	0.84773	0.83911	0.83910
90	0.82228	0.82228	0.81362	0.81360
100	0.79360	0.79360	0.78506	0.78505

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

METEOROLOGY.—*The earth's radiation zones.* W. J. HUMPHREYS. Bulletin of the Mount Weather Observatory, **4**: 129–135. 1911.

If, as it is now generally believed, the temperature of the atmosphere above the level of vertical convection is determined by radiation from lower levels, then it follows that the greater this radiation the greater also will be the resulting temperature of the upper atmosphere.

Also, since water vapor has a high coefficient of absorption for long wave lengths, the lower atmosphere of any place may, without materially affecting the temperature of the corresponding isothermal region, be replaced by an equivalently radiating black surface. From this it can be shown that the absolute temperatures of these equivalently radiating black surfaces at different parts of the world would be to each other approximately as the absolute temperatures of the isothermal region in the corresponding places.

Hence, to the same degree of approximation, the intensity of the outgoing radiation at one place is to that at another as the fourth powers of the corresponding absolute temperatures of the isothermal region.

The curious conclusion this leads to is, that the intensity of the earth's outgoing radiation is much greater in middle latitudes, than it is in equatorial regions, as shown in the accompanying table.

EARTH RADIATION (GRAM CALORIES PER SQUARE CENTIMETER PER MINUTE) AT DIFFERENT LATITUDES

0°–10°	10°–20°	20°–30°	30°–65°	65°–70°	70°–90°
0.26	0.27	0.31	0.34	0.31	0.27

W. J. H.

GEOLOGY.—*Economic geology of Richmond, Virginia, and vicinity.* N. H. Darton. Bulletin U. S. Geological Survey No. 483. Pp. 48, with maps, sections, and views. 1910.

The Richmond region belongs in part to the Piedmont province, in part to the Coastal Plain. Granite of undetermined age constitutes the oldest rock of the area, and is succeeded by sedimentary formations as follows: (1) Patuxent (Lower Cretaceous), Aquia, (Eocene), Calvert (Miocene), Lafayette (Pliocene?), and terrace alluvium (Columbia). All these formations except the Columbia dip gently to the east and are separated by unconformities. A. H. Brooks.

GEOLOGY.—*Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska.* U. S. Grant and D. F. Higgins. Bulletin U. S. Geological Survey No. 443. Pp. 89, with maps, sections, and views. 1911.

Prince William Sound lies within highlands which form a part of the Chugach Mountains. The fairly accordant tops of these mountains, composed of highly folded strata, suggests an elevated peneplain which has been warped and highly eroded. In this erosion glaciation has played a prominent part. The topography of Prince William Sound is that of a maturely eroded mountainous district with the forms of river erosion modified by ice erosion. Into such a district the sea has come, filling the main basin of the sound and extending far up the valleys that lead into it. The evidence of glaciation are smoothed and striated rock surfaces, roches moutonnées, hanging valleys, U-shaped valleys, fiords, etc., with some deposits of till and glacial gravels.

The sedimentary rocks of the region are chiefly closely folded slates and graywackes, separable into two unconformable series, a lower, the Valdez group, and an upper, the Orca group. Locally a conglomerate formation occurs at the base of the Orca, with which is also associated a large amount of greenstone. These greenstones are altered basic lavas having in many places an ellipsoidal character. Intruded in these series are granites and acid and basic dikes.

The copper-bearing lodes occur along zones of fracture and mainly in the greenstones, but some are in slates and graywackes, and some in the contact between the sediments and the greenstones. Mineral deposition in the shear zones in part followed open spaces, in part impregnated the country rock. The deposits are not definitely known to be related to intrusives, but some basic dikes occur which may have had some mineralizing influence. A. H. Brooks.

THERAPEUTICS.—*XV. Attempts at specific therapy in leprosy.* DONALD H. CURRIE, MOSES T. CLEGG,, and HARRY T. HOLLMANN, U. S. Public Health and Marine Hospital Service, Honolulu, T. H. Public Health Bulletin 47.

The authors, after fully reviewing an extensive literature, bearing on previous attempts at specific therapy in leprosy, describe several substances that they have prepared from their artificial cultures of B. leprae. These substances were given to several cases of leprosy for varying periods of time, and in some instances caused general and local reactions.

Up to the time this article was prepared, there was no evidence that any of these substances were of benefit to the patients receiving them, nevertheless, experiments of this nature are being continued in hopes that more success will be met with in future.

Among the substances employed was the serum of a horse, which animal had been partially immunized to live cultures of B. leprae. This animal's serum showed distinct evidence of containing agglutinins, it being able to clump B. leprae in dilutions of 1 to 1000.

DONALD H. CURRIE.

PHARMACOLOGY.—*Digest of comments on the Pharmacopoeia of the United States of America (eighth decennial revision) and the National Formulary (third edition) for the calendar year ending December 31, 1909.* MURRAY GALT MOTTER and MARTIN I. WILBERT, U. S. Public Health and Marine Hospital Service. Bulletin of the Hygienic Laboratory 79. 1911.

The present bulletin is the fifth of the series of "Digests of Comments" on the Pharmacopoeia of the United States and the National Formulary, now in course of revision. These books, as is well known are recognized by the Food and Drugs Act of June 30, 1906, as the standard authority with reference to the identity, purity and strength of the medicaments therein described and are, therefore, of direct interest and value as public health measures.

The available literature of the year 1909 containing matter of interest to the revisers of the Pharmacopoeia and the National Formulary has been carefully reviewed and practical suggestions and references, bearing on the improvement of the two books as standards under the law, are presented in as concise a form as possible.

As in previous Bulletins of this series, considerable space is devoted to the consideration of the possible development of international standards for potent medicaments, and the gradual compliance of foreign

Pharmacopoeias, with the provisions of the treaty signed at Brussels in 1906, is noted. The Pharmacopoeias published during 1909 and 1910 are reviewed and a summary of the compliances with the Protocol of the Brussels Conference as evidenced by the Pharmacopoeias published from 1905 to 1910 is presented in the form of a table.

Several additional tables presenting a comparison of the standards for various official articles are also included and will no doubt prove to be of value in connection with the present revision of the Pharmacopoeia of the United States.

In addition to their direct use as a ready reference to the comments on the articles included in the Pharmacopoeia and the National Formulary these Bulletins will also be found to be of value as a résumé of the current literature relating to widely used medicaments. M. G. M.
M. I. W.

BACTERIOLOGY.—*XVI. Complement deviation and agglutination in leprosy-immunity.* Donald H. Currie and Moses T. Clegg, Public Health and Marine Hospital Service. Public Health Bulletin 50.

The authors report on complement deflection and on the presence of agglutinins in immune sera, as a means of differentiating acid-fast bacteria.

They used for their experiments acid-fast bacilli, cultivated from leprous lesions, as well as a number of acid-fast bacilli isolated from other sources. The authors found that similar extracts of both the lepra bacillus and the Margarine bacillus would deflect the complement when combined with certain lepers' serum, and further the serum of artificially immunized animals against B. leprae would deflect the complement when extracts of the Margarine bacillus was used as the antigen.

Physiological salt solution, extract of the acid-fast bacilli and extracts prepared with alkalinized hydrogen peroxide would bind the complement, whereas very small amount of alcohol extracts and alcohol chloroform extracts absorbed the complements.

The authors were able to produce specific agglutinins in a horse by repeated injections of increasing amounts of a suspension of the cultivated leprosy bacillus. This serum agglutinated in relatively high dilutions, all acid-fast bacilli cultivated by the writers from patients suffering with leprosy. On the other hand agglutination did not occur with suspension of acid-fast bacilli other than B. leprae.

Donald H. Currie.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE BOTANICAL SOCIETY OF WASHINGTON

The seventy-seventh regular meeting was held at the Cosmos Club, Tuesday, January 9, 1911, at 8 p.m., with President W. A. Orton in the chair. Prof. E. O. Wooton and F. D. Farrell, both of the Bureau of Plant Industry were elected to membership.

Papers were read as follows:

Botanical gardens of the east. LYSTER H. DEWEY. A trip to Java to attend the International Fiber Congress and Exhibition held at Soerabaia in July, 1911, afforded an opportunity to visit several botanical gardens at points along the route. The gardens visited were as follows: Alameda Garden, Gibraltar; Jardin d'Essais and University Grounds, Algiers; Botanical Garden, Penang; Botanical Garden and Experimental Grounds, Singapore; Botanical Garden, Buitenzorg; Public Gardens, Hongkong; and Botanical Garden, Taihoku, Taiwan (Formosa).

The Alameda Garden is an attractive tho rather formal little public park in the upper part of the town of Gibraltar at the foot of the great rock. It is in about the same latitude as Raleigh, N. C., but the vegetation is more like that of southern Florida.

The Jardin d'Essais, at Algiers, extends from the sea shore back to about 200 feet up the hillside and covering an area of 80 hectares. It was founded in 1832, and is doubtless the oldest and certainly the most important garden of its kind in Africa. Its avenues of plane trees, date palms, magnolias, bamboos, chamaerops, latanias and dracaenas are especially worthy of note. Eucalyptus and Araucaria from Australia are growing well in the upper part of the garden. Many of the plants in the older part of the garden are crowded and labels are sadly lacking.

The University Grounds, mostly blasted out in terraces on the rocky hillside in Mustapha, the upper part of Algiers, is the special production and field of study and work of Dr. Trabut, for many years botanist at the University and botanical authority of northern Africa. This collection of thousands of plants crowded together and made to grow under difficult conditions, with the large number of hybrid agaves, eucalyptus, papayas, solanums, citrus, etc., bear evidence of the tireless energy and devotion to work of this botanical gardener of Algiers.

The twelve-hour stop at Colombo, Ceylon, was too short to visit the garden at Peridiniya.

At Penang, in the Straits of Malacca, is one of the most beautiful botanical gardens in all the world. Its Malay name, "Ayer terjun," is derived

from the waterfall coming over a cliff at the back of the garden. The exquisite beauty of this garden is due to the well kept green lawn, the grouping of many kinds of palms and especially to the splendid specimens of rajah palms, *Cyrtostachysl akka*, with brilliant scarlet midribs and graceful feathery leaves. There are many economic as well as ornamental plants in this garden and all are well labeled.

The large and well planted Botanical Garden on the island of Singapore, about 2½ miles from the heart of the city, is the most attractive feature of this combined Gibraltar and Liverpool of the Orient. It is only one degree north of the equator, less than 100 feet above sea level, and is watered with 100 to 140 inches of rain annually. There isn't a water pipe or piece of garden hose in all Singapore. The numerous palms and bamboos are among the most attractive features, while not the least interesting are the Para rubber trees, *Heva braziliensis*, from which have developed the great rubber plantations of the East Indies. One of these trees, planted in 1879, measures 10 feet 3 inches in circumference. Dr. Ridley, who recently resigned the position of Director, has kept the garden in remarkably good condition, considering the lack of funds and the small force at his disposal.

The Botanical Garden at Buitenzorg, founded in 1817, is justly regarded as the great botanical garden of the world. It is 5° 20″ south of the equator, 861 feet above the sea, covers 83 acres all planted, and with 219 rainy days a year has about 16 feet of rain. The garden is strictly tropical and one looks in vain for plants of temperate or even semitropical regions. Among hundreds of palms, the date palm and palmetto are conspicuously absent. The plants, all perennials and largely trees, are arranged by families, each species represented by two specimens, and each specimen labeled with a number and the technical name. The visitors' laboratories connected with this garden, where visiting botanists may carry on research work, is a feature for which the generous management of the gardens deserves the gratitude of the botanical world.

The Public Gardens at Hongkong are perched on terraces on the steep mountain side above the town, and are accessible to no conveyance except a Sedan chair. The 16 acres in the gardens contain plants of the tropics, semitropic and warmer temperate climates. The herbarium at this garden contains one of the best collections of south China plants in existence. One of the most attractive trees in the garden is *Araucaria rulea* from New Caledonia, about 6 m. high and almost perfect in form and color.

The small garden at Taihoku, the Japanese capital of Taiwan (Formosa), is only a few years old. The Japanese effect produced by ponds, mounds, rustic bridges and dwarfed trees is quite different from anything seen elsewhere. Camphor and other trees of Taiwan are represented and plants are being introduced from other countries.

These botanical gardens are fulfilling a many sided mission, in attracting tourists, educating even the casual observer as to the identity of plants, indicating the sources of plant products, introducing and dis-

tributing plants of economic value, and affording research workers exceptional opportunities for study.

Fermentation of cellulose. K. F. Kellerman, I. G. McBeth and F. M. Scales. In the formation and maintenance of humus in agricultural soils the fermentation of cellulose is probably of fundamental importance yet our knowledge of this question is inadequate. Omeliansky's generally accepted conclusions that cellulose is destroyed only under anaërobic conditions and gives rise either to hydrogen or methane are erroneous.

Two species of cellulose-destroying and five species of contaminating bacteria were isolated from a culture of Omeliansky's hydrogen organism, and one cellulose-destroying and two contaminating forms from his methane culture; none of the three fermenting species showed any resemblance to Omeliansky's hydrogen or methane ferments. In addition to the species isolated from Omeliansky's cultures eleven other species have been isolated from various other sources; one isolated from manure belongs to the thermophile group.

Contrary to Omeliansky's observation that cellulose-destroying bacteria do not grow upon solid media, most of the species isolated were found to grow readily upon such media as beef agar, gelatin, starch, and potato. Some are facultatively anaërobic, but none are strictly anaërobic.

It is usually supposed that filamentous fungi are of little importance in agricultural soils; these investigations show them to be at least as important as bacteria in destroying cellulose. About seventy-five species of molds have been isolated representing a large number of genera; species of Penicillium, Aspergillus, and Fusarium are perhaps most numerous.

In the destruction of pure cellulose either by bacteria or molds in synthetic media the associative action of organisms which presumably have no cellulose-dissolving enzymes frequently stimulates the growth of the cellulose organism and increases its destructive power.

Some phases of microscopical detection of decomposition in food products. B. J. Howard.

W. W. Stockberger, *Corresponding Secretary.*

THE GEOLOGICAL SOCIETY OF WASHINGTON

The 247th meeting was held in the Cosmos Club, November 8, 1911, President Brooks presiding. As an informal communication Mr. Charles A. Davis discussed the presence of locomotive cinders in salt marsh deposits near Boston as affording evidence of continuing subsidence during the last half century.

REGULAR PROGRAM

Is there a Permian Series?: LAURENCE LA FORGE. The question might be better put "Is there a Permian system, or a Permian series in the *Carboniferous* system?" Probably nowhere is the entire "Permian" found in conformable sequence with Demetian (Pennsylvanian) below and Triassic above. Where lower "Permian" conformably overlies Demetian it is with difficulty separated from it and is limited above by an unconformity and upper Permian is commonly absent; likewise where upper Permian is conformably succeeded by Triassic it is limited below by an unconformity and lower Permian is absent. Where lower and upper Permian are found together they are commonly separated by an interval of mountain-building with a consequent strong unconformity. Evidences of Permian glaciation have been discovered in all the continents, indicating a marked epeirogenic uplift, occurring generally thruout the world and accompanied in several continents by mountain-building, early in Permian time.

These facts seem to indicate that to form the Permian system or series there were combined formations and stages not properly belonging together, and the earlier and later of which are separated by a deformation of world-wide importance. This time of epeirogenic uplift, glaciation, and mountain-building would seem to be the best-defined and most reasonable point of separation of the Paleozoic and Mesozoic eras. Hence it is suggested that Permian be abandoned as a separate system or as a series in the Carboniferous, and that the lower part be included in the Demetian (Pennsylvanian), while the upper part forms a new series in the Triassic.

In the scheme of the International Geological Congress the Permian series is subdivided into the Autunian (or Artinskian), Lodevian, and Thuringian stages. In the United States the Dunkard group of the Ohio valley, the Chase and Wichita groups of the Great Plains, and the Cutler formation of Colorado are Autunian, which stage appears to be wanting in England, but is well developed in continental Europe. In the proposed new scheme it becomes the closing stage of the Demetian (Pennsylvanian) and remains Carboniferous. The Lodevian stage is sparingly developed in America, but the Sumner and Clear Fork groups of the Great Plains are correlated with it. It is well developed in Europe and farther east. In the western United States the Kiger, Salt Fork and Double Mountain groups, and the lower part of the Chugwater group, with perhaps other formations farther west, are Thuringian, which stage includes the typical Permian of Russia, the Zechstein of Germany, and the bulk of the English Permian. In the new scheme the Lodevian and Thuringian stages make up the initial series of the Triassic system, for which series the name Permian (or Permic) might well be retained.

This is virtually a return to the original classification, in which the middle and upper parts of the present Permian of Europe were combined with the present Triassic in the New Red Sandstone or Poikilitic system, while the lower part was considered Carboniferous. It is not proposed,

however, to revive the name Poikilitic, but simply to retain the name Triassic, extended downward to include the new, reduced, Permian series. It will be seen that the new scheme avoids the difficulty in various regions of distinguishing between Permian and Carboniferous, resulting in the hybrid name Permo-Carboniferous, since all such strata fall within the Carboniferous by virtue of the establishment of the base of the Permian at a higher horizon.

The bonanza of National, Nevada: WALDEMAR LINDGREN. This paper gave the preliminary results of a reconnaissance examination in the vicinity of the National mining camp, which is remarkable for the richness of the gold ore in its principal mine.

The northern end of the Santa Rosa Range, from the Oregon line for almost sixteen miles south to Canyon Creek, is made up of a succession of basalt flows, interbedded with tuffs. Some of these flows are scoriaceous, others massive; they are well exposed north of Eight-Mile Creek, where the whole series, over 2000 feet in thickness, dips east at gentle angles. They form part of the great volcanic area of the Columbia River lavas and extend far to the north, east and west of National. They were erupted in early Tertiary time, a time of intense volcanic activity all over the Cordilleran region.

In the earlier portion of this epoch of vulcanism the lavas in the National district were basaltic in character. At a later time rhyolites were poured out, and at the same time dikes and masses of rhyolite and obsidian, generally trending north and south, forced their way up thru the basalts and tuff beds, in places disturbing them greatly. Big blocks of basalt are sometimes imbedded in the rhyolite. A third and later intrusion was of a dark, fine-grained rock provisionally called an andesite. It is of importance because of the ore bodies that it contains. Still later volcanic activity produced successive basalt flows covering the rhyolites, and basalt dikes cutting those of rhyolite.

The formation of mineral veins followed the eruptions of rhyolite and andesite. Shortly after these eruptions fissures trending north and south were opened, mainly along the rhyolite dikes, sometimes also breaking into the basalt flows and the tuffs. The fissures are generally small, rarely over a few feet in width, and commonly much less. The fissure filling is mainly quartz, with drusy structure, and the characteristic combination of metals is antimony (stibnite), iron (pyrite or marcasite) gold and silver. Lead, copper and zinc are generally absent. Cinnabar has been observed at a few places. The veins thruout bear evidence of having been deposited by hot, ascending springs at a moderate depth below the surface. The majority of the veins so far described are clearly dependent upon the rhyolite eruptions; they sometimes carry considerable amounts of stibnite and the silver values usually prevail over those of gold. None of the veins of the type so far described has as yet yielded any considerable amount of shipping ore. The case of the National vein is somewhat different. It is mainly contained in an andesitic rock but it also cuts into basalt and rhyolite. Tho its ore yields some antimony (both as stibnite and ruby silver) the

quartz is distinctly different from that of other veins, being more massive and milky and less drusy, and there is in fact some reason to believe that its mineralization took place a little later than that of the veins following the rhyolite dikes.

This quartz vein, of very moderate thickness, contains along a well-defined shoot a most remarkably rich bonanza ore, consisting of coarse and hackly pale gold (possibly electrum) firmly imbedded in the white quartz. An interesting characteristic is that within the bonanza shoot rich and barren quartz may intermingle capriciously. The gold is not a secondary deposit; in fact, there is scarcely any evidence at all of such secondary solution and redeposition of the gold by descending surface waters, while there is evidence that some of the silver has been leached by surface waters and redeposited as ruby silver. There is also some secondary marcasite. The shoot has been followed for a distance along the dip of the vein of about 800 feet, the lowest level being opened by a cross cut from Charleston gulch. The production of this extraordinary bonanza since its discovery two years ago is said to have been no less than $2,000,000 up to last fall, mainly in gold. Most of the ore had a tenor of from $10 to $40 per pound. Some high silver values were found at the surface, but the apex of the gold shoot was not encountered until about 60 feet below the surface. No placers have been found in Charleston gulch or in Eight-Mile Creek, in spite of the fact that a great deal of rock has been removed by erosion. Hence it is probable that this gold shoot never reached the surface, and that no other of a similar nature existed within the rock volume carried away by erosion. The almost inevitable conclusion is that such shoots must be scarce below the present surface.

The exploration of the Noatak River, Alaska: P. S. Smith.

The 248th meeting was held in the Cosmos Club, November 22, 1911, Vice-President Stanton in the chair. As an informal communication Mr. Robert Anderson gave an account of the formation of a new island two miles off the south coast of Trinidad by an outburst of gas from the Tertiary oil and gas-bearing strata of the submerged coastal shelf. The island is of mud, sand and boulders, is about 10 acres in extent and has a height of 10 or 15 feet above the sea. The later stage of the eruption of this mass was accompanied by a great flame, due to the ignition of the gas. This ignition probably resulted from friction between sulphur-bearing rocks which were shot out.

REGULAR PROGRAM

The Carlyle oil field of Illinois: E. W. Shaw. The Carlyle oil field is about forty miles east of St. Louis and was discovered in the spring of 1911. It lies about fifteen miles west of the Sandoval oil field which was discovered in 1909. The excitement at Carlyle was intense and fabulous prices were paid for leases on farms which later proved to be outside the

productive territory. In structure the rocks have the form of an arch about 50 feet high on a general eastward dip of about 20 feet to the mile. The oil is found in a soft, porous sandstone in the uppermost part of the Mississippian series, a little over 1000 feet below the surface. There are many layers of barren sandstone above and below, which, like the producing sand, are arched; but they differ from it in that they extend out beyond the borders of the field, whereas the producing sand pinches out on three sides of the pool. On the fourth side this sand is full of salt water. All of the wells yield gas, oil, and water, the initial production of oil ranging up to 2000 barrels a day. There are now over a hundred wells and the total production is about 6000 barrels a day. The oil has a gravity of 33 to 37 degrees Baumé. Most of the wells are shot with about forty quarts of nitro-glycerine.

An old erosion surface in eastern Utah, its age and value in time determinations: JOSEPH B. UMPLEBY. During reconnaissance studies in 1910 and 1911 an old erosion surface was recognized in eastern Idaho. It was seen to be older than one group of mineral deposits but to truncate the other. Thus its age if definitely established would place limits on two great periods of mineralization. The aim of this paper is (1) to show that an old erosion surface extends over much of Idaho and into adjacent regions; (2) to outline the evidence for the conclusion that it is of Eocene age; (3) to suggest that the elevation of the highlands which were later planed down was accompanied by great granitic intrusions, and (4) to point out the relations of the Eocene surface to the ore deposits.

1. A correlation is suggested between the erosion surface in eastern Idaho and the plateau-like surfaces that have been recognized in west central Idaho and the Clearwater Mountains by Lindgren, in the Coeur d'Alene range of Idaho and the Cabinet and Purcell ranges of western Montana by Calkins, in the Galton and possibly also the Livingston and Lewis ranges farther east by Willis, in the Interior Plateau of British Columbia, where Dawson describes an Eocene peneplain, and in the Republic district of Washington by the speaker.

2. Early Miocene sediments, laid down in great erosion valleys developed after the last important elevation of the old erosion surface, indicate its pre-Oligocene age, allowing Oligocene time for the development of the valleys. On the other hand the surface cuts all the older formations, including the Idaho granite which is post-Triassic. Furthermore, the Eocene sediments of the Northwest surround the plateau region and were evidently derived from it. They could not have come from this region after its last elevation for two reasons: (a) It is doubtful if there has been sufficient dissection of the plateau to supply the volume of sediments represented, and (b) all the more important later valleys of the region drain westward. The conclusion, therefore, is that the Eocene sediments were derived from the plateau region during that cycle of erosion which resulted in gentle topographic forms, and hence that the old erosion surface is of Eocene age.

3. The plateau region as before defined is characterized by numerous granitic batholiths which are of about the same age and comprise pos-

sibly one-third its area. It is safe to assume that the intrusion of this material either caused or accompanied a profound elevation of the surface; yet the area of granitic intrusions shows no significant relation to surrounding sedimentary deposits until the Eocene. It is suggested, therefore, that the granitic intrusions initiated or accompanied the initiation of the cycle of erosion which resulted in the gentle topographic forms of Eocene age.

4. The Eocene erosion surface truncates the earlier mineral deposits. On the other hand these are younger than the granite which encloses some of them. They are therefore assigned to the late Cretaceous or early Eocene. The later veins are enclosed in or associated with eruptive rocks which occupy valleys developed after the elevation of the Eocene surface. Allowing the Oligocene period for the development of these valleys and evaluating the amount of erosion that took place between the extravasation of the lavas and the beginning of the Pleistocene, it is concluded that the younger veins are Miocene or early Pliocene.

Mines and prospects of southwestern Oregon: J. S. Diller. This paper presented the preliminary results of a study not yet completed, which will later be embodied in a report by the Geological Survey. A general geological map of northwest California and southwest Oregon illustrated the distribution of the larger groups of formations and called attention to the fact that the Sierra Nevada and Klamath Mountains are composed in large measure of the same formations and that these formations are closely allied also to those of the Blue Mountains of eastern Oregon. All these mountains are important mining regions.

The rocks of the Klamath Mountains have been subjected to vigorous compressive stresses in two directions approximately at right angles to each other. One set of stresses folding the rocks along axes running northwest and southeast, and prevailing in the southwest portion of the Klamath Mountains, connects them with the Sierra Nevada; the other set of stresses folding the rocks along axes running southwest and northeast, and prevailing in the northeast portion of the mountains, connecting them with the Blue Mountains of Oregon.

As a result of the divergent stresses there has been widespread crushing on diverse lines among the rocks of the Klamath Mountains. Consequently the later igneous intrusions with their mineralizing ore-bearing solutions from within the earth found many scattered lines of egress towards the surface, and the ore deposits, though abundant, represent in general a low instead of a high degree of concentration.

On a map of southwest Oregon was shown the location of the principal gold and copper mines from the California line thru the Grant's Pass region to Bohemia, and on a special sketch map was outlined the geology and mines in the vicinity of Galice and Kerby. Attention was called to the fact that the Galice slates contain fossils characteristic of the Mother Lode district in California.

Robert Anderson, *Secretary.*

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. II, MARCH 4, 1912 No. 5

RADIO-TELEGRAPHY.—*Damped and undamped oscillations.*

L. W. Austin, U. S. Naval Wireless Telegraphic Laboratory.

The idea has occurred to me that the ground absorption of damped and undamped oscillations might differ from each other, other conditions being the same. Therefore the following experiment was carried out between the Naval Academy at Annapolis, Md., and the Radiotelegraphic Laboratory at Washington. The antenna at Annapolis is of the harp form, approximately 150 feet high. In this damped oscillations were produced by a Fessenden rotary gap 2 kw. sending set of the type used in our long distance quantitative measurements.[1] The continuous oscillations were produced by a Poulsen arc. In both cases the resonance curve of the antenna was examined by means of a wave meter to make certain that only one definite wave length was emitted The coupling of the Fessenden set was made extremely loose so as to reduce the antenna current to the value obtainable from the arc, the decrement being approximate y 0.15. This antenna current was 3.5 amperes and the wave length with each set was 1060 meters.

The antenna at the Radiotelegraphic Laboratory is an eight wire harp approximately 180 feet high at top and 60 feet high at bottom. This makes the center of capacity 120 feet above the earth. Taking the height of the center of capacity of the Annapolis antenna as 75 feet from the earth, from the data

[1] Bulletin Bureau of Standards, 7:315. 1911.

given in Table XVI of the paper already cited it is possible to calculate the amount of energy which would have been received at the given distance (30 miles) over salt water. The current reduced to a receiving antenna resistance of 25 ohms would amount to $210 \cdot 10^{-6}$ amperes. The actual current received was $76 \cdot 10^{-6}$ amperes, therefore, the ground absorption amounts to 64 per cent.

The currents were measured as in the former experiments[2] by means of a rectifying detector with galvanometer in a circuit coupled to the antenna. The galvanometer deflections amounted on an average to 80 millimeters and no certain difference could be detected between the deflections due to the damped and to the undamped oscillations. The uncertainty of the observations amounted to probably 10 per cent. No correction was made for the difference in effective resistance of the receiving antenna for the damped and undamped waves. This might amount to from 10 to 20 per cent.

The conclusion to be drawn is that the absorption of the energy of the waves in passing over the country in question was the same in the case of the undamped and moderately damped oscillations within the limits of the errors of observation.

RADIO–TELEGRAPHY.—*Suitable wire sizes for high frequency resistance.* L. W. Austin, U. S. Naval Wireless Telegraphic Laboratory.

It often becomes necessary in high frequency testing to introduce definite amounts of resistance into the circuits. For the sake of convenience in calculation it is usually desirable to have the wires composing the resistances of such size as to make the so-called skin effect negligible since in this way it is possible to measure the resistance by direct current methods and to be sure that the high frequency resistance will be practically the same in value. If the experimenter does not take the trouble to calculate the relation between high frequency and direct current resistance, he is frequently led to use resistance wires of too small size, thus unnecessarily sacrificing current carrying capacity.

[2] Bulletin Bureau of Standards, 7:295. 1911.

I have, therefore, from data given by Professor Zenneck[1] graphically computed the sizes of wire which may be used at various wave lengths without causing the difference in direct and high frequency resistance to exceed 1 per cent. Doubling the diameter given in the table will produce a difference between direct and high frequency resistance of approximately 10 per cent, while one-half the diameter given in the table will reduce the difference to approximately $\frac{1}{10}$ per cent, (Zenneck). The values are given for copper and platinum as well as the high resistance materials constantan and manganin. Advance wire is practically identical electrically with constantan, while for high resistance German silver the values are nearly the same as for manganin.

TABLE OF WIRE SIZES

For Which the High Frequency Resistance Will be Less Than 1 Per Cent Greater Than Direct Current Resistance

Wave Length	Constantan or Advance Wire		Manganin Diameter	Platinum Diameter	Copper Diameter
	Diameter	Maximum Current			
m.	*mm.*	*amp.*	*mm.*	*mm.*	*mm.*
100	0.30	3.5	0.29	0.13	0.006
200	0.46	4.5	0.40	0.20	0.045
300	0.57	5.5	0.50	0.27	0.09
400	0.66	7.0	0.60	0.30	0.10
600	0.83	8.0	0.75	0.37	0.15
800	0.98	10.0	0.88	0.42	0.20
1000	1.10	11.5	0.99	0.50	0.21
1200	1.20	12.5	1.10	0.57	0.22
1500	1.30	14.0	1.21	0.63	0.26
2000	1.52	17.0	1.38	0.73	0.30
3000	1.80	24.0	1.62	0.80	0.33

The column of the table under Maximum Current gives the approximate current which may be carried by the various sizes of constantan wire without undue heating. The current capacity of the manganin is very nearly the same.

[1] Zenneck, Leitfaden der drahtlosen Telegraphie, p. 352.

Of course carbon and various electrolytes may be used instead of the metals, with even smaller corrections but the temperature resistance coefficients of these are so large that they are generally less suitable for use as resistances than constantan or manganin.

When a greater current carrying capacity is desired the wires may be frequently used in parallel soldered between parallel metal strips, provided the spacing is not too small.

ANALYTICAL CHEMISTRY.—*The accurate volumetric determination of phosphoric acid in phosphate rock.* JOHN G. FAIRCHILD. Communicated by F. W. Clarke. To appear in the Journal of Industrial and Engineering Chemistry.

The method here proposed is a modification of Pemberton's caustic alkali titration. In its original form Pemberton's method gives results 1.5 per cent low in comparison with the standard method of weighing the phosphoric acid as magnesium pyrophosphate. This error is reduced to zero by precipitation of the soluble phosphate with barium chloride in excess. The greatest error resulting in the analysis of eight phosphate rocks by this method was 0.32 per cent of P_2O_5, parallel determinations being made by the gravimetric method. The average error was 0.03 per cent of P_2O_5. The accuracy is 99 per cent as compared with an accuracy of 99.5 per cent for the gravimetric method. The advantage of the volumetric method is its rapidity, not more than one hour being required for a complete determination. Attention is called to the fact that the barium phosphate precipitated undergoes hydrolysis, necessitating moderate sized portions for titration. Also, that without this modification the apparent percentage of phosphoric acid is less, the larger the portions titrated.

GEOLOGY.—*Age of the Worcester phyllite.* DAVID WHITE.

The Worcester phyllite consists largely of altered clay shales, some of which are very highly carbonaceous, but comprises also thin beds of sandy shale and sandstone. The rock, which has generally been termed an argillite, is, under the name phyllite,

clearly described in great detail, by Perry and Emerson in the "Geology of Worcester, Massachusetts,"[1] and is mapped as occupying two synclines lying with a northeast trend beneath the city of Worcester. The formation in the eastern syncline is best exposed by the Boston and Albany Railway cut, between the Union Station and Lake Quinsigamond. Another outcrop, classic in the literature, occurs at the "Old coal mine" northwest of Wigwam Hill, in the grounds of the Normal College of the Sisters of Notre Dame. Several times during the last century attempts have been made at this old "mine" to work a thin bed of graphitized impure coal. Here the strata, which dip steeply to the north-northwest appear to be less altered than in most places, and the bedding is fairly distinct.[2] The minerals resulting from the metamorphism are fully described by Perry and Emerson. Dark, slaty phyllite and schist, richly carbonaceous, accompany the graphitic bed. A lower stratum still retains certain features which to the writer strongly suggest the so-called fire-clay beneath a coal bed. Veins of quartz or other minerals are inconspicuous at this locality, though the results of deformation are obvious in the slicken-sided layers. The more graphitic portions of the section now consist largely of thin, curly, slicken-sided, carbonaceous scales.

The phyllite rests on a quartzite described by the above-named geologists as the Worcester quartzite. The agreement of the quartzite with the phyllite in structure, probable conformity, and comparable alteration, is made a basis for regarding both as probably belonging to the same period. Both the phyllite and the quartzite are reported to be less altered at Worcester than elsewhere. Away from this point the phyllite is said to change to a mica schist, and the quartzite to a mica quartzite, which, according to Perry and Emerson, becomes their Paxton schist on the west, in the plateau of central Massachusetts, and the Bolton

[1] "The Geology of Worcester, Massachusetts," by Jos. H. Perry and Benj. K. Emerson. Worcester, 1903, pp. xii and 166, with map and numerous plates.

[2] The outcrop is photographically shown opposite p. 12 of the work just cited. The term "phyllite" is employed in conformity with the usage of Merrill (Rept. U. S. Nat. Mus., 1890, p. 390).

gneiss, on the east, the sediments having been more argillaceous westward, and more arenaceous eastward. The Brimfield schist, described by Emerson and Perry as overlying their Paxton schist, is accordingly correlated by them as a more highly metamorphosed phase of the Worcester phyllite.

Tho these beds were described more than three-quarters of a century ago and have been visited by scores of geologists, the widest views have prevailed regarding their age. As often happens in graphitic argillites, mineral or cleavage forms accidentally resembling graphitized remains of plant fragments are plentiful. Some of these closely imitate imperfect fragments of Cordaites, Calamites, Lepidodendron, etc. In 1883 a specimen was found by Professor Perry which appeared to be a true fossil, consisting of a fragment of a Lepidodendron stem impression, in which the somewhat indistinct leaf cushions were still comparatively regular in their quincunxial arrangement. This specimen was submitted by Perry to Leo Lesquereux,[3] who regarded it as probably belonging to *Lepidodendron acuminatum,* a Carboniferous species. On the evidence of the relatively minor degree of alteration, the occurrence of the graphitic bed, and this unfortunately rather obscure fossil,[4] Perry and Emerson have courageously insisted on the Carboniferous age of the phyllite, notwithstanding the scepticism of most geologists and paleontologists, some of whom, denying the validity of the fossil, have continued to regard the beds as not younger than Algonkian. Spurred by criticism, Professor Perry continued the search, with the result that after sixteen years the counterpart or reverse of the same stem fragment impression was discovered. This side, however, was scarcely more distinct than the other, and accordingly added nothing to the evidence as to the age of the phyllite.

Since it was evident that in the midst of soft clay shales, after such squeezing and alteration as at Worcester, there could be

[3] Am. Jour. Sci., Vol. XXIX, 1885, p. 157. See frontispiece "Geology of Worcester, Mass.," 1903.

[4] Another specimen, never reported on by a paleontologist, is said to have been sent to Columbia University.

little chance for the recognizable preservation of the delicate types of land plants most useful for age determination, the writer on the occasion of his brief visit to the old "mine" in October, 1911, set about the search for either clay ironstones or pyritic nodules ("niggerheads") which when occurring in the shales above coal beds are so often found to contain vestiges of more or less decayed but undeformed organic structures. The expectation that such sulphide nodules when surrounded by soft, plastic, and therefore compensating material, might, if present, have escaped serious deformation, was essentially borne out by the discovery of concretions containing recognizable fossils in the graphitic argillite. However, contrary to expectation, the concretions were found to contain brecciated shale fragments of various sizes and in varying attitudes. It appears that this shale was fractured or brecciated prior to the segregation of the sulphide. At present the interstices between the shale pieces, some of which were found to be as large as the palm of the hand, are largely occupied by asbestiform prochlorite (after fibrous pyrite?), though more or less iron sulphide is present.

The concretions above the graphite bed in the phyllite are few and rather hard to extract, and the included plant fragments in the particular shale layers represented therein appear to be scarce and generally small, but fortunately they are fairly distinct and practically undisturbed, the pieces of shale being less deformed so that the paleobotanical details are clear. In the relatively few fragments found during the writer's brief search, small portions of Cordaites leaves, probably *C. borassifolius*, are relatively plentiful. Other fragments include a small leaflet of Sphenopteris comparable to *S. dicksonioides* Stur; an isolated leaf cushion of Lepidodendron, possibly *L. obovatum;* a Sporocystis, and a small Equisetalean cone.

Thru the courtesy of Professor Perry the opportunity has been given the writer to examine and photograph one side of the Lepidodendron found by him in gritty schist. As to the validity of this impression there is no room for doubt. Though the bolsters are partially defaced and alteration products largely mask

the surface, there may be seen at several points imperfect outlines of what are, presumably, deformed leaf scars instead of mere pseudo-fossils. The trunk, which was perhaps a foot in diameter, may have belonged to *Lepidodendron Veltheimii*, or possibly *L. obovatum*.

Description of the fossils is deferred in the expectation that new efforts will bring to light additional material in the protected brecciated shale fragments. The specimens at present in hand, tho few and very fragmentary, are such as to put beyond question the Carboniferous age of the phyllite at Worcester, thus confirming the opinion of Professors Perry and Emerson. Judging by the details of the few pieces collected, the writer suspects that further discoveries will show the beds to be of Pennsylvanian, possibly Pottsville, age.

BOTANY.—*Annona diversifolia, a custard-apple of the Aztecs.* W. E. SAFFORD, Bureau of Plant Industry.

While engaged in the study of Annonaceae the writer found a specimen of Annona, or custard-apple, in the U. S. National Herbarium, remarkable on account of certain large, orbicular, leaf-like bracts at the base of the flowering branches, from which appear the peduncles, or flower stems, a peculiarity found in no other Annona thus far known, except *A. macroprophyllata* Donnell Smith. It proved to be an undescribed species, and a short description of it was published in *Science*,[1] under the name *Anona diversifolia*. The type material included bark, leaves, flowers, and immature fruit, (fig. 1) and the collector's field notes stated that the fruit, locally known as *ilama* or *izlama*, was reported to be edible. No description of the mature fruit was given, however, and it remained to be proved whether or not it could be identified with the celebrated *illamatzapotl*, or "zapote de las viejas," of the ancient Mexicans, the specific identity of which had never been established.

This fruit was first mentioned by Francisco Hernandez, the "protomedico" of Philip II, who was sent in 1570 to study the

[1] New ser., **23**: 471. March 24, 1911.

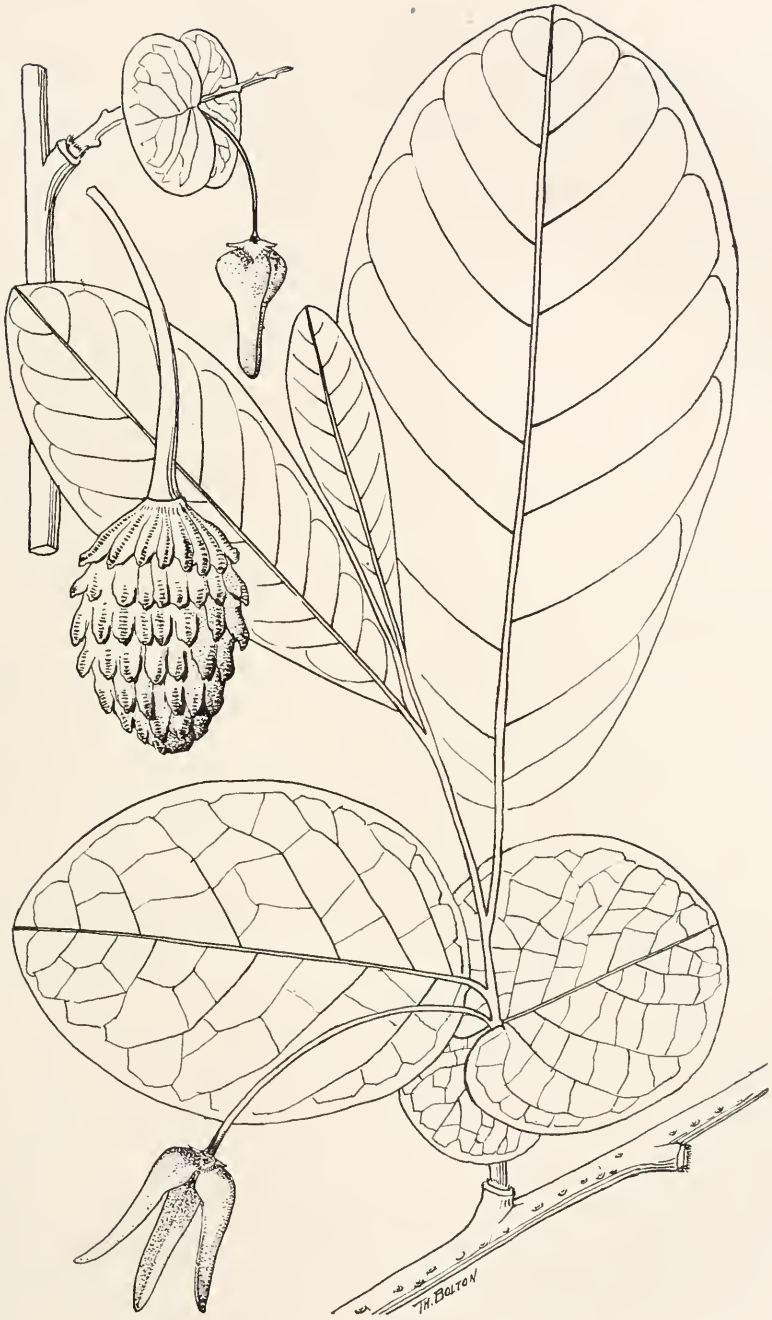


Fig. 1. *Annona diversifolia* Safford, natural size

products of New Spain. A figure of it was published in the first edition of his works, under the name *yllamatzapotli*,[2] and in a subsequent edition it was said to be identical with the *guanábano* (*Annona muricata* L.),[3] tho the original figure does not show the fruit to be muricate like the latter.

Nearly all writers on Mexican fruits have mentioned the ilama, or illamatzapotl, but there is a wide diversity of opinion among them as to its botanical identity. Altamirano and Ramirez thought it to be *Annona excelsa* of Humboldt, Bonpland and Kunth;[4] Dr. Urbina identified it with *Annona muricata* of Linnaeus;[5] and Professor Alcocer calls it *Annona reticulata* Linn.[6] In a monograph on the edible Annonaceae of Mexico, Professor Felix Foex, citing Ramirez as authority, refers the ilama of Colima and Guerrero to *Annona excelsa* H. B. K., without describing its flowers or fruit, and referring to its leaves as "*acuminadas*," a description which applies to *Annona excelsa* but not to the ilama of Colima and Guerrero.[7]

At the request of the writer much valuable information relating to economic Annonaceae has been obtained by Mr. David Fairchild, Agricultural Explorer in charge of Foreign Seed and Plant Introduction, chiefly from our consular representatives in Mexico and Central America, thru the courtesy of the State Department.

In reply to inquiries regarding the fruit known as ilama growing in the vicinity of Acapulco, Mr. Marion Letcher, American con-

[2] Recchi, Nardo Antonio: Nova Plantarum, Animalium et Mineralium Mexicanorum Historia a Francisco Hernandez Medico. . . . compilata. p. 444. Rome. 1651.

[3] "Illamatzapotl, quam Haitini Guanabanum vocant"—Francisco Hernandez. Opera, **1**: 178. Madrid. 1790.

[4] Altamirano, Fernando and Ramirez, José: "Lista de nombres vulgares y botanicos de árboles y arbustos propios para repoblar los bosques de la República." p. 3. 1894.

[5] Urbina, Manuel: "Los zapotes de Hernandez." Anales del Muséo Nacional, **7**: 212. 1902.

[6] Alcocer, Gabriel V.: "Catálogo de los frutos comestibles mexicanos." Anales del Muséo Nacional, segunda época, **2**: 419. 1905.

[7] Foex, Feliz: "Algunas Anonáceas frutales de Mexico." Estacion Agr. Centr. Bol., No. **9**: 25. 1908.

sul at that port, forwarded seeds and photographs, which showed it to be an Annona somewhat resembling the chirimoya (*Annona cherimola*) and sugar-apple (*Annona squamosa*) but quite distinct

Fig. 2. *Annona diversifolia* Safford, showing fruit leaves and bracts, one-half natural size.

specifically from them both. Photographs, taken by Dr. H. K. Pangborn about two leagues back from the coast, show a tree with dense glossy foliage and pendant conoid fruit which appeared to be covered with whitish felt or cotton (fig. 2). The leaves are

distinctly rounded at the apex, very different in shape from the leaves of the other species mentioned, and the photograph of fruits, fully ripe and bursting open, show them to be shaped "like pine apple cheeses," as Mr. Letcher aptly describes them (fig. 3). The seeds forwarded by Mr. Letcher were totally unlike those of any known species of Annona. They resembled, however, some seeds in the economic collection of the U. S. Department of Agriculture of an unidentified Annona growing in the republic of El Salvador.

Fig. 3. Mature fruit of Ilama (*Annona diversifolia*) one-third natural size.

Photographs of the Acapulco fruit were accordingly sent by the writer to the Agricultural Department of Salvador, and a prompt and courteous reply was received from the Director General of Agriculture of that republic, Don Rafael Castillo, who identified it with the species called in Salvador "anona blanca." Señor Castillo also forwarded seeds and leaves of the "anona blanca," which identified it unmistakably with the ilama of Colima (*Annona diversifolia*) and with the ilama of Acapulco. The following is an amended description of the species.

Annona diversifolia Safford. ILAMA, or ILLAMATZAPOTL Fig. 1.
Anona diversifolia Safford. Science, n. ser., **23**: 471. 1911.

Leaves petioled, blades varying from broadly elliptical, near the base of the flowering branches, to obovate-oblong and oblanceolate, higher up, rounded or obtuse at the apex, and rounded or acute at the base, membranaceous, glabrous, feather-veined, punctulate with minute dots; peduncles solitary 1-flowered, long and slender, recurved or pendent, issuing from one or two suborbicular, amplexicaul, glabrous, leaf-like bracts near the base of the flowering branches; flower buds obpyriform; petals linear-

oblong, swollen and concave at the base; fruit conoid or broadly ovoid, covered with dense felt-like pubescence, the individual carpels scale-like when immature, and projecting in thick blunt points directed toward the apex when mature, but sometimes suppressed so that the fruit is ovoid or subglobose in shape; seeds golden-brown or buff colored, obovoid to oblong, with a hard smooth testa devoid of a marginal groove or wing, enveloped in a thin membranous covering when fresh, and surrounded by a richly flavored, cream-colored or rose-tinted, edible pulp.

Type in the U. S. National Herbarium, No. 398834, collected near the city of Colima, western Mexico, July 1897, by Dr. Edward Palmer (No. 60).

Distribution: Colima and Acapulco, western Mexico, to El Salvador; cultivated for its edible fruit. Local names: Ilama, Hilama, Illamatzapotl (Mexico); Anona blanca (Salvador).

Annona diversifolia is a small tree with deep green foliage, and light-colored brownish-gray bark, longitudinally furrowed and set with numerous lenticels. The tender young leaves at first are reddish or copper-colored, somewhat like those of a mango in color, but at length turn green and have a parchment-like texture. They differ essentially from the leaves of the closely allied *Annona macroprophyllata* Donn. Smith in size and form and in the length of the petiole. Diversity in shape and size of the leaves is common to many species of Annonaceae, usually the smaller and relatively broader leaves being found near the base of the flowering branches, and larger and relatively narrower leaves following in succession; but in the present species this diversity is most pronounced. The possession of persistent leaf-like clasping bracts at the base of the petioles separates this species together with *A. macroprophyllata* from the rest of the Annonas thus far known, and places them in a section apart, which I have called Ilama.[8] These bracts are glabrous in the present species, while in *A. macroprophyllata* the bracts are ciliate on the margin. The smaller and relatively broader leaves at the base of the branches

[8] See Safford, W. E.: "The Genus Annona: the derivation of its name and its taxonomic subdivisions." Journ. Washington Acad. Sci., 1: 118–120. September, 1911.

are 5 to 6 cm. long and 3.8 to 4.8 cm. broad; the largest are 10 to 14 cm. long and 4 to 6 cm. broad, rounded or obtuse at the apex and usually acute or cuneate at the base, with petioles 12 to 16 mm. long. The basal amplexicaul bracts are 25 to 35 mm. in diameter; the floral peduncles, remarkably long for this genus, are 4 to 5 cm. long. The small ovate or triangular calyx divisions are ferrugineous-ciliate on the margins. The fresh petals (20 to 24 mm. long) are described by Dr. Palmer as "light reddish or chocolate colored within and mauve or purple on the outer surface, becoming snuff-colored with age." They differ from those of *Annona cherimola* and its close allies in opening to the base when mature.

The fruit may be described as having the form of an enormous artichoke with an axis of 13 to 15 cm. and a diameter of 12 to 13 cm. On the same tree specimens may be found with the salient points of the carpels quite pronounced while in others they are scarcely apparent. In comparing it with the fruit of the chirimoya (*Annona cherimola*), Mr. Letcher states that the flesh of the ilama is usually pink, sometimes deep rose-colored, the hard nutlike seeds are yellow or yellowish brown (fig. 4 a), and the peel or rind is scurfy and inclined to be covered with projecting points. The chirimoya, on the other hand, has white flesh; dark brown seeds with a thin testa easily cut with a knife and surrounded by a marginal ridge (fig. 4 b); and an almost smooth skin usually with a wart-like protuberance near the apex of each outlined areole.

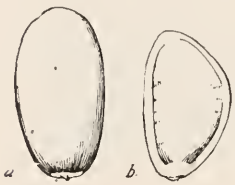


Fig. 4; *a*, seed of *Annona diversifolia*, *b*, seed of *Annona cherimola*, natural size.

Seeds sent by Mr. Letcher from Acapulco and by Don Rafael Castillo from Salvador are exactly alike; they resemble pine-nuts rather than ordinary Annona seeds. They are 20 to 21 mm. long, 12 to 11 mm. broad, and 10 mm. thick, so that they have a broadly elliptical or oval cross-section. The basal hilum is more or less depressed and is devoid of the thickened caruncle which usually surrounds the hilum in other species of Annona and in the allied genus Rollinia.

Mr. Letcher describes the fruit as "quite delicious" and in a recent communication received through the State Department from Mr. Samuel E. Magill, American consul at Guadalajara, he refers to the "ilama of Colima" as having a richer flavor than the chirimoya, the species which has hitherto been considered the queen of the custard apples.

ETHNOLOGY.—*Definitions of two primitive social states.* O. F. Cook.

Primitive social systems are usually classified by standards borrowed from legal or political science, such as the different systems of inheritance of property or rank. Familiarity with two groups of primitive people, in West Africa and Central America, has suggested the possibility of a different system of sociological classification, based on facts that have a more fundamental relation to the development of civilization.

That a primitive society be matriarchal or patriarchal, or that it be governed by a priestly or a military caste, does not determine its possibilities of progress, for progressive peoples have shown many differences and have survived many changes in these respects. More important factors have been contributed by the external environment, but none of these can be considered indispensable. Capable peoples have developed in apparently unfavorable environments, until they were able to choose their own environments. The underlying question of civilization is to know what conditions are really favorable for the development of human talent.

The essentials of civilization, considered as characters of human races, are not transmitted from one generation to another by prenatal inheritance like the instinctive arts of animals. Human arts and social adjustments have to be acquired by postnatal inheritance, thro the medium of contacts with parents and elders during the years of childhood and youth. It is reasonable, therefore, to believe that any factors or conditions that tend to increase or diminish these contacts are of practical importance in the development of civilization.

Two types of social organization may be distinguished by reference to the contacts between parents and children. In the choripedic state the children of different families are kept apart from each other, and remain associated with the parents and older members of the family. In the sympedic state the children of a community are associated in groups with others of similar age. The choripedic state provides complete contacts with the parents, the sympedic state only partial and imperfect contacts.

In his most primitive condition man may be thought of as roaming thru the forests in simple family groups, as the anthropoid apes and some very backward savages still do. After settled agricultural habits are adopted and permanent food supplies assured it becomes possible for the original family group to expand into a community. The dwelling may expand with the family into a large communal house, or the community may live in a cluster of houses, constituting a village. Both of these conditions are found among the natives of Liberia. The Kroo people of the coast live in large communal houses that may shelter two or three score of people. The interior tribes, such as the Veys, Golahs and Pessahs, live in very small, closely clustered houses. The social condition of the children is the same in the two kinds of communities, both representing the sympedic state. Children of nearly the same age spend most of their time playing together or chattering about in little groups, much like the squads or gangs of street children with us.

The social organization of the Kekchis and other related tribes of eastern Guatemala is essentially different from that of the Africans. Although these tropical Indians are even more strictly agricultural than the natives of tropical Africa, they do not associate in communal dwellings or villages. Each family lives by itself, often quite remote from any other. The Kekchis and neighboring tribes were aptly described by Otis T. Mason as "poor relations of the Mayas." Though unusually primitive and unorganized, they are closely related in language and other respects to the tribes that were farthest advanced toward civilization at the time of the Spanish invasion.

When families live isolated on the land, as among the Kekchis, the children have full opportunities to learn all the facts and acquire all the skill that the parents may possess, and transmit these arts in turn to their descendants. Capable parents not only produce more capable children, but give them a more effective equipment for life. It is easy to understand that civilization develops under such conditions, by gradual accumulation of the experience and accidental discoveries of successive generations. Among the Africans, on the other hand, the premature socialization of the children interferes with progress toward civilization. Postnatal inheritance is restricted when contacts between the generations are inadequate. There are smaller chances that progress made by capable individuals will be preserved and transmitted to their descendants.

With this difference of social organization in mind, it becomes easier to understand the striking contrast noted by so many travellers, historians and ethnographers, between the natives of Africa and America. The general distribution and diversity of archaeological remains on the American continent afford evidences of a generally favorable condition for the development of civilization. In tropical Africa, on the other hand, civilization has not only failed to develop but many introduced civilizations have degenerated into barbarism. This is not because the Africans are inferior as individuals to the Indians, for they generally have both physical and mental superiority. But the Indians were able to make more progress because they retained the superior social organization of separate families instead of taking the false step of premature socialization. It is true that many tribes of Indians in different parts of the American continent went over to the communal, sympedic system, but it does not appear that such tribes made progress toward civilization, even as far as the Africans.

The sympedic condition is not confined, of course, to primitive peoples, but supervenes whenever the family organization is weakened by crowding people together in villages or cities, becoming most intensified among urban populations that have ceased to practice any of the agricultural arts. Village-dwelling agricultural or pastoral people may preserve effective contacts

between the parents and the children, for the families usually separate for several months of the year, to plant their crops or tend their herds.

Agriculture is to be considered as the basis of civilization, not only because it affords the physical support of civilized man, but because it represents the condition of existence necessary for the development of civilization. Farm life usually supplies both society and solitude, the prime essentials of intellectual progress. All of the highly civilized races seem to have developed their powers during a primitive agricultural stage, preparatory to more conspicuous exploits in other lines of activity, military, political, industrial or artistic. The highest developments of specialized arts are often attained after civilizations reach the urban stage, but urban conditions are finally destructive of civilization.

When people leave the land and become continuously occupied with urban pursuits constructive contacts between parents and children are at an end. The home may still supply food, lodging and clothes, but other parental responsibilities are disregarded or transferred to the school. The child really belongs to a group of school children of his own age, rather than to a family group. He spends all his active hours with the other children, thinks their thoughts, speaks their language, and sees the world entirely from their point of view. Under farm conditions the children share in all the activities of their parents, instead of being relegated to an artificial scholastic state, apart from the life of the community.

The school makes for progress when it serves to supplement the parental contacts with other opportunities of learning. Civilization is a synthetic process, as some ethnologists have pointed out, but herding young children together does not advance civilization. Compulsory instruction of parents in the interest of home rearing of children would be a much wiser measure than compulsory attendance at schools. The school becomes an agent of disorganization when it weakens the family relations and gives the child less than he might have obtained from his parents. The juvenile savagery now recognized as a regular feature of our city populations is not a normal state of the children of civilized races,

as some educators have inferred, but is a result of the sympedic state, the premature association of the children with each other, and the lessening of contacts with parents and elders.

EVOLUTION.—*The story of evolution as revealed by a scolytid beetle.* ANDREW D. HOPKINS.

If the principle of evolution has the broad application we believe it to have, one should find in any individual form of life, as for example, a scolytid beetle, some evidences of its origin, some records of the more important events and progressive changes in its line of descent and of its near and remote relationship to other forms.

A review of this evidence and the facts made available by the living beetle shows that its body is composed of organic elements, that it is rendered active by the element of life, and that in this and other evidences of its relationship to organic and inorganic nature there is proof of universal unity. In its development from an organic unit or mother cell it has furnished some of the evidences of its line of descent from a simple protozoid source to a complex metazoid form, from a simple vermiform type to a complex larval-form type, and thence thru radical changes and transformations to the adult, so that the development of the individual indicates the processes in the development and evolution of the race. It suggests that, since all organisms develop from a primitive cell, all existing forms of life have evolved from a common unicellular base. It also indicates that each major division of the various classes of animals and plants have descended thru more or less direct and independent lines of divergence from a primitive mass rather than from pairs of individuals.

This scolytid beetle represents, in its structural characters, the order Coleoptera, suborder Rhynchophora, superfamily Scolytoidae, family Scolytidae, genus Scolytus, and species scolytus. Thus, it belongs to a great coördinate system, and in its combination of elements of structure and vital and social activities it manifests the fundamental processes, principles, and laws under which it is enabled to exist as a unit of this system.

Therefore, we do find in the individual beetle much of the story

of evolution, both in a restricted and broad application to organic and inorganic nature. In other words, we find the story revealed by existing evidences and facts rather than by those of the past.

The dominant elements of structure and habit which serve to distinguish the individual beetle from all other forms are significant. In a review of the morphological evidence, we find that in addition to the fundamental cellular structure common to all forms of life, it is distinguished from the protozoans by characters common to the metazoans, from the vertebrates by characters common to the invertebrates, from other invertebrates by characters common to anthropods, from the other anthropods by characters common to the hexapods, from other hexapods by characters common to the Coleoptera, from other Coleoptera by characters common to the Rhynchophora, and so on, down to the characters of the family, genus, and species, and finally, to those peculiar to the individual. But this is only an outline of the chapters and volumes of the story of evolution as revealed by the morphological elements alone. The story is continued and verified in the physiological evidence revealed by the characteristic activities common to the various groups it represents, such as those found in the methods and processes of acquirement, ingestion, digestion, and assimilation of food, the processes of development and reproduction, the struggle for existence, and finally the influences of heredity and environment on the character of the individual, the species, and the race.

Thus, the individual in its ontogeny and its morphological and physiological elements, reveals a long interesting story—a story with many complex and poorly defined features which are subject to a wide range of interpretation and theories as to the fundamental and minor features of the processes of evolution.

The more plausible theories that have been advanced are not entirely satisfactory because in the final analysis there is so much that is yet to be explained. As applied to biology, the principle of natural selection is the most satisfactory but natural selection is only one of the many and complex factors in the process of evolution as applied, in its broadest sense, to matter and consciousness.

A study of the scolytid beetles to determine their relation to forest trees and other plants, to each other, and to nature in general, has suggested some lines of thought and interpretation which have led to the consideration of some of the problems of evolution from a viewpoint somewhat to the reverse of the usual.

It seems to me that there is a higher, more powerful, more dominating, and universal principle of evolution than has yet been recognized; a principle which is manifested to a greater or less extent in all progressive changes in inorganic and organic forms and activities.

That there is a universal law of progressive adjustment towards an equilibrium between opposing elements and manifestations in matter and consciousness and a dominant law of progressive and parallel development and modification of structural and physical elements towards ultimate and definite forms, and that these laws are fundamental in all evolutionary processes.

That evolution from a primitive source has been by the process of accession, combination, and progressive modifications of structural and physical elements rather than by that of reduction and loss of elements. That a specific element once acquired is never entirely lost.

That among organisms natural selection and heredity, Mendel's law and the mutations of DeVries exert their greatest influence on the minor characters and characteristics of the individual, the variety, and the local section of the species, rather than on the characters and characteristics of the species as a whole, the genus, or the major division of the greater systems of so-called natural affinities.

That the independent origin and development of the same kinds of animals and plants in different parts of the world under continued similar environments is no more remarkable or improbable than the independent origin and development of the same kind of crystal, elemental metal, or chemical element.

That the development of the same kind of appendages in different classes and orders of animals could not have been due to phylogenetic descent from a common ancestor with similar appendages unless we admit special creation. Therefore, the origin

of the same or similar elements of structure and activity, in widely separated classes and orders, must have been independent. It is also evident that the progressive modification of these elements from the simple to the complex must have been along parallel lines in response to the momentum of a dominant tendency towards a common plan under the strain of similar requirements in the struggle for individual and racial existence and supremacy.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

METEOROLOGY.—*Waves of pressure in the atmosphere recorded by an interferometer barograph.* ALBERT C. CREHORE and GEORGE O. SQUIRE. Bulletin of the Mount Weather Observatory, 4: 115–118. 1911.

In addition to the large changes in atmospheric pressure that are indicated by every barometer, there are numerous minute and rapid fluctuations that are neither recorded nor shown by any ordinary barometer, whether mercurial or aneroid.

Several methods have been developed, however, for showing and recording these minute and often nearly rhythmical changes in atmospheric pressure; but the one under review probably is the most exact and delicate of all.

It consists essentially of a vertical pile of aneroid cells capped by a silvered flat that, with change of pressure, correspondingly changes its distance from a fixed half-silvered surface.

When properly supplied with monochromatic light the resulting interference rings are almost constantly in motion, first in one direction and then the other, in quick and delicate response to every pressure change.

By the aid of a slit across the interference rings, a camera, and a uniformly moving film, the pressure changes can be permanently recorded: —the negatives and the prints they yield looking like ribbons of watered silk. W. J. HUMPHREYS.

TERRESTRIAL MAGNETISM.—*Distribution of the magnetic declination in the United States for January 1, 1910.* R. L. FARIS, Coast and Geodetic Survey. Special Publication No. 9, pp. 14, with 1 map.

This publication just issued by the Coast and Geodetic Survey contains secular change tables of the magnetic declination and a magnetic declination chart of the United States for the year 1910. On the chart are also shown the lines of equal annual change of the magnetic declina-

tion in 1910. Since the publication of the 1905 declination chart so many additional data have been accumulated and the secular change has undergone such material modification that a new chart was needed. January 1, 1910, was chosen for the date of the chart in order that the reduction of the declination data to a common epoch, might be based upon actual observations of the annual change. Special attention was given in 1909 and 1910 to obtaining observational data of the secular change.

The isogonic lines are shown on the chart for each degree of magnetic declination. The distribution of the lines of equal change shown on the chart differs materially from that of the lines on the 1905 chart (which the present chart now supersedes), the most marked characteristic being a crowding of the lines toward the line of no annual change. West declination is increasing much more rapidly in the North Atlantic states than was supposed in 1905, the annual change now being about six minutes in the New England states. On the Pacific coast east declination is increasing more rapidly than it was in 1905, but apparently the region of maximum annual change is now some distance inland.

Under the present conditions of rapidly varying annual change it is not possible to predict accurately what these changes will be even for a few years in advance.

In connection with the present large annual change in New England it may be noted that west declination is increasing about seven minutes a year in Bermuda and about nine minutes per year at Vieques Island, Porto Rico. R. L. F.

PHYSICAL CHEMISTRY.—*Die Untersuchung von Silikaten.* ARTHUR L. DAY. Z. Elektrochem., **17:** 609. 1911.

An address given at the annual convocation of the Bunsen Gesellschaft, held at Kiel, Germany, reviewing some of the more interesting phases in the laboratory investigation of silicates compared with some of the more familiar fields of physico-chemical research.

MINERALOGY.—*The melting points of minerals in the light of recent investigations on the gas thermometer.* ARTHUR L. DAY and ROBERT B. SOSMAN, Geophysical Laboratory. American Journal of Science (4) **31:** 341. 1911.

Before the completion of the gas thermometer measurements to 1550° C. at the Geophysical Laboratory, the temperature measurements made in this laboratory with thermo-elements had been interpreted in the

usual way, by extrapolating the curve of temperature and thermal electromotive force. These results now require to be corrected by the amount of the difference between the old temperature scale and the new, which makes it necessary to recalculate the existing temperature data of this laboratory in terms of the new gas scale. This paper presents a summary of the values resulting from this recalculation.

Some of the European students of silicate solutions have encountered difficulties in the determination of mineral melting-points which have led to the belief that most or perhaps all minerals do not melt at a determinable "point," but rather that the phenomena of melting extend through a considerable temperature interval. Experimental evidence is here offered, in the case of two of the typical minerals in question, that this uncertainty was merely the result of the experimental method employed. This is a matter of some importance, because the above conclusion, if true, would necessitate a new system of definitions for melting silicates. A. L. D. and R. B. S.

GEOLOGY.—*Geologic atlas of the United States, Folio No. 174, Johnstown, Pa.* W. C. Phalen. U. S. Geological Survey, Pp. 15, with maps, sections, and views. 1911. *Mineral resources of Johnstown, Pa., and vicinity.* W. C. Phalen and Lawrence Martin. Bulletin U. S. Geological Survey No. 477. Pp. 142, with maps, sections, and views. 1911.

The Johnstown quadrangle, embracing 228 square miles, is situated in west-central Pennsylvania near the eastern escarpment of the Appalachian Plateau. The rocks are entirely sedimentary and range in age from Devonian (Catskill formation) to the Conemaugh formation of the Pennsylvanian series of the Carboniferous. They have a thickness of about 3200 feet and are bent into northeast-southwest folds. The structure as worked out differs in some particulars, especially near Johnstown, from the results obtained by the Second Geological Survey of Pennsylvania.

The mineral resources include coal, clay, shales, limestone, and cement materials, building stone, paving block, concrete materials, glass sand, and iron ore. Numerous analyses of these commodities are given with the results of steam, coking, briquetting, cupola, producer-gas, and float and sink tests of the coals.

At least five coals, confined to a vertical interval in the Allegheny formation, ranging from 150 to 200 feet, are locally workable.

W. C. P.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE WASHINGTON ACADEMY OF SCIENCES

The 75th meeting, the 14th annual meeting, of the Washington Academy of Sciences was held at the Cosmos Club, 8 p.m. January 20, 1912, with President F. W. Clarke in the chair, and forty-two members present. The minutes of the previous annual meeting, and abstracts from the minutes of all subsequent meetings were read and approved. The reports of the officers and Auditing Committee were received.

The following were elected resident members:

Eugene Thomas Allen	J. A. Le Clerc
William Bowie	William Gerry Morgan
Charles John Brand	John B. Nichols
Edgar Brown	Perley Gilman Nutting
A. Hugh Bryan	Carl S. Scofield
Edgar Buckingham	Homer Le Roy Shantz
Guy N. Collins	Cornelius Lott Shear
Charles Albert Davis	Philip S. Smith
Edgar Curtis Franklin	George Owen Squier
Albert W. C. Herre	Paul C. Standley
William Francis Hillebrand	William Alton Taylor

The report on the ballot by mail for officers for 1912 showed the following elections: President, F. V. Coville. Non-resident Vice-Presidents: T. C. Chamberlain, David Starr Jordan. Corresponding Secretary: Arthur L. Day. Recording Secretary: W. J. Humphreys. Treasurer: Alfred H. Brooks. Managers, Class of 1915: J. S. Diller, David T. Day.

The following were elected resident vice-presidents as nominated by the affiliated societies: Anthropological Society: F. W. Hodge. Archeological: Mitchell Carroll. Biological: E. W. Nelson. Botanical: W. R. Maxon. Chemical: J. A. Le Clerc. Engineers: George W. Littlehales. Entomological: L. O. Howard. Geographic: Henry Gannett. Geological: David White. Historical: James Dudley Morgan. Medical: John B. Nichols.

It was moved by Dr. Briggs and seconded by Dr. Howard, that a vote of thanks be extended to the retiring Corresponding Secretary, Dr. Frank Baker, for his long and valuable services to the Academy. This was unanimously carried by a rising vote. Dr. Baker made an appreciative reply.

A unanimous vote of thanks was also extended to the retiring President, Dr. F. W. Clarke.

The newly elected President, Mr. F. V. Coville, then took the chair, and after a few happy remarks, introduced the speaker of the evening, Dr. F. W. CLARKE, who traced the origin and history of the Washington Academy of Sciences, and dwelt especially on the need for and value of the Academy's newly established Journal.

W. J. HUMPHREYS, *Recording Secretary.*

ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 455th regular meeting of the Soc'ety was held October 24, in the New National Museum. The first paper read was by Mr. J. MOONEY, on *Indian Survivals in the Carolinas.* He gave a brief account of his summer's work with the eastern Cherokee on their reservation in the mountains of western North Carolina, and with some mixed-blood survivors, locally known as Croatan Indians, in the eastern part of the state. The east Cherokee numbering about 2000, are descendants of those who fled to the mountains when the body of the tribe was removed to the Indian Territory in 1838. They still retain most of their aboriginal customs and beliefs, together with their language, although the larger tribal ceremonies are nearly obsolete.

The Croatans, so-called from an attempt to identify them with Raleigh's lost colony of 1585, are centered chiefly in Robeson County, to the number of about 8000 according to the last census, with bands in adjoining counties and in South Carolina. They appear to be descendants of the original native tribes of the same region, largely mixed with alien blood, the Indian blood still predominative, altho they have completely lost all knowledge of Indian customs, language or tribal names. They are intelligent and prosperous people, farmers and small tradesmen, fully up to the level of their white neighbors. They have official recognition from the state as Indians, with a separate school appropriation and support of a small paper called the *Indian Observer* devoted to their interests.

Mr. HODGE gave an exhibition and talk on the speech and civilization of the seventeenth and eighteenth centuries in New Mexico. Dr. P. RADIN spoke on *Some Archeological problems of the Winnebagoes.* Dr. Hrdlička suggested that the fact that physical anthropology found of the skulls in the Wisconsin mounds should be taken into consideration by the speaker.

The 456th regular meeting of the Society was held in the New National Museum November 14. The speaker of the evening was, Mr. W J McGEE on *Conditions limiting the growth of population in United States.* His talk was an elaboration of his paper in Science. (Oct. 6, 1911, pp. 428–435.)

The 457th regular meeting of the Society was held in the New National Museum January 16. Dr. J. W. FEWKES lectured on the *Western neighbors of the Prehistoric Pueblos,* illustrating his remarks with lantern slides. The early Spanish discoverers designated the habitations of the sedentary Indians of the Southwest by several names as pueblos, casas grandes, rancherias, and trincheras, the word pueblo being espe-

cially assigned to a compact several storied community house of terraced form represented most abundantly along the Rio Grande. The large houses on the Gila river they called casas grandes and they gave the name rancherias to fragile walled dwellings made of brush and clay supported by logs. Defensive walls were sometimes called trincheras. Each of these names indicates distinct architectural types altho they were not used with accuracy. In late years it happens that all ruined buildings of the Southwest, especially those independent of cliffs are called pueblo ruins, the culture of the people that once inhabited them being designated, the pueblo culture. It is well to preserve the term pueblo for the crowded terraced many storied buildings to which it was originally applied, and when this is done the distribution of the pueblo type in our Southwest is considerably restricted. The stone ruins ascribed to the ancient sedentary inhabitants of Arizona from the upper Verde river west to the Colorado are not true pueblos. In this region there predominated massive stone forts of magnitude and fragile walled houses with stone foundations; a duality everywhere evident. The indications are that both kinds of buildings were constructed and used simultaneously by the same people. The forts being situated on inaccessible hill tops were asylums for safety, and more perishable buildings on the river terraces were habitations near aboriginal farms. The great number of these forts on the western border of the pueblo region implies a great necessity for defense along the whole western border of Arizona and Sonora in Mexico.

Dr. Fewkes gave a brief account of the different forts and terrace dwellings on the upper Gila and its tributaries, Sycamore, and Granite creeks, the Chino and Williamson valleys and Walnut creek to the mouth of the Santa Maria and other tributaries of the Colorado, all examples cited substantially agreeing in the duality of architectural type and the absence of true pueblo structure.

The simple construction of the forts and the rude character of the masonry made of undressed stone, without mortar, was referred to. Views of the remains of dwellings or rancherias on the river terraces were shown and commented upon. Terrace sites indicated by rectangular and circular rows of stones and low mounds occur all along the Chino and Walnut valleys to Aztec Pass. These show no evidences of kivas or sacred rooms, or many storied dwellings. The pottery found near them is rude, sometimes decorated, the pictography is characteristic, the people made extensive irrigation ditches.

The most important forts mentioned were those on the upper Verde near del Chino, and on the limestone ridge west of Jerome Junction. Two important forts (one is situated near the mouth of Walnut creek and the other at Aztec Pass, the latter being the "Pueblo" first described by Wheeler) were referred to. Maps of the Walnut creek region are defective, the most prominent elevation, Mount Hope, being wrongly located on some of the latest maps issued by the Land Office. Big Burro and other streams west of Aztec Pass have forts overlooking enormous canyons of great scenic interest.

The geographical distribution of the forts and trincheras in western Arizona corresponds in a general way with the northern extension of the Yuma stock according to Major Powell's linguistic map. The country west of the Verde valley in which the ruins occur was peopled by Yavapai, Hualapai, Havasupai, and other Indians called by Cortez, Apaches. The Havasupai who now live in the depths of the Cataract Canyon, and the Hualapai are said to have legends that their ancestors constructed some of the buildings considered. The Hopi Indians dwelling in the pueblo Oraibi claim that certain of their clans came from the west and are of Yuma stock. The question of the kinship of the ancient builders is of interest to the physical anthropologist as well as to the linguist and student of culture history. As the Indians of Yuma stock formerly extended to the Pacific the possible kinship of the western neighbors of the pueblos to tribes of southern California is significant.

Dr. Hrdlička in discussion said that the results of the direct study of man himself in the region west of the pueblos agree in a large part with the conclusions arrived at by Dr. Fewkes, but in part they also differ. It is quite possible that the region about and west to southwest of the Aztec Pass was once occupied by either the Mohave or Yuma. The people against whom they had to defend themselves, however, were more probably the Apaches. The Walapai and Supai who today speak the Mohave language, are physically Apache and the same is true of the Yavapai. As the Apache type is a very distinct one, this conclusion is quite definite. Both tribes contain, of course, some Mohave and probably also Pueblo admixture.

Dr. Hrdlička showed a series of views of special Supai and Walapai huts which are related to those of the Apache but are totally distinct from those of the Mohave and Yuma, and numerous types of men and women from the several tribes, showing great resemblance between the Walapai and Supai and the Apache, while the Mohave resemble much more closely the pueblos.

Mr. George Stetson then spoke on the code of Hammurabi. His remarks showed how humanitarian the code was, and what advance it was on Roman law in several respects tho antedating the latter by centuries. The speaker also demonstrated how the laws of various states of the union and certain foreign nations might well be advantageously amended on the lines of the code under discussion.

Truman Michelson, *Secretary.*

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 702nd meeting was held on January 13, 1912. Two papers were read. *Krümmel's Handbuch der Ozeanography, Vol. II:* R. A. Harris, of the Coast and Geodetic Survey.

The speaker gave a condensed review beginning with the treatment of ocean waves. The errors concerning the energy of waves were pointed out. Then seiches, tides, ocean currents, vertical circulation and ocean streams were discussed. This extensive and valuable treatise on oceanography contains a lot of information not elsewhere brought together.

The determination of the pole distance of a very small magnet: J. M. MILLER, of the Bureau of Standards.

If two circular coils, which are linear single turns, are adjusted so that they are coplanar and concentric, and if two currents are sent in opposite sense around the coils, the two magnetic fields will annul each other at the common center if the ratio of the two currents is equal to the ratio of the radii of the two coils. This gives a method of comparing the radii of coils experimentally. In such a comparison the neutralization of the two fields is usually indicated by a short magnetic needle which is suspended at the common center of the two coils and lies in their common plane.

On account of the finite length of the magnet an error is introduced into the comparison equal to $\frac{3}{4} K$ where K is a known function of the pole distance of the magnet and the radii of the coils. If, however, the needle is rotated by torsion or otherwise, out of the plane of the coils, the ratio of the neutralizing currents is changed by a factor $\frac{15}{4} K \sin^2\alpha$ where α is the angle through which the magnet has been rotated. Hence by measuring the angle α and also the change in the ratio of the neutralizing currents, K can be determined and from this, the pole distance of the magnetic needle can be calculated.

A piece of steel of only 2.314 mm. length was used as the magnetic needle and the pole distance for this very short magnet was determined to an accuracy of about three per cent. The resulting value for the pole distance was 1.956 mm.

Kohlrausch's modulus which is the ratio of the pole distance to the total length of the magnet is, therefore, equal to 0.845. Thus in the case of this extremely short magnet, the poles are situated approximately one-twelfth of the total length from the ends, which agree closely with the results obtained by Kohlrausch and others for long magnets.

R. L. FARIS, *Secretary.*

THE BOTANICAL SOCIETY OF WASHINGTON

The 78th meeting was held February 6, 1912. Mr. W. W. Ashe, of the Forest Service, and Dr. H. W. Wollenweber, of the Bureau of Plant Industry, were elected to membership. The following papers were read:

Conditions favorable to Septoria lycopersici Speg.: J. B. S. NORTON.

The author gave a brief résumé of a series of observations on the development of Septoria under different conditions influencing growth.

The relation of soil acidity to plant societies: A. W. SAMPSON.

The plant ecologist has long recognized the fact that different soils support different plants. The significance of characteristic plant societies and communities, with respect to the acidity or alkalinity of the soil and its effect on the growth of cultivated plants, was strikingly brought to my attention in a study of the revegetation of depleted grazing lands on the Wallowa National Forest in northeastern Oregon.

It was found that the soil preference of some of the most promising

cultivated species, such as *Trifolium repens*, for example, like a great many other Leguminosae, was extremely sensitive to acid or sour soils. Many such plants can exist only for a couple of seasons in a soil requiring more than 6000 pounds of lime per acre foot, that is, to a depth of one foot. On the other hand, some forage species, notably *Agrostis alba*, as evinced by the luxuriant growth made, prefer sour soils. Thus, in a judicious reseeding of the native depleted grazing lands, a study of the native plant societies, as indicators of acid alkalinity or neutrality of the soil, is imperative.

In general, strongly acid habitats are characterized by a superabundant supply of moisture coupled with poor drainage. Locally, such lands usually support dense stands of vegetation, such as Carex, which often produce a matted surface and an entanglement of long root stalks which bind the soil firmly.

When this study was first undertaken, it was presumed that the latter soils—those with an intricate mass of interwoven roots and having an air dry weight of 15 pounds per cubic foot, were the more acid. Later, however, it was found that the sour soils are those of the well-drained lands which support the mountain bunchgrass (*Festuca viridula*) society. The soils upon which this society occurs vary in lime requirements for neutrality from 5000 pounds as a minimum to 41,000 pounds as a maximum. Such habitats are found to be acid to a depth of about five feet. The greatest lime requirements for neutrality occur in the superficial layer.

The acid endurance and requirements of the various local conspicuous plant societies follows: They are arranged in accordance with the degree of acidity of the substratum.

(1) *Festuca viridula* society, (2) Carex society, (3) Alnus-Salix society, (4) Veratrum-Rudbeckia-Mertensia-Valeriana society, (5) Phleum-Elephantella-Dodocatheon society, (6) Vaccinium-Phyllodoce society, (7) Deschampsia-Juncoides society, (8) Pinus-Calamagrostis society, (9) Pinus-Abies-Polemonium society, (10) Panicularia-Cinna society.

The mountain bunchgrass (*Festuca viridula*) society, as stated, has the most acid soil. It occurs throughout the extensive well-drained meadows, and bald buttes of the Hudsonian zone on the characteristic basaltic clay loam soils.

While the genera that make up these associations are mainly confined to sour soils, some species seem to show no particular preference for acid lands, or at least they occur abundantly alike on sour, neutral, and alkaline soils. The most important genera that inhabit the calcareous rock formations are: Pteridium, Aquilegia, Achillea, Pentstemon, Lupinus, Erigeron, Agropyron, Elymus, Sitanion, Stipa, Berberis, Artemisia, and Populus. Of these it is definitely known that Pteridium, Lupinus, Stipa, and Populus occur also on somewhat sour soils.

Ever since the day of Unger and Thurmann, there has been considerable difference in opinion regarding the relationship between soil acidity and vegetation. A grouping together of plants into societies, doubt-

less depends both upon the physical and chemical condition of the substratum. In the regions studied, however, the physical texture and the water content seem to be of secondary importance.

Notes of travel in Central America: A. S. Hitchcock.

Having visited the Canal Zone as members of the Smithsonian Biological Survey, Mr. Hitchcock and his son, made a two months' side trip to Central America. Collections were made in Costa Rica at Port Limón, San José and Puntarenas, in Nicaragua at San Juan del Sur, Corinto, Masaya and Jinotepe, in Honduras at Amapala, in Salvador at La Unión, Acajutla, Santa Ana and San Salvador, in Guatemala at Guatemala City, Volcano Agua, and Port Barrios.

The botanical results of the trip were very satisfactory, consisting of 760 numbers of grasses, and many photographs illustrating the habit of growth of the larger species. The collections in the National Herbarium from Central America, with the exception of Costa Rica, were meagre, especially from Nicaragua and Salvador. There appear to be several new species in the collections and also many species that have been rare in herbaria but have proven to be abundant in this region. Among the rare species may be mentioned: *Bouteloua pringlei*, from Salvador, only known heretofore from Guerrero, Mexico; *B. americana*, known only from the West Indies; *B. disticha*, common on the Pacific slope, of Central America; *Uniola pittieri*, common on sandy beaches from Puntarenas to Panama; *Jouvea straminea*, abundant at Corinto and Acajutla. In a recent monograph upon the genus Panicum in North America all our knowledge of this group was brought together but many species of the southern portion of this region were very imperfectly known. In the subdivision of the genus, known as Parviglumia, many collections during the past season from various localities have shown certain species such as *Panicum virgultorum* and *P. parviglume* to be widely distributed and not uncommon. The genus Lasiacis, allied to Panicum of which it was formerly considered a section, has presented many difficulties because herbarium specimens have shown only the panicles and a few leaves. The plants however are large, usually much branched and woody. Notes and photographs taken from the living specimens show that there are good characters based upon habit, method of branching and the appearance of the young shoots. The species of this group are numerous and well-marked and it is hoped that the distinctive characters observed in the field may be coordinated with those observed in herbarium specimens and thus lead to a satisfactory revision of the genus. One outlying member, *L. procerrima* (*Panicum procerrimum*), known only from the type collection in Costa Rica, was found to be wide spread, though not abundant, from southern Mexico to Panama. It is remarkable that this species, growing to the height of 5 to 8 feet, and having a panicle as much as two feet broad, should have been so little-known. These collections made in Panama and Central America together with those made the preceding year in Mexico give a fair knowledge of the grass flora of these regions.

W. W. Stockberger, *Corresponding Secretary.*

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. II, MARCH 19, 1912 No. 6

MINERALOGY.—*The crystallography of variscite.* WALDEMAR T. SCHALLER, Geological Survey.

In a recent publication[1] I gave a description of variscite crystals from Utah. All of the material then available showed the same crystal habit, a rectangular, tabular one which was illustrated by crystal drawings and by a photograph. Thru the kindness of Messrs. Edison and Bird, of Lucin, Utah, I have recently examined a larger number of specimens and found that the mineral crystallizes in several additional habits, such as very thin plates, long prisms and octahedral pyramidal crystals of which the unit pyramid $\{111\}$ is the dominant form. Beautiful little twin crystals were also found in a measurable condition.

The number of crystal forms has been extended from the four given in the paper above cited to over fifteen. A full description of these crystals with their angular measurements is to be given in a paper nearly ready for publication.

MINERALOGY.—*New manganese phosphates from the gem tourmaline field of Southern California.* WALDEMAR T. SCHALLER, Geological Survey. To be published in a Geological Survey Professional Paper, entitled: "The Gem Tourmaline Field of Southern California."

The various properties of these new minerals and their relation to each other will be fully described in the report referred to above.

[1] Schaller, Waldemar T.: Crystallized Variscite from Utah. Proc. U. S. National Museum, **41**: 413-430, plate. 1912.

All of these minerals were found at Pala, San Diego County, California.

Palaite.[1] Probably monoclinic. A flesh-colored hydrous manganese phosphate, resulting from the alteration of lithiophilite. D. 3.14 – 3.20; mean refractive index about 1.655, slightly lower than that of hureaulite; double refraction low. Forms crystalline masses in the cavities of which are found distinct crystals. In thin section colorless, and non-pleochroic. Formula $5MnO.2P_2O_5.4H_2O$, (Analysis 1). It alters to hureaulite. Found in the Stewart Mine at Pala, from which the name of the mineral is derived.

Stewartite. Probably triclinic. A hydrous manganese phosphate from the Stewart Mine, after which it is named. It is very abundant as an alteration product of lithiophilite which it replaces along its cleavage cracks. The first formation of stewartite is in fine fibers arranged normal to the cleavage cracks of the lithiophilite. Irregularly bounded areas and minute but distinct crystals of stewartite were also noted. The crystal form and optical properties of these minute crystals serve to characterize the mineral and to show that it cannot be identified with any known species. Altho abundant, it is so intermingled with the other minerals of similar composition that a pure sample of it, sufficient for quantitative analysis, could not be obtained. Its importance in the alteration of lithiophilite necessitates a name for the mineral which its physical properties suffice to establish. D. 2.94. Mean refractive index about 1.65. Double refraction very high, probably not under 0.05. Pleochroic: colorless, pale yellow, yellow. Extinction inclined on all crystal edges. Axial angle large, negative, dispersion strong. Probably the same as the unknown mineral "A" described by Lacroix.[2]

Salmonsite. Named after Mr. Frank A. Salmons, formerly of Pala, and found in the Stewart Mine. It results from the partial oxidation and hydration of hureaulite, and forms cleavable masses of a buff color, seamed by small veins of fibrous palaite and sprinkled with small masses of blue strengite. D. 2.88.

[1] Pronounced Pá-la-ite.

[2] Lacroix, A.: Mineralogie de la France, **4**: part 2, p. 506. 1910.

Mean refractive index about 1.66, double refraction low. In thin section yellow and non-pleochroic. Formula $Fe_2O_3.9MnO.4P_2O_5.14H_2O$, (Analysis 2).

Sicklerite. Named after the Sickler family, formerly of Pala. Found in cleavable masses at the Vanderburg-Naylor Mine on Hiriart Hill near Pala. Dark brown color with a light yellow-brown streak. D. 3.45. Refractive indices about 1.74, double refraction moderate. Pleochroic in yellow and brown. Formula $Fe_2O_3.6MnO.4P_2O_5.3(Li,H)_2O$, (Analysis 3). Readily fusible before the blowpipe giving a lithium flame. Results from the alteration of lithiophilite.

In addition to the above named new minerals, there occur at Pala, associated with them, the following whose properties and relations to one another will be given in detail in the full report: lithiophilite, hureaulite, strengite (the same as the angelardite of Lacroix,[3]) triplite, purpurite,[4] manganite and psilomelane.

Analyses and Ratios of New Minerals

	Palaite		Salmonsite		Sicklerite	
	Analysis	Ratios	Analysis	Ratios	Analysis	Ratios
FeO	7.48	5.00	0.13	9.18	33.60	6.28
MnO	40.87		37.74			
CaO	1.77		1.06		0.20	
Fe_2O_3	0.16		9.53	1.00	11.26	1.09
Mn_2O_3					2.10	
P_2O_5	39.02	1.93	34.86	4.10	43.10	4.00
$H_2O(110°)$			0.43			
H_2O+	10.43	4.07	15.30	14.17	1.71	2.92
Li_2O	trace				3.80	
Insoluble	0.89		1.40		4.18	
	100.62		100.45		99.95	

[3] Loc. cit., p. 522.

[4] Compare this Journal, 1: 113. 1911.

PHYTOPATHOLOGY.—*An external dry rot of potato tubers caused by Fusarium trichothecioides*, Wollenw. C. O. JAMIESON and H. W. WOLLENWEBER, Bureau of Plant Industry. Communicated by C. S. Scofield.

Certain types of decay of potato tubers have been ascribed by various authors to the action of the fungus Fusarium (Clinton, 1895; Smith and Swingle, 1904). Conclusive infection experiments have been performed by several (Pizzigoni, 1896; Wehmer, 1897; Pethybridge and Bowers, 1908; Longman, 1909 and others).[1] In most cases *Fusarium solani* (Mart.), or a species thought to be a synonym of it, is said to be the real cause of the rot. The different kinds of decay described on the one hand, and the negative results often secured on the other, directed attention to a more complete study of the morphology of potato Fusaria and their differentiation. During this study, which was done in Germany, not less than fifteen species were isolated, of which nine have been published (Appel and Wollenweber, 1910). As a result of recent and as yet unpublished experiments at Dahlem-Berlin only two of the nine species have been found to be wound parasites of the stored tuber: *F. coeruleum* (Lib.); *F. discolor* var. *sulphureum* (Schlecht. s. sp.). Closely related to the latter is a new species, found in the United States and characterized by a peculiar injury known as external dry rot. This disease has been studied by Miss Jamieson during the past two years.

Attention was first called to the disease in February, 1910, in potato tubers sent from Spokane, Washington. Since then we have examined samples of similarly diseased tubers from the same locality, as well as from Iowa, Minnesota, Nebraska, and South Dakota. Symptoms of this disease have been noticed in the field at the time of harvesting potatoes, in one instance the estimated infection being about 10 per cent of the crop, but it is

[1] See also Appel and Kreitz. Der derzeitige Stand unserer Kenntnisse von den Kartoffelkrankheiten und ihrer Bekämpfung. Mitt. a.d. Kais. Biol. Anst. f. Land und Forstw., Heft 5, 1907. Berlin. (With lists of the more important references up to 1907), and Pethybridge and Bowers. Dry Rot of the Potato Tuber. The Economic Proceedings of the Dublin Society, vol. I, 14, 1908, p. 547–558. 1 Tab.

concerning the loss of potatoes in storage that complaint is most frequently heard.

Potatoes affected with this external dry rot are characterized by wrinkled, discolored, and somewhat sunken external spots, frequently but not always occurring at the "eye" end of the tuber, and varying in diameter from a few centimeters to several inches according to the progress of the disease. The color of these diseased areas is in general brownish, considerably darker than that of the normal epidermis and often having a slightly grayish cast. In a more advanced stage of the disease the epidermal tissue often breaks or cracks irregularly, exposing a substratum of fungus mycelium within. The surface of the tuber about the cracks may also be overgrown with a delicate pinkish-white, powdery growth, composed of fungus threads and spores. From sections made thru diseased tubers, the internal fleshy portion is seen to be seriously affected, often to a greater extent than is apparent from the external appearance. The internal discoloration is sepia brown, a cross section of a badly diseased potato often showing a pronounced contrast of shades varying from light to deep brown. As infection proceeds internal cavities are formed, from one to several centimeters in diameter, within which the fungus mycelium grows abundantly, presenting the same powdery appearance as noticed on the surface of the tuber. Gradually the whole substance of the potato becomes involved, until finally it is reduced to a dry, powdery, brownish-colored mass of broken-down cells, starch grains, fungus mycelium and spores. Tissue from various parts of infected tubers showed a fungus belonging to the genus *Fusarium* thruout the discolored portions as well as in the firmer tissue bordering upon these areas. A pure culture of this Fusarium was isolated from the inner tissue by the agar plate method. During our further investigations the same fungus has been isolated several times from dry-rot infected potatoes.

The following description and diagnosis of this Fusarium is now being added in the monograph of Dr. Wollenweber:

Fusarium trichothecioides Wollenw. In general appearance this fungus closely resembles *Trichothecium roseum* (Link); Conidia in nature as a rule not in sporodochia, but, in pure culture the

sporodochium or Pionnotes stage also occurs: Conidia of the former 1–3 septate, medium size, 15–26 x 4–5$\frac{1}{4}$ microns, formed as a slightly curved comma, ellipsoidally rounded on both sides; conidia of the latter type 3–5 septate, 24–42 x 4$\frac{1}{2}$–5$\frac{1}{2}$ microns; form of the Discolor type. Conidia masses and plectenchyma salmon colored to carrot red when slightly moist, but lighter and usually rosy-white when powdery dry and intermixed with mycelium. Yellowish to brown stromata may be formed. Conidiophores of the comma type, mostly irregularly branched, with prominent sterigmata, the arrangement of which is scattered, or especially at the top, trifurcate. Conidiophores in the sporodochia more highly developed, like those of *F. discolor*. Chlamydospores seldom occur, and when present are intercalary, in chains or single.

Causes decay of potato tubers, especially under storage conditions. Diseased spots sepia-brown within. The early stage shows a very brownish black discoloration of the layer bordering the sound tissue. Spokane, Washington; St. Paul, Minnesota; Dayton, Iowa; Alliance, Nebraska; and Spearfish, South Dakota.

The two stages of conidial development above mentioned give this fungus an individual place in the genus. Less developed spores of other species may occur under abnormal conditions, but disappear when grown on a favorable host; but *F. trichothecioides* as a rule produces this smaller form abundantly both in nature and in pure culture. Spores of this stage resemble (Fig. A, E, F) exactly Trichothecium (Link) Corda, described and figured by Corda.[2] The sterigmata of the conidiophores, often trifurcate at the tops (Fig. C), seem to indicate a relationship to Basidiomycetes. Most important for the determination of the fungus, however, is the development of the higher type (Fig. B) in pure cultures. It forms salmon-colored sporodochia of the well known tubercularia-like type on the surface of sterilized, not too moist grains of cereals and mature stems of plants. The conidiophores of these sporodochia (Fig. D) are verticillately branched and show

[2] Icones fungorum, 1838, p. 10, cum tab., IX, fig. 48, 49.

a striking contrast to the smaller form (Fig. C). All the intermediate grades from the comma stage (like Trichothecium) to the sporodochia stage are easily produced by a selection of media. Beginning with the higher (sporodochia) stage we can reduce the fungus to the inferior (comma) stage by means of a transfer of mycelium; on the contrary, spores of the comma type once or repeatedly transferred on grains or stems, will give normal sporodochia with three to five-septate spores, sharply pointed at the ends (Fig. B).

The relationship to the discolor group may be determined only by the higher form; a confusion of the new fungus with *F. discolor* and its variety "*sulphureum*" is impossible because *F. discolor* differs by producing a purple mycelium, while that of "sulphureum" is brimstone-colored, and both differ from *F. trichothecioides* by the absence of the comma stage.

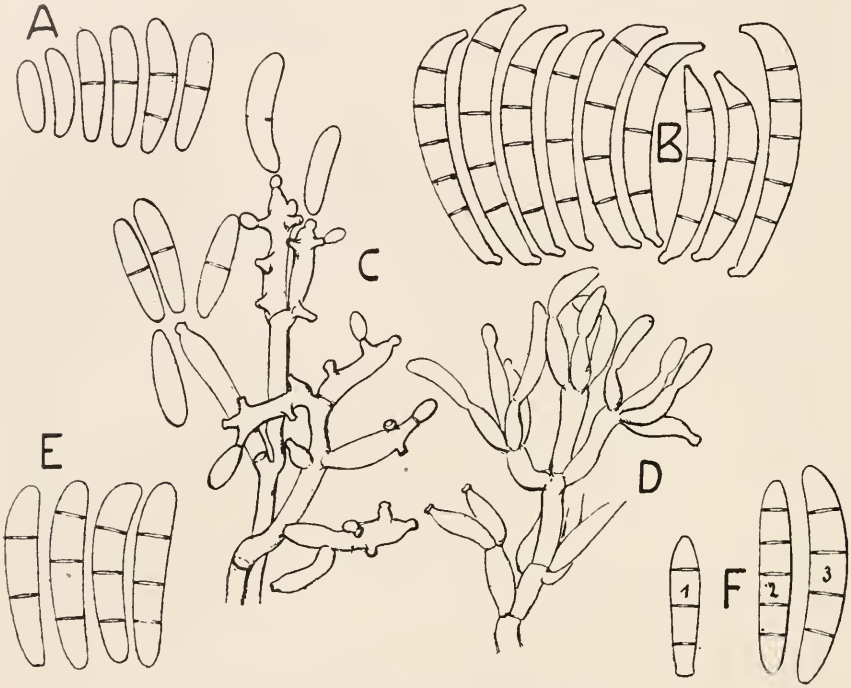
The occurrence of *F. trichothecioides* on other hosts is as yet unknown. A comparison with earlier studies of other authors shows that 5 different Fusaria cause similar tuber rots, 4 of which are fully described:[3] *F. solani* (Mart.), *F. coeruleum* (Lib.), *F. discolor* var. *sulphureum* (Schlecht. s. sp.), *F. trichothecioides* Wollenw. Probably Miss Longman[4] has dealt with a species different from the four. She names it *F. solani*, but to judge from her figures and her description, she had to do with a quite distinct species.

In order to prove the parasitic nature of *Fusarium trichothecioides*, inoculation experiments have been carried on under controlled conditions in our greenhouses during the past two seasons. Potato plants, grown in sterilized soil, from selected and disinfected seed were used, and pure cultures of *F. trichothecioides* inoculated into the stem just above the surface of the ground (Dec. 1910). In twelve days a wilting of the foliage was noticed accompanied by a yellowing of the leaves and a discoloration of

[3] Appel and Wollenweber: "Grundlagen einer Monographie der Gattung Fusarium (Link)," Bd. VIII, Heft 1, m., 10 Textfig., 2 schwarz., 1 farbig. Doppeltafel. Berlin: P. Parey u. J. Springer. 1910. Preis, 10 M.

[4] Longman, Sibyl: "The Dry-Rot of Potatoes," Linnean Society's Journal, Vol. XXXIX, Aug., 1909.

the tissue about the inoculation pricks. In three weeks time the fungus infection had produced a pronounced effect upon the plants, shown in the wilted condition of the foliage, in the constriction of the stem at point of inoculation, and in a brownish black



EXPLANATION OF THE FIGURE

A,E, F. Conidia of the comma-stage, grown on sterilized potato stems. F_1 seen from the back, F_2, F_3, extra large and highly septate. B. Conidia of the sporodochia-stage, grown on sterilized grains of corn (twenty days old). C. Conidiophore which in masses forms a dense growth on the surface of the medium like *Trichothecium roseum*, and produces spores shown in A, E. F. D. Conidiophore from a sporodochium, that forms the spore shown in B. Magnification 870.

discoloration of the tissue above and below the constriction. Upon the surface of the discolored area could be seen a growth of powdery slightly pinkish mycelium and spores. Microscopic examination and isolation showed this fungus to be *F. trichothe-*

cioides. Pure cultures of this same Fusarium were later obtained from tubers produced upon a plant diseased thru inoculation.

Further experiments are now being made to determine the most favorable conditions under which the infection of *F. trichothecioides* takes place. For this experiment sound healthy potato tubers of Burbank and Early Ohio varieties were selected, disinfected and placed in inoculation chambers. Two methods of inoculation were tried, one by stabbing the tuber with a thick needle and inserting fungus mycelium and spores from a pure culture of *F. trichothecioides,* the other by rubbing the surface with a platinum loop bearing the fungus. The ten inoculation chambers were then placed under different conditions of heat and moisture and examined at definite intervals. Thus far, results from this test indicate that of the two methods stabbing is the most effective, altho infection follows the rubbing of the fungus on the surface of the tubers. Discoloration of the tissue was noticed in the inoculation chambers after ten days and this was followed by a decay which penetrated into the tissue 2–3 cm. in twenty days. Rapid discoloration of the tissue was observed in both moist and dry chambers placed at a temperature of 10–12° C. In the drier atmosphere however, there was a deeper penetration of the decay into the tissue, than occurred at the same temperature under increased humidity. Two months after inoculation, the potato tubers were carefully examined and their appearance compared to the diseased specimens sent in from the field. Externally and internally the disease characteristics in field and laboratory specimens were similar. The brown grayish spots on the outside of the inoculated tubers frequently surround the "eyes," except in the case of the stab inoculations where the discoloration spreads about the wound. On the surface of the diseased tissue there is usually an abundant growth of pinkish powdery mycelium in the moist atmosphere, but very little of the external fungus growth in the drier air. The discoloration caused by the penetration of the fungus and extending several centimeters below the epidermis varies from light to dark sepia brown in color, the darkest portion forming a band which surrounds the cavities. In every

instance the decay appears to work from the surface inward. From results of this experiment it is clear that conditions of temperature and moisture undoubtedly play an important part in the beginning and in the progress of infection, and a better understanding of these conditions may prove of great value in attempting to control this dry rot disease especially among potatoes kept in storage.

SUMMARY

1. *F. trichothecioides* Wollenw. is a wound parasite capable of destroying potato tubers.

2. This fact is proved by the inoculation experiments of Miss Jamieson.

3. This disease is clearly differentiated from the wilt and dry rot ascribed by Smith and Swingle to *Fusarium oxysporum* Schlecht.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

METEOROLOGY.—*Free air data at Mount Weather for April, May and June*, 1911. Wm. R. Blair. Bulletin, Mount Weather Observatory, 4: 144–181. 1911.

Ninety-three free air observations were made at Mount Weather in these three months, 65 by means of kites and 28 by means of captive balloons. One pilot balloon observation to the altitude of 2626 meters was made. The kites reached an average altitude of 3257 meters above sea level, the captive balloons, 2072. These observations have been reduced and the data tabulated in connection with weather notes made at the times of observations. Based upon these data charts have been made of the free air isotherms, two degrees apart, for the three months. The air temperatures observed during this period, near the earth's surface on the mountain and in the adjacent valleys, have been charted and discussed. It is concluded that the important factors in the determination of the temperatures observed at a station well out in the bottom of the Shenandoah valley are insolation and radiation; and that the temperatures observed at a station close to the foot of the mountain on the southeast side are those of air being transferred to and from the mountain top by convection currents. The latter temperatures are comparatively slightly modified by insolation and radiation at the observing station.

W. R. B.

METEOROLOGY.—*The height and temperature of the isothermal region at different latitudes and under different conditions.* W. J. Humphreys. Bulletin of the Mount Weather Observatory, 4: 136–142. 1911.

The assumption that the height and temperature of the isothermal region are determined essentially by outgoing radiation has but one serious objection. This is, the fact that near the equator, where the surface temperature is highest, the isothermal region is not correspondingly warmer than elsewhere, as its winter to summer changes in middle latitudes would lead one to expect, but on the contrary much colder.

It is suggested that a greater prevalence of cirrus clouds in the equatorial regions than in other parts of the world (and observations indicate this inequality in their distribution) would largely account for the change with latitude of the temperature and height of the isothermal region. These clouds, whenever and wherever present, must act as a shield and partially protect the outer atmosphere from the radiation of lower levels, and thus allow it to grow colder through its own radiation to space. The somewhat entrapped heat below the tropical cirri must expand the atmosphere and thus increase its horizontal flow to higher latitudes where presumably there is less cirrus and freer direct radiation from the denser and lower atmosphere, and hence a warmer isothermal region.

W. J. H.

PHYSICS.—*Recent advances in high-temperature gas thermometry.* ARTHUR L. DAY. Trans. Faraday Society, London. **7:** 1911.

An address before the Faraday Society of London, reviewing the more important features of the recent work with the gas thermometer conducted at the Geophysical laboratory.

PHYSICS.—*The detection of small heat effects at high temperatures.* WALTER P. WHITE, Geophysical Laboratory. Physical Review, **32:** 604. 1911.

The general principle of the method is simple and fairly familiar. No moving bodies are present, and changes in the temperature of the charge are brought about solely by changing the furnace temperature. The heat effects in the charge are inferred from the changes in its temperature. The temperature of the charge thus depends upon two things: first, the furnace temperature, and second, the heat effects in the charge. The manipulation consists in observing the temperature rise, regulating the furnace current accordingly, and observing the temperature difference of furnace and charge.

The interpretation of the results may, in theory, be made very simple.

The temperature gradient, G, between charge and furnace, serves as the measure of heat-flow to the charge. The flow actually is proportional to G, and to the heat-transmittance, F, of the space between furnace and charge. The exact values of both G and F are usually unknown, and may vary with time, temperature, rate of heating, etc., so that accurate heat determinations by means of them, tho possible, are quite difficult. But in the *detection* of a small heat effect we have merely to determine the change in G caused by the addition of the effect to the heat which is required to change the temperature of the charge. For

instance, a silicate charge (2 grams) of specific heat 0.3, heated 10° per minute, lagged 3° behind the furnace ($G = 3°$). Hence 3° in G corresponds to 3 calories per minute. If an inversion absorbing 3 calories and extending over 100° should occur, G would be increased 0.1, or 0.3° for 10 minutes; if the inversion should take place in one minute, G would be doubled, or increased 3°, etc. The detection of small heat-effects is easier: (1) The larger G is, per calorie per minute, (2) the freer G is from other variations, (3) the quicker the inversion occurs; it is only sluggish inversions whose detection gives any trouble.

G increases with the furnace-rate; hence a rapid rate is of the first importance. G also increases with the diameter of the charge, but can be made steadier in the case of a small charge, and the advantage of the small charge appears to be greater on the whole. Fluctuations in the furnace rate cause variations in G; these are partly eliminated by measuring G, not between charge and furnace, but between the charge and another body ("neutral body") closely resembling it. The apparatus now used is small, two platinum crucibles holding 1 cc. each, 3 mm. apart, and surrounded by a wider porcelain tube to increase uniformity of temperature. A differential thermo-element is also used, which gives directly the temperature difference of the two bodies at any instant. A complete platinum inclosure shields the whole system from leakage currents out of the furnace-coil. In one set of determinations made on different days with the same set-up, conditions were reproduced over a 300° interval with a maximum variation of from 0.03° to 0.06° in the different determinations. This was with a silicate charge and indicates that 1 calorie distributed over 100° could be detected. But this would be a more difficult case than has yet been found in practice. In one case it was observed that the first heating in each day which, of course, occurred immediately after the furnace had been cold, gave results differing by 0.3° from later heatings, altho the furnace was cooled 300° between all the heatings. This condition reproduced itself at 0.1° on successive days and could, therefore, be largely eliminated, but might prove decidedly deceptive if overlooked, and if the heat effect was, as happens, one occurring only in the first heating. W. P. W.

GEOCHEMISTRY.—*The geochemical interpretation of water analyses.* CHASE PALMER. Bulletin U. S. Geological Survey No. 479. Pp. 31. 1911.

This paper presents a statement of water analyses in purely chemical terms; a general chemical formula representing water character in terms of the proportional reaction capacity of the constituents; a similar but

simplified chemical formula based on groups of constituents and expressed in terms of properties of reaction; a purely chemical water-classification scheme based on the simplified formula; applications of the classification scheme and character formulas to the solution of practical geologic problems.

The analytical statement is an enumeration of the radicles in terms of reacting values (milligram-equivalents) as well as in parts per million, and these reacting values, when expressed as pecentages of their totality, constitute the general character formula. The radicles are segregated into their natural groups: Alkalies (represented chiefly by sodium and potassium); earths (represented chiefly by calcium and magnesium); a miscellaneous group of positive radicles represented chiefly by hydrogen, for which the group is named; strong acids (represented chiefly by chloride and sulphate); and weak acids (represented chiefly by carbonate and bicarbonate). Salinity (saltness) of water is a property such as is caused by the solution of salts of strong acids and alkalinity is a property such as is caused by the solution of salts of weak acids; but these general properties vary in nature in accordance with the proportions of the alkali, earth, and hydrogen groups in the salts. The simplified formula is, therefore, a statement (in per cent) of the proportional reaction capacity of five special properties, as follows: Primary salinity, salinity such as is caused by the solution of strong-acid salts of the alkali group; secondary salinity, salinity such as is caused by the solution of strong-acid salts of the earths group; tertiary salinity or persalinity, salinity such as is caused by the solution of strong-acid salts of the hydrogen group; primary alkalinity, alkalinity such as is caused by the solution of weak-acid salts of the alkali group; and secondary alkalinity, alkalinity such as is caused by weak-acid salts of the earths group. Secondary salinity is a measure of permanent hardness, secondary alkalinity of temporary hardness, tertiary salinity of acidity, primary alkalinity of permanent alkalinity, and primary salinity of saltness in the more popular acceptation of the term.

The water-classification scheme is based on the proportional reaction capacity of the five groups of radicles, and five classes of water result. The first class is characterized by primary salinity, primary alkalinity, and secondary alkalinity, and is exemplified in general by waters such as Lake Champlain and Oswegatchie River, derived mainly from igneous rocks. The second class is characterized by primary salinity and secondary alkalinity and is exemplified by waters such as Shenandoah River, derived from the older limestones. The third class is characterized by primary salinity, secondary salinity, and secondary alkalinity, and is exemplified by waters such as Miami and Maumee rivers, derived

from sedimentary rocks in general. The fourth class is characterized by primary and secondary salinity and is exemplified chiefly by highly concentrated waters such as brines and the ocean. The fifth class is characterized by primary, secondary, and tertiary salinity, and is exemplified by waters of peculiar origin, such as the mine-polluted Youghiogheny River.

There are presented studies of stream waters of southeastern United States, industrially important by reason of primary alkalinity, in which the influence of varied geology on character is clearly indicated; studies showing the persistence of high silica content in primary-alkaline waters; and studies of the mixing of waters of diverse character in the Laurentian and Mississippi River basins.

The conclusion that natural water may be definitely characterized if the mineral constituents are considered not as load but as a chemical system of balanced values is fully justified and the great value and wide application to water problems of the method of treatment is clearly shown. HERMAN STABLER.

CHEMISTRY.—*The determination of chromium and its separation from vanadium, in steels.* J. R. CAIN. Journal Industrial and Engineering Chemistry, **4**: 17, 1912. Technologic Paper No. 6, Bureau of Standards.

Sources of error in some of the usual methods for determining chromium in chrome or chrome-vanadium steels, which limit the accuracy of the results, are described.

The precipitation of chromium from solutions of steels and its separation from practically all the iron can be effected quickly and easily by boiling with a number of precipitants, herein described.

The chromium may be readily extracted from the precipitates by fusion, and separated from vanadium by precipitating as lead chromate under the conditions prescribed, the chromium being determined volumetrically in the lead chromate. J. R. C.

CHEMISTRY.—*A rapid method for the determination of vanadium in steels, ores, etc., based on its quantitative inclusion by the phospho-molybdate precipitate.* J. R. CAIN and J. C. HOSTETTER. To appear as Technologic Paper No. 8, Bureau of Standards. Also to appear in Journal Industrial and Engineering Chemistry.

1. It was found that vanadic acid may be quantitatively precipitated by ammonium phospho-molybdate.

2. The vanadium-bearing phospho-molybdate shows different solubility relations compared with normal phospho-molybdate with respect to the usual washing solutions used in determining phosphorus.

3. Conditions are given for quantitatively precipitating vanadic acid when in solution alone, or accompanied by a variety of other elements, by means of ammonium phospho-molybdate.

4. In order to determine quantitatively the vanadic acid so precipitated, (a) the possibility of freeing it from accompanying molybdic acid was investigated; (b) conditions for reducing it without reducing the associated molybdic acid were developed; and (c) a method for reducing it by hydrogen (and other) peroxides, and titrating it against permanganate was elaborated.

5. Method (c) was applied to a variety of steels, to iron ores, manganese ores, and to synthetic mixtures, in all of which the vanadium was determined accurately. J. R. C.

HYDROLOGY.—*Some stream waters of the western United States, with chapters on sediment carried by the Rio Grande and the industrial application of water analyses.* HERMAN STABLER. Water Supply Paper, U. S. Geological Survey No. 274. Pp. 188. 1911.

This paper presents the results of more than two years' analytical work at the Berkeley, Cal., laboratory of the U. S. Reclamation Service. The tables include mineral analyses of water from more than fifty important streams of western United States, samples having been collected daily for a period of one to two years, and miscellaneous analyses of water from streams, springs, lakes, wells and borings. With the analyses are tables of stream flow and estimates of daily discharge of suspended matter and dissolved solids. Analyses of the suspended matter carried by Colorado River and the Rio Grande are also included.

One chapter is devoted to a study of the quantity of sediment carried by the Rio Grande at the site of the proposed storage reservoir near Engle, N. Mex., the conclusion being that the probable mean annual discharge for a long term of years may variously be expressed as representing 11,300,000 tons of suspended matter, 3150 acre-feet of rock-matter, 5200 acre-feet of soil, 6110 acre-feet of compacted sediment, or 8650 acre-feet of freshly deposited sediment. Attention is called to the wide error likely to be introduced thru the customary method of making such estimates.

The final chapter is a study of the industrial application of water analyses stated in ionic form. Soap consumption; water softening; foaming, corrosion, and scale-formation in boilers; and irrigation value are

discussed in detail and formulas are presented to facilitate the evaluation and classification of waters with respect to these tendencies in quality. H. S.

GEOLOGY.—*Potash-bearing rocks of the Leucite Hills, Sweetwater County, Wyoming.* ALFRED R. SCHULTZ and WHITMAN CROSS. Bulletin U. S. Geological Survey, No. 512, p. 1 to 39, with maps.

The Rock Springs district in Sweetwater County, Wyoming, consists structurally of a low anticlinal dome of Cretaceous and Tertiary rocks plunging to the north and to the south. The major north-south axis is approximately 90 miles long and the width of the dome is about 50 miles. The beds on the west side of the anticline dip from 5° to 10°. From the central part of the dome have been removed all of the Tertiary Green River and Wasatch beds, the late Cretaceous ("Laramie"), and part of the Montana formations.

Resting on or cutting thru the sedimentary rocks in the north half of this dome are the Leucite Hills, composed of leucite-bearing lavas rich in potash. These lavas are certainly younger than the Green River beds and were presumably poured out on the more or less level plain upon which the Bishop conglomerate was deposited. The masses of leucite-bearing rock occur as dikes, sills, sheets, stocks and surface flows and rest upon or come in contact with Green River, Wasatch, "Laramie" and various formations of Montana age.

The lavas of the Leucite Hills contain on the average a larger percentage of potash than any other known igneous rocks. However, the extraction of the entire potash content of these rocks must be effected by a process applicable to leucite, sanidine, and phlogopite at least, and probably to other minerals, as the potash in the leucite-bearing rocks occurs in each of the above mentioned minerals. A. R. S.

GEOLOGY.—*The granites of Connecticut.* T. N. DALE and H. E. GREGORY. Bulletin U. S. Geological Survey No. 484. Pp. 137, with colored geologic map, 4 text maps, 8 figs., 6 pls. 1911.

To Part I, Gregory contributes a brief outline of the geology and geologic history of the State with brief descriptions of granite, granite-gneiss, pegmatite, porphyry, also paragraphs on granitic intrusions and the age of Connecticut granites and granite-gneisses which, with the exception of the Becket Gneiss, are regarded as post-Carboniferous. Dale has in the same part 18 pages on the structure, variation, discoloration, decomposition of granite, repeated from his previous granite bulletins, and a few observations on micro-structure, flow, inclusions, plicated

gneiss, dikes, mineral veins, contacts, etc. At the end of Part II, which is economic in character and is by Dale, the commercial granites of Connecticut are divided into 10 petrographic groups including 20 well-defined varieties. T. N. D.

GEOLOGY.—*Geologic atlas of the United States, Folio No. 175. Birmingham (Alabama) Folio.* CHARLES BUTTS. Maps and sections. 1911.

The Birmingham folio deals with an area of 1000 square miles. The broad surface features are the Birmingham and the Cahaba anticlinal valleys, with the low synclinal plateaus of the Chaba, Coosa, and Blount Mountain coal fields, with northeast-southwest trend, in the southeastern part; and the low plateau of the Warrior coal field in the northwestern part. The deeply dissected upland surfaces are probably remnants of the Cumberland plateau or peneplain (Schooley?), and the valleys may represent the Coosa peneplain.

The geologic section is as follows: Pottsville formation 2300–5100 feet; unconformity; Parkwood formation (new, Mississippian), shale and sandstone 200–2000; Pennington shale and Bangor limestone to northwest-Floyd shale to southeast, 1000 feet; Fort Payne chert 250 feet; unconformity; Chattanooga shale 20 feet; unconformity; Frog Mountain sandstone (Oriskany); unconformity (Helderbergian, Cayugan, and Niagaran absent); Clinton formation, sandstone and shale, with fossiliferous ore beds, 250–500 feet; unconformity (Cincinnatian and Mohawkian absent); Chickamauga limestone (mainly Chazyan) 200–450 feet; unconformity (Canadian absent in Birmingham valley); Knox dolomite, Ketona dolomite (new name) at base 3300 feet; uncomformity; Conasauga limestone 2000 feet; unconformity; Rome formation 500 feet.

The rocks are folded and faulted in the southeast and nearly flat in the northwest. The Warrior and Cahaba coal fields are bounded on the east by thrust faults, with displacement of 8000 to 10,000 feet, bringing the Cambrian into contact with the Pottsville. Minor thrust and normal faults occur also.

The principal mineral resources of the quadrangle are (1) coal, (2) iron ore, (3) limestone and dolomite, (4) shale, and (5) clay. The close association of the first three is the chief factor in the industrial prominence of the region. In the Warrior field are eight, and in the Cahaba field are two or more workable coal beds.

The iron ore is hematite, called red "fossil" ore on account of the abundant fossil shells which make it very calcareous. The weathered or "soft" ore carries 55 per cent metallic iron and 0.5 per cent lime, and the

deeper "hard" ore, 37 per cent metallic iron and 20 per cent lime. This composition of the "hard" ore holds from about 400 feet to the greatest depths reached, even to 2000 feet in bore holes over a mile from the outcrop. C. B.

GEOLOGY.—*The Sitka mining district, Alaska.* ADOLPH KNOPF. Bulletin U. S. Geological Survey, No. 504. Pp. 32, with maps and sections. 1912.

The Sitka mining district comprises Chichagof, Baranof, and Kruzof islands, together with a few smaller islands. The total land area roughly approximates 4500 square miles, the greater portion of which is included in Chichagof and Baranof islands.

The rocks lie in broad belts, which strike northwest and southeast, conforming thus with the prevailing structural trend of southeastern Alaska. The cores of the islands are made up largely of granitoid rocks, mainly quartz diorites, which, as a rule, have been intruded parallel to the stratified rocks.

The ore deposits are auriferous lodes, commonly occupying shear zones in graywacke. Two mines, both of which are situated at Klag Bay on the west coast of Chichagof Island, have so far been productive. The ores, which range in value from $15 to $90 a ton are of higher grade than the general gold ore of southeastern Alaska, which in 1910 averaged $2.78 a ton. A large number of ore bodies of the same general character have long been known to occur near Sitka, but owing to their low grade none has yet been brought to a producing stage. A. K.

ECONOMIC GEOLOGY.—*Coals of the State of Washington.* E. EGGLESTON SMITH. Bulletin U. S. Geological Survey, No. 474. Pp. 206, with maps and views. 1911.

Washington coals range from low-grade subbituminous to anthracite; but as the anthracite owes its character to metamorphism by igneous intrusions, it is of slight extent and limited range. In general, the highest grade of coal is found near the Cascade Range and the quality decreases westward from the mountains.

This is the first thoro systematic attempt to study the quality and character of the Washington coals. Every mine in the State was visited and from one to eight samples were obtained from each bed of coal mined, the samples being analyzed at the Pittsburgh Laboratory of the Bureau of Mines. Each mine is briefly described, and the location of each sample is recorded, with a section of the coal bed at that point. The physical characteristics of the coals and the effects of various impurities are fully treated

These data make it possible to compare the products of different mines or beds and to determine which is best adapted for any particular use. The investigation also shows the importance of careful preparation for the market, in the way of picking and washing.

M. R. CAMPBELL.

BOTANY.—*Three new plants from Alberta.* PAUL C. STANDLEY. Smithsonian Miscellaneous Collections, **56**[33]: 1–3. 1912.

The plants described are from a collection obtained in western Alberta and eastern British Columbia in the summer of 1911 by J. H. Riley and N. Hollister. *Vagnera pumila, Artemisia laevigata,* and *Gaillardia bracteosa* are described as new while one new combination, *Svida pubescens* (= *Cornus pubescens* Nutt.) is formed. The Gaillardia is especially interesting, since it is the northernmost representative of the genus so far discovered. P. C. S.

BOTANY.—*A new leather flower from Illinois.* PAUL C. STANDLEY. Smithsonian Miscellaneous Collections, **56**[34]: 1–3, pl. 1. 1912.

Viorna ridgwayi is described from specimens collected by Mr. Robert Ridgeway in the summer of 1910 near Olney in southern Illinois. The species is related to *Viorna viorna,* the common leather flower, but is distinguished by the peculiar form of the leaves. A brief account is also given of the trees and shrubs of the locality from which the type comes. P. C. S.

BOTANY.—*Report on a collection of plants from the Pinacate region of Sonora.* J. N. ROSE and PAUL C. STANDLEY. Contributions from the U. S. National Herbarium, **16**: 5–20, fig. 1, pls. 3–16. 1912.

An annotated list is given of the plants collected by Dr. D. T. MacDougal in the Pinacate region during the autumn of 1907. The expedition during which these plants were collected is described by Dr. W. T. Hornaday in his book *Camp-Fires on Desert and Lava.* Altogether 83 species are listed, the type locality of each being given. Twelve new species are described, the most of which are illustrated by line drawings, and six new combinations are formed. J. N. R. and P. C. S.

BOTANY.—*Tumamoca, a new genus of Cucurbitaceae.* J. N. ROSE. Contributions from the U. S. National Herbarium, **16**: 21, pl. 17. 1912.

Tumamoca macdougalii represents a new genus of this family, allied to Ivervillea. The type was collected by Dr. D. T. MacDougal on Tumamoc Hill on which the Desert Laboratory of the Carnegie Institution is situated, near Tucson, Arizona. J. N. R.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE WASHINGTON ACADEMY OF SCIENCES

The 76th meeting of the Washington Academy of Sciences, a business meeting, was held at the Cosmos Club, 7:45 p.m., February 13, 1912, with President Coville in the chair.

The following were elected resident members:

R. V. Anderson	C. N. McBryde
E. S. Bastin	H. D. McCaskey
W. R. Calvert	F. H. Moffitt
R. L. Faris	Chase Palmer
N. C. Glover	E. W. Shaw
Karl F. Kellerman	Daniel W. Shea
Adolph Knopf	Herman Stabler
W. T. Lee	G. W. Stose

W. J. Humphreys, *Recording Secretary.*

The 77th meeting was held on February 13, 1912. Dr. L. A. Bauer gave an illustrated address on the *Recent work of the* Carnegie *and the total solar eclipse of April 28, 1911.* The speaker, enroute to Colombo, Ceylon, to join there the magnetic survey vessel, the *Carnegie*, under his charge, while awaiting connections at Suva, Fiji, for New Zealand, succeeded in getting into the belt of totality for the total solar eclipse of April 28, 1911. Since all the observing parties were to congregate at various points in the Tonga Islands, he thought it desirable to make the effort to reach some other point in order to multiply the chances of getting results. At the time that his official duties permitted him to leave Washington, viz., March 16, 1911, it could not be definitely ascertained that the necessary connections would be made at Suva, hence only a limited equipment was taken consisting of magnetic instruments to determine a possible effect on the earth's magnetism during the eclipse, and an improvised photographic apparatus. For the same reason it was not warranted to incur the expense of taking with him specially trained assistants, all the more so since every possible preparation had been made by the many astronomers in the Tonga Islands. The photographic apparatus had to be hastily improvised by Mr. Abbot, Director of the Astrophysical Observatory of the Smithsonian Institution; it consisted of a double-barreled, hand-driven, equatorially-mounted camera of about $11\frac{1}{2}$-foot focus. The camera tubes, for convenience in packing, were made in three sections of stove pipe and the tripod in a similar manner of gas pipe. The entire equipment was packed in water tight cases to ensure against accidents, as landings on the islands chosen cannot always be effected safely on account of breakers.

Reaching Pago Pago, Tutuila, on April 24, he was transported, through the courtesy of His Excellency the Governor, Commander W. M. Crose, on the U. S. S. *Annapolis*, to Tau Island, the nearest accessible point in the belt of totality. This island is near the western edge of the belt, the approximate position of the station chosen being latitude 14°.2 S., longitude, 169°.6 W. In addition to putting the *Annapolis* at Dr. Bauer's disposal, Governor Crose also assigned to him several of his ablest officers.

The party arrived at the station late Wednesday afternoon, April 26, the remainder of the day being spent in selecting suitable points of observation and unpacking and assembling the instruments. The following day, April 27, was more or less cloudy and showers fell repeatedly thus hampering considerably the preparations for the morrow's work. However, the weather on the following day, April 28,—the day of the eclipse—was all that could be desired and so final preparations were made immediately. The photographic work was placed in charge of Lieutenant McDowell, U. S. N., aided by Dr. Connor and Messrs. Steffany and Reed. The times of contacts were observed by two independent parties, one aboard the *Annapolis*, anchored in Faleasau Bay, in charge of Lieutenant Baker, U. S. N., and the other ashore by Dr. Connor aided by Chaplain Pearce. The readings of the magnetic declination were made by Quartermaster Urle, Dr. Bauer assuming the general charge of the entire work, making the necessary astronomical observations for geographic position, azimuth and time, as well as determining the magnetic elements.

Owing to the inclement weather of the day before, it had not been possible to place the camera in final position so as to try out the finder until a few minutes before the eclipse, when it was unfortunately learned that the finder did not work satisfactorily and Lieutenant McDowell was accordingly obliged to improvise some simple device with the aid of which he might keep the sun's disk as central as possible on the photographic plates. For orientations of camera tubes in azimuth and altitude it was necessary to resort to the preliminary lines established by Dr. Bauer and his calculated azimuths and altitude of the sun for the totality phases. Four photographs of the eclipse were secured and upon development of the plates at Apia on May 3, it was found that the present corona fulfilled the expectations of chief development in the equatorial direction during the sunspot minimum. The totality began shortly after 10:00 a.m. and lasted 2^m3^s according to the ship party, and $1^m\ 59^s\frac{1}{2}$ according to the shore party, which is as satisfactory an agreement as could be expected with the limited observing means. No member of the party observed visually the great equatorial extensions shown in the photographs. One of the observers aboard ship stated that he saw two stars. It is possible that although the sky was seemingly clear there may have been a fine haze sufficient to obscure the faint light from the coronal extensions. Perhaps due to the fact that the station was not far from the western edge of the belt of totality, it was not very dark at the time of totality, writing being easily read.

By special arrangement magnetic observations simultaneous with those at Tau Island were made at the five Coast and Geodetic Survey magnetic observatories, also at Melbourne, Christchurch, and Apia, where quick-run magnetograms were obtained for five hours. Until the records have been received from stations over the entire globe, it will not be possible to say definitely whether or not the present eclipse was accompanied by any minute and temporary change in the earth's magnetism.

The speaker referred appreciatively to the many courtesies extended and the valuable assistance rendered not only by Governor Crose and his able officers, but also by Queen Vaitupu and the Samoan chiefs who provided for the party's entertainment during their brief stay on the beautiful island of Tau. The *Annapolis* being required for other purposes, it was necessary to leave the station immediately after the eclipse work was over.

The speaker next gave a general account of the results of the work aboard the *Carnegie* on her present cruise, referring especially to the Indian Ocean portion on which comparatively large errors in the charts used by mariners were disclosed. Some statements pertaining to these corrections in the western half of the Indian Ocean have already been published in this Journal (1: 178–179. 1911). Serious errors have likewise been found since in the eastern part of the Indian Ocean. Special observations were also made for the definite location of the agonic line which passes through the Arabian Sea, Southern India and the Bay of Bengal. A preliminary draft of a new isogonic chart for the Indian Ocean as based upon the recent observations of the *Carnegie* was shown.

A brief account was likewise given of the present status of the magnetic operations of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington under the speaker's direction. The hope was expressed that, judging from the present rate of progress and with the coöperation of the various organizations engaged in magnetic work, it would be possible to issue a new set of magnetic charts for the entire globe within the next five years.

Fuller publication with regard to the matters touched upon by the speaker will be made in the journal *Terrestrial Magnetism and Atmospheric Electricity*.

W. J. Humphreys, *Recording Secretary*.

PHILOSOPHICAL SOCIETY OF WASHINGTON

The 703rd meeting was held on January 27. 1912. Mr. W. J. Humphreys, of the Weather Bureau, spoke on *Some scientific institutions at home and abroad*. An interesting account was given of a visit to a number of the scientific institutions of Great Britain and the Continent, and of how some of the scientific societies abroad are conducted, special mention being made of the British Association, the Royal Society of London, and the French Academy.

The activities were outlined of several meteorological bureaus, including those of Great Britain, Netherlands, Germany, Austria and France.

The speaker then mentioned the physical laboratories and astronomical and astrophysical observatories visited in England, Scotland, Holland France, Germany, Belgium and Austria, and spoke briefly of the men and the instrumental equipment at these institutions and the chief research work now being carried on by them.

Mr. N. E. DORSEY spoke informally of the recent absolute measurement of current at the Bureau of Standards and gave a few figures showing (1) the precision (something better than 1 in 1,000,000) attained in the determination of the ratio of the radii of two coils, (2) the relative constancy of the radii of 6 coils over a period of one year, and (3) the relative constancy of the standard cells used in that work.

R. L. FARIS, *Secretary.*

THE CHEMICAL SOCIETY OF WASHINGTON

The 212th regular meeting was held at the Cosmos Club, January 11, 1912. President Le Clerc appointed the following committees for 1912: Program: Phelps, Seidell, Moore, McKelvy, Palmer. Entertainment: Boughton, Bunzel, Custis, Lathrop, Nothstine. P. H. Walker was elected local councilor. The following papers were read:

Notes on the specific gravity of solids. J. JOHNSTON and L. H. ADAMS of the Geophysical Laboratory. Read by Mr. Adams. Discussion by R. C. Wells, Boughton, Walker, Robinson and Byrnes.

Pacific coast kelps. J. W. TURRENTINE, Bureau Soils. Discussion by Dole, C. C. Moore, R. B. Moore, Herstein, Huston.

Chemical investigation of American spearmint oil. E. K. NELSON, Bureau Chemistry.

Note by Dr. P. A. YODER on *Marking of porcelain crucibles.*

Note by Dr. J. JOHNSTON exhibiting the *May-Nelson vacuum-pressure ring pump.*

A special meeting was held on January 25 in the Cosmos Club. Prof. EDWARD HART, of Lafayette College, gave a lecture on *Some early chemists.* It was illustrated by numerous reproductions from the lecturer's collection of rare books on chemistry and alchemy. A smoker followed the lecture.

The 213th regular meeting was held at the Cosmos Club on February 8. The following papers were read:

A modification of the volumetric determination of phosphoric acid in phosphate rocks. J. G. FAIRCHILD, Geological Survey (see this Journal, **2**: 114, 1912).

Standardization of potassium permanganate by sodium oxalate. R. S. MCBRIDE, Bureau Standards. Discussion by Foster, Johnston, Seidell, Hillebrand, Phelps, Waters.

Refractive index of beeswax. LEONARD FELDSTEIN, Bureau Chemistry.

Quantitative oxidase studies. H. H. BUNZEL, Bureau Plant Industry. Discussion by Waters and R. C. Wells.

ROBERT B. SOSMAN, *Acting Secretary.*

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. II, APRIL 4, 1912 No. 7

PHYSICS.—*The nitrogen thermometer scale from 300° to 630°, with a direct determination of the boiling point of sulfur.* Arthur L. Day and Robert B. Sosman. Geophysical Laboratory, Carnegie Institution. To appear in full in the American Journal of Science.

1. PURPOSE AND PLAN OF THE INVESTIGATION

In our recent investigation of the fundamental high temperature scale with the gas thermometer[1] attention was chiefly directed to the temperature region above 1000°. The lower temperatures had been determined with considerable accuracy in an investigation undertaken in the Reichsanstalt[2] some years earlier (1900) and there was no reason to suspect in it any uncertainty of greater magnitude than the errors of observation determined at that time (2° to 3°). Our determinations (1911) of the temperatures below 1000° came out about 1° lower than those of the Reichsanstalt scales.

The situation from our viewpoint at the time of publication of our final results (1911) was accurately summed up in one of our closing paragraphs as follows:

[1] Preliminary publications:—Day and Clement: Physic. Rev., **24**: 531, (Abstract) 1907. Day and Clement: Am. J. Sci. (4), **26**: 405–463. 1908. Day and Sosman, Am. J. Sci. (4), **29**: 93–161. 1910. R. B. Sosman: Am. J. Sci. (4), **30**: 1–15. 1910. Final publication:—Day and Sosman: Carnegie Institution Pub. No. 157. 1911.

[2] Holborn and Day: Ann. Physik. (4), **2**: 505–545. 1900. Am. J. Sci. (4), **10**: 171-206. 1900.

The chief source of present uncertainty [in high temperature gas-thermometer measurements] is the temperature distribution over the surface of the bulb in an air bath. It would be possible to eliminate this error in the lower portion of the scale by substituting a liquid bath which could be stirred. In fact, this was done for temperatures below 500° in the earlier work of Holborn and Day, but has not, so far, been tried in the present investigation because of the relatively secondary importance of the lower temperatures to the ultimate purpose of the investigation (the study of silicates). For the higher temperatures, no sarisfactory liquid bath has been found.[3] (Publication of the Carnegie Institution of Washington No. 157, p. 115. 1911).

It was nevertheless thought wise to establish the identity and the magnitude of the error in these low temperature measurements which may have been due to this cause.

2. APPARATUS

No attempt will be made to describe in detail the gas thermometer and accessories used in this investigation. A full description of the apparatus, with illustrations, will be found in the publications to which reference has been made. No change whatever was made in the gas thermometer system for these measurements, except for the substitution, about the bulb, of a liquid bath, made up from potassium and sodium nitrates in eutectic proportions (55 per cent KNO_3, 45 per cent $NaNO_3$). This bath was introduced into the furnace bomb described in connection with the earlier apparatus in place of the platinum-wound furnace previously used. The insulating material was dry magnesia, as heretofore, and the bomb was water jacketed thruout to protect the manometer. The heating apparatus amounted, briefly, to one bath within another, that is, the tube containing the stirrer was continued across the bottom of the tank and upward about the bulb, which it fitted with but little clearance (10 mm.) in order to insure the very rapid circulation of a thin layer of liquid past the bulb, while the remainder of the bath remained at an approximately uniform temperature without. With this arrangement, no systematic temperature differences greater than the errors of observation of the thermoelement (0°.1) were observed.

[3] Professor Holborn has directed attention to the same limitations in our results at these temperatures (Ann. Physik., 35: 761–774. 1911).

3. METHOD OF PROCEDURE

In this apparatus temperatures were read simultaneously (1) upon the gas thermometer, (2) upon three thermoelements distributed at different points in the bath—one in a reëntrant tube extending to the center of the bulb, and one each at the top and bottom of its outside wall.

For the measurements at the benzophenone boiling-point, thermoelements of copper-constantan and of platinum-platinrhodium (Heraeus) were used, for the higher temperatures platinum-platinrhodium only. After a trial of the copper-constantan elements at the next higher temperature (zinc) evidence of permanent changes in their readings was obtained which was more than sufficient to offset their increased sensitiveness. They were accordingly abandoned at the higher temperatures.

Thru the courteous coöperation of the Bureau of Standards, a sensitive resistance thermometer in charge of Dr. Dickinson and Mr. Mueller of the Bureau was placed alongside the bulb during a part of the measurements, and later a similar instrument ingeniously constructed for the purpose by Dr. Dickinson was introduced into the reëntrant tube of the gas thermometer bulb itself. The resistance thermometer, which was easily sensitive to a few thousandths of a degree, revealed small temperature fluctuations (0°.05) in the rapidly circulating liquid outside the bulb but no systematic temperature differences. Within the reentrant tube the fluctuations were no longer felt.

With these precautions to guard against temperature differences about the bulb, temperatures were measured (1) at the boiling point of benzophenone, (2) at the melting point of zinc, (3) at the melting point of antimony.[4] The three thermoelements were then removed from the bath next day and placed in one or other of the following: in a vapor bath of boiling benzophenone, in an apparatus for determining the zinc melting point, or in a similar apparatus containing antimony; after which they were returned to the gas thermometer furnace for the verification of their read-

[4] The zinc and antimony were the same charges which were used in the previous investigation. The analyses may be found in Pub. No. 157, pp. 87 and 88; Am. J. Sci., 29: 159.

ings. This series of operations constituted a set of observations as carried out in the tables which follow. Inasmuch as the gas thermometer was brought as close as practicable to the temperature of the points (benzophenone, zinc, etc.) selected as standards, the intermediaty rôle of the thermoelements was merely that of a transfer agent, in which rôle the individual properties of the thermoelements do not appear at all, provided the wires were originally homogeneous. The danger of contamination of the elements and consequent inhomogeneity is negligible at these temperatures. Even if such contamination had crept in it would have discovered itself in differences between the readings of the three elements with each change in the gradient, of which differences no trace was found.

By way of providing a strictly rigorous test of the accuracy of the transfer of temperature from gas thermometer bulb to the reference standards and its independence of the intermediary thermoelement, a special arrangement was devised in the case of zinc as follows: A steel bulb was made up with approximately the dimensions of the gas thermometer bulb and suspended in the same position in the nitrate bath. Enclosed in this bulb was the charge of zinc in its graphite crucible. In this crucible the thermoelement occupied the same position which it occupied in reference to the gas thermometer bulb, and all other conditions were, of course, identical. The zinc melting points were determined in this way, i.e., in a nitrate bath in which there were no measurable temperature differences in the region about the melting zinc and with the temperature gradient along the thermoelements identical with that surrounding the gas thermometer bulb itself.

4. BOILING POINT OF SULFUR

Finally an attempt was made to establish one temperature in this region from which the intermediary thermoelement should be completely eliminated. The gas thermometer bulb itself was immersed in the vapor of boiling sulfur. For this determination the nitrate bath was replaced by an appropriate sulfur boiling-point apparatus, all other conditions remaining the same. In building this apparatus, the experience of the Bureau of Stand-

ards was utilized for the most part. To this design certain modifications suggested by the unpublished work of Prof. G. A. Hulett of Princeton were added by way of rendering the determination as far as practicable independent of particular experimental conditions employed.

Heat was supplied electrically from a coil of high resistance wire about the sulfur tube, the coil ending about 2 cm. below the surface of the liquid sulfur (Bureau of Standards usage). An independent coil surrounded the vapor region, separated from it by an annular air space of about 1 cm. (Hulett). The bulb was surrounded first by a shield of sheet aluminum (Bureau of Standards) with holes near the top and bottom to permit the free circulation of the sulfur vapor, and a hole in the center of the bottom to permit the escape of liquid sulfur which chanced to condense on the shield. The shield afforded protection against any direct interchange of radiation with the furnace or with the boiling liquid, and its steep conical roof diverted the condensing liquid sulfur away from the bulb. Subsequently, with the purpose of varying these conditions, the aluminum shield was replaced by another of similar form but of glass (Hulett) and of somewhat smaller diameter. This was suspended from the conical aluminum roof of the first shield, which now overhung the side walls by several millimeters, with the effect that liquid sulfur condensing upon the cone could drip from the overhang instead of running down the side wall past the bulb. The radiation conditions were also radically altered by the substitution of glass for aluminum both around the bulb and below it.

Further variation was provided by changing the current in the two heating coils. Variations of some 40 per cent in the main coil about the boiling liquid were tried and the upper coil was varied from zero (Bureau of Standards usage) to nearly 40 per cent of the current in the main coil. Or, in other terms, the 1 cm. air jacket about the vapor was varied in temperature from the normal gradient (without heat in the upper coil) to a temperature equal to that of the sulfur vapor itself.

None of these changes produced any measurable change in the temperature of the sulfur vapor as recorded by the gas ther-

mometer, provided enough heat was supplied to fill the tube with vapor. During some of the measurements, the vapor escaped freely between the glass tube and aluminum cover and burned there.

TABLE I

GAS THERMOMETER MEASUREMENTS IN NITRATE BATH

DATE 1911	SERIAL NO.	p'	p	t	e	e AT FIXED POINT	TEMPERATURE OF FIXED POINT
Benzophenone, boiling point							
October 18.....	2	1023.36	1024.47	306.97	2379.8	2369.2	305.82
20.....	6	1020.60	1021.69	305.37	2364.7	2369.2	305.86
30.....	11	1053.07	1054.18	304.91	14944[1]	14996	305.82
November 1.....	14	1054.84	1055.97	305.91	15002[2]	15005	305.96
Mean.....							305.87
Zinc, melting point							
October 18....	3	1216.27	1218.05	418.78	3429.4	3433.7	419.24
20....	5	1215.85	1217.61	418.53	3427.1	3433.7	419.24[1]
November 4....	16	1256.96	1258.76	419.32	3432.2	3433.7	419.48[2]
17....	25	1256.54	1258.35	419.18	3432.9	3433.7	419.27
18....	27	1255.85	1257.69	418.80	3429.0	3433.7	419.31
18....	28	1254.96	1256.80	418.29	3423.8	3433.7	419.36
Mean.....							419.28
Antimony, melting point							
November 10....	19	1627.10	1630.58	629.66	5525.8	5527.7	629.84
10....	20	1627.09	1630.57	629.66	5525.2	5527.7	629.90
10....	21	1626.96	1630.44	629.58	5524.2	5527.7	629.92
14....	23	1625.08	1628.59	628.54	5515.5	5527.7	629.73
Mean.....							629.85

[1] Copper-constantan thermo-element.

[2] Wide temperature variation on manometer. This value is omitted from the mean.

5. EXPERIMENTAL RESULTS

In Table I, column 3, P' is the measured pressure of the gas in mm. of mercury at 0°; the application of the correction for the "unheated space" gives the pressure P of column 4; t (column 5) is the gas thermometer temperature in the nitrate bath, and e (column 6) the corresponding electromotive force of the thermoelement in microvolts; e (column 7) is the electromotive force of the same elements in benzophenone, zinc and antimony respectively, and the final column contains the corresponding gas thermometer temperatures.

Table II contains the measurements made in the sulfur vapor bath. p' and p represent the gas thermometer pressures corrected as before, t the resulting temperature, followed by the barometer reading reduced to sea level at lat. 45°, and the boiling temperature reduced to 760 mm. pressure.

TABLE II

DIRECT MEASUREMENT OF BOILING POINT OF SULFUR

DATE—1912	SERIAL NO.	p'	p	t	BAROMETER	t AT 760 MM.
January 31	49	1298.77	1301.07	443.21	746.3	444.45
	50	1298.83	1301.16	443.26	747.0	444.43
	51	1298.84	1301.17	443.27	747.0	444.44
February 1	52	1299.14	1301.44	443.42	748.4	444.47
	53	1299.14	1301.44	443.42	748.2	444.48
February 3	55	1299.70	1302.00	443.73	752.0	444.45
	56	1299.50	1301.81	443.62	751.4	444.40
	57	1299.55	1301.87	443.66	751.0	444.47
Mean						444.45

In Table III are brought together all the gas thermometer determinations of the boiling point of sulfur since 1890 with the necessary information for an intelligent comparison of the determinations. Column 5 contains the initial pressure of the gas used and column 6 the original value published by the author with a reference to the place of publication. Two of these determinations were subsequently corrected by the authors themselves. These corrections (with the references) are given in column 7.

TABLE III

GAS THERMOMETER DETERMINATIONS OF THE BOILING POINT OF SULFUR SINCE 1890

DATE	AUTHOR	THERMOMETER	GAS	PRESSURE	ORIGINAL FIGURE	CORRECTED FIGURE	THERMODYNAMIC SCALE	NOTES
				mm.				
1890	Callendar and Griffiths	Const. pr.	Air	760	444.53[1]		444.91	Indirect thru Pt. res. therm.[7]
1902	Chappuis and Harker	Const. vol.	N_2	530	445.2[2]	444.7[3]	444.80	Indirect thru Pt. res. therm.
1908	Eumorfopoulous.	Const. pr.	Air	760	443.58[4]	444.55[5]	444.93	Direct.
1911	Holborn and Henning	Const. vol.	H_2	623	444.51[6]			
			He	612				
			N_2	625	(444.39)		444.51	Indirect thru Pt. res. therm.
1912	Day and Sosman	Const. vol.	N_2	502	444.45		444.55	Direct.

[1] Phil. Trans., A **181**: 119–157. 1891.

[2] Trav. Mem. Bur. Int., **12**. 1902.

[3] Ibid., p. 90.

[4] Proc. Roy. Soc., A **81**: 339–362. 1908.

[5] Ibid., A **83**: 106–108. 1910.

[6] Ann. Physik, **35**: 761–774. 1911. The value given for N_2 is calculated from the authors' table of experimental results. They give in their paper only the final mean value on the thermodynamic scale.

[7] This determination, often quoted as direct, is in reality indirect. In his first investigation (Phil. Trans. 1887) Callendar showed that his parabolic formula represented within 1° the variation of resistance with temperature as determined by the constant pressure air thermometer to 600°. In his later work (Phil. Trans. 1891) he showed by a comparison of two resistance thermometers with the air thermometer, using sulfur merely as a constant temperature bath, that his original value of $\delta = 1.57$ would still represent the results for these thermometers within the limits of error (about $\pm$ 0°3). This value of δ was then used to calculate the sulfur boiling point determined with several platinum thermometers in the usual form of sulfur boiling tube.

Inasmuch as these various determinations were made under somewhat different gas conditions, the results are not directly comparable without reduction to some common unit. The fairest comparison is afforded by reduction to the thermodynamic scale.

6. SUMMARY

The new gas thermometer temperatures which this investigation has given us are brought together in Table IV, expressed (column 2) in terms of nitrogen expanding at constant volume from an initial pressure of 760 mm., and (column 3) in terms of the thermodynamic scale. These values replace the corresponding temperatures published in our papers to which reference has been made.

TABLE IV

SUMMARIZED TABLE

POINT	TEMPERATURE		NOTES
	Constant volume $p_0 = 1$ at	Thermodynamic	
Benzophenone (Kahlbaum) boiling point at 760 mm.	305.85	305.9	Transferred by platinrhodium and copper-constantan thermo-elements.
Cadmium, melting point	320.8	320.9	Interpolated.
Zinc, melting point	419.3	419.4	Transferred by thermo-elements.
Sulfur, boiling point at 760 mm.	444.4	444.55	Direct.
Antimony (Kahlbaum), melting point	629.8	630.0	Transferred by thermo-elements.
Aluminum, melting point	658.5	658.7	Interpolated.

Finally, a comparative table (Table V) is added showing in terms of the same (thermodynamic) scale a comparison of our results with those obtained by Holborn and Henning in the latest work published from the Reichsanstalt.[5]

[5] Holborn and Henning. 1911. Loc. cit.

TABLE V

COMPARATIVE TABLE. THERMODYNAMIC SCALE

POINT	HOLBORN AND HENNING 1911	DAY AND SOSMAN 1912
Benzophenone	305.9	305.9
Cadmium	320.9	320.9
Zinc	419.4	419.4
Sulfur	444.5_1	444.5_5
	Holborn and Day	
Antimony	630.6	630.0

PHYSICS.—*Comparison of the resistance thermometer scale with the nitrogen scale from 300° to 630°.* H. C. DICKINSON and E. F. MUELLER, Bureau of Standards.

The temperature scale which at presents serves as the basis for the work of the Bureau of Standards in the interval 100° to 600°C. is the scale of the platinum resistance thermometer as defined by the work of Waidner and Burgess: *Platinum resistance thermometry at high temperatures.*[1] The resistance thermometer scale was established by assigning to the temperature of the sulfur boiling point the value 444°.70 at normal pressure, as the best value available at the time. On this resistance thermometer scale the following temperatures, among others, were found:

Boiling point of benzophenone	306°.02
Boiling point of sulfur (by definition)	444°.70
Freezing point of antimony	630°.71

A direct comparison of the temperatures cale as defined above, and the temperature scale of the nitrogen gas thermometer previously described by Day and Sosman, was suggested, and as such a comparison seemed very desirable we undertook the resistance thermometer measurements. Two thermometers were used, one "D" of the ordinary Callendar type which had been in use in the laboratory, and the other "R" constructed especially for this work. The latter was made with the lower part bent into the

[1] Bull. Bureau Standards, 6: 149–230. 1910. Reprint No. 124. 7: 3–11. 1910. Reprint No. 143.

form of a U so that the resistance coil could be placed in the reentrant tube of the gas thermometer, occupying the same position as had the thermocouple in the measurements of Day and Sosman. These two resistance thermometers represent the temperature scale already referred to. The thermometers were compared in the fused salt bath with the gas thermometer, which was operated by Messrs. Day and Sosman[2]. The points at which comparisons were made were approximately 306°, 445°, and 630°. After the observations in the salt bath the constants of the resistance thermometers were verified by recalibration. Two series were made with each thermometer. The results will be seen from the tables below:

TABLE I

Calibration of Thermometer D		*Calibration of Thermometer R*	
R_0	26.6733	R_0	4.8321
F.I.	10.3171 ± 0.0002	F.I.	1.8892 ± 0.0001
δ	$1.520 \pm 0.000_4$	δ	$1.503 \pm 0.000_3$

Eight determinations of each constant were made.

The figures indicate an accuracy of about 0°.01 in the determination of the fundamental interval and about 0°.03 in the determination of the boiling point of sulfur (440.70 in above) from which δ is computed, and show that either one of the thermometers adequately represents the resistance thermometer scale of Waidner and Burgess.

The results of the comparisons in the salt bath with the gas thermometer are shown in table II.

The figures in the second column are the serial numbers assigned to the gas thermometer observations. In the fourth column is given the temperature in the salt bath as indicated by the resistance thermometer. In the next three columns are the nitrogen thermometer data: p' is the original measured pressure in the nitrogen thermometer bulb in millimeters of mercury at 0°; the application of the correction for the "unheated space" gives the pressures (p) of column six; and in column seven is the temperature. From the differences in the eighth column and the values

[2] This Journal, 2: 171. 1912.

given on page 175, the following temperatures on the nitrogen scale of Day and Sosman are found:

B.P. of benzophenone ..... 305°84
B.P. of sulfur ..... 444°28
F.P. of antimony ..... 629°75

TABLE II

DATE 1911	SERIAL NO.	RESISTANCE THERMOMETER USED	TEMPERATURE BY RESISTANCE THERMOMETER	NITROGEN THERMOMETER DATA p'	p	t	RESISTANCE MINUS GAS
			Comparisons at 306°				
12–7	31	D	304.92	1052.58	1053.71	304.72	+0.20
	32	D	305.48	1053.60	1054.73	305.28	+0.20
12–21	41	R	306.72	1055.77	1056.92	306.52	+0.20
	42	R	306.91	1056.49	1057.64	306.93	−0.02*
							+0.18
			Comparisons at 445°				
12–7	33	D	446.55	1304.21	1306.22	446.06	+0.49
	34	D	446.54	1304.25	1306.26	446.09	0.45
12–9	36	D	446.38	1304.19	1306.22	446.07	0.31
	37	D	446.21	1303.92	1305.95	445.92	0.29
12–21	39	R	447.15	1305.25	1307.29	446.70	0.45
	40	R	447.15	1305.37	1307.41	446.77	0.38
12–26	46	R	443.30	1298.44	1300.47	442.88	0.42
	47	R	442.92	1297.44	1299.47	442.30	0.62*
							+0.42
			Comparisons at 630°				
12–26	44	R	631.20	1627.95	1631.46	630.21	+0.99
	45	R	630.96	1627.61	1631.12	630.02	0.94
							+0.96

* Rapidly changing temperature, not given full weight in mean.

For the sake of comparison, these temperatures, reduced to the thermodynamic scale, and those found by Messrs. Day and Sosman[3] by transfer with thermocouples, and also by direct measurement with the gas thermometer in sulfur, are shown below:

[3] This Journal, 2: 171. 1912.

The agreement of the transfer methods is complete. The difference of 0°.17 between the transfer and the direct determination at the boiling point of sulfur may be due to (1) difference in the sulfur baths used, (2) an unusual accumulation of accidental errors, (3) a systematic error affecting all transfer measurements.

TABLE III

POINT	TRANSFER BY RESISTANCE THERMOMETER	DAY AND SOSMAN	
		TRANSFER BY THERMOCOUPLES	DIRECT
B.P. of benzophenone	305.89	305.9	
B.P. of sulfur	444.38		444.55
F.P. of antimony	629.93	630.0	

1. The two sulfur baths were compared side by side by means of thermometer "R." The Day and Sosman sulfur bath was operated by Dr. Sosman. Exploration with the resistance thermometer showed no temperature differences as large as 0°.05 within the aluminium shield which had been used with the gas thermometer. The temperature in this shield was found to be 0°.03 to 0°.04 lower than in the Bureau of Standards gas-heated apparatus, a difference which is hardly significant.

2. The accidental errors of either the gas thermometer or the resistance thermometer are not as large as the difference found. The three values found by transfer with the resistance thermometer as well as the two values found by transfer with the thermocouples, give the same value of δ (1.484) for the resistance thermometer "R."

3. The above agreement, together with the fact that the value of δ computed from the value 444.55 for the sulfur boiling point is 1.494, may be taken as indicating a possible systematic error affecting all the transfer values. On account of the absence of a direct transfer with the thermocouples, however, this cannot be considered as proven. The indirect determination of the sulfur boiling point would appear to have less weight than the direct determination, since the sulfur bath used for the latter was found to define the same termperature as that obtained in the conventional form of sulfur boiling apparatus.

The boiling point of sulfur. The evidence based on all the data at present available is that the best value for the temperature of the boiling point of sulfur at normal pressure, is 444°.6 to the nearest 0°.1 on the thermodynamic scale.

PHYSICS.—*On the deduction of Wien's displacement law.* EDGAR BUCKINGHAM, Bureau of Standards.

The least satisfactory step in deductions of this law is usually the treatment of the change of wave-length of perfectly diffuse radiation upon reflexion from a moving surface. This step may be taken in the following manner:

Let a closed evacuated shell, with walls which are perfectly but somewhat irregularly reflecting, be filled with perfectly diffuse, approximately monochromatic radiation of wave-lengths between λ and $\lambda + d\lambda$. Let $R_\lambda \, d\lambda . ds . dw$ be the amount of radiant energy which passes in unit time from the negative to the positive side of a small plane surface element of area ds, inside the shell, in directions comprised within a cone of the infinitesimal solid angle dw described about the normal to ds. For diffuse radiation, the "radiant vector" R_λ is the same at all points and in all directions.

Let M be a small plane piece of the shell wall of area s, and let it have a normal velocity βC outward, C being the velocity of light and β an infinitesimal. The rest of the shell wall remains at rest. If $T = \lambda / C$ is the period of the waves at a point fixed in space, their period of arrival at a point fixed on M, from an angle of incidence φ, is $T' = T/(1 - \beta \cos \varphi)$ and the effect of arrival at this angle is to increase the period in the ratio

$$r_a = 1 + \beta \cos \varphi \qquad (1)$$

terms of higher orders in β being negligible. Similarly, a disturbance starting from a point on M with a period T' and propagated at an angle of reflexion ψ, suffers a further increase of its period, measured at a point fixed in space, in the ratio

$$r_d = 1 + \beta \cos \psi \qquad (2)$$

Our problem is to find the effect on the original period T, of all the arrivals and departures at all possible angles φ and ψ

between 0 and $\pi/2$, within a long time t; and we shall evidently have to evaluate a product of the form

$$r_a r_d \,.\, r'_a r'_d \,.\, r''_a r''_d \text{ etc.}$$

But since multiplication is commutative, if we treat all the arrivals by themselves, then all the departures, and finally multiply the two results together, we shall arrive at the same value as if we considered the effects alternately, as they occur in fact.

We start from the consideration that in a sufficiently long time, every element of the energy within the shell must undergo reflexion from M at any particular angles (φ, ψ) just as often as every other element, so that the number of times n that any element is affected in a given way within a long time t is the quotient of the total amount affected in that way by the total amount present within the shell to be affected.

Taking the arrivals first, the whole energy which strikes M at angles between φ and $\varphi + d\varphi$, within t, is $t \cdot R_\lambda \, d\lambda \, s \cos\varphi \cdot 2\pi \sin \varphi d\varphi$, and the total energy present within the shell of volume v is $v \cdot 4\pi R_\lambda d\lambda / C$, so that we have

$$n = \frac{Cts}{2v} \cos\varphi \sin\varphi \, d\,\varphi \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

All these n arrivals together increase the period in the ratio

$$r_a^n = (1 + \beta \cos\varphi)^n = 1 + n\,\beta \cos\varphi \ldots\ldots\ldots\ldots (4)$$

Inserting the value of n from (3) and noting that $\beta Cts = \Delta v$ is the infinitesimal increase of volume which has occurred during t, we have

$$r_a^n = 1 + \frac{1}{2}\frac{\Delta v}{v} \cos^2\varphi \sin\varphi \, d\,\varphi \ldots\ldots\ldots\ldots\ldots (5)$$

The effect of arrivals during t at all possible angles is found by taking the product of all the factors of this form from $\varphi = 0$ to $\varphi = \pi/2$ or, neglecting higher powers of β,

$$1 + \frac{1}{2}\frac{\Delta v}{v} \int_0^{\frac{\pi}{2}} \cos^2\varphi \sin\varphi \, d\,\varphi = 1 + \frac{1}{6}\frac{\Delta v}{v}.$$

Similar reasoning on the effect of departures at the angle ψ leads to the same final expression, and we have for the combined effect of all the alternate arrivals and departures in all possible directions,

$$\frac{T + \Delta T}{T} = \left(1 + \frac{1}{6}\frac{\Delta v}{v}\right)^2 = 1 + \frac{1}{3}\frac{\Delta v}{v}$$

or, in terms of the wave-length,

$$\frac{\Delta\lambda}{\lambda} = \frac{1}{3}\frac{\Delta v}{v} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

This equation holds for any value of λ, hence the interval $d\lambda$ changes in the same ratio as λ itself. The result is valid for any element of the shell which is small enough to be treated as plane, for we have not assigned to M any special properties different from those of the rest of the shell wall. Equation (6) may therefore be integrated into the form.

$$\lambda = \text{const} \times v^{\frac{1}{3}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

We have treated R_λ as remaining perfectly diffuse, but this is not exact because the motion of M disturbs the diffuseness. The resulting error, however, may easily be shown to involve only terms of lower orders of magnitude than those retained—which are sufficient— and equation (7) remains valid. There is, also, no objection to making the long time t infinite, if we still make βCts an infinitesimal of the first order by making $\beta s = \text{const} \times t^{-2}$.

Equation (7) gives the effect on wave-length caused by change of volume of diffuse monochromatic radiation enclosed within a non-absorbing envelope. It may be put into words as follows: if the shell retains its form during expansion or contraction, the wave lengths change in the same ratio as the linear dimensions of the shell, and the whole system of waves and shell remains geometrically similar to itself.

In the extended form of this paper, to appear in the Bulletin of the Bureau of Standards, more details are discussed and the remaining steps required to complete the deduction of the displacement law are given.

PHYSICS.—*A new precision colorimeter.* P. G. NUTTING, Bureau of Standards.

It is well known that any color may be analyzed and specified in either of two different ways: (1) in terms of three primary components, red, green and blue (trichromatic analysis) or (2) in terms of wave length of dominant hue or its complementary and per cent white (monochromatic analysis). In mathematical terms, the color point may be located by either trilinear or by polar coördinates. Of the three elements of color, hue, tone and luminosity, hue and tone are determined with a colorimeter, luminosity with a photometer or a photometric part of the colorimeter.

Colors to be analyzed consist of light either emitted from some source, transmitted through some selective screen or reflected from some mat or semi-mat surface. Any of these colors to be analyzed may be either spectral or purple according to whether or not its dominant hue lies in the visible spectrum. Any analyzing colorimeter must then be applicable to emitted, transmitted or reflected light of either spectral or purple dominant hue.

A trichromatic analyzer, the Ives[1] colorimeter, has been in successful use for several years. A monochromatic method of analysis was devised and used by Abney[2] in a laboratory investigation as early as 1890. The colorimeter here described is a monochromatic analyzer designed to be a practical working instrument of wide range, high precision and of the utmost simplicity.

The advantage of monochromatic analysis lies in the elimination of the arbitrary reference standards (red, green and blue), readings being given directly in wave length and per cent white. Both methods involve the definition and adoption of some standard of white. The trichromatic method may be used for either spectral or purple hues indifferently, the use of the monochromatic method involves an interchange of two sources or arms in passing from spectral to purple hues. Both methods give readings varying somewhat with the observer involving in some cases,

[1] F. E. Ives: J. Franklin Inst., 421–3. 1907.

[2] W. de W. Abney: Color Measurements and Mixtures, pp. 162–6. 1891.

correction to the absolute color scale based on the average properties of a number of normal eyes.

The new colorimeter is so arranged that light of a pure spectral hue may be mixed with white light to match the unknown or, in the case of purples, it is mixed with the unknown to match white. The match is made with a Lummer-Brodhum photometer cube.

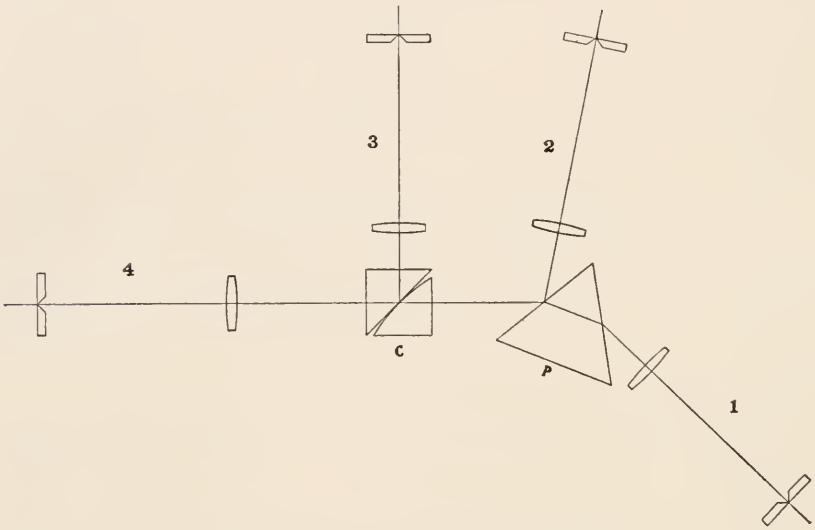


Fig. 1. Diagram of precision Colorimeter.

The figure is a diagram of the optical parts of the instrument. Collimator 1 is movable, all the remaining parts are fixed. Collimators 1 and 4 with prism *P* form an ordinary spectroscope with pin hole ocular. The white and unknown lights enter thru collimators 2 and 3, in direct or inverse order according as the match is to be made with the dominant hue or its complementary. In analyzing reflected light the necessary collimator is raised or rotated or even removed entirely if sunlight is used.

Wave lengths are varied simply by rotation of collimator 1. Intensities may be varied by (1) varying slit widths, (2) rotating sectors, or (3) by rotating one of a pair of nicols placed just inside each slit. The colorimeter now in use is provided with a bilateral slit on the first collimator while collimators 2 and 3 are provided with pairs of nicols.

After a match has been secured, the wave length of the dominant hue is either read from the position of collimator 1 or by throwing in a small hand spectroscope before the pin hole ocular of 4.

Intensities are determined by interposing between collimator 4 and photometer cube *C*, a white 180° (Whitman) rotating disk illuminated by a standard lamp. This gives the intensity in meter candles of each of the three component beams separately. Instead of this flicker photometer arrangement, a simple equality of brightness photometer may be used to determine the relative brightness of any two beams. To intercompare beams 1 and 2 for example, the top half of the objective of collimator 1 and the lower half of 2 are covered with a black card and then the width of slit 1 is varied until equality of brightness is secured. This slit width, compared with the original width used to secure a color match, gives the relative intensities of the two beams.

An experimental colorimeter of the type above described was assembled at the Bureau of Standards in the early Spring of 1911 and given a thoro test. Later special optical parts were ordered from Fuess and the instrument constructed in the Bureau shops. This new instrument has been in constant use at the Bureau since the first of January 1912 in routine tests and special research work. A patent dedicated to the public has been applied for.

Various problems arising in colorimetry are being investigated with the new instrument and will be reported upon in later papers. The sensibility of the instrument is, of course, that of the eye (chromatic and photometric) viewing objects directly. The precision attainable and the systematic errors to which the instrument and method are subject will be reported upon later.

GEOLOGY.—*Notes on the geology of the San Rafael Swell, Utah.* CHARLES T. LUPTON, Geological Survey. Communicated by Alfred H. Brooks.

The San Rafael Swell is an irregular elliptical dome, situated in east-central Utah between the Wasatch Plateau and Green River. It extends southwest from Price River almost to the Fremont or Dirty Devil River, a distance of about 80 miles.

G. K. Gilbert, in his monograph on "The Geology of the Henry Mountains, Utah," C. E. Dutton, in "The High Plateaus of Utah," and J. A. Taff, in Bulletin U. S. Geological Survey No. 285, refer briefly to this geologic feature. Other than the short statements in these reports the writer is unaware of any geological literature on this region.

During the field season of 1911, F. L. Hess spent two days on the east flank of the Swell on San Rafael River. References to that portion of the region are based on his observations. A party under the supervision of the writer, during the same season, mapped in detail the Upper Jurassic and Lower Cretaceous rocks along the west flank of the Swell in Castle Valley. In August, 1911, in company with W. R. Calvert, the north end of the region in the vicinity of Cedar Mountain or Red Plateau was visited. A little later accompanied by W. C. Mendenhall the writer entered the interior of the dome. At the close of the field season a reconnaissance trip was made with B. W. Clark to the north end of the Henry Mountains region, at which time the southern end of the San Rafael Swell was crossed. The observations made on these and other excursions form the basis of these notes.

The most prominent feature of the topography of this region is a series of buttes, mesas and "castles" which encircle an area, locally known as "Sinbad," which is 40 to 50 miles long and 10 to 20 miles in width. These fantastically eroded forms represent the outcrop of a gray massive cross-bedded Jurassic sandstone 800 feet thick. It is practicable to cross the Swell at only a few places on account of the almost impassable barrier formed by the sandstone rim. Nearly vertical scarps and canyon walls 300 to 500 feet in height are not unusual. The buttes and "castles," above referred to, are conspicuously shown on the San Rafael topographic sheet. Low "hogbacks," formed by resistant beds in the overlying strata, the tops of which produce dip slopes of varying extent depending on the inclination of the beds, encircle this belt of rugged topography. A view to the west from the interior of the Swell gives one the impression of looking up a very gently inclined varicolored stairway, the steps of which increase in height as the top, represented by the Wasatch Plateau, is

approached. Badland topography is common, especially near stream courses.

Structurally, the Swell is an elongated almost flat-topped dome extending northeast and southwest. The dip of the strata along the west flank is generally less than 10°, whereas that almong the east flank is as much as 70°. The strata in the interior of the dome are comparatively flat-lying, the principal line of flexure being near the east flank. Local minor domes were noted along the west side. Faults with displacements ranging up to more than 100 feet were observed in and near Cedar Mountain or Red Plateau at the north end of the region. Considerable faulting probably has occurred along the east flank.

Carboniferous (?), Triassic, Jurassic, and Cretaceous formations are well exposed. The lower part of the section described below was correlated with the section noted by Gilbert in the Henry Mountains regions, whereas the upper part is almost equivalent to the Book Cliffs section to the north. The lowest rocks exposed in this region are represented by a limestone probably of Carboniferous age noted by F. L. Hess near the San Rafael River on the east side of the Swell. Above the limestone there is a series of several hundred feet of sandstone and shale interbedded which probably are representatives of the Shinarump group (of Permian and Triassic age) and the Vermilion Cliff sandstone (of Triassic age). Unconformably (?) overlying these beds is a massive much cross-bedded gray sandstone 800 or more feet thick. This is the Gray Cliff sandstone (of Jurrassic age) of Gilbert's Henry Mountains section, which forms the striking topography referred to above and is, in all probability, the same as the White Cliff sandstone of the eastern Uinta and southern Utah sections of Powell. Conformably overlying this sandstone is a sequence of 1350 feet of reddish and gray sandstone, sandy shale, and thick beds of gypsum, which is approximately equivalent to the Flaming Gorge formation of Powell and corresponds closely with the Flaming Gorge formation as described by Gilbert in the Henry Mountains. Five hundred feet of conglomerate, sandstone and sandy shale of greenish drab color, overlying these strata correspond to the larger part of the Henrys Fork formation as identified by Gilbert in the

Henry Mountains, but probably should be classified with the Flaming Gorge formation of Powell. Sixty to one hundred feet of grayish sandstone (which, near Cedar Mountain, is replaced by conglomerate) and sandy shale with thin streaks of coal at the top and base, unconformably (?) overlie the conglomeratic strata just described and probably represent the Dakota sandstone. This sandstone corresponds to the uppermost part of Gilbert's Henrys Fork formation. The Mancos shale, about 4000 feet thick and consisting of three members, rests upon the Dakota(?) in apparent conformity. In places, however, a thin bed of conglomerate separates the Dakota(?) sandstone from the overlying shale. The Mancos outcrops in a monoclinal valley, the west part of which is known as Castle Valley. The lowest member consists of about 600 feet of bluish drab shale which is sandy in its lower and upper portions. Overlying this is a sandstone member approximately 500 feet thick containing coal beds near the top. This sandstone probably is equivalent to the Bluegate sandstone of Gilbert's Henry Mountains section and is represented at the north end of the Swell in the vicinity of Sunnyside Junction by a thin concretionary sandy formation. Overlying the sandstone is about 3000 feet of grayish drab shale which is sandy in its lower and upper parts. Conformably overlying the Mancos shale is the Mesaverde formation 1100 feet thick (in the vicinity of Emery) which caps the east scarp of the Wasatch Plateau. This formation consists mainly of sandstone with beds of sandy shale and coal intercalated.

Sills and dikes of basalt, which were noted at several localities near the south end of the Swell, extend as far north as Muddy or Curtis Creek.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEODESY.—*The effect of topography and isostatic compensation upon the effect of gravity.* JOHN F. HAYFORD and WILLIAM BOWIE. Special Publication No. 10, Coast and Geodetic Survey, pp. 130, with illustrations. 1912.

The introduction of isostasy in the determination of the figure and size of the earth from observed deflections of the vertical resulted in a marked increase in the accuracy of the values deduced. It was logical that isostasy should be considered in the reduction of gravity observations in order that a corresponding increase in accuracy of the shape of the earth might be obtained from these data.

A preliminary report on the reduction of 56 gravity stations in the United States, by the new method, was made to the International Geodetic Association at London and Cambridge in 1909 by Hayford. The present publication is a complete report on the reduction of 89 gravity stations in the United States.

By the new method a correction is applied at each station for the attraction of the topography of the whole earth and also a correction for the isostatic compensation of the topography in addition to the correction for the height of the station above sea-level. The compensation is assumed to be complete and uniformly distributed from the surface to a depth of 113.7 kilometers. This was the most probable limiting depth as determined by the first investigation of the figure of the earth and isostasy from measurements in the United States. The better value of 120 kilometers, obtained from the second investigation of the figure of the earth and isostasy, was not available at the time the tables were computed for the gravity reductions.

The methods used in applying the effect of the topography and its compensation are fully described and the necessary working tables are

given. In fact, all the data are given that are necessary for making reductions at any gravity station in the world.

The procedure at each of the gravity stations was to compute the theoretical gravity for the latitude of the station in question by the Helmert formula, correct this for the elevation of the station above sea level and then apply the correction for the topography of the world and its compensation. The resulting theoretical value is then compared with the actually observed value of gravity at the station. The difference between the computed and observed values is the anomaly which indicates a departure at that station from the assumed density of the earth's surface and of the computed excesses and defects of density in the crust to the depth of compensation.

A comparison is made of the new method anomalies in size and sign, with the anomalies given by the free air and Bouguer methods and the result is in practically every case in favor of the new method.

The 89 stations in the United States were arranged in groups with reference to their relation to topography. The groups are: 16 coast stations; 18 stations near the coast (within 325 kilometers); 27 continental stations not in mountainous regions; 16 stations in mountainous regions, below the general level; and 12 stations in mountainous regions, above the general level. The mean without regard to sign of the anomalies at 87 stations (two stations not considered) is 0.017 dyne. For the five groups mentioned above the corresponding means are 0.017, 0.020, 0.018, 0.012, and 0.014 dyne, of which no one is much above the general mean of all.

The means with regard to sign for the five groups are: − 0.004, + 0.002, + 0.002, − 0.002, and + 0.003 dyne. The general conclusion from the examination is that the anomalies by the new method show no relation to the topography either in sign or average magnitude. It is shown on the other hand that there are decided relations between the anomalies by the two older methods of reduction and topography.

It was found that there appears to be a relation between the surface geologic formation and the size and sign of the new method anomalies. The mean of the anomalies at seven stations on Pre-Cambrian formation is + 0.019 dyne, with regard to sign, and 0.026 dyne, without regard to sign. This indicates an excess of material in the crust in the vicinity of these stations. The means with and without regard to sign of the anomalies at 20 stations in the Cenozoic are − 0.011 and 0.021 dyne, respectively. This appears to indicate a deficiency in mass in the crust at these stations. It is shown that these anomalies are probably caused by

erroneous assumptions as to the density of the surface materials and also by a departure from a state of complete isostasy.

The mean without regard to sign of the new-method anomalies at the 89 stations in the United States is only 0.017 dyne. An anomaly of + 0.017 dyne would be produced by an excess of mass corresponding in amount to a stratum about 570 feet thick of density 2.67 (the mean surface density of the earth) with the station at the center of one surface of the disk and the disk of indefinite extent. An anomaly of − 0.017 dyne would be produced similarly by a deficiency of mass corresponding to a stratum about 570 feet thick. The gravity observations indicate, therefore, that the isostatic compensation is everywhere so nearly complete that the excesses and deficiencies of mass above the limiting depth of compensation correspond upon an average to a stratum only 570 feet thick. The average elevation of the surface of the ground in the United States is about 2500 feet, more than four times 570 feet.

The evidence furnished by the new method gravity anomalies in regard to the location and extent of the continuous areas of excess or deficiency of mass in the United States, that is, of under-compensation or of over-compensation, confirms and supplements that given by the observed deflections of the vertical previously considered and published by the Coast and Geodetic Survey in the second publication on the Figure of the Earth and Isostasy. W. B.

GEOLOGY.—*The Tertiary gravels of the Sierra Nevada of California.* WALDEMAR LINDGREN. Professional Paper U. S. Geological Survey No. 73. Pp. 226, with maps, sections, and illustrations. 1911.

This report attempts to trace the Tertiary history of the Sierra Nevada, by an examination of the Tertiary gravels and volcanic flows which cover a large part of their western slope. The gravels, as well known, have had, and still have, great economic importance, altho at present restrictions connected with the disposal of débris have put a stop to most of the hydraulic mining. The report is really a summary and includes observations made not only by the author, but by numerous other members of the Geological Survey.

In the early Tertiary age this region was a deeply eroded mountain range, this erosion having occupied the larger part of the Cretaceous period. Pauses in the erosion, when the topography had been reduced to gentle outlines, permitted deep rock decay and promoted the liberation of gold from its matrix. Renewed uplift quickened erosion and facilitated concentration. These conditions continued thruout Cre-

taceous and Tertiary time. Flucuations of the western shore line caused the streams at times to extend far into the areas now occupied by the Sacramento and San Joaquin valleys and at times to debauch upon flood planes high on the flanks of the range. Faulting movements with downthrow on the east side, probably beginning in Cretaceous time, had transformed an approximately symmetrical range into a monoclinal one with steep easterly slope. Gradually the mountains were worn down, the rivers flowed from low divides, meandering among longitudinal ridges, and the whole slope was covered by the dense vegetation of a damp semitropical climate.

Toward the end of Tertiary time rhyolite flows filled the valleys, covered the auriferous gravels, and new stream courses were outlined. Renewed disturbance began along the scarcely healed eastern breaks, resulting in a westward tilting of the main blocks, combined with normal faulting and subsidence of the blocks in western Nevada. In consequence of this disturbance the monoclinal nature of the range became strongly emphasized, and the streams immediately began to cut their beds deeper. At the end of the Tertiary, eruptions of andesites and their tuffs and breccias began in enormous volume and filled the Tertiary valleys to the rims. During the subsequent canyon-cutting epoch which belongs in part at least to the Quaternary period, the erosion has laid bare the old gravels and in most cases completely intersected the old valleys.

The first part of the book outlines the history of the valley border and describes the sedimentary and volcanic formations exposed at the western base of the range. The Tertiary drainage system and the prevolcanic surface is then described. The courses of the main rivers of Tertiary age draining the northern part of the range are traced in detail. Toward the southern part of the area the present drainage corresponds fairly well with that of the Tertiary period, the principal difference appearing to be that many of the Tertiary rivers flowed parallel with the range in longitudinal valleys which have been in most cases squarely intersected by the present Quaternary rivers. Feather River, one of the greatest of the present water courses, had no adequate representative in Tertiary time, but that part of the slope now belonging to it drained to the north.

Evidence is adduced by numerous profiles and sections of the character of the Tertiary topography, and of the present grade of the Tertiary stream channels. These profiles, by the infallible relation between extremely steep transverse grades and extremely flat longitudinal grades,

proves that a tilting uplift has taken place whereby the grades of the rivers flowing west have been considerably increased. The increase is so uniform as to show that the block tilted without deformation. The tilting of a marginal continental block 80 miles wide and 300 miles long, with inconspicuous deformation, must have required forces acting thru depths of miles.

In chapter 3 the fossils of the auriferous gravels are described, principally by Prof. F. H. Knowlton. Chapter 4 deals with the gold in the Tertiary gravels, its distribution, size, and value, as well as with the minerals accompanying the gold in the gravel. A brief account is given of methods of mining and of legislation concerning mining débris. An appendix gives a summary of the latest developments in the gold-dredging industry at the foot of the Sierra Nevada. W. L.

GEOLOGY.—*Alunite, a newly discovered deposit near Marysvale, Utah.* B. S. Butler and H. S. Gale. Bulletin U. S. Geological Survey No. 511. Pp. 64, pls. 3. 1912.

The alunite deposit described in this bulletin is located about 7 miles southwest of Marysvale, Piute County, Utah, on a spur of the Tushar range.

The deposit occurs filling a fissure vein cutting volcanic rocks. It outcrops in places for a distance of 3500 feet and has a maximum measured thickness of about 20 feet. Much of the vein material is nearly pure alunite, while in other parts it contains some quartz and kaolin.

The bulletin also contains a brief description of other known occurrences of alunite both domestic and foreign and a review of commercial processes of treatment of this mineral. B. S. B.

PHYTOPATHOLOGY.—*The history and cause of the coconut bud-rot.* John R. Johnston, Bureau of Plant Industry. Bulletin 228. February 5, 1912.

A disease of coconuts called the bud-rot has long been known in Cuba, Jamaica, British Honduras, Trinidad, and British Guiana; it probably occurs in the Philippines, Ceylon, British India, German East Africa, and Portuguese East Africa The symptoms of this disease are the yellowing and falling of the leaves and the dropping of immature nuts. Eventually the middle folded leaves shrivel and bend over and the entire heart of the crown is involved in a vile-smelling soft rot. The tree may be killed within a few months after infection, and entire groves may be destroyed within two or three years. The cause of the disease in eastern

Cuba is an organism practically identical with *Bacillus coli* (Escherich) Migula. Inoculations into coconut seedlings with *B. coli* of animal origin gave infection similar to inoculations with the coconut organism. It is believed that birds and insects are carriers of this disease; stomatal infections are common on the young tissues. The study of the bud-rot disease of the coconut palm suggests that diseases of several other palms may be due to the same cause. No coconut district is secure from danger of infection of the bud-rot disease. The control of the disease will probably depend upon better sanitation and improved methods of cultivation. The cutting out and burning of all diseased tree tops and the removal of fallen leaves and nuts are especially necessary. It is believed that the bud-rot disease of coconuts does not occur in the island of Porto Rico. K. F. KELLERMAN.

PROGRAMS AND ANNOUNCEMENTS

PHILOSOPHICAL SOCIETY OF WASHINGTON

Saturday evening, April 6, 1912; Cosmos Club. MR. A. F. ZAHM: *Evolution of the Aeroplane; its Fundamental Features of English origin.*

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. II, APRIL 19, 1912 No. 8

PHYSICS.—*The Ether.*[1] P. G. Nutting, Bureau of Standards.

The whole of theoretical Ether-Physics has been profoundly modified within the past two decades. Many of the fundamental concepts of electricity, gravitation, radiation and even matter itself have been revised from their foundations. Our task today is to examine the storm center, the ether. In anticipation, it may be stated that the task will prove not to be a mortuary one, but rather one of removing and getting rid of rubbish. The new ether is the old ether freed from useless and incongruous attributes.

What we wish to know about the ether is whether it exists or not, what are its nature and properties, and what are its relations to electricity, gravitation, radiation, induction and chemical affinity. Material bearing on these problems is scanty and we can do little more than review the experimental facts and their interpretation, contrasting their present interpretation with that of twenty years ago and placing in their proper setting the more recent important discoveries.

First then as to the *existence of the ether.* We shall discuss first the evidence in favor of an ether and then sum the evidence against it. The older reasons for supposing the existence of the ether hold as forcibly today as they ever did and to these have been added a few new ones of some significance.

1. There is the old question of *action at a distance.* Wherever two objects are attracted toward or repelled from each other and

[1] Presented before the Physics Association of the Bureau of Standards, February 5, 1912.

there is no material connecting link, such as a wire or pulsating fluid, between them, it has always been customary to put the burden upon an immaterial medium. Gravitational attraction, electrical and magnetic attraction and repulsion are of this nature. Chemical affinity should probably be included but some hold that a material link actually holds the atoms together.

In my opinion not much weight can be attached to action at a distance as evidence for the existence of an ether. The assumption of an ether is doubtless the *simplest* explanation of the facts, but it is certainly not the *only possible* explanation. It is easy to imagine an intervening medium pulled by one body and itself pulling a second body. However, in imagining such a medium, we are endowing it with mechanical properties and with such extreme properties as no known material possesses. In discarding the mechanical assumption we may either assume a non-mechanical ether or else assume that these forces really belong to some higher mechanical system in which the apparent action at a distance is in reality contact action. Perhaps there are still other alternatives. I merely cite these two to show how far we are from a final disposition of the problem.

2. The *propagation* of *electromagnetic energy* from one body to another. Radiation is emitted by one body and received after an interval of time by another. Where and what was this energy during that interval of time? Until recently, these questions were readily answered; radiation travels as wave energy, where waves are there is *motion,* where motion is there is something that *moves,* namely, the ether. At present with an ether devoid of mechanical properties, there are wide differences of opinion as to just how electromagnetic energy travels through space, but if we knew how it is propagated through any material di-electric, we could very probably give at least a tentative explanation of how it travels from one body to another.

So far as we now know, such energy could be propagated through *void* space only in corpuscular form. If we assume corpuscular light, we have to contend with a solid array of firmly established facts. Further, electromagnetic theory itself shows that energy thus propagated is essentially *alternating* in character and in definite relations to the direction of propagation. To my mind,

all the evidence afforded by the propagation of radiation through space is against that space being void and in favor of an ether with very definite electric and magnetic but without mechanical properties.

3. A third group of evidence bearing on the existence of the ether consists in those phenomena indicating a storage of energy in the neighborhood of an electric charge in actual motion. These phenomena correspond with self induction in the case of ordinary electric currents. Cathode ray particles, the Beta particles from radium and similar objects carrying electric charges with high velocities, carry more energy than corresponds with their material mass and velocity, electro-magnetic energy of the adjacent medium. This may even be separated from the matter and charge and measured as energy in the form of Röntgen or of Gamma rays.

These phenomena, to my mind, supply the most direct evidence of the existence of a medium. If there were no medium how could a moving charge carry or conduct along with itself, *outside itself* energy of motion. How could a bullet moving in void space possess energy of motion exterior to itself? It may be thought that the assumption of lines and tubes of force as physical entities would provide an escape from the assumption of a medium. But such an assumption merely displaces the dilemma. If we consider that the region adjacent to a moving charge is filled with actual tubes of force instead of merely being an electromagnetic field, how, without a medium, could the sizes and shapes of these tubes be a function of the velocity of the charge.

4. To most of us it is a significant fact that not one of those whose work has been largely instrumental in the overthrow of the mechanical theory—H. A. Lorenz, Poincaré, Planck, Larmor, J. J. Thomson, Schuster, Whittaker, Heaviside, Wiechert, or Michelson—appears to question the existence of an ether *without* mechanical properties.

The no-ether school may fairly be compared with the no-atom school of Energetics. If we ignore the ether or the atom we may treat a considerable portion of physics quite satisfactorily but we must ignore a great many vital and significant phenomena in so doing.

The evidence *against* the existence of the ether falls into two distinct classes; it is either evidence against the *mechanical* theory or else evidence based on the negative results of attempts to detect ether drift. In the last analysis these two are the same but we shall discuss them separately.

The mechanical theory never did have high standing with thinking men, and but for the support of a few leading physicists having mechanical minds, would never perhaps have been developed beyond a mere tentative hypothesis. We have no reason to think that even Lord Kelvin himself, chief exponent of the mechanical theory, ever considered it more than such a working hypothesis.

We are all familiar with the character and properties assigned to the mechanical ether; its enormous elasticity and infinitesimal density to give the proper value to the velocity of light, its enormous tensile strength to support gravitational forces, its solid properties to propagate transverse light waves, its fluid properties to permit heavenly bodies to move through it with fixed velocities, and so on. The mechanical ether reached its highest development as a vortex sponge at the close of the last century. It has passed away, not by violence but by starvation. It always was a monstrosity and we are only too glad to be able to discard it forever.

The stubborn refusal of all phenomena, both natural and artificial, to show any indication of absolute motion in space has no direct bearing on the question of the existence of an electromagnetic ether. The Lorenz contraction hypothesis, with the electron theory of matter, offers us one loophole of escape from the stubborn facts, the relativity theory several. It is too early to say what will be the outcome, into what framework of theory, our experimental facts will fit with least violence to themselves.

Some relativists would have us reject the ether entirely on the ground that it is useless. I, myself, fail to see how it can be dispensed with, any more than atoms or molecules can be dispensed with, nor how anyone, at all versed in theoretical optics or electricity, can consider it unnecessary.

In short, the mechanical ether of Kelvin, Lodge and Helmholtz, the ether most of us were brought up on, has been proven

untenable, the electromagnetic Maxwell ether stands just where it always stood. It has been attacked, without much effect, by the extreme relativists, strengthened by the electron theory and brought into prominence by the pruning away of the mechanical theory.

As the conservation of energy is the simplest general principle which will make perpetual motion impossible, so the simplest physical law that will permit of discarding all the mechanical attributes of the ether is the principle of relativity. Each of these principles are, however, but limited forms of more general laws.

Before outlining the properties of the ether let us consider briefly its mathematical framework in the newer physics of which the relativity theory is the most conspicuous landmark. Mathematical physicists (Lorenz, Minkowski, Abraham, Einstein) have found that apparent experimental contradictions disappear and the mathematical framework of physics is greatly simplified if, instead of referring phenomena to a set of three space axes and one time axis of reference, they are referred to a set of *four* interchangeable axes involving 4 homogeneous coördinates, three of space and one of time. There are an infinite number of ways of projecting the four dimensional (x, y, z, t) space into the x, y, z, and t space. Phenomena that are ambiguous and contradictory when one projection is used are simple and harmonious with another projection. Further, if a star, say, is in motion relative to one x, y, z, t system, it will be at rest with respect to some other system of axes. Relativity is a particular instance of the application of these principles. Already gravitation, that most recondite of all physical facts, is yielding to this four dimensional analysis. What we have here to keep in mind is that in order to explain the lack of ether drift it is unnecessary to annihilate or ignore either space or time intervals but merely to generalize our axes of reference.

Three classes of physical phenomena may take place within or across space void of matter:

(a) *Forces* may *act*. Electric, magnetic, gravitational (and possibly chemical) forces act across space even when no matter inter-

venes. Electric and magnetic forces may be either positive or negative, gravitational and chemical forces are negative only. The signs of these forces can not be altered by any intervening medium. Electric forces are a maximum when no matter intervenes. Magnetic forces are intermediate in value while gravitational force is the same whatever the intervening medium. The speed of propagation of electric and magnetic forces across space is a finite constant independent of the sign or magnitude of those forces. The speed of propagation of gravitational forces is certainly greater than 10^{14} cm/sec and probably infinite. In no case is there any evidence of a force too small or too great to be propagated; that is of any finite maximum or minimum load. In other words, there is no evidence that the ether, if the ether be responsible, has any finite inertia or viscosity on the one hand or breaking strength on the other, certainly not in any mechanical sense.

(b) The absence of matter is no bar to *induction*. An electric charge induces an electric charge as readily across a vacuum as through matter, and similarly with magnetic and electromagnetic induction. Induction is always of the same sign, unlimited in magnitude and propagated with the speed of light.

(c) Electromagnetic radiation is propagated across a vacuum as freely as through matter. Beams of light and electric waves, whatever their nature, travel independently of each other, i.e., no matter how filled with radiation of *one* kind and direction a certain space is, neither the wave length, velocity, direction, damping or polarization of any other beam traversing the same space at the same time is in any way affected. Neither electric nor gravitational *strain* of any amount produces birefraction in a space devoid of matter nor does a magnetic field affect the *plane of polarization* unless matter be present. That these effects do exist in matter indicates an actual mechanical strain. Of the two astronomical methods for determining the velocity of light, the satellite method gives the *group* velocity, while the aberration constant gives the *wave* velocity; the close agreement between the values obtained indicates that wave and group velocity is the same, hence that there is *no* dispersion in space, waves of all frequencies travel with the same velocity.

Two important facts give us clues to the actual magnitudes of the constants of the ether (a) the fixed finite nature of the velocity of propagation (independent of the motion or intensity of the source) indicates definite electrodynamical properties in the space traversed, in fact that

$$c = (k\mu)^{-\frac{1}{2}}$$

We but require a second independent relation between c, k, and μ to determine the actual values of k and μ for the ether. (b) Again, space has a definite fixed *capacity* for radiant *energy*, a function of the frequency of the radiation, its spectral distribution, the velocity of propagation and the amount already present. Expressions for what correspond with entropy and specific heat may be derived without difficulty. This capacity for energy is dependent upon boundary conditions while the velocity constant is *not*.

There exists rather conclusive evidence that short wave and pulse electromagnetic energy is emitted in even multiplies of a small but finite quantity proportional to the frequency. On the other hand there is no evidence that such is the case with the long waves of wireless telegraphy. However, it does not follow that even light waves or gamma rays are necessarily propagated in space in these discrete units. A spherical wave or pulse may be subdivided radially by an absorbing screen, a lens or a mirror; tangentially by partial absorption or reflection or by double refraction and there is no evidence of any limit to the attenuation a pulse or wave may suffer during propagation.

To summarize the properties of the ether we may say that it has no *mass* and no *ridigity* in the mechanical sense and that its parts have no *identity*. Having no mass it can have no *density*, having no rigidity it cannot be subject to *strain*. The ether does, however, possess electromagnetic properties analogous to each of these.

Having no identity, its displacements and velocities, if it has any, are unknown to us. Tagging the ether with electromagnetic disturbances is, as we have seen, ineffective. The core of the matter is this: What kind of a medium can have *real tangible*

forces acting at its boundaries and conduct real energy with a finite velocity and yet itself have no inertia or rigidity in any mechanical sense.

Two of the many possible explanations are suggested. (1) the properties of the ether may be mechanical after all but in four dimensions. If this be the case it is for the mathematical physicist to work out the solution of the problems of gravitation, induction and radiation; it would be useless for the experimental physicist working in three dimensions to seek a solution. Or (2) the properties of the ether may be non-mechanical of unknown nature. In this case, it is for the experimentalist to find out the nature of electricity and ponderomotive electrical effects. The four dimensional mathematical method appears to be the only one capable of attacking the gravitational field; yet we feel instinctively that the final solution *must be* physical and three dimensional.

PHYSICS.—*Thermometric lag.* D. R. HARPER 3RD. Communicated by C. W. Waidner. To appear in the Bulletin of the Bureau of Standards.

The transfer of heat from any medium to a mercurial thermometer of the common "chemical" type may be expressed with a high degree of accuracy by the relation

$$\frac{d\theta}{dt} = \frac{1}{\lambda}(u-\theta) \qquad (1)$$

where

θ = temperature of thermometer (average) at time t
u = temperature of medium at same instant
λ = a "constant" with respect to θ, u, and t.

λ is not an absolute constant of a given thermometer but depends upon the medium in which it is immersed and the rate at which the meduim is stirred. By equation (1) it is seen that λ has the dimensions of time, and it may be interpreted as a definite number of seconds:

1. If a thermometer has been immersed for a long time in a bath whose temperature is rising at a uniform rate, λ is the number of seconds between the time when the bath attains any given

temperature and the time when the thermometer indicates this temperature; i.e., the number of seconds the thermometer lags.

2. If a thermometer be plunged into a bath maintained at a constant temperature (the thermometer being initially at a different temperature), λ is the number of seconds in which the difference between the thermometer reading and bath temperature is reduced to ϵ^{-1} times its initial value.

From a series of thermometer readings (θ) obtained at sufficiently close intervals, the variation of θ with t may be considered as given and the value of the temperature (u_1) corresponding to any thermometer reading (θ_1) is at once obtainable by employing (1) in the form

$$u_1 = \theta_1 + \lambda \left.\frac{d\theta}{dt}\right]_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Conversely θ may be obtained from u, i.e., the behavior of the thermometer in a bath whose temperature varies with time according to some given law, can be predicted from the solution of the differential equation. The general solution is

$$\theta - u = (\theta_o - u_o)\,\epsilon^{-\frac{1}{\lambda}t} - \epsilon^{-\frac{1}{\lambda}t}\int_o^t \frac{\partial u}{\partial t}\,\epsilon^{\frac{1}{\lambda}t}\,dt \quad \ldots\ldots\ldots (3)$$

and can be much simplified for the most important special cases by employing the appropriate value of $\frac{\partial u}{\partial t}$. For instance if the bath be maintained at constant temperature

$$(\theta - u_o) = (\theta_o - u_o)\,\epsilon^{-\frac{1}{\lambda}t} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

and if the temperature of the bath rise linearly with time (at rate r) the relation

$$u - \theta = r\lambda \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

will hold a short time after the introduction of the thermometer into the bath.

These equations are the source of the interpretations of λ given above. Other cases may be likewise developed, the results being somewhat more complex than (4) or (5). The equations furnish

a suitable basis for the development of methods of determining λ under a given set of conditions, and for computing the lag corrections in cases of applied thermometry where the corrections are appreciable.

Variation of λ with stirring, and the lag of a thermometer as a fluid current meter.—The lag of the same thermometer in water, viscous kerosene, and air, each forced past the bulb at different velocities covering a wide range, furnished the data from which is taken the table below. The method employed was to plunge a previously cooled thermometer into a fountain of the fluid, gushing out of one arm of a vertical U-tube, the other arm of this tube being connected to a source of supply maintained at constant temperature. A suitable throttle gave the desired current, which was measured by weighing the spill in a given time, or by a gas meter. The velocity of flow past the bulb was obtained from the current and area of the annular orifice.

TABLE 1

λ IN SECONDS. SMALL BULB "CHEMICAL" THERMOMETER

VELOCITY PAST BULB CENTIMETERS PER SECOND	0	1	5	10	50	100	500	1000	∞
Water.....	10	5.1	3.3	2.9	2.4	2.3			2.2 sec.any
Oil.....	40 to 50	13.4	7.5	6.4	4.8				medium
Air.....	190	170.0	148.0	128.0	71.0	58.0	33	25	(see note)

"Infinite stirring" means bringing the wall of the bulb instantaneously to its final temperature and maintaining it there by an "infinite" heat source while the average temperature of the thermometer changes from its initial to its final value. The λ corresponding to this condition should be a real constant of the thermometer, bearing no relation to the medium of immersion. The condition is probably very closely realized for a small thermometer when it is plunged into live steam, in view of the high latent heat of the steam, and the value 2.2 seconds was so obtained.

The agreement between observations taken at any one velocity was good, and the mean values, for the different velocities tested, gave points all of which were close to a smooth curve. Interpolation on this would seem, therefore, to be reliable, and the use of the method to determine velocities of flow of fluids is suggested.

The process of obtaining the data is tedious but the advantage is offered of a minimum of interference with the current to be measured. As an example of its application may be mentioned a determination of the flue draft of a continuous flow combustion calorimeter of the Junkers type, where it is evident that none of the more usual forms of anemometer could be used.

Lag of a Beckmann thermometer.—While the ordinary "chemical" thermometer was found to operate in close accord with the behavior predicted by equation (1), this was not the case for a thermometer with part of its bulb in good thermal contact with the immersion bath and part in very poor thermal contact owing to enclosure in a surrounding air jacket. The usual form of Beckmann instrument has a large capillary between the bulb and the fine capillary extending along the scale, and this large capillary, containing from 0.2 per cent to 0.5 per cent of the total mercury, is to be regarded as a secondary bulb of appreciable influence.

Assuming that equation (1) represents the behavior of the main bulb, with a lag λ_B, and that also such an equation represents the behavior of the large capillary, with a lag λ_C (much greater than λ_b) we can develop a theory analogous to the simpler one, but containing two λs. The equations are of course more complicated. For instance

$$\frac{\Theta - u_o}{\Theta_o - u_o} = (1-k)\,\epsilon^{-\frac{1}{\lambda_B}t} + k\epsilon^{-\frac{1}{\lambda_C}t} \quad \ldots\ldots\ldots\ldots\ldots (6)$$

replaces (4). k is the fraction of the total mercury contained in the large capillary. Similarly (5) is replaced by

$$u - \theta = (1-k)\,r\lambda_B + kr\lambda_C \quad \ldots\ldots\ldots\ldots\ldots (7)$$

Methods of determining λ_B and λ_C were devised, and the actual behavior of a Beckmann thermometer, when plunged into a bath maintained at constant temperature, was found to be very closely represented by equation (6); in marked contrast to the failure of equation (4) in this respect. The assumptions made seem therefore to be justified and the theory based on them is offered as a better representation of the behavior of such a thermometer than is the simpler theory employing but one lag.

Electrical thermometers.—Electrical thermometers in common use fall into one of two classes, thermo-electric or resistance. Some form of galvanometer is necessary as an indicator for either, and the lag of this galvanometer is part of the total lag of the system, in fact often the only part which is appreciable.

Galvanometer lag.—From the fundamental equation of motion of a galvanometer, critically damped, it can be shown that the deflection follows an impressed e.m.f., changing linearly with time, so as to lag behind it by a constant time, numerically $4 \times \frac{\text{Moment of Inertia of Moving System}}{\text{Damping Coefficient (critical)}}$. This expression is simply related to the period, T, of the system when oscillating absolutely free, giving to the lag of the galvanometer the extremely simple form $\lambda = T/\pi$ seconds. For T may be substituted, without appreciable error, the period of the system when oscillating much underdamped, for this does not differ materially from T until the conditions are closely those of critical damping.

Resistance thermometers.—The equations developed from (1) have been found to represent fairly well the behavior of resistance thermometers as well as of mercurial thermometers, in approaching the temperature of a medium in which immersed. They were employed in determining the lag, in ice or well-stirred water, of a number of such thremometers. Thermometers of the Callendar type depart somewhat from following these equations, the departure being of the same general nature as that observed in the case of a Beckmann thermometer. The two term formulæ, with appropriate constants, proved to be rather better than the simpler ones, and may be said to be an empirical second approximation to the statement of the behavior of a Callendar type instrument. While a definite interpretation of all the various constants is lacking, a reason for such a double lag is in evidence. The temperature of the platinum coil is partly determined by that of the inner surface of the containing tube, of which the lag is relatively small, and partly by that of the support for the coil, of which the lag is relatively great.

The Callendar type of resistance thermometer was found to be slow in comparison with the average mercurial instrument.

The values obtained in vigorously stirred water ranged from 15 to 30 seconds, while for a mercury thermometer under the same conditions the usual value is between 2 and 6 seconds, except for the very largest bulbs. The Dickinson-Mueller type of resistance thermometer, an improved form of the instrument described in 1907, was found to be very much faster than a mercury thermometer. The only result of some attempts to measure directly the lag when immersed in well stirred water, was to ascertain definitely that it was but a small fraction of the lag of the galvanometer employed, which was about $1\frac{1}{2}$ seconds.

The Jaeger-Steinwehr method of computing the lag of a resistance thermometer.—Only a very meagre discussion of this method can be attempted here. It is probably the best, and perhaps in many cases the only possible way of determining the lag of such instruments as are constructed in a form permitting of applying it at all. The principle involved is the equating, in the equilibrium state, of the heat supplied to the thermometer by a small current, to the heat transferred to the bath because of the elevation of the temperature of the coil slightly above that of the bath. The lag and the heat capacity of the system whose temperature is so elevated, enter the equation together with other quantities which are readily measured experimentally. The possibility of determining the lag depends therefore upon whether or not a satisfactory estimate of the heat capacity factor can be made. In this respect the paper suggesting the method is decidedly misleading, stating for the proper value of the heat capacity that of the wire alone, the formula being reduced to terms of the dimensions, specific heat, specific resistance, etc., of the wire. Some portion of the supports of the coil, and the covering if there be one, must always be heated along with the coil, and in most cases the fraction to be included has several times the heat capacity of the wire in the coil. A thermometer of the Dickinson-Mueller type has, in the region of the platinum coil, an amount of mica whose heat capacity is about 0.15 calorie per degree. A probable distribution of the temperature gradient from the coil to the bath, places the portion to be included with the coil as about one-third, i.e., 0.05 calorie per ° C. The heat capacity of the coil

itself is 0.01 calorie per ° C. These figures lead to a value of λ of one-half second, for immersion in vigorously stirred water.

Thermo-electric thermometers.—The lag of a thermocouple, like that of a resistance thermometer, is almost entirely a question of the form of mounting. Depending upon the way of supporting and enclosing the junction, one would expect to find lags ranging all the way from a fraction of a second to perhaps 30 seconds, for immersion in water, and correspondingly greater values in air. With the wide latitude of variation in design without impairing the usefulness of the thermocouple, there have appeared almost as many forms of instruments as there are makers, in consequence of which it seemed unimportant to determine the lag of any particular form.

Thermometric lag in calorimetry.—Although the controversy concerning the effect of thermoelectric lag on calorimetric results may be said to have been settled by a recent conclusive paper published by W. P. White, the widespread attention attracted to the subject by the conflicting views expressed by eminent writers prior to the publication of the paper cited, has made it seem worth while to treat the subject rather fully in the more complete paper. An analysis, differing radically from that of White, will be found there, the conclusions being, however, substantially those stated by him.

BIOLOGICAL CHEMISTRY.—*The measurement of the oxidase content of plant juices.* H. H. Bunzel, U. S. Department of Agriculture. Bulletin 238, Bureau of Plant Industry. 1912.

The very voluminous literature on the rôle and importance of oxidizing enzymes in many life processes of plants and animals makes a thoro study of their behavior, function, and distribution necessary. They

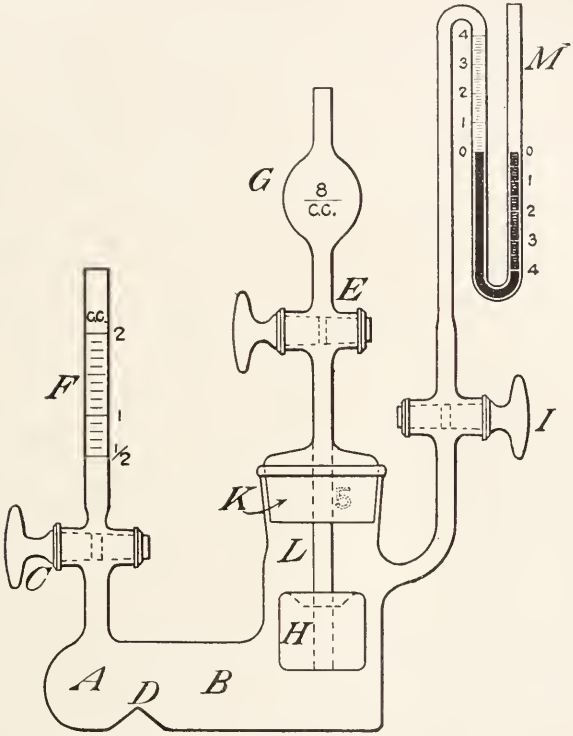


Fig. 1. Apparatus for measuring oxidase action

play an important part in certain pathological conditions, and in numerous industrial, and agricultural problems. As specific examples may be mentioned the work done by Woods, in the Bureau of Plant Industry, on the mosaic disease of tobacco, the work of Palladin and his school on the respiration of plants, and the causal relationship between the oxidases and color production as shown for plants by Palladin, and for animals by Gortner. They also play an important part in the darkening of tea, and the manufacture of the Japanese lacquer.

Nearly all of the experiments made thus far have not been carried on quantitatively because of the lack of satisfactory methods.

The method described is based on oxygen absorption. For this reason a constant temperature is essential. The apparatus in which the oxidations are carried out is shown in the text figure. Eight cubic centimeters of the solution of the substance to be oxidized are measured in the pipette *G* and allowed to run into the compartment *B*. The plant juice, the oxidizing power of which it is desired to study, is measured in pipette *F* and run into compartment *A*. Basket *H* holds 1 cc. of normal sodium hydrate to absorb the carbon dioxide formed in the process; *M* is a manometer charged with mercury to indicate the pressure within the oxidase apparatus. The whole apparatus is clamped to a specially constructed shaking machine. In the air-thermostat the temperature is brought to 37° C. and maintained at that point to within 0.1° thruout the experiment. Half an hour after the temperature of 37° is reached, all stopcocks but *I* closed, and a shaking machine set into operation. The plant juice mixes with the oxidizable material and the reaction begins. From time to time the shaking is interrupted and manometer is read. In the course of several hours the oxygen absorption is completed, as indicated by no further change of pressure within the flask. The ultimate reading expresses the oxidase content of the juice or extract towards the particular substance used. As a unit an oxidase solution is chosen of such a strength that 1 liter of it will be capable of bringing about the consumption by pyrogallol of the equivalent of 1 gram of hydrogen.

So far pyrogallol, tyrosin, hydrochinone, guaiacol, benzidine, and alphanaphthol have been used in the experiments. The concentration of the material to be oxidized has no effect on the end result provided it is used in excess. The carbon dioxide produced is absorbed by the alkali in the basket and may be determined at the end of the experiment by means of a special apparatus devised for the purpose. The result obtained is directly proportional, or at least nearly proportional, to the concentration of the oxidase present.

The method described was used successfully during the summer of 1911 at Utah in the study of the curly-top disease of sugar beets. In this study a very striking fact was brought out. It was found that the plants suffering from the curly-top disease have leaves with a much higher oxidase content than the normal, similarly, an unusually high oxidase content was observed in plants whose growth was stunted for other reasons, such as excessive watering, drought, or failure to produce seed. H. H. B.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE BOTANICAL SOCIETY OF WASHINGTON

The 79th meeting was held at the Shoreham Hotel, March 5, 1912. This was the annual open meeting at which the retiring President, Prof. W. J. SPILLMAN, presented his address on, *The present status of the genetics problem, which will appear in Science.*

The 80th meeting was held April 2, 1912. Dr. Errett Wallace and Messrs. L. H. Evans, S. M. McMurran and S. C. Stuntz were elected to membership. The following papers were read:

The celebration of the one hundredth anniversary of the Academy of Natural Sciences of Philadelphia: W. E. SAFFORD, delegate of the Botanical Society of Washington.

The meetings of the celebration were held on the evening of March 9, and during the two following days, in the new lecture hall of the Academy. A reception was given by the President of the Academy, Dr. Samuel G. Dixon, on the evening of March 20, and a banquet on the following evening at the Academy.

In enumerating some of the principal achievements of the Academy, Mr. Safford referred to the second arctic expedition of Dr. Kane, and to the more recent expedition of Peary, in 1891, which was wholly under the Academy's auspices. In speaking of the educational facilities offered by the Academy, he called attention to the fund left in trust by Mr. A. E. Jessup, for assisting young men to pursue studies in natural history. Some of its beneficiaries have become distinguished zoölogists and geologists.

Among the most valuable bequests and gifts received by the Academy are the botanical collections of the Rev. Lewis David von Schweinitz and of Dr. Charles W. Short, of Louisville, Ky., as well as the priceless collection of birds presented to the Academy by Dr. Thomas B. Wilson, which includes the types of Gould's *Birds of Australia.*

In conclusion Mr. Safford gave an account of the Academy's herbarium, of the Zoölogical Garden of Philadelphia, and the admirable Commercial and Economic Museum established in that city. This museum, which had for its nucleus, collections from Columbian Exposition of 1893, has received important additions from each subsequent exposition held in this country.

Studies in European herbaria with special reference to preservation of type specimens: W. T. SWINGLE. The speaker referred to his experiences during two visits in the past year to the principal European herbaria. The superiority of the European herbaria over the American in the cosmopolitan nature of their collections was emphasized. In many

respects, however, the herbaria both of Europe and America are managed much as they were a century ago. There is no adequate realization of the enormously increased facilities for travel and for the collection, shipment and preservation of perishable material. It would seem absolutely essential that directors of herbaria recognize the necessity of not only maintaining the usual collection of dried plants, but also full collections of fruits and of alcoholic material of delicate and characteristic portions of the plant such as inflorescences and parts of the flowers. Such collections are occasionally to be found, but are very rarely indexed so as to be easily accessible.

The increasing importance given to type specimens leads to a consideration of the best method of preserving them. The present method of leaving types with the other specimens, is certain to result in their rapid deterioration and ultimate loss. Type specimens should by all means be kept in a separate collection under special protection against fire and insect depredations and should be examined only in the presence of a custodian.

In considering type material it is important to recognize that in plants, type specimens can often be multiplied indefinitely simply by cutting branches from the same plant or by securing flowers or fruits from the same plant during successive years. These types which are secured from the same plant individual are designated as merotypes.[1] They are destined to become of very great importance in the future development of taxonomic botanical research. It is an easy matter nowadays when a new species of tree or shrub is found to mark the plant in a permanent way and to provide for supplying all the principal herbaria of the world with merotypes, by collecting material from this plant every time it comes into flower or fruit.

W. W. Stockberger,
Corresponding Secretary.

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 494th regular meeting of the Society was held at the Cosmos Club on February 17, 1912. Under the head of brief notes E. M. Kindle exhibited lantern slides showing impressions made by tadpoles in the ooze of very shallow ponds and suggested a similar origin to many of the peculiar markings in rocks.

The first regular communication was by H. M. Smith and Lewis Radcliffe: *Notes on some remarkable deep sea fishes from the* Albatross *Philippine cruise.*

The first speaker referred in a general way to the reults of the *Albatross* expedition to the Philippine Islands, and then discussed some features of the fish collections from deep water. This region was an almost

[1] This word may be defined as follows: Merotype, (μέρος a part; τύπος a type) In taxonomy, a part of an organism that furnished the type specimen of a new species. It is obvious that merotypes are of importance only in case of perennial plants or of vegetatively propagated lower animals.

virgin field for deep-sea work, and time after time as the kam-trawl was hauled in depths of 100 fathoms and over, there were obtained species of fishes on which the human eye had never before gazed. Specimens and illustrations of a few of the more remarkable deep-water forms were shown, including a new family and several new genera of sharks, a new family and two new genera of pediculates, a new macruriod family, etc. Among the most noteworthy of the fishes referred to is a new noridanoid shark from the Sea of Mindanao which is intermediate between the two known families of the order, and is characterized by only five gill openings.

A few of the rarer deep-sea fishes were exhibited and commented upon by Mr. Radcliffe. Among these were specimens of *Ipnops murrayi* and *Halimochirurgus centriscoides* (the deep-sea snipe fish). Some comparative figures were presented showing the extent to which the collection will add to the known fish fauna of the region. One of the illustrations used was that of the family Macronsilæ, of which there are in the collection 1300 specimens referable to about forty species; only two species had previously been recorded from the Philippine Islands.

The two talks were illustrated by numerous drawings and specimens in alcohol.

The second communication was by A. S. Hitchcock: *Botanizing in Panama.*

As members of the Smithsonian Biological Survey, Mr. Hitchcock and his son visited Panama during the fall of 1912, remaining from August 24 to October 19, and, after a side trip to Central America, from December 14 to December 20.[1] From Culebra as headquarters, explorations were made, in the Canal Zone, the entire length of the Panama Railroad, and also at Toro Point, in the Savannas between Panama City and Old Panama, and at Taboga Island. Outside of the Canal Zone collections were made at Point Chamé and in the vicinity of Chorrera, and in western Panama on a trip to the Volcano Chiriqui.

There are extensive grassy savannas along the Pacific coast. The grasses are mainly species of Andropogon, Axonopus, and Paspalum. *Andropogon fastigiatus* and *Paspalum notatum* are typical of this region. Along the line of the Panama Railroad an abundant and aggressive introduced grass, *Panicum barbinode* (Pará grass) lines reservoirs and ditches and is found everywhere in moist soil where the native vegetation has been disturbed. It was found growing in Gatun Lake in 7 feet of water. Upon recently formed embankments it spreads rapidly by long strong stolons as much as 20 feet in length. *Panicum maximum* (Guinea grass), cultivated for forage, has abundantly escaped and is now common upon drier soil than that upon which Para grass flourishes. A conspicuous native species is *Paspalum fasciculatum* common along water courses and often abundant upon new ground. Another large species of Paspalum, rather rare in collections but common on banks in the Canal Zone is *P. saccharoides*, conspicuous because of its feathery inflorescence. Both these species produce stout stolons similar to those of Para grass. Herbarium

[1] See this Journal, 2: 142. 1912.

specimens rarely show stolons and many other habit features that are conspicuous and characteristic in the field. *Paspalum mucronatum*, common in Gatun Lake, produces long stolons that creep upon the surface of the water, being floated by means of inflated sheaths.

There is evidently considerable periodicity in the flowering time of grasses in Panama even in localities when the rainfall is fairly well distributed throughout the year. *Paspalum saccharoides* and *P. fasciculatum* mentioned previously were in full flower during September but in December not an inflorescence could be seen. On the other hand, *Panicum barbinode*, flowerless during the fall, was in full flower in December, while many species frequently observed in flower in Central America were in December just beginning to flower in the savannas of Panama, as for example, *Andropogon fastigiatus* and *A. brevifolius*.

There were collected in Panama 564 numbers, together with a large number of duplicates. These numbers probably represent about 200 species. It is interesting to note that Nees von Esenbeck lists in Seeman's Flora of Panama, 27 species of grasses.

This communication was profusely illustrated by lantern views.

D. E. Lantz, Recording Secretary.

PROGRAMS AND ANNOUNCEMENTS

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 709th meeting will be held at the Cosmos Club, Saturday evening, April 20, 1912, when Mr. Alexander Macfarlane will give (by invitation) an *Account of Researches in the Algebra of Physics*.

THE CHEMICAL SOCIETY

The Centennial of the Gas industry will be commemorated by a meeting on Wednesday May 1, 1912, at the Institute of Industrial Research.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. II, MAY 4, 1912 No. 9

CHEMISTRY.—*The ammonia system of acids, bases and salts.* Edward C. Franklin, Hygienic Laboratory, U. S. Public Health and Marine Hospital Service. To appear in full in the American Chemical Journal.

A consideration of the may points of resemblance between water and liquid ammonia[1] as electrolytic solvents has led the writer to the conception of a system of acids, bases and salts in which ammonia occupies a position similar to that held by water in its relation to the ordinary oxygen acids, bases and salts. The compounds which are thus related to ammonia are respectively the familiar acid amides, the less familiar metallic amides and imides and the metallic derivatives of the acid amides and imides.

The formal analogies between the typical substance, water, with its family of derivatives, the aquo acids, aquo bases and aquo salts on the one hand, and ammonia with its derivatives, the ammono acids, ammono bases and ammono salts, on the other, will be clear from an inspection of the following table in which are given the names of formulas of a number of representatives of each class.

Nor are the analogies thus indicated merely formal, for the well known properties which characterize the ordinary acids, bases and salts are found to attach also to the ammonia derivatives as follows: (1) Liquid ammonia solutions of the ammono acids, bases and salts are conductors of electricity, which property, it

[1] Not the familiar aqua ammonia, but pure ammonia gas liquefied by pressure or low temperature.

will be remembered, is exhibited by the corresponding water derivatives to a conspicuous degree. (2) Ammono acids and bases[2] produce the familiar reciprocal color changes in liquid ammonia solutions of phenolphthalein and other indicators. (3) When an ammono acid and an ammono base are brought together in liquid ammonia solution a reaction takes place resulting in the formation

TABLE 1

THE WATER SYSTEM		THE AMMONIA SYSTEM	
Aquo acids		*Ammono acids*	
Acetic acid	CH_3COOH	Acetamide	CH_3CONH_2
Nitric acid	NO_2OH	Nitramide	NO_2NH_2
Carbonic acid	$CO(OH)_2$	Urea	$CO(NH_2)_2$
Sulphuric acid	$SO_2(OH)_2$	Sulphamide	$SO_2(NH_2)_2$
Orthosilicic acid	$Si(OH)_4$	Silicon amide	$Si(NH_2)_4$
Aquo bases		*Ammono bases*	
Potassium hydroxide	KOH	Potassium amide	KNH_2
Zinc hydroxide	$Zn(OH)_2$	Zinc amide	$Zn(NH_2)_2$
Lead hydroxide	$Pb(OH)_2$	Lead amide	$Pb(NH_2)_2$
Aquo salts		*Ammono salts*	
Potassium acetate	CH_3COOK	Monopotassium acetamide	CH_3CONHK
Potassium carbonate	$CO(OK)_2$	Dipotassium acetamide	CH_3CONK_2
Mercuric nitrate	NO_2Ohg	Dipotassium urea	$CO(NHK)_2$
		Mercuric nitramide	NO_2NHg

of an ammono salt. For example, acetamide acts upon potassium amide in accordance with the equations

$$CH_3CONH_2 + KNH_2 = CH_3CONHK + NH_3$$
$$CH_3CONH_2 + 2KNH_2 = CH_3CONK_2 + 2NH_3$$

to form monopotassium or dipotassium acetamide. (4) Liquid ammonia solutions of ammono acids attack certain metals with the evolution of hydrogen gas and the formation of ammono salts as represented for a specific example by the equation,

$$Mg + 2CH_3CONH_2 = (CH_3CONH)_2Mg + H_2$$

[2] Ammonia itself exhibits basic properties only in the presence of water. It is not surprising therefore to find that the dry liquid acts quite as indifferently towards indicators as does water itself.

The products of the action of acetamide on metallic magnesium are magnesium acetamide, an ammono salt, and hydrogen. (5) As potassium hydroxide in aqueous solution dissolves metallic zinc to form potassium zincate, so a liquid ammonia solution of potassium amide attacks the same metal with the evolution of hydrogen and the formation of a beautifully crystalline potassium ammonozincate. The action is represented by the equation

$$Zn + 2KNH_2 = Zn(NHK)_2 + H_2$$

(6) Just as the soluble alkali hydroxides when added to aqueous solutions of the salts of the heavy metals brings about the precipitation of the hydroxides or oxides of the latter, so the analogous metallic amides, imides and nitrides are formed when potassium amide is added to solutions of the salts of the heavy metals in liquid ammonia. Silver iodide is readily soluble in liquid ammonia. When potassium amide is added to such a solution a precipitate of silver amide is formed in accordance with the equation

$$AgI + KNH_2 = AgNH_2 + KI$$

In a similar manner a soluble lead salt when treated with a solution of potassium amide gives a precipitate of lead imide, PbNH, and a soluble mercuric salt a precipitate of mercuric nitride, Hg_3N_2. (7) A considerable number of ammonia analogs of the compound formed by the solution of the hydroxides of certain heavy metals in aqueous solutions of alkali hydroxides have been prepared by the action of liquid ammonia solutions of potassium amide on the amides and nitrides of a number of heavy metals. For example a beautifully crystalline ammonoplumbite has been prepared in accordance with the reaction represented by the equation

$$PbNH + KNH_2 = PbNK + NH_3$$

The analogous reaction in the water system taking place in aqueous solution may be represented by the equation

$$Pb(OH)_2 + 2KOH = Pb(OK)_2 + 2H_2O$$

The preparation of potassium ammonoplumbite and of other ammono salts of this class is especially interesting in view of the fact that the analogous aquo salts have never been satisfactorily isolated. (8) The analogies between the water system and the

ammonia system extends to the formation of ammonobasic salts, that is to say to the formation of compounds which are related to ammonia as the ordinary aquobasic salts are related to water. For example, mercuric chloride in the presence of liquid ammonia undergoes ammonolysis in a manner represented by the reversible equation

$$HgCl_2 + 2NH_3 = Hg\begin{matrix} Cl \\ NH_2 \end{matrix} + NH_4Cl.$$

The formation of ammonium chloride[3] limits this ammonolytic reaction just as the liberation of acid brings to an end the familiar hydrolytic decomposition of salts of weak bases in water solutions.

In the longer paper the many points of resemblance between water and ammonia are enumerated; a system of nomenclature is outlined and an account is given of a considerable number of typical reactions and new compounds of the ammonia system.

BOTANY.—*Jointed leaves of Amygdalaceae.* O. F. Cook. Bureau of Plant Industry.

The leaves of the plum, peach, and apricot have a joint at the base, just above the insertion of the stipules, as do many leguminoseae. The basal section of the leaf, below the joint is in all cases short, but is often as long as broad, and is the part to which the stipules are attached. It does not fall off with the petiole but remains alive and serves as a supplementary bud-scale. The stipules are deciduous at an early stage, a fact which may have allowed the persistance of the base of the leaf to remain overlooked.

It is not to be supposed, of course, that this specialization has remained entirely unnoticed by preceding observers, but Sargent and other authorities do not allude to it further than to state that

[3] Ammonium salts, whether of aquo acids or halogen acids, in solution in liquid ammonia show certain truly acid properties. They bring about the reversal of ammonolytic reactions, they dissolve many metallic oxides, they attack certain metals with the evolution of hydrogen and they discharge the red color of alkaline phenolphthalein solutions. Their solutions in liquid ammonia are excellent conductors of electricity.

the stipules are distinct from the petiole, and the botanical significance of this fact is not pointed out. The reader is left to infer that the stipules are attached directly to the branch, for nothing is said of another foliar element below the base of the petiole.

Without attempting to determine whether this joint in the leaves of the Amygdalaceae is truly homologous with the leaf-articulations of leguminoseae, it is at least to be considered as a vegetative character that sets the Amygdalaceae one stage farther away from the Malaceae and true Rosaceae. Botanists have long recognized a very close approximation between the rosaceous and leguminous series. Such types as Chrysobalanus have often been passed back and forth between the two series by different authorities on classification. Some botanists may not consider tha attachment of the stipules as a sufficient indication that the persistent base is really a part of the leaf instead of an outgrowth from the internode. But it is believed that a comparison of the stone fruits with other rosaceous types will convince most observers on this point.

Reduced to the simplest terms of morphology, the leaves of the higher plants, including the monocotyledons, consist of two structural elements, a more or less sheathing base and a more or less expanded blade. The petiole is a secondary specialization, in some cases representing an elongation of the upper part of the basal sheath, in others a narrowing of the lower part of the blade. In the fan-palms the petiole is a part of the leaf sheath, with the ligule at the end, while in Desmoncus and other related genera of Cocaceae, the ligule is below the petiole which evidently represents only the naked base of the rachis.

In most of the dicotyledonous families the sheathing character of the basal element has been lost, but in this respect the Rosaceae, Ranunculaceae and related families are less specialized, so that there can be little question of the homology of the stipular portions of the leaves with the bud-scales and sheaths of Artocarpaceae, Piperaceae, aroids and palms.

The leaf-bases of the Amygdalaceae are able to persist because of the joint that allows the petiole to separate and fall off with the blade at the end of the season. At San Antonio, Texas, where

these facts were first noticed, the persistent leaf-base of the peach remains alive for a year or for two but finally dies and withers away. In Maryland peach trees the petiole base lives through the winter and separates when the buds start in the spring, leaving a fresh green leaf-scar.

The apple and its relatives do not share these specialized leaf characters of the stone fruits. There is no joint above the attachment of the stipules and basal section of the leaf falls off with the rest. The stipules of the quinces are much closer to the base of the leaf than those of the apple, and might be supposed to have a separate attachment to the branches. But on "water shoots" of Chinese quinces at San Antonio some of the stipules were of very large size and had strongly dentate margins. In these cases there could be no question regarding the attachment of the stipules to the petiole.

Another fact that may indicate greater complexity of leaf structure among the ancestors of the Amygdalaceae is the presence of small oblong or spatulate leafy organs on the upper part of the petiole, taking the place of nectaries. In some varieties of apricots these small accessory blades are of frequent occurence. They suggest the possibility that the nectaries of the petioles of Amygdalaceae may correspond to the marginal glands of the blade and may represent rudiments of divisions of compound leaves. If this be true the petiole in this group may correspond to the rachis of a compound leaf rather than to the more specialized petioles of some of the simple-leaved families.

BOTANY.—*Merotypes as a means of multiplying botanical types.* WALTER T. SWINGLE Bureau of Plant Industry.

Type specimens are now the most treasured possessions of natural history museums. The type specimen of an organism constitutes a fixed point in the taxonomic survey of the group of individuals which make up the species, and while it may not be typical of the latter in the ordinary English sense, it does at least determine one form which must remain in the species no matter how opinions may vary as to its limits.

It is now generally held that only one specimen is to be regarded

as the true type (holotype), all others studied by the author in describing his species being paratypes or cotypes.

It is becoming increasingly evident that the views of an author as to the limits of a new species are only too often considerably modified or even completely changed by subsequent research. This means that a paratype or even a subsequently collected specimen considered by the author to be practically a duplicate of the type cannot have anything like the same value in taxonomic work as the true type itself.

It has not been adequately realized that the botanist often has it in his power to collect a large number of specimens from the plant that yielded the type and that if these specimens represent homologous organs they may be practically equal to the type itself for taxonomic study. This is because the plant body is usually composed of homologous nodes or metamers[1] so that a branch if selected with care, is almost absolutely identical with the type specimen itself. In many cases it is even possible to multiply such plants indefinitely by vegetative propagation, thereby producing a practically unlimited number of such specimens. Trees or shrubs often can furnish scores or even hundreds of specimens practically identical with the type specimen and of very much greater value from a taxonomic point of view than specimens taken from other individuals, no matter how closely these latter may resemble the type plant.

In the case of trees, shrubs and perennial herbs, it is furthermore possible to collect fresh sets of specimens in subsequent years from the type plant, thereby rendering it possible to send specimens to all parts of the world.

The word *merotype*[2] has been proposed to designate such specimens and may be defined as follows:

Merotype (μέρος a part; τύπος a type). A part of the individual organism that furnished the type specimen of a new species, such part usually containing organs homologous to those represented in the type specimen.

[1] Cook, O. F., Dimorphic branches in tropical crop plants, Bull. 198, Bur. Pl. Ind., U. S. Dept. Agr., p. 8. Jan. 14, 1911.

[2] This word was first defined in this Journal 2: 212 as follows: "Merotype, (μέρος a part; τύπος type) in taxonomy, a part of an organism that furnished the type specimen of a new species."

Merotypes secured at the very time the type specimen was collected and which might be called synchronous merotypes have, of course, the highest value in taxonomy since there is almost no chance of error through mistaking another individual plant for the one that yielded the type. If studied by the author prior to publishing the species merotypes may also be paratypes and as such have still greater authenticity and value.

Merotypes collected later may differ more or less in their characters because of climatic or other environmental factors varying in different seasons. Still, such subsequently collected merotypes are of great value and if chosen carefully may have almost the value of synchronous merotypes.

It is to be hoped that in future botanists and collectors will arrange to label in some permanent way and to indicate clearly the exact location of trees or other perennial plants from which important specimens are collected which may by any chance be used as the basis for describing a new species. Of course it is imperative that the collector keep the material from this one plant distinct from any material that may be collected from other plants no matter how similar such plants may appear to be. In this way a collector can often provide a supply of merotypes which the author of the species may arrange to distribute to other specialists in his group and to the principal herbaria of the world.

BOTANY.—*A method of preserving type specimens.* MAUDE KELLERMAN, Bureau of Plant Industry, communicated by Walter T. Swingle.

As the importance of type specimens is more and more recognized by taxonomists of the present day, the necessity not only for fixed rules governing their selection but also some practical method for their preservation becomes apparent. The botanist, at any rate, cannot hope to bequeath his types to future generations with prevailing herbarium methods. Many type specimens are so fragile that even enclosing each sheet in a species cover is a very inadequate protection.

For type specimens, especially those of a fragile nature, a new method of preservation has been found that promises to be satis-

factory. This consists in the use of shallow cardboard boxes covered with binder's cloth and having a glass top. The box is about a half inch deep and is filled with several layers of cotton. The specimen is laid on the cotton, which presses it up against the glass cover when the mount is closed. The cover is held in place by long pins. Any fragments may be enclosed in small pockets of transparent paper. A small piece of Japanese lens paper placed under small or woolly portions of the plant will prevent their becoming enmeshed in the cotton. The label is placed under the glass at one corner as on regular herbarium sheets. A second label may be pasted on the lid so that the specimen can be found at once when in a herbarium case, without pulling out the box to see the label inside. Small pieces of camphor in the corners of the box will effectually prevent the entrance of insects. Mounted in this way the specimen is protected from dust and the danger of breakage to which it is exposed if mounted on a regular herbarium sheet. It may be examined without handling, and when using a lens for close study it is scarcely possible to detect the presence of the glass over the plant. At the same time access to it is possible in case it is necessary to study the reverse side of some part of the plant. Any original labels may be placed inside the box, thereby preventing their loss or separation from the specimen.

Specimens which are too thick to be mounted as described above may be placed in boxes from one to two inches thick. Such specimens often cannot be mounted in the ordinary way without danger of breakage and loss. Specimens with loose leaves may be temporarily reconstructed in such boxes, whereas one would hesitate to mount these leaves in a permanent manner. Minute fragments of types which would inevitably crumble away if mounted in the usual manner or enclosed in pockets may be placed in smaller boxes of this kind, and these boxes arranged in trays (with or without glass tops) the size of a herbarium sheet.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*A geologic reconnaissance of the Iliamna region, Alaska.* G. C. MARTIN and F. J. KATZ. Bulletin U. S. Geological Survey No. 495, pp. 138, with maps, sections, and views. 1912.

The Iliamna region, as here defined, covers an area of about 5000 square miles, situated in southwestern Alaska, west of the southern half of Cook Inlet and north of the Alaska Peninsula. Most of this field is new to the geologist, and the work accomplished contributes facts, particularly with reference to the Mesozoic sequence, which may help elucidate the stratigraphy and structure of adjacent districts.

The general stratigraphic section includes Quaternary deposits; Tertiary basaltic flows and tuffs, with some sedimentary beds; upper and Middle Jurassic shales, sandstones, and conglomerates; Lower Jurassic porphyries and tuffs; Upper Triassic limestone and chert; early Triassic or late Paleozoic greenstone and slate; and Paleozoic gneiss, schist, and crystalline limestone.

The more important stratigraphic features of this region are the recognition of the highly metamorphosed and presumably early Paleozoic gneisses in a district where they had not been previously known; the description of a newly discovered Triassic limestone containing an interesting coral reef fauna of Noric age, which extends the known distribution of Triassic reef corals into a latitude (60° N.) far beyond their previously known range; the re-definition of the Jurassic formations of Cook Inlet, which, because of the stratigraphic completeness of their development and the abundance and variety of the fossils of their several faunas and floras, constitute the best Jurassic section in North America; and the recognition of a large area of Tertiary lavas. The provisional lists of fossils consist however, chiefly of undescribed species.

The detailed structure of the district is largely unknown, but in general the Paleozoic rocks are severely deformed by folding and are metamorphosed; the Triassic rocks are strongly folded, the Jurassic rocks moderately flexed, and younger formations are flat or only slightly inclined. Triassic rocks are locally thrust upon Upper Jurassic rocks and normal faulting has affected all pre-quaternary systems. The principal structural trend is northeast and southwest. There were great abysmal intrusions during the Lower or Middle Jurassic, and there has been volcanic activity in Triassic, Lower Jurassic, Upper Jurassic, Tertiary, and Recent times.

The entire region was glaciated during the Quaternary, and a few small glaciers still persist.

The principal copper prospects of the region are in limestones at or near the contacts of greenstone and of granite. Others are in quartz veins traversing greenstone and granite. The silver prospects are manganiferous sphalerite-galena veins in limestones. The gold prospects are in pyritized fracture zones in granite and in quartz-latite tuffs, and these are reported gold placers. Petroleum seepages occur along the outcrop of the Middle and Upper Jurassic rocks. G. C. M.

GEOLOGY.—*Geology and coal fields of the lower Matanuska valley, Alaska.* G. C. Martin and F. J. Katz. Bulletin U. S. Geological Survey No. 500, pp. 98 with maps, sections, and views. 1912.

The coal field, situated in the lower part of the Matanuska valley, in the south-central part of Alaska, is one of the most important in Alaska. About 200 square miles of this region, including the larger part of the known coal field, has been mapped on a scale of 1 : 62,500, while adjacent areas have been covered by reconnaissance surveys.

The stratigraphic sequence within the area studied in detail includes Lower Jurassic, Lower (?) and Upper Cretaceous, Tertiary, and Quaternary deposits. There are also granitic masses of Mesozoic age, and intrusive diorite porphyries; trachytic rocks, and diabase and gabbro of Tertiary age. In addition to these rocks there are, in the surrounding region, Paleozoic or early Mesozoic schists, slates, graywackes, and greenstones, Middle and Upper Jurassic shales, sandstones, and conglomerates. The provisional lists of fossils include marine invertebrates from Lower, Middle, and Upper Jurassic and Upper Cretaceous horizons, together with Tertiary and possibly Upper Cretaceous plants.

The great structural feature of the region is the fault or fault zone which marks the straight south front of the Talkeetna mountains and

parallels the general course of the Matanuska river. The nearly parallel northern edge of the Chugach mountains may also be determined by faulting. In the valley the sedimentary rocks have been strongly folded. In most places definite structual details could not be determined. Two broad simple synclines which are modified by bounding fault planes are known.

The coal of the Matanuska Valley occurs in several isolated fields, only part of which are included in the area here described. The coal ranges in character from low-grade bituminous to a good grade of semi-bituminous, there being a progressive increase in degree of alteration from west to east. F. J. K.

HYDROLOGY.—*Ground water in Juab, Millard, and Iron counties, Utah.* O. E. Meinzer. Water-supply Paper, U. S. Geological Survey, No. 277, pp. 162, with maps and diagrams. 1911.

Juab, Millard, and Iron counties which lie in western Utah, are occupied by desert plains interrupted by Basin ranges, and are bounded on the east by the Plateau province. The formations exposed range from Pre-Cambrian to Recent. Much of the desert was covered by ancient Lake Bonneville and is underlain by lake beds.

Water is found chiefly in unconsolidated sediments confined within rock basins, igneous rocks forming more impervious basins than limestones. Alkali flats indicate the water level and therefore serve as guides in prospecting for underground supplies. Flowing wells are obtained from the unconsolidated sediments but not from the rock formations.

Characteristic of the region are large "pool" and "knoll" springs that yield warm water and are apparently related to faults. The pools are deep reservoirs bordered by projecting shelves formed of vegetable fibers and wind-deposited sand and dust. The knolls are a development of these shelves. Their flow is inversely proportional to their height, and their growth is limited by the hydrostatic head of the water.

O. E. M.

HYDROLOGY.—*Geology and water resources of Eastancia Valley, New Mexico, with notes on ground-water conditions in adjacent parts of central New Mexico.* O. E. Meinzer. Water-Supply Paper U. S. Geological Survey No. 275, pp. 69, with maps and illustrations. 1911.

The drainage basin of Estancia Valley, New Mexico, has an area of about 2000 square miles and forms a depression that has no outlet. Pre-Carboniferous crystallines, Carboniferous and Cretaceous sediments,

and later intrusives constitute the rock formations of the basin. The Carboniferous contains red beds and thick ledges of gypsum. Alluvial, lake, and wind deposits and precipitates from solution cover the rock floor of the valley. The lake beds are finely laminated; the wind deposits include dunes of gypseous dust or clay 100 feet high; the precipitates include one bed of common salt that is commercially valuable. In Pleistocene time a lake 450 miles in area occupied the basin, the strand of which is marked by ancient cliffs, terraces, beach ridges, spits, and bars. Post-lacustrine wind erosion has formed numerous basins with steep walls and flat bottoms that coincide with the ground-water level.

Encino and Pinos Wells valleys are small undrained depressions east of Estancia Valley. The former held a Pleistocene lake about 18 square miles in area, as is shown by an ancient strand and stratified beds, and has both pre-lacustrine and post-lacustrine wind deposits. Flat-bottomed, wind-scooped basins, characteristic of Estancia Valley, are found also in both of these valleys. The susceptibility of the clay to wind erosion is probably due to its gypsiferous character. Typical gypsum sand occurs in the Pinos Wells depression. O. E. M.

PHYTOPATHOLOGY.—*A plant disease survey in the vicinity of San Antonio, Texas.* FREDERICK D. HEALD and FREDERICK A. WOLF. Bulletin Bureau of Plant Industry No. 226, pp. 129, text figs. 2, plates 19. 1912.

The authors report a plant disease survey made during the summer and fall of 1909 and the winter and spring of 1910, in the area comprised within a circle having a radius of 100 miles from San Antonio, Texas. This region occupies the coastal plain of Texas in the south and east and extends into the Edwards Plateau and Llano country in the northwest. Maps show the places visited and the rainfall for 1909. Tables give the elevation of the principal stations, the annual precipitation for 1909 at 24 points, the maximum, minimum, and mean temperatures, and the average daily evaporation at the San Antonio Experiment Farm. The rainfall of the area studied is limited, ranging for the most part from 20 to 30 inches, while one-half of the area had a total annual precipitation of only 10 to 20 inches. The temperatures in summer are high and the evaporation large. The authors describe the crops and native vegetation of the area, and discuss the relation of the environmental factors to the plant diseases found. Chlorosis, probably due to excess of lime and to drought, is one of the most noticeable and characteristic pathological features noted.

The report is based on the determination of about 3200 specimens collected. These have been deposited in the mycological collections of the Bureau of Plant Industry, and most of them are duplicated in the herbarium of the University of Texas. Each specimen is referred to by number in the text.

For convenience of reference the diseases are grouped under ten headings: fruit trees, small fruits, truck crops, cereals, forage crops, wild and cultivated grasses, fiber plants, trees and shrubs, ornamental plants, and wild plants. Under each group the several crops are arranged alphabetically with their several maladies. The fact that the territory has been previously little explored has resulted in the finding of a large number of new fungi, which have been described by the authors in Mycologia, vol. 3, (1911), pp. 5 to 22. An index to literature of 51 titles is appended. W. A. Orton.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 704th meeting was held on February 10, 1912. Two papers were read: *Constancy of wire resistance standards*: FRANK WENNER, of the Bureau of Standards. To appear in this Journal.

The Measurement of inaccessible displacements, the production of temperature uniformity, and the determination of the expansion of gas thermometer bulbs: A. W. GRAY, of the Bureau of Standards. To appear in this Journal.

The 705th meeting of the Society was held on February 24, 1912. Two papers were read. *The nitrogen scale between 300° and 600°, and a new determination of the boiling point of sulphur:* A. L. DAY and R. B. SOSMAN, of the Geophysical Laboratory. See this Journal **2**: 167. 1912.

Comparison of the nitrogen and platinum resistance scale between 300° and 600°: H. C. DICKINSON and E. F. MUELLER, of the Bureau of Standards. See this Journal **2**: 176. 1912.

The 706th meeting was held on March, 9, 1912. Two papers were read: *Experiments on the light of the sky:* C. G. ABBOT, of the Smithsonian Institution. This paper gave an outline of progress in a research on the quantity and distribution of the solar radiation received indirectly by diffuse reflection from the sky. Preliminary experiments were begun in 1905 on Mt. Wilson and were continued in 1906. Further experiments were made at Flint Island in 1907, and in 1910 on Mt. Whitney with new and improved apparatus. The relative brightness of the sky with reference to zenith distance and to distance from the sun was given. The total quantity of indirect solar radiation, as compared with the direct, proved to be about seven per cent for Mt. Whitney (4420 meters elevation) at high sun. By adding the observed direct radiation on Mt. Whitney (1.71 calories per square centimeter per minute), the indirect (0.12), and that absorbed by water vapor (0.04) the va'ue 1.87 calories was reached This was less (as it ought to be) than the intensity found for the solar radiation outside the atmosphere at the sun's actual distance on the day of observation. This latter value was 2.00 calories.

On the formation of the solar corona, and the total solar eclipse of October 10-12, 1912: L. A. BAUER, of the Carnegie Institution of Washington. The speaker gave a preliminary summary of the general observat ons thus far made regarding the formation of the solar corona and the variations exhibited during the sun-spot cycle. Lantern-slides were given in illustration. It would appear that some force, in addition to the explosive forces and the repellant action of the pressure of light, of an electric or magnetic nature, is necessary to explain the curvatures of the coronal streamers, as has already been pointed out by various investigators. Thus a detailed and persistent study of the solar corona may throw light on the question of the magnetization of the sun itself. The subject

thus becomes one of interest not alone to the astronomer but also to the magnetician.

A brief statement was made with regard to observing parties during the total solar eclipse of October 9-10, 1912, the path of totality of which passes through the northern part of Ecuador and the central part of Brazil. The Department of Terrestrial Magnetism of the Carnegie Institution of Washington is planning to place as many of its South American parties as possible along the belt of totality. The special work to be undertaken will be the necessary observations for testing whether there is an observable magnetic or electric effect during the time of totality. The plans contemplate coöperation with astronomical parties sent out by other organizations.

Mr. Abbot spoke informally of the variable light transmission for different wave lengths in a spectroscope containing ultra-violet glass, the absorption being different for different wave lengths.

Mr. Humphreys spoke informally of Subring's observations of the variability in the position of one of the neutral points in sky polarization, and gave an explanation of its three different observed positions

The 707th meeting of the Society as held on March 23, 1912. Two papers were read: *An account of the work of the 26-inch equatorial at the Naval Observatory:* Asaph Hall, of the U. S. Naval Observatory. The speaker gave a brief historical account of the 26-inch equatorial telescope, and spoke of the changes that had been made in some of its parts since its installation in 1873. Lantern slides were exhibited illustrating its original and its present mounting in the new observatory.

The class of work for which the telescope has chiefly been used was mentioned and proposed work with it was outlined.

A new colorimeter: P. G. Nutting, of the Bureau of Standards. See this Journal **2**: 183. 1912.

R. L. Faris, *Secretary.*

GEOLOGICAL SOCIETY OF WASHINGTON.

The 250th meeting was held in the Cosmos Club January 10, 1912, and the following papers were given: *General remarks on mines, mining etc. in Peru, Chile and Bolivia.* Illustrated. Howland Bancroft.

Vanadium deposits in Peru. Illustrated. D. F. Hewett. This paper described vanadium deposits in two districts in western central Peru, the Yauli district in which vanadium is a constituent of asphaltite, and the Quisque district in which vanadium is found as the sulphide, associated with vanadiferous bitumens. The two districts are situated on the east slope of the Andes, at altitudes of 15, 300 and 16,200 feet respectively.

The Yauli deposits are numerous lenses of asphaltite lying parallel to the steeply dipping bedding-planes of Jurassic thin limestones and shales. The largest lens is 550 feet long and 22 feet wide. A dike of igneous rock lies parallel to the bedding planes in the footwall. Chemical data were given which indicated the association of vanadium with the bituminous material. The deposits are not exploited for vanadium at present.

The Quisque deposit, 80 miles northwest, was discovered in 1905. Vanadium is found as the sulphide, patronite, which is one of three substances forming a dike-like mass which fills a fault-fissure in Cretaceous shales. The deposit is in the center of an area in which igneous activity has been intense. The three substances composing the dike, are patronite, a sulphide of Vanadium; quisqueite, a highly sulphuretted bitumen; and a substance composed almost wholly of carbon. Analyses of the substances as well as microphotographs were shown which indicate their origin. The dike appears to have been forced into the fault fissure when molten; quisqueite and carbon segregated successively and patronite forms the eutectic of the mass.

By oxidation of the sulphide of vanadium a heavy gossan of oxidized minerals was formed, in which three new vanadates were found. The deposit is actively exploited and is the source of most of the vanadium of the market at present.

Remarks on the geology of the Panama Canal Zone. D. F. McDonald and T. Wayland Vaughan.

The 251st meeting was held in the Cosmos Club January 24, 1912.

New dolomite formations in Alabama. Charles Butts. In a recent survey of the Birmingham district, Ala., three new dolomite formations have been recognized, which were included in the reports of the Alabama Geological Survey in the lower part of the Knox dolomite. These are named, in descending order, the Potosi, Ketona, and Brierfield dolomites. The Brierfield is a steely-gray, highly siliceous formation 1200 feet thick. Some samples carry 40 per cent silica. The silica is mostly disseminated in the forms of quartz, filling small cracks and replacing the dolomite. On weathering the silica forms on the dolomite a crust which is either cavernous or covered on the outside with an irregular network of narrow ridges, giving a highly characteristic appearance, by which the formation can be recognized easily and certainly. The name is from Brierfield, Ala. The Ketona is a light-gray, coarse-grained, and very pure dolomite, running generally less than 2 per cent of insoluble matter. It is 275 to 800 feet thick. This rock is used for flux almost exclusively by the smelting furnaces of the district. The name is from Ketona, a quarry town several miles north of Birmingham. The Potosi is almost identical in character with the Brierfield and 275 to 500 feet thick. It is correlated with the Potosi dolomite of Missouri, whence the name. The Potosi and Brierfield dolomites are known only in the southwest corner of the Bessemer quadrangle, while the Ketona extends throughout the Bessemer and Birmingham quadrangles.

The Brierfield dolomite overlies the Conasauga limestone, the top of which is correlated with the top of the Nolichucky shale in Tennessee, where the Nolichucky is immediately overlain by the typical Knox dolomite. In Alabama, however, where the three new dolomites described above occur, the Potosi dolomite is overlain by the Knox dolomite, which is the equivalent of the Knox of Tennessee. Therefore in the Tennessee section there is a hiatus between the Knox dolomite and the Nolichucky shale which in Alabama is filled in part by the 2500 feet more or less of dolomite described above.

Clinton problems in the Southern Appalachians. E. O. Ulrich.

On certain constituents and the genesis of coals. Reinhardt Thiessen. Coals are chiefly composed of residue consisting of the most resistant components of plants, of which resins, resin-waxes, waxes and higher fats, or the derivatives of these, are the most important.

Living plants are chiefly composed of celluloses and proteins. The former comprising by far the larger bulk, constitutes the framework, while the latter is concerned in the vital functions. With these are associated other substances, among which are starch, sugars, fats, and oils which constitute reserve food-stuffs; waxes, resin-waxes, resins, and higher fats which perform mainly protective functions—as in cuticles, spore-exines, pollen-exines, bark, and waxy coverings; and resins and gums which are waste products.

These components differ very markedly in their resistance to various agencies. Those substances involved in the life and support of the plant are relatively labile, whereas those which perform some protective function, or are to be looked upon as waste products, are relatively very stable. The various members of these groups, of course, differ much in stablility and the first group as a whole may over-lap upon the second in this respect. The celluloses, for example, which form a complex, represented by a series of substances, like cuto-cellulose, true-cellulose, ligno-cellulose, hemi-cellulose, oxy-cellulose, lignin, xylan, pectine and nucine, differ considerably and stand about in the order given in their resistance to decomposing agencies. Of all the substances the resins, waxes, resin-waxes and higher fats are the most resistant.

At the death of the plants, governed by various conditions imposed in the deposit, a partial decomposition, maceration, elimination, and chemical reduction begins, brought about chiefly by organisms, mainly fungi at first and bacteria later. The least resistant components are removed first leaving the more resistant behind in a residue called peat. Peat contains a large amount of cellulose, possibly in a changed condition. The process of decomposition, begun in the peats, chiefly by biochemical means, is taken up and continued by dynamochemical means into and through the later stages and results in the various grades of coal, such as lignites, subbituminous, bituminous, cannel, and anthracite.

Of these coals, as far as examined microscopically, the lignites show a marked elimination of cellulosic components and a decided concentration of resins cuticles, spore-exines, and pollen-exines as compared with the peats. The subbituminous coals, although of the same or nearly the same age as the lignites, and originally of similar composition and origin, have been subjected to greater dynamochemical agencies and show a far greater reduction of cellulosic components and a greater concentration of resins, cuticles and exines than the lignites, and are composed largely of the latter groups of substances. In the bituminous coals, the concentration of resins, exines, and cuticles or their derivatives, is such that the coals are chiefly composed of these. The cannel coals are almost wholly composed of spore-exines, or the derivatives of the compounds composing them.

The degree of decomposition depends upon the species, kinds of parts, organs and products of the plants that contributed to the deposit originally, the efficiency and duration of action, chiefly of the biochemical agencies during the peat stages, and the efficiency and duration of the action of the dynamochemical agencies during the coal stages. The greater the efficiency of the agencies during the biochemical stages and of the dynamochemical agencies, and the longer the time of their activities, the greater the concentration of the more resistant components.

The paper was illustrated by lantern slides from photographs of thin sections of the various grades of coal.

ROBERT ANDERSON, *Secretary.*

THE BIOLOGICAL SOCIETY OF WASHINGTON

The 496th regular meeting was held at the Cosmos Club, March 16, 1912.

Under the head of *Brief notes and exhibition of specimens,* H. M. Smith exhibited a lantern slide picture of a bluebird that was found frozen fast in the opening of a hollow tree.

T. A. Palmer reported that about 250 elk have been captured during the winter in Jackson Hole, Wyoming, and in Yellowstone Park and its vicinity and have been transferred to National and State game preserves in other parts of the country.

The regular program consisted of three communications. E. W. NELSON presented translations of two extracts from the *Monarquia Indiana,* A Spanish work by Juan de Torquemada, published in 1723. The original edition was published at Seville in 1615. The first extract was an account of the Zoölogical Garden kept by Montezuma at the time of the conquest by Cortez. This large garden contained animals of all kinds indigenous to the country, and included also human albinos, dwarfs, and cripples. The care of the captive birds alone required the attendance of 300 servants. The fish-eating birds required 250 pounds of fish, and the flesh-eating mammals, the killing of 500 fowls each day. The Spaniards were greatly astonished at the display.

The second extract from the book was an account of a great hunt given by the Aztecs in honor of the Viceroy Don Antonio de Mendoza in 1540. On the day of the hunt more than 15,000 Indians went out very early in the morning and surrounded over five leagues square of land. They advanced from all sides and by noon had formed a circle man to man in the midst of which were a prodigious number of deer, rabbits, and coyotes. On account of the vast amount of game, openings were made in the circle and a part of the animals permitted to escape. The lines were then reformed and the people moved up until the enclosure was little more than a half league square and the Indians formed a wall two or three men deep. The killing then began and resulted in the destruction of 600 deer, 100 coyotes, and great multitudes of foxes, hares, and rabbits. The prong horn antellope was mentioned among

the deer, this being the most southerly record ever made for this animal and being hundreds of miles south of its present range.

The second communication was by W. E. Safford on *Cymbopetalum penduliflorum*, the ear-flower of the Aztecs. Among the plants brought from a distance to be planted in the gardens of the Aztec emperor was the *xochinacaztli*, or ear-flower, the aromatic, ear-shaped petals of which were used for flavoring chocolate. The botanical identity of this plant has remained unknown until recently, when it was established by the author of the present paper.[1] An account of it was first written about 1569 by Padre Bernardino de Sahagun, who called it *teunacaztli*, "the sacred ear," and said that it was much used for its fragrant odor and for drinking, ground up with chocolate. Dr. Francisco Hernandez, sent by Philip II, in 1570, to study the resources of New Spain described it under the heading "De Xochinacazli, seu Flore auriculæ." The description, in Latin, together with an imperfect and rude figure, was published in 1651, in the Roman edition of his work, prepared by Antonio Recchi; but a translation of this work into Spanish, by Fray Francisco Ximenez, without illustrations, had already appeared in the City of Mexico in 1615.

The tree is described as bearing long narrow leaves of a deep green color. The flowers, borne on a pendent peduncle, have petals purplish within and greenish without, shaped almost exactly like ears and having a very agreeable odor. It is a native of the *tierra caliente*, and in the *tiangues* and markets of the Indians there is nothing else more frequently found nor more highly prized than this flower, "the which is wont to give the greatest charm and taste, together with a very fragrant odor and flavor to that celebrated drink cacao, which they call *chocolate*, and it imparts to it certain tonic properties and wholesomeness as well. It is said that when drunk in water this flower dispels flatulency, causes phlegm to become thin, warms and comforts the stomach which has been chilled or weakened, as well as the heart; and that it is efficacious in asthma, ground to a powder with addition of two pods of the large red peppers called *texochilli*, with their seeds removed and toasted on a *comal*, which is a kind of griddle on which the natives toast and make their bread called by us *tortillas*, adding to the same three drops of balsam and taking it in some suitable liquor."

Since the time of Hernandez many works have appeared in which the economic plants of the Aztecs are discussed, including the recent *Notes sur la medecine et la botanique des anciens Mexicains*, by the Rev. A. Gerste, of the Society of Jesus, Rome, 1910. In none of these is the botanical identity of the *xochinacaztli* hinted at, though it is invariably mentioned.

The author of the present paper while working on the botany of the Annonaceæ, came across a photograph of annonaceous flowers, with ear-like petals, in the files of the Bureau of Plant Industry.[2] These

[1] *See Science*, 33: *470, March 24, 1911*

[2] See Smithsonian Report for 1910, p. 428. 1911

flowers were found by Mr. O. F. Cook in 1904 in the market of Coban, a town situated in the department of Alta Verapaz, Guatemala. The photograph was unaccompanied by notes as to the uses to which the flowers are applied, but in his journal Mr. Cook states that at Coban the flowers of an Anona were offered for sale both fresh and in the form of dried black petals curled up on the edges and heavily veined inside; and that they had a pleasant spicy odor. He describes the sepals and three outer petals as light green and the three inner thicker petals as pale dull salmon colored, breaking with a bright orange-colored fracture. No specimens of the plant were collected at this time, but on May 30, 1906, two years afterward, Mr. Cook collected an Annonaceous plant at Jacaltenango, Guatemala, which he did not associate with the flowers of the Coban market so beautifully photographed by Mr. C. B. Doyle, his assistant. The specimens in the U. S. National Herbarium (sheet no. 574411) consisted of young branches with leaves and flowers. It was a simple matter to test the nature of the petals by chewing one of them They proved to be pungently aromatic, suggesting the flavor of nutmeg or perhaps of cubebs. The identity of the *xochinacaztli* was revealed. From its taste it seemed to have been appropriately placed, as Hernandez had placed it, among the spices.

Cymbopetalum penduliflorum, first described by Dunal, in 1817, from drawings made by Mociño and Sessé, without any indication of its aromatic properties or its common name, is endemic in the forests of northwestern Guatemala and southern Mexico. Closely allied to it are two other species *Cymbop talum stenophyllum* Donnell Smith, and *Cymbopetalum costaricense* (Donnell Sm.) Safford. It is not yet known whether the flowers of the latter species are aromatic like those of the species above described. *Cymbopetalum costaricense* was described by Captain John Donnell Smith from specimens accompanied by fruit but without flowers as *Asimina costaricensis*. The fruit, which consists of a cluster of oblong berries, containing a number of seeds, formed from the individual carpels and radiating from a common receptacle, strongly suggests that of our common *Asimina triloba*, though considerably smaller, and it is not surprlsing that in the absence of flowers Captain Smith should have placed it in the genus Asimina. Its true generic position was determined by flowering specimens in the National Herbarium (sheet no. 592582) collected by Professor Henri Pittier, accompanied by immature fruit and the characteristic flowers of Cymbopetalum, with their 3 inner ear-shaped petals. Professor Pittier's specimens (ex Herb. H. Pittier no. 13459) were collected by him in July, 1899, on the banks of the Rio Blanco, Santa Clara, Costa Rica, at an elevation of 300 meters.

Mr. Safford's paper was illustrated with many lantern slides from photographs and drawings of the plants mentioned.

The third paper was by H. L. Shantz and L. J. Briggs on *The wilting coefficient as an aid in the study of plant associations*. (See Bull., Bureau Plant Industry No. 230).

D. E. Lantz, *Recording Secretary*.

ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 458th regular meeting was held in the New National Museum, February 6, 1912. Professor MITCHELL CARRELL presented a paper entitled *The excavations at Knossos or labyrinth of Minos,* illustrated.

On February 20 the retiring president, DR. J. W. FEWKES, made an address on *Great stone monuments in history and geography,* in the New National Museum. This paper wi l appear in full elsewhere.

The 459th regular meeting was held in the New National Museum, March 12, Miss DENSMORE read a paper on the *Sun dance of the Teton Sioux.* This was based upon a study made among the Teton Sioux on the Standing Rock reservation in North Dakota and represents the usage in that band of the tribe. The study was conducted in a series of councils to which the old leaders of the tribe came from a radius of about 100 miles. Fifteen reliable men were selected to give the account of the dance, their authority being established by interviews with about forty members of the tribe, in widely separated localities. Those who took part in the councils were men who bore upon their bodies the scars of their participation in the sun dance tortures, and among them were the man who acted as intercessor in the ceremony and the man who "did the cutting of those who fulfilled vows," both men being the only Tetons living who had performed these official acts. The men comprising the sun dance council, with the speaker and an interpreter, visited the site of the last sun dance held by the Teton Sioux in 1882, the site being identified by the Indians. The place where the dance pole was erected, the outline of the "shade-house" and the location of the "sacred place" were recognized and measurement showed them to be correct, according to the usual plot of the sun dance grounds.

This dance was held annually by the Sioux and was distinctly a religious ceremony. The fulfilling of vows of torture was an important part of the ceremony, the vows having been made by men in danger on the warpath. When making the vow they asked for a safe return and that they might find the members of their family alive and well, and the fulfilment of the vow was required whether the prayer was granted or denied.

The paper was illustrated by songs of the sun dance which had been recorded by the phonograph and were played on the piano. Many of these were ceremonial songs and known only to the man who sang them for the speaker. One of these men has died since the songs were recorded. A collection of old ceremonial articles used in the sun dance was also exhibited.

The 460th regular meeting was held April 10 in the New National Museum. Professor PITTIER delivered an address on *Notes on the native tribes of Panama,* with all of whom he came in contact in the course of his recent travels in the Canal Zone.

There is much confusion current as to the number of the so-called tribes and the stocks to which they are related. The many names recorded correspond in fact not to distinct tribes, but merely to villages, names of chiefs, or, in a general way, to what the old Spanish chroniclers used to design as "parcialidades."

In the present time, there are east of the Canal Zone only two distinct "nations," viz., the Cunas, or Cuna-Cuna, to which the San Blas Indians belong, and the Chocoes to the South, beyond the Tuyra River. The line that separates these two stocks is at the same time the ethnological boundary between South and Central America.

The Cunas are a numerous and strong race, almost uniformly of short stature and broad shoulders. They are very jealous of their independence and shun all interference on the part of strangers, including the Panamanian government, the authority of which over them is only nominal. The Cunas of the northern coast, east of Nombre de Dios, or San Blas Indians, are far above the other Panamanian aborigines in their social and economic development; they constitute one of the best elements of the population included in the territory of the young republic, being thrifty and enterprising and having made of their extensive coconut palm plantations a real source of wealth. The remaining Cunas, known as Bayanos, Chucunacas and Payas, live in the interior and are less advanced, the two former groups being acknowledged as real "Indios bravos." All speak one language, with slight local variations.

The Panamanian Chocoes are but the northernmost branch of a numerous stock which extends more or less continuously along the Pacific coast of South America, from Punta Garachine in Darien, to the Ecuadorian boundary. In the Sambu Valley, where Professor Pittier found them, they are a happy lot, usually tall and well built, scantily clothed and living near to nature.

West of the Canal Zone, in the mountains of Veraguas and eastern Chiriqui, live the ploygamous Guaymies, once under the care of the Spanish missionaries, but who have long since gone back to their own independent life and customs. They do not however avoid or repel the contact with the other natives, and owing to the rapid expansion of the neighboring populations, so-called civilized, the Guaymies are doomed soon to lose their characteristic and individuality as a race. Certain ethnological traits, as well as their physical appearance point to a relationship with Costa Rican tribes.

In consequence of what Professor Pittier calls a "caprice of arbitration," the Republic of Panama has acquired the northern branch of the Térrabas or Tirúb of Costa Rica. These dwell in small and rapidly dwindling numbers at the headwaters of the Tararia or Tilorio, the main branch of the Changuinola River. They have been investigated by Pittier in the course of his survey of Costa Rica.

These four are the tribes represented today in Panama. The Dorasques, supposed by some to descend from the great Chiriqui pottery makers, seem to have disappeared, unless the Brunka of Costa Rica are really what is left of them.

With reference to the possible affinities of the Panamanian tribes with the neighboring stocks, the speaker took absolute exception to the theory of the Chibchan relationship, which he was one of the first to advocate about twenty years ago and which has since received general acceptation under the authority of Brinton, Deniker, and others. The assumed

relationship is founded merely on linguistic analogies and on the apparently common origin of a number of words. But these facts can be taken as conclusive only if supported by common anthropological characteristics and also by partial community of uses and customs. Physically, the Cunas are strikingly distinct of the Guaymies and the Costa Rican Indians, and both stocks offer none but general racial likeness to what is left of the original Chibchas. In the opinion of Professor Pittier the origin of the Cuna-Cuna has to be looked for elsewhere than in the interior of Columbia, and the Guaymies, Valientes, Bribri, Térrabas, Sumos, etc., are more likely to be the remnants of a primitive autochtonous stock. Pittier's talk was illustrated by lantern-slides and by objects collected among the Chocoes and Guaymies.

TRUMAN MICHELSON, *Secretary.*

PROGRAMS AND ANNOUNCEMENTS

WASHINGTON ACADEMY OF SCIENCES AND THE PHILOSOPHICAL SOCIETY OF WASHINGTON

A joint meeting of Academy and Philosophical Society will be held Saturday evening, May 4, 1912, at the Cosmos Club. Professor DAYTON C. MILLER of the Case School of Applied Sciences will speak on *Sound waves; how to photograph them and what they mean.* To be illustrated by lantern slides, apparatus and experiments.

THE CHEMICAL SOCIETY

The 216th regular meeting will be held Thursday evening, May 9, 1912, at the Cosmos Club. Dr. H. M. WILEY will speak on *The value of chemistry to the medical profession.*

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. II, MAY 19, 1912 No. 10

ASTRONOMY.—*On "earth light," or the brightness, exclusive of starlight, of the midnight sky.* W. J. Humphreys. To appear in the Astrophysical Journal.

Investigations begun some years ago by Newcomb,[1] and continued by Yntema,[2] Fabry,[3] Abbot[4] and others, have conclusively shown that there is more light in the midnight sky than can be accounted for by the stars alone. It is not due to nebulae or any other constant source since its brightness varies from night to night and even during the same night; nor can it be caused by anything entirely outside the atmosphere, since it increases in brightness as the horizon is approached.

It has been suggested by Yntema that it may be due, at least in part, to a permanent Aurora, and indeed this is highly probable from the fact that the green "auroral line," λ5770, may be seen on almost any dark clear night in any part of the sky.[5]

But there is another possible source of sky light, possibly of the "permanent aurora" itself, that deserves consideration; namely, the bombardment of the outer atmosphere by material of meteoric origin. So far as such a bombardment produces light at all it must be through a considerable depth of the rarer portion of the atmosphere, and therefore it should appear brighter as the zenith distance is increased.

For simplicity of numerical calculations it will be assumed that "earth light" is both constant and uniform—the same over

[1] Astrophysical Journal, 14: 297. 1901.

[2] On the Brightness of the Sky and the Total Amount of Starlight. Gronigen: Gebroeders Hoitsema. 1909.

[3] Astrophysical Journal, 31: 394. 1910.

[4] Annual Report Smithsonian Institution, 1911, p. 64.

[5] Campbell, Astrophysical Journal, 2: 162. 1895.

all parts of the sky, invariable, and continuous. It will also be assumed that whatever the size of meteoric masses, (doubtless the vast majority are but minute grains) their light producing efficiency, or ratio of luminous to total energy, is the same as that of the sun.

With these assumptions it is possible to compute, from known data, the rate at which meteoric material must be picked up to produce the observed amount of "earth light," as follows:

"Earth light" per 10 square degrees = star of first magnitude.

Full moon = star of -11.77 magnitude = 120,000 stars of first magnitude.

Area full moon = 0.2 square degree.

Hence, brightness full moon = 6×10^6 brightness of "earth light."

But the brightness of the full moon is equal to that of a white-mat surface illuminated by a 1200 candle-power light at one meter's distance,[6] or, in symbols, 1200 m.c. (meter candles).

Hence brightness of earth light = 2×10^{-4} meter candles.

Now normal zenith sunshine = 10^5 m.c.,[1] or is 5×10^8 times brighter than "earth light," and consequently delivers 25×10^7 times as much energy per square centimeter as would be radiated from both sides combined of a self-luminous shell equivalent in brightness to "earth light."

Hence, since the solar constant is about 1.92 calories per square centimeter per minute, the total energy used, according to the above assumptions, in the production of "earth light" is

$$4\pi R^2 \times \frac{1.92}{25 \times 10^7} \text{ calories per minute,}$$

in which R is the radius of the earth in centimeters, or

$$27 \times 10^{15} \text{ ergs per second, roughly.}$$

Let this energy be supplied by M grammes of matter moving with the average velocity of meteors, or 42 kilometers per second, then

$$\tfrac{1}{2} MV^2 = 27 \times 10^{15}$$

$$\text{or} \qquad M = 3 \times 10^3 \text{ roughly.}$$

[6] Circular of the Bureau of Standards, 28: 7. 1911.

This is less than three times the amount of meteoric material Young[7] assumes as allowable, and, so far as there is any present means of knowing, may be even less than the actual amount caught up by the earth per second. Indeed it is so small that it would take about two hundred million years for it to increase the radius of the earth a single centimeter!

Numerical calculations, therefore, show that, though not proved, it is within the bounds of reason to assume "earth light" somehow due to bombardment of the outer atmosphere by fine meteoric material; and hence the possible effect of such bombardment should be taken into account in the planning of much needed further observations.

METEOROLOGY.—*Dust layers in the atmosphere and changes in the neutral points of sky polarization.* W. J. HUMPHREYS. To appear in the Bulletin of the Mount Weather Observatory, 4: pt. 6.

It is well known that sky light is, in general, partially polarized, and that the percentage of polarization varies from one point to another in the sky and also from day to day.

If the light is analysed into vibrations parallel and perpendicular respectively to the horizon, certain neutral arches will appear whose direction at every point makes an angle of 45° with the plane of polarization. If however the analysis of the light is not into these two arbitrary planes, but into the planes of maximum and minimum vibration, and if the direction indicated by the maximum vibration be followed, one is led to a neutral point, the lowest or highest, as the case may be, of the above mentioned arches. The lowest, if it is above either the sun or the antisolar point; the highest, if it is below either of them. In this latter case however, only one of these points, the one below the sun, known as Brewster's neutral point, can be actually observed, the other is always in the shadow of the earth, and, in fact, is purely imaginary.

Along the sun's vertical, but between the sun and its nearly

[7] General Astronomy, p. 475.

equally distant neutral points, Brewster's point below it, and Babinet's above, the polarization plane is parallel to the horizon, as it also is between the antisolar point and its companion, Arago's neutral point. Between Babinet's point and Arago's point however, the plane of polarization along the sun's vertical is perpendicular to the horizon. Hence, when observations are confined to the sun's vertical, as they often are, the neutral points are those points of this vertical at which the two polarizations, vertical and horizontal, are equal.

The vertical polarization is due almost entirely to the primary scattering of solar light by the dust in and the molecules of the atmosphere, while the horizontal polarization appears to be due essentially to secondary scattering. And as both the relative and the absolute intensities of these two quantities of light, as seen by an observer at the surface of the earth, are functions of the amount and distribution of dust in the atmosphere, it follows that the positions of the neutral points must also be functions of the dust in the atmosphere and its distribution; and, as a matter of fact, observations indicate the existence of distinct dust layers with fairly defined upper boundaries.

The first of these, effective in its action on the position of the neutral points when the sun is only about 1° below the horizon, is only that lower and relatively dense layer of dust, seldom more than 1 kilometer thick, that is so frequently seen from mountain tops and from balloons. It is essentially a dry weather condition and is due to dust caught up from the surface of the earth by winds at times when there is but little vertical convection.

The second dust layer, effective when the sun is roughly 3°.5 below the horizon, and therefore extending to an elevation of about 4 kilometers, is due to that great quantity of dust that is distributed thru the atmosphere up to this level at the times of rather strong vertical convection, or at the times when cumulus clouds prevail. It is well known that 4 kilometers is one of the levels of maximum cloud formation—the level of the cumulus cloud. That is, it is the ordinary limit of vertical convection during clear weather. Hence, as a result of this considerable

and frequent mixing of the lower atmosphere, from the surface of the earth up to a level that averages 3 to 4 kilometers, there must in general be considerably more dust up to this same level than there is at greater elevations.

The vertical temperature gradient thru the first 3 kilometers or so, generally is much less than the adiabatic, and hence ordinary convection, cumulus clouds, and, of course, the corresponding dust layer, usually are all restricted to comparatively low levels. Strong cyclonic storms, however, produce convections that overcome the temperature gradient of the lower atmosphere and extend quite to the undersurface of the isothermal region, beyond which level vertical convection obviously can not greatly extend. Dust, therefore, in greater or less extent is distributed, on such occasions, thruout the convective atmosphere, or up to the under surface of the isothermal region, 11 kilometers or thereabouts above sea level.

This then is the third and last possible dust layer of the atmosphere, each layer in turn being of increasing thickness and decreasing density, and all three, but not more, are essential to the physical interpretation of observations on the neutral points of sky polarization.

METEOROLOGY.—*Holes in the air.* W. J. Humphreys. To appear in Popular Science Monthly.

There are, of course, no holes in the ordinary sense of the term in the atmosphere, no vacuous regions, but for all that the picturesque phrase "Holes in the air," is likely to become a permanent acquisition to the language of aeronautics since it is both brief and elegantly expressive of the fact that occasionally there are conditions in the atmosphere which, so far as flying is concerned, are quite like unto holes—conditions that cause sudden drops and disastrous falls.

These may be classified as follows:

1. *Aerial fountains.* More or less vigorous uprushes of air occur over dry heated ground, and especially above barren conical hills, during warm summer afternoons. When the vertical velocity of this heated air is 10 feet per second or more, as it often

is, the inexperienced aeronaut may be seriously disturbed by running suddenly into or out of the rising column. It is probable however that the chief danger is not in the rising column itself but rather at its top where, as we see by the motions of the heads of cumulus clouds, there is great turbulence and a confusion of currents.

2. *Aerial cataracts.* Downrushes of air, like the uprushes with which they are associated, must also be most frequent during warm weather when the ground is strongly heated. But though annoying to the beginner they should not be dangerous to the experienced aviator, because, however strong their descent at considerable elevations, they necessarily become horizontal before the surface is reached.

3. *Aerial cascades.* The swift downward sweep of the wind on the lee side of steep mountains tends to carry the aviator with it to lower levels, but this in not a source of danger unless by flying low he gets caught in an eddy.

4. *Wind layers.* As fair weather is giving way to foul sharply defined layers of air often slide over each other in different directions and with different velocities, and by so doing produce one of the most serious dangers the aeronaut has to confront. Suppose, for illustration, that in making a straight away glide with the engine at rest the aeronaut should suddenly enter a wind layer moving in the same direction and with the same velocity. Under these extreme but possible conditions all dynamical support and all power of adjustment are instantly lost and a drop, either to the earth or until a considerable velocity with reference to the air is again obtained, is inevitable. Such an extreme case of course is unusual, but less extreme cases are frequent, and since the support is proportional to the square of the velocity of the machine with reference to the air even a comparatively small decrease in this velocity may cause a considerable drop, which, if begun near the surface of the earth, may well be dangerous.

5. *Wind billows.* Wind layers, as they glide over each other, are thrown into billows quite like unto water billows under the influence of strong winds; and since they mark the boundary of currents of different velocity or direction or both, it obviously

is not safe, as just explained, for an aeroplane to take the billow level and thus pass back and forth from the one to the other wind layer.

6. *Wind eddies.* Wherever the wind is forced by obstructions markedly to change its direction, and wherever it flows over steep hills and mountains eddies are certain to exist. These generally are most marked during strong winds and on the lee sides of steep hills and bluffs. The upper portion of the eddy moves in the same direction as the prevailing wind to which it is due and the under portion in the opposite direction. Hence in passing thru such an eddy an aeronaut may, as explained under "wind layers," get into serious trouble. He may also get caught on the forward side of the eddy and be rapidly carried down. Therefore during strong winds the lee sides of hills and bluffs should be avoided.

7. *Aerial torrents.* Air drainage down steep and barren valleys occasionally amounts to a veritable aerial torrent near the surface of the earth while the atmosphere directly above is relatively at rest. Hence it necessarily must be dangerous to land an aeroplane under such circumstances, and especially so, as above explained, if it is headed with the torrent.

8. *Aerial breakers.* At the onset of thunder storms the wind often is of the breaker nature, violent and irregular, and therefore so dangerous to the aeronaut that it would be fool hardy to attempt a flight under such conditions.

CLASSIFICATION

All the above atmospheric conditions may conveniently be divided into two groups with respect to the method by which they force an aeroplane to drop as if in a hole of some kind:

a. The vertical group. All those atmospheric conditions, fountains, cataracts, cascades, breakers, and eddies that, in spite of full speed ahead with reference to the *air*, make it impossible for an aeronaut to maintain his level depend for their effect upon a vertical component in the motion of the atmosphere.

b. The horizontal group. Those conditions of the atmosphere,

wind layers, billows, torrents and the like, that, in spite of full speed ahead with reference to the *ground*, abruptly deprive an aeroplane of a portion of its support, owe their effect to a running of the wind more or less with the machine.

Both groups are sources of danger to the aeronaut and therefore he should become well acquainted with the meteorological conditions under which and the places at which they are most likely to occur. But this is a story whose details are beyond the scope of the present article.

METEOROLOGY.—*Hurricanes of the West Indies and other tropical cyclones.* OLIVER L. FASSIG. Communicated by W. J. Humphreys. To appear as a special Bulletin of the U. S. Weather Bureau.

An analysis of 135 storms of hurricane force that occurred in the West Indies, as recorded by the U. S. Weather Bureau, from 1876 to 1910, shows that there is a well marked path of greatest hurricane frequency which, beginning near the Windward Islands, runs nearly due west across the northern half of the Caribbean Sea to Jamaica, gradually turns northwest, passes thru the Yucatan Channel, recurves in the eastern portion of the Gulf of Mexico, and finally, after crossing the Florida Peninsula, passes out over the North Atlantic with a northeast trend.

A secondary hurricane path, not so well defined, extends from the northern group of the Windward Islands in a west-northwest direction across the Bahamas and, recurving east of Florida, passes out also northeasterly onto the Atlantic. Tho the Greater Antilles lie between these paths two of them, Porto Rico and Haiti, are comparatively free from the devastating winds near the hurricane centers. The western half of Cuba, however, is crossed in the recurve of a large percentage of the Caribbean storms that belong to the main path.

From the above descriptions it will be observed that the two storm paths closely coincide with the two branches of the great equatorial current of the North Altantic.

In both cases the normal path for the entire season resembles a parabola, though the exact path pursued by an individual

storm depends to a great extent upon the point of its origin, which indeed may be at any portion of the track. (Of 134 individual storms examined 84 originated in the first branch of the normal track, 23 in the recurve and 27 in the second branch.) But wherever the storm may originate, for the balance of its existence it will follow approximately the normal path for the month in which it occurs. Thus those that originate far to the east, as they generally do in August and September, are most likely to move west-northwest for a considerable distance before recurving, while those that originate in the western waters of the Caribbean Sea, as do most of the storms early in the season and also those of October, move northwest or north along the recurve of the normal track.

The following tables give some of the more important facts in regard to hurricanes.

HURRICANES OF 1876–1900

	MONTH OF OCCURRENCE						
	May	June	July	August	September	October	November
Number of storms.....	1	8	5	33	43	42	2
Percentage of total....	1	6	4	25	32	31	1

MEAN VELOCITY OF 136 STORMS

	LOCATION		
	First branch	Recurve	Second branch
Miles per day	260	260	390

DURATION OF HURRICANES IN FIRST BRANCH AND IN RECURVE

NUMBER OF EXAMPLES	DURATION IN DAYS								
	1	2	3	4	5	6	7	8	9
First branch.....	15	21	16	7	7	13	4	1	1
Recurve.....	26	46	15	5	3	2			

AREAS WITHIN WHICH TROPICAL CYCLONES ORIGINATE

NAME	LATITUDE	LONGITUDE	MEAN ANNUAL FREQUENCY
Hurricanes (West Indies).....	12°–28° N	55°–95 W	4
Cyclones (Bay of Bengal).....	8°–22° N	80°–100° E	9
Typhoons (North Pacific).....	5°–20° N	115°–150° E	20

Conditions favoring the formation of the West Indian and other cyclonic systems in the tropics are produced by changes in the positions and intensities of the so called permanent areas of high and low atmospheric pressure incident to seasonal changes and to variations in the intensity of isolation. Hence there are three and only three regions, as listed above, all more or less similar, in which destructive tropical storms originate. Once formed these systems are carried along in the general drift of the atmosphere—from east to west below about latitude 30°N., and from west to east in higher latitudes.

PHYSICS.—*New methods for displacement measurements and temperature uniformity applied to the determination of linear expansivity.* ARTHUR W. GRAY. Bureau of Standards. Communicated by L. A. Fischer.

This communication describes certain improvements in two of the fundamental operations involved in the determination of linear expansivity, viz., (1) The measurement of displacements that occur within places difficult of access, and (2) The production of uniform temperature thruout an extended region. The paper concludes with pointing out how the methods set forth might find a special application in the problem of gas thermometry. Some features were outlined at the Washington meeting of the American Physical Society in December, 1911.[1]

The measurement of inaccessible displacements. Essentially the method consists in determining the displacement of an inaccessible point by observing a stretched wire so arranged that its motion follows that of the point in a known way. In order to eliminate from the measurements any elongation of the wire,

[1] A. W. Gray, Phys. Rev. 34: 139. 1912.

whether from thermal expansion or other sources, the direction in which it is stretched should be as nearly as possible perpendicular to the displacement. This procedure of arranging the link connecting the accessible with the inaccessible region at right-angles to the displacement is, perhaps, the most important feature of the method; and it is applicable to a greater or less extent in mechanical schemes for transferring motions thru the intervention of rods as well as of wires.

Two simple arrangements in which the principle has been successfully applied for determining the linear expansion of bars are represented diagramatically by figs. 1 and 2. In each the expanding bar

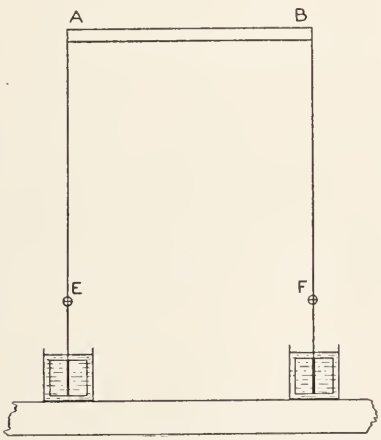


Fig. 1. Elongations by method of suspended wires.

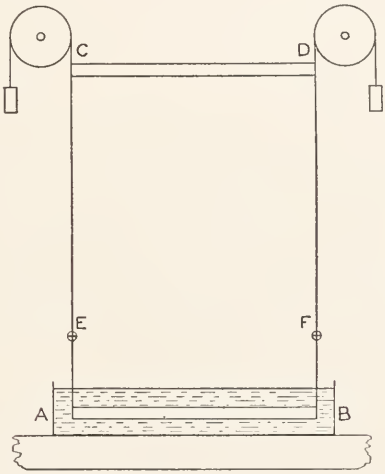


Fig. 2. Elongations by method of stretched wires.

is indicated by AB. In the former, wires are freely suspended over the ends of the bar and stretched vertically by the weight of vanes immersed in oil, the viscosity of which is adjusted to damp any swinging of the wires so that their motions will be almost, but not quite, aperiodic. In the latter, suitable for cases in which the bar is immersed in a liquid, wires are stretched upward to another bar CD rigidly connected with the central portion of AB. In both arrangements the motions of the wires are observed through micrometer microscopes focused at convenient points E and F. A piece of thin white paper, illuminated from behind by a small incandescent electric light form a bright background most agreeable to the eye, on which a wire stands out as a dark bar with smooth, straight edges. Disturbances from changes in level of

AB are avoided by grinding its ends to form portions of a horizontal cylinder, the axis of which passes thru the center of the bar. The wires should be protected from air drafts.

In the arrangement of fig. 1 the change in the distance separating the wires is the same as the elongation of AB. When adjustments are properly made, the damping is so effective that the wires appear perfectly still without the need of any such stable support as a pier; yet if disturbed, even by such vigorous treatment as removing and replacing the oil bottles, they promptly return to their original positions. Repeated trials have shown that a precision of better than a micron is easily obtainable in measuring the distance between two wires thus suspended.

In the arrangement of fig. 2 deduction of the length of AB from the measurements is a simple matter. The influence of possible changes in CD can be rendered negligible by suitably controlling its temperature and by placing it far enough away from AB and EF; but if this is not feasible, the proper correction can usually be computed without difficulty.

Since the passages thru which the wires enter the inaccessible region may be very long and of cross-section barely sufficient to permit free motion, the effect of the openings upon conditions within (such as temperature distribution) can be reduced to a minimum. If it is desired to work in a vacuum, or in some special atmosphere, the passages may be extended on the outside by an envelope completely incasing the wires and the external bar or damping vanes. The motions can be observed through plate-glass windows. A further decided advantage of the method consists in eliminating certain optical difficulties which present themselves when direct vision thru openings into the interior is attempted.

The production of temperature uniformity. If a region in which no heat is generated or absorbed be surrounded by an isothermal envelope maintained constantly at the same temperature, all points within will ultimately come to this temperature. The approach to thermal equilibrium will be hastened by anything which increases the influence of radiation, conduction, or convection within the region. The main difficulty of the problem, then reduces to that of securing such an isothermal envelope.

If the region in question has, by any suitable means, been heated uniformly to the desired temperature T, then any procedure which will eliminate heat loss or gain at every point of the surface will maintain T constant and uniform. The rate dQ/dt at which heat will be conducted away from any portion of the bounding surface in consequence of a normal temperature

gradient $-dT/dN$ and a thermal conductivity k in the surrounding substance, will be directly proportional to both dT/dN and k. Encasing the region in a poor conductor of heat will reduce the latter, and making the layer thick will reduce the former; but this procedure will never eliminate completely either of these factors. However, dT/dN and, consequently, dQ/dt can be made to vanish by supplying heat around the surface in such a way as to compensate exactly for the loss at every place. But the accurate regulation of such a supply presents difficulties which augment rapidly as T departs from the surrounding temperature, because the increased heat flow involved is subject to greater irregularities of surface distribution and to greater fluctuations with time. Conductivity parallel to the boundary, or the much more efficient action of a circulating fluid, will promote a uniform distribution of both the losses and the supply. The usual practice of abundant thermal insulation outside the source of heat will reduce variations in the former but not in the latter. But the effect that variations in either will produce upon the temperature of the region to be controlled can be materially lessened by the introduction of an insulating layer between the region and the source; since the mere separation of the two will reduce the already small dT/dN and also its rate of change $\frac{d}{dt}\left(\frac{dT}{dN}\right)$ at the surface of the former, while the reduction in k will still further lessen dQ/dt and d^2Q/dt^2. Whatever variations continue to exist near the region can be still further reduced by applying a small, properly regulated supply of heat around the surface, but best separated from it by an insulating layer for the reasons just given.

Neglect of certain of the conditions discussed above is quite justifiable where simplicity of construction and operation is more essential than refinement of temperature control. However, proper design of the temperature bath and its accessories can go a long way towards realizing the ideal conditions without introducing troublesome complications.

Attention is first directed to a simple device in which the principles just enunciated have been successfully employed to reduce the long-

itudinal temperature gradient in a tubular air bath of considerable length. It is a plug formed of two thick blocks of a good heat conductor united by a thin shell and separated by a considerable layer of a poor conductor. Fig. 3 represents one in each end of a tube the circumference of which is heated by a fluid circulating spirally around it and returning to the inlet end by linear flow through an outer concentric passage. In such a return-flow tube, whose ends were plugged for 10 cm. essentially as indicated, though not quite so well, an air column 4 cm in diameter and more than a meter long has been repeatedly heated by circulating oil to over 100°C. so uniformly thruout its entire length that right against the plugs the temperature was only a few hundredths of a degree lower than in the center, while several centimeters farther inward the drop was only a few thousandths. Yet with

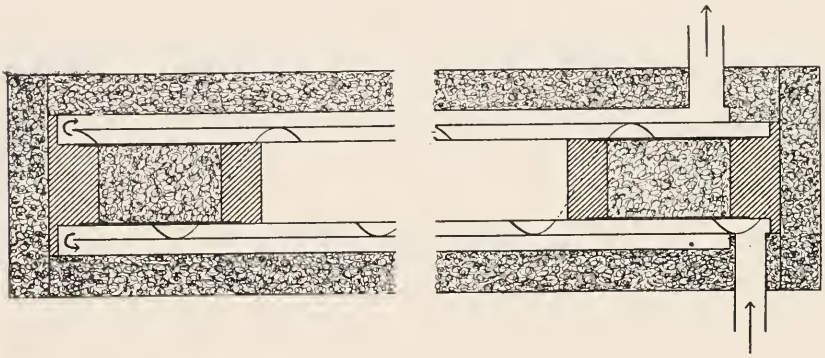


Fig. 3. Oil-heated return-flow tube showing double plugs to reduce temperature gradient.

the ends closed by equally long plugs of such heat insulators as cotton-wool and cork there was a marked lowering of the temperature in the immediate vicinity within, even when the interior was only slightly warmer than the room; and in many of the experiments made this drop was apparent for a long distance within the tube. If the inside tube (of brass 1 mm. thick) were extended 4 cm. beyond the heating jacket, relatively enormous end effects were produced in the air column, especially if the projections were not well protected by lagging. But unhindered radiation and conduction through the sides of the tube to the surrounding air was found to disturb the distribution of temperature within only slightly. In nearly all cases where the tube was not surrounded by an insulating jacket, there was evidence of a small progressive drop in temperature in the direction away from the inlet and exit end. Doubtless this could have been made imperceptible by substituting a poorly conducting tube for the thin brass one separating the oppositely directed currents of heating fluid.

One important object of the experimental study that developed the simple plug just described was to secure data for improving the design of electric furnaces, especially in the direction of bettering the distribution of temperature. The return-flow, oil-heated tube was used in order to secure uniform lateral heating, and thus to avoid confusing the observations by the effect of such irregularities as would be almost sure to exist in an electrically heated helix, no matter how carefully wound.

Previous experimenters have tried to secure uniformity of temperature in an electrically heated air column by using the central portion of a sufficiently long tube and by crowding the windings near the ends or other places where heat was lost most rapidly. In this way Daniel Berthelot[2] secured uniformity within 2° over the central 22 cm. of a tube 85 cm. long heated to 917.° Jaquerod and Perrot[3] in a well-insulated furnace without crowded windings heated a gas thermometer bulb 8 cm. long with variations of less than 2° at 1066°. Waidner and Burgess[4] constructed a black-body in which compensation for heat losses thru the ends was secured in great measure by the use of a second independent heating coil surrounding the first and projecting 8 cm. beyond each end. The winding of the secondary coil was very close about the ends and very open about the center. At 1244°.9 this arrangement gave such remarkably uniform temperature that there was no variation of more than one or two tenths of a degree over a length of 12 cm. However, the method of varying the distribution of heat supply to compensate for lack of uniformity in the distribution of heat losses suffers from two serious defects: (1) It is a method of cut and try. (2) The proper arrangement to secure uniformity at one particular temperature does not give uniformity at any other temperature, necessitating a repetition of the cut and try process for every temperature desired. This is strikingly illustrated by one of the compensated black-bodies of Waidner and Burgess. While the temperature

[2] D. Berthelot, Ann. Phys. et Chim. **26**: 119. 1902.

[3] A. Jaquerod and F. L. Perrot, Archives des Sciences Phys. et Nat. **20**: 45 and 57. 1905.

[4] C. W. Waidner and G. K. Burgess, Bull. Bur. Standards **3**: 165. 1907.

uniformity was practically perfect for 12 cm. in front of the radiating diaphragm at 1244°.9, drops of 8°, 10°, and 11° took place within the second 4 cm. of this same region when the diaphragm was at 621°, 1041°, and 1308°, respectively. Day and Sosman[5] made five separate attempts to wind a tubular furnace with two small side openings so that it would produce a uniform temperature along a platinum-iridium bar 25 cm. long, the linear expansivity of which they were determining. The deviations that they report within the central 24 cm. of their two most successful furnaces amount to 5° at 300°, increasing steadily to about 20° at 700°, and reaching about 50° at 1000°. While the thick-walled iron tube used in these latter trials produced markedly better results than the porcelain tube used in the earlier ones; still it is quite clear that even the conductivity of the iron was very far from adequate to secure uniformity, expecially at temperatures much removed from the one at which a particular distribution of the heating coils gave the best results.

The double plug with small temperature gradient across an insulating layer, which was described above, indicated a way of reducing such difficulties as have just been enumerated. Accordingly, an electrically heated furnace was constructed for determining the expansivity of bars, the elongations being measured by the suspended-wire method outlined in the first section of this paper. Fig. 4 represents the essential features.

Since this furnace was designed primarily for convenience of manipulation and for securing merely moderate uniformity of temperature, only a partial use was made of the principles enunciated on page 251. The furnace tube, of iron fairly uniformly wound for its entire length with constantan ribbon, had its central portion completely filled with an iron block pierced by two longitudinal cavities, of square cross-section, symmetrically situated above and below the geometrical axis of the tube. The lower cavity was almost completely filled by the bar to be measured, while the upper one contained a similar dummy bar, the temperature of which was determined by a thermo-element placed within a hole following the axis of the bar. While the conductivity of the large metal masses probably contributed considerably toward the production of temperature uniformity within this furnace, and while

[5] Described in a paper by A. L. Day and J. K. Clement, Am. Jour. Science **26**: 425. 1908.

the smallness of the passages required for the suspended wires certainly prevented much disturbance, a very important feature of the whole construction was undoubtedly the type of plug used for closing the ends. This was essentially the same as the simple one described above, with the addition of an independent electrical heating coil wound in a groove within the outside conducting block. This coil made it easy to maintain the end at a temperature almost the same as that of the interior, thus reducing the longitudinal temperature gradient and thereby the outward conduction of heat. Suitably arranged differential thermoelements in the plugs, together with a convenient grouping of rheostats, make the temperature control an easy matter.

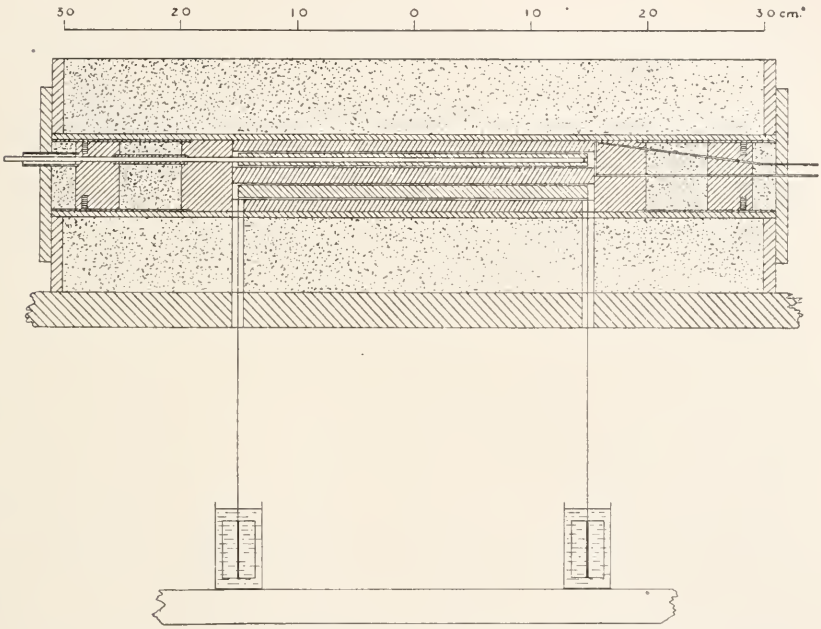


Fig. 4. Electrically-heated furnace for expansion measurements by method of suspended wires, showing double plugs with outside ends independently heated.

The furnace was built to accommodate bars 30 cm. long. Examination of the temperature distribution throughout this length for various temperatures up to 684°C. showed that, if the outside end of the plugs was within 10° of the interior, no variation exceeding a few tenths of a degree occurred in the right-hand 15 cm. except at the highest temperature to which the furnace was forced, when the extreme deviation was found to be 4°. Since the constantan ribbon burned out in the vicinity of the hottest place the next day, considerably before this temperature was again reached, it seems likely that this deviation was due to exces-

sive local heating. The left-hand half of the bar was not, however, so uniformly heated as the right and was consistently warmer, the maximum rise of 2° occuring in the second 5 cm. from the left end. The most plausible explanation is irregularity in either the heating coil or the insulation at this place. It is to be noted that the thermal conductivity of such a large mass of iron as was used proved still insufficient to produce a uniform distribution; and further that the distribution observed at any one temperature did not differ essentially from that observed at any other. Even making the outer ends of the plugs considerably colder than the interior affected the temperature within but little.

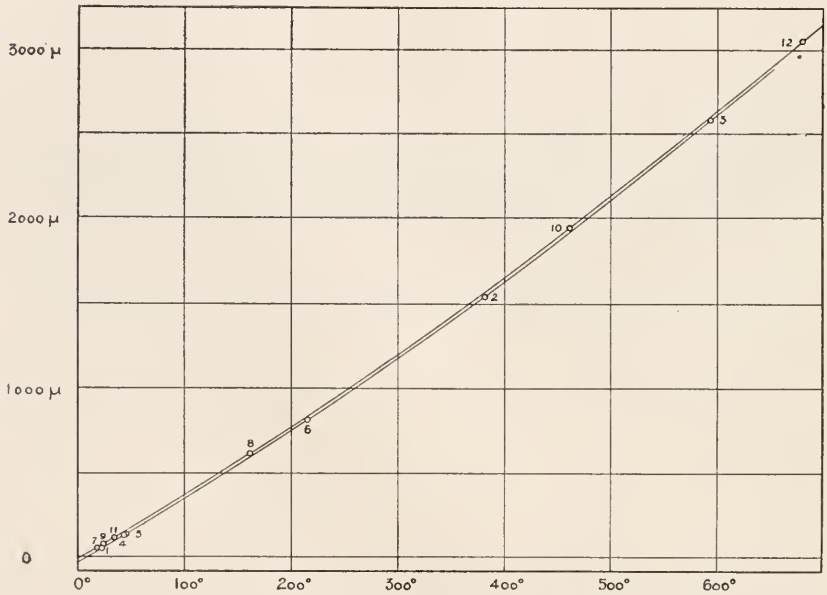


Fig. 5. Expansion of annealed cold-drawn Bessemer steel

Changes in this furnace are now in progress for securing a fuller application of the principles discussed at the outset of this section. Two concentric heaters separated by an insulating layer are provided, and a recently devised scheme of longitudinal winding is introduced to facilitate, among other things, uniform distribution of the heat supply.

It is apparent that the end-heated plug, conducting transversely while insulating longitudinally, affords a ready means of preventing heat loss for any temperature of operation, and, consequently, the entire interior, regardless of its length, will be

uniformly heated if lateral loss and supply are uniformly distributed by some such construction as that just outlined in the preceeding paragraph. And in cases where it may not be practicable to heat the ends as hot as the interior, much is still to be gained by bringing them as near to the proper temperature as circumstances permit.

The expansion of cold-drawn Bessemer steel. Some results obtained on the first trial of the methods outlined in this paper are exhibited by Fig. 5, which shows the expansion of a steel bar 30 cm. long. The elongations were measured by sighting on platinum wires 1/30 mm. in diameter suspended over the ends as indicated in Figs. 1 and 4. Changes in the distances separating the axes of the observing microscopes were determined by reference to wires similarly suspended from another bar kept so nearly at a constant temperature that any changes in it could readily be calculated. The unannealed cold-drawn steel was first subjected to several alternations in temperature, extending from that of the room up to between 150° and 380°. In conformity with the experience of other observers, the bar was always found noticeably shorter upon cooling than when at the same temperature before the preceding heating; and it was found to return slowly towards its original length if left undisturbed at room temperature. The bar was then heated to about 800° and annealed by slow cooling over night. A few days later the measurements represented by the lower curve in Fig. 5 were made in the order indicated by the numbers, the curve passing almost exactly through all the points obtained. After allowing the bar to rest undisturbed for about a month, a new series of similar measurements was made with the upper curve as the result. The lengthening accompanying the period of rest seems to have extended throughout the whole temperature range—nearly 700°C.

A suggested application to gas thermometry. Thermal expansion of the material forming the thermometer bulb necessitates corrections for changes in volume, which become of increasing importance as the temperature range is extended. The difficulties involved in determining this expansion have been recognized by investigators in the field of precision of gas thermometry.

Jaquerod and Perrot[6] sought to avoid them by the use of fused silica, whose expansivity is small. Day, Clement, and Sosman[7] conducted elaborate secondary investigations to determine the linear expansivity of rods, the composition of which was made as nearly as possible the same as that of the bulb, though the physical treatment of the two must of necessity have been decidedly different. Apparently, however, in no case have changes in the dimensions of the bulb itself been measured simultaneously with the measurements of pressure necessary to determine the temperature.

The possibility is here suggested of accomplishing this by the method described in the first section of this paper. The wires for transferring the displacements could be applied to the ends of a thermometer bulb, the capillary of which is placed a little to one side of the axis for the purpose of leaving the adjacent end unobstructed. These same measurements yield the expansivity of the material of the bulb, using the bulb itself as an integrating thermometer. The openings necessary for the wires can be arranged so as not to disturb the temperature distribution within, and can be used for admitting a gas to equalize the pressure on both sides of the bulb walls.

It is obvious that the method, which determines total linear change, whether arising from thermal expansion or other influences, could be used for following alterations of the bulb in other directions.

It is also suggested that the methods of temperature control discussed above might possibly be advantageously employed in this connection.

[6] A. Jaquerod and F. L. Perrot, Archives des Sciences Phys. et Nat. **20**: 35. 1905.

[7] A. L. Day and J. K. Clement, Am. Jour. Science **26**: 405. 1908. A. L. Day and R. B. Sosman, Am. Jour. Science **29**: 93. 1910.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. II, JUNE 4, 1912 No. 11

ELECTRICITY.—*Work of the International Technical Committee on Electrical Units.* E. B. Rosa and F. A. Wolff.

The International Electrical Conference at London in 1908 adopted specifications for the mercury ohm, the silver voltameter and the Weston Normal Cell, and fixed a provisional value (1.0184 international volts at 20°C.) for the last. The specifications for the mercury ohm and the Weston cell were more or less complete, but for the silver voltameter the specifications were very inadequate, and since the value to be assigned to the Weston cell necessarily depends upon the specifications for the silver voltameter, and the results of different investigators were not in close agreement, the conference selected an approximate value which it adopted as provisional only, until further experiments could be made and more precise values determined.

The Weston normal cell, officially adopted at the London Conference in place of the Clark cell, has had the following values: In America, 1.0189 at 25°, equivalent to 1.0191 volts at 20°; in Germany, 1.0186 volts at 20°; in England, 1.0184 volts at 20°. Some of the other countries have the same value as America, others the same as Germany.

In order that the different countries might coöperate in fixing and maintaining uniform throughout the world the values of the electrical units, the London Conference established an International Committee on Electrical Units and Standards, charged with the duty of promoting investigations in electrical standards and electrical measurements, and of securing the intercomparison of the standards of different countries. This committee represents eleven different countries, there being two members each from America, England, France and Germany, and one

member each from Austria, Italy, Russia, Switzerland, Holland, Belgium and Japan. The president of the committee is Professor Dr. E. Warburg, president of the Physikalisch-Technische Reichsanstalt, Berlin; vice-president, Dr. R. T. Glazebrook, director of the National Physical Laboratory, London; treasurer, Dr. S. W. Stratton, director of the Bureau of Standards, Washington; secretary, Dr. E. B. Rosa, physicist, Bureau of Standards.

It had been suggested at the London Conference of 1908 that delegates from the several national standardizing laboratories might come together under the auspices of the International Committee for coöperative work on standards whenever that seemed necessary, and this was a case where it did seem necessary.

Accordingly, it was suggested to the president and vice-president of the International Committee by Drs. S. W. Stratton and E. B. Rosa jointly in letters dated March 15, 1909, that such an investigation be carried out at Washington, in the laboratories of the Bureau of Standards. This suggestion was adopted and a special committee, known as the International Technical Committee was appointed. This committee assembled at Washington April 4, 1910, under the presidency of Dr. Stratton.

The committee was as follows: Dr. E. B. Rosa, Chairman; Dr. W. Jaeger, Geheimer Reigierungsrat, Mitglied der Physikalisch-Technischen Reichsanstalt; Prof. F. Laporte, Sous Directeur du Laboratoire Central d'Électricité; Mr. F. E. Smith, Principal Assistant, National Physical Laboratory; Dr. F. A. Wolff, Associate Physicist, Bureau of Standards.

The committee unanimously appointed Dr. F. W. Grover secretary for the preparation of the minutes and records.

From April 4 to May 25, 1910, the committee held nineteen meetings, made or had made seventeen series of experiments on the silver voltameter, besides numerous comparisons of resistances, of standard cells and of weights.

The apparatus and installations which were used in carrying out these experiments and these comparisons were those which are in use at the Bureau of Standards, except such of the voltameters, resistances, standard cells, weights and chemical materials as were brought by the delegates.

1. RESISTANCE COMPARISONS

Each delegate brought with him one or more resistance standards with the object of furnishing data on the relative values of the unit of resistance employed in the four laboratories, and of deriving a basis for the voltameter measurements made in Washington. The results obtained also served the further purpose of establishing the magnitude of one of the corrections to be applied to the voltameter measurements previously made by the delegates, to reduce them to a strictly comparative basis.

The necessary electrical comparisons were all made in a thermostatically controlled and well stirred oil bath, the standards being substituted in turn in the same arm of a Kelvin double bridge. The connecting resistance between the standard and an auxiliary 1-ohm coil was so small as to require no adjustments of the auxiliary (10-ohm) bridge arms, the coils under comparison all having approximately the same values, and the resistance of the connections to the auxiliary bridge arms being very low.

The results of the comparisons of the different metallic resistances were as follows:

$$\text{Ohm PTR} - \text{Ohm NBS} = +2 \times 10^{-6}$$
$$\text{Ohm NPL} - \text{Ohm NBS} = +12 \times 10^{-6}$$

From these can be deduced that the differences between the values of the ohms in use in the different laboratories, and as represented by the coils brought to Washington, and the value adopted by the technical committee are as follows:

For the PTR ohm $-\ 5 \times 10^{-6}$
For the NPL ohm $+\ 5$
For the NBS ohm $-\ 7$
For the LCE ohm $+\ 110$

The relative measurements of the metallic resistances showed that the resistances inclosed in sealed boxes gave, during the experiments in Washington, results more regular than the metallic resistances for which this precaution had not been taken.

The Technical Committee therefore decided to choose, actually and until new mercury ohms shall have been constructed, as the value of the international ohm, to be recommended to all coun-

tries, the mean of the values of the units realized at the Physikalisch-Technische Reichsanstalt and National Physical Laboratory. Altho the international ohm, as defined by the London Conference, has not been strictly realized, the committee believed that its value has been obtained in two independent laboratories, with a good degree of precision, and that future work will not change its value by more than 2 or 3 parts in 100,000.

The committee expressed the hope that new international ohms, fulfilling all the specifications of the London Conference, might be realized as soon as possible in different laboratories.

2. STANDARD CELL COMPARISONS

Each of the delegates brought with him a considerable number of cells, which were repeatedly compared, under the most favorable conditions, with those of the Bureau of Standards, thus furnishing a basis for expressing the results of the voltameter work undertaken at Washington, as well as for further work in the home laboratories. In addition, this made possible the direct comparison of the standards of electromotiveforce employed in the four institutions, and furnished data of value on the accuracy attainable in the reproduction of the Weston Normal Cell. Further data on the last question were obtained from 48 cells set up in Washington, with four samples of mercurous sulphate representing the methods of preparation adopted in the four institutions. Portions of each sample were washed according to the procedure followed in the four laboratories, and three cells were set up with each washed sample. In addition, two cells were set up with each of four samples of cadmium sulphate submitted; comparative tests were also made of four samples of mercury and of cadmium or cadmium amalgam.

The comparisons were made in a basement room especially fitted up for such work, in automatically controlled petroleum baths, each of which was provided with coils for electric heating, a cooling coil for water circulation when operating at temperatures below that of the room, an efficient stirrer and means for directing the circulation in the bath, and a sensitive thermoregulator, in addition to a rack for mounting the cells.

From the point of view of the methods of preparation of the mercurous sulphate, the following differences exist among the cells:

At the PTR, by precipitation by adding hot sulphuric acid to acid mercurous nitrate, or the reverse.

At the NPL, by precipitation by adding mercurous nitrate to sulphuric acid.

At the NBS, by electrolysis with direct current.

At the LCE, part by electrolysis with direct current, the rest by alternating current electrolysis.

All the cells were compared several times during the work of the delegates. As a result of these comparisons, the technical committee decided to choose as "value of the *Weston Normal Cell*, the mean value of the cells submitted by the delegates of the four laboratories. This mean has been calculated in the following manner: The mean of the values of the standard cells, presented by each delegate, has first been taken, and then the mean of the four numbers thus found."

Differences in Microvolts between Separate Group Means and the Bureau of Standards Basis of Reference

Group Mean—NBS Basis of Reference

NUMBER OF CELLS	APRIL 7	APRIL 8	APRIL 11	APRIL 15	APRIL 22	APRIL 29	MAY 10	MAY 16	MEANS	MEANS MINUS GROUP MEAN	AVERAGE DEVIATION OF INDIVIDUAL CELLS FROM SEPARATE GROUP MEANS
PTR 15..	+26	+27	+27	+26	+27	+26	+25	+25	+26	0	±10
NPL 34..	+22	+25	+26	+25	+25	+25	+24	+23	+24	−2	± 9
LCE 15..	+35	+38	+37	+35	+34	+34	+32	+35	+35	+9	±25
NBS 40..	+17	+18	+19	+18	+18	+17	+16	+16	+17	−9	± 6
Mean of group means	+25	+27	+27	+26	+26	+26	+24	+25	+26		

The cell (no. 109) used in making the voltameter measurements, was frequently compared with the original reference cells

of the Bureau of Standards and its value in terms of the mean of the group means was thus known. The cells set up by members of the Committee in Washington confirmed in the main the conclusions derived from the cells brought from the home laboratories, although considerably larger differences than shown in the above table were found.

3. DESCRIPTION OF THE EXPERIMENTS ON THE VOLTAMETER

The current in the voltameter circuit was held at such a value that the drop of potential over the 2-ohm resistance standard was equal to the electromotive force of the standard cell used. To correct, however, for errors in the potentiometer, such as errors in the adjustment of the relative values of the coils, thermoelectromotive forces, changes in the potentiometer current and the like, a control circuit was arranged. Cell no. 109 whose value was to be determined by means of the voltameters, was joined in series with a sensitive galvanometer, so that by depressing a key the drop of potential over the standard resistance could be opposed directly to that of the standard cell. This circuit served as the ultimate control for the current. The procedure adopted was as follows: While one observer adjusted the current until the electromotive forces in the circuit just described were balanced, a second observer at the potentiometer took note of the resting place of the potentiometer galvanometer which corresponded to this balance. The reading of the potentiometer galvanometer was then held at this point, by means of the Kelvin rheostat, with an occasional check on the correct resting point by the method just described. This procedure not only allowed the errors of the potentiometer to be eliminated, but permitted a second observer to judge of the steadiness of the current at the same time.

The duration of each experiment was timed by a chronograph recording the ticks of a standard Riefler clock.

The deposits were weighed in a constant temperature room constructed especially for the purpose and a high order of accuracy was obtained.

In all the experiments with the silver voltameter, the strength of the current was maintained constant at the value of approximately 0.5 ampere, the length of time of its passage being two hours, and the weight of silver deposit being slightly greater than 4 grams.

The delegates originally employed the silver nitrate and the voltameters which they brought with them and carried out the work under experimental conditions similar to those used by them ordinarily in their respective laboratories.

In the greater part of the experiments Dr. Jaeger used a form of voltameter employing silk and a glass cup, to separate the anode from the cathode.

Mr. Smith employed the arrangement designated by him by the name of "the new form."

Dr. Rosa made use ordinarily of the porous pot of porcelain.

M. Laporte employed the filter paper form.

In some of the experiments, certain of the delegates exchanged materials and used the apparatus of one another.

While the delegates carried out their experiments, members of the Bureau of Standards, under the direction of a subcommittee, made other experiments on the silver voltameter, with the end in view of studying the different electrolytes and forms of voltameter used.

SUMMARY OF RESULTS OF 89 DEPOSITS, EXCLUDING RELATIVE VALUES OF EXPERIMENTS 1, 14, AND 16

1. With Voltameters Using Porous Cups or without any Septum (with Electrolyte neutral by the iod-eosine test and free from reducing substances by the permanganate test)

(1) Mean of 10[1] deposits, NPL, new form voltameter	1.01831_1
(2) Mean of 4 deposits, NBS, porous cup, large voltameter	28_9
(3) Mean of 9 deposits, NBS, porous cup, small voltameter	28_5
(4) Mean of 1 deposit, NBS, porous cup, medium voltameter	28_8
Mean 24 deposits, two types, several sizes of voltameters	1.01829_7
Mean excluding two determinations with unsteady current	1.01828_6

[1] Two deposits in NPL, new form, in seventh experiment, gave 1.01841_8. The current in this experiment was unusually unsteady. If these two determinations be excluded, the mean of 8 deposits is 1.01828_7 and the mean of 22 is 1.01828_6.

2. Using Filter Paper

(6)	Mean of 3 deposits, PTR, with filter paper	1.01846_9
(8)	Mean of 6 deposits, LCE, with filter paper	43_7
(15)	Mean of 1 deposit, NPL, with filter paper	47_5
	Mean of 10 deposits	1.01845_0

3 Using Silk

(5)	Me n of 6 deposits, PTR, with silk	1.01828_2
(14)	Mean of 2 deposits, NBS, with new silk	58_0
(13)	Mean of 6 deposits, NBS, with used silk	28_5
(17)	Mean of 1 deposit, NPL, with used silk (electrolyte slightly alkaline)	29_0
	Mean of 15 deposits	1.01832_3
	Mean of 13 deposits, excluding new silk	1.01828_6

4. Electrolyte Indicated by the Chemical Tests to be Slightly Impure

(7)	Mean of 1 deposit, PTR, with no septum	1.01837_3
(9)	Mean of 2 deposits, LCE, with no septum	22_1
(16)	Mean of 2 deposits, NPL electrolyte, with no septum, large voltameter	45_8
(11)	Mean of 11 deposits, NBS electrolyte, with porous cups, large voltameter	43_0
(12)	Mean of 18 deposits, NBS electrolyte, with porous cups, small voltameter	28_0
(10)	Mean of 1 deposit, LCE electrolyte, with porous cups, medium voltameter	21_4
	Mean of 35 deposits	1.01833_5

5. Electrolyte Slightly Alkaline—NaOH *added*

(18)	Mean of 2 deposits, electrolyte, alkaline, added $2.1/10^6$ NaOH	1.01836_3
	Mean of 1 deposit, electrolyte, alkaline, added $5/10^6$ NaOH	58
	Mean of 1 deposit, electrolyte, alkaline, added $10/10^6$ NaOH	75
	Mean of 4 deposits	1.01851_5

6. Electrolyte Slightly Acid, HNO_3 *added*

Mean of 1 deposit, electrolyte acid, added $10/10^6$ HNO_3	1.01820_0
Mean of 2 deposits, electrolyte acid, added $100/10^6$ HNO_3	16_0
Mean of 3 deposits	1.01817_3

Summary

Mean of 22 experiments, group 1 equals	1.01828_6
Mean of 13 experiments, group 3 equals	1.01828_6
Mean of 35 experiments, group 4 equals	1.01833_5
Mean of 70, giving each equal weight, equals	1.01831_0
Mean of 70, giving group 4 half weight, equals	1.01830_2

There was a difference of opinion among the delegates as to how the results should be weighted in taking the mean, but for the purpose of fixing the value of the Weston Normal Cell to five figures it fortunately makes little difference how the results are combined. If equal weight is given to all, the result is nearly the same as though the weights were unequal.

The results showed that voltameters in which filter paper is used as septum lead to results which are too high. The delegates were therefore unanimously of the opinion that the results of experiments made under these conditions should not be used for the determination of the value of the emf of the Weston Normal Cell.

The committee were of the unanimous opinion that "the mean of the results which they have obtained will not be modified by more than several parts in one hundred thousand when the specifications shall have been completed.

"The committee decides to recommend to the International Committee for Electrical Units and Standards the following value for the emf of the Weston Normal Cell:

$$E = 1.0183 \text{ international volts at } 20°C."$$

The delegates were unable in the light of the data at hand to agree on final specifications for the voltameter. No time was available for considering specifications for the standard cell.

The work done clearly established the importance of employing exceedingly pure silver nitrate for the voltameter and the need for suitable tests of purity, as very slight percentages of certain impurities considerably affected the amount of deposit obtained.

Further work has been in progress in two of the laboratories since the Washington meeting and it is hoped that at an early date, specifications for the voltameter can be agreed upon. There will then remain to be considered similar specifications for the standard cell.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

METEOROLOGY.—*The temperature at Mount Weather, Va. and adjacent valley stations.* ALFRED J. HENRY. Mount Weather Bulletin 4: 310–341. 1911.

The simultaneous mountain and valley temperatures as obtained by automatic registers are reported upon in some detail. It is shown that the variations of temperature between the mountain top and the valley below are not wholly dependent upon slope and topography but vary to a great extent with the weather conditions.

Attention is also directed to the temperature changes in the free air above Mount Weather from hour to hour and from day to day, as disclosed by kite flights. The belief is expressed that the temperature of the free air is largely controlled, at least up to the 3 kilometer level, by horizontal air currents in the strata near the earth's surface. A. J. H.

BOTANY.—*Agricultural varieties of the cowpea and immediately related species.* C. V. PIFER. Bulletin, 229. Bureau Plant Industry. 1912.

This bulletin presents the results of an extended study of the varieties of *Vigna sinensis, Vigna catjang* and *Vigna sesquipedalis,* which are treated for convenience, as three separate species, but which integrade fully and all hybridize.

In the course of the study of these varieties, extending over eight years, about one thousand lots of seed have been grown; 370 from foreign sources and the remainder form the United States. As a result of these studies, 35 varieties of Asparagus bean, 50 of Catjang and 220 of Cowpeas were found to be distinct varieties in an agronomic sense, and descriptive notes concerning them are given. As all of these can be hybridized, the number of varieties obtainable is practically limitless, or in other words, "Practically every combination of seed, color and shape, with habit and life period can be obtained."

In habit the three species vary from prefectly prostrate to perfectly erect, five types being recognized for purposes of description, namely, prostrate; procumbent; low, half bushy; tall, half bushy; and treelike or erect. The last two types are considered most valuable from an agricultural standpoint. In general, Asparagus beans produce slender vines, prostrate or procumbent without support, while the Catjung and Cowpea possess all the types of habit.

Natural hybrids are rare in the United States, but they have been found at Madison, Indiana, and at North Lansing, Michigan. In the agricultural literature there is much confusion due to the fact that there are many more varieties than has been generally recognized, and also to the fact that seed color alone had been accepted as a criterion of the variety. Of the numerous named varieties it is possible now to identify satisfactorily very few, excepting those of which pedigreed or otherwise authentic seed is available. In the main the names have been preserved only in a traditional way by seedsmen. The characteristics most important in the cowpea, considered mainly as a forage crop, are outlined and the most valuable varieties to use in breeding are indicated. C. V. P.

ZOOLOGY.—*The northern elephant seal,* Macrorhinus angustirostris Gill. CHAS. HASKINS TOWNSEND, Director of the New York Aquarium. Zoologica No. 8, pp. 159–73, figs. 52–72. April 15, 1912.

This is the second publication of the scientific results of the expedition to the Gulf of California, in charge of C. H. Townsend, by the U. S. Fisheries Steamship *Albatross* in 1911, published by permission of the U. S. Commisssion of Fisheries in Zoologica (Scientific Contributions of the New York Zoological Society).

The author gives an account of the rediscovery of a species long on the verge of extinction. He refers to the extensive slaughter of the elephant seal for its oil about sixty years ago and its subsequent occurrence at rare intervals in Lower California.

The *Albatross* expedition found about 150 of the animals at Guadalupe Island, off the coast of Lower California, and procured specimens and photographs illustrating the great size of the adult male, its remarkable proboscis and its manner of fighting. The food and breeding habits of the animals are also considered.

The following points are noted: The northern species is unquestionably distinct from the southern elephant seal of the Antarctic islands

(*Macrorhinus leoninus*). It now breeds only at Guadalupe Island, and there are about 150 of the animals in existance. The trunk, or proboscis, of the adult male is not capable of inflation, but is retracted into heavy folds on top of the head by muscular action. The breeding season begins a few days before March 1 and the period of gestation is 12 months. The color of the young at birth is black. The yearling utters a call or scream unlike the voice of any other seal. In captivity its favorite food is fish. The yearling and two-year-old have a peculiar habit of lifting the head and hind flippers above the back until they nearly meet.

One important statement is to the effect that the Mexican authorities have already taken steps to prevent further killing of this species.

W. E. Safford.

PHYSIOLOGY.—*Sound as a directing influence in the movements of fishes.* G. H. Parker. Bulletin of the Bureau of Fisheries, **30**: 97–104. 1910. Issued April 27, 1912.

Pursuing his researches upon the sense of hearing in fishes, Dr. Parker has found that different species of fish differ not only in sensitiveness to sound but respond by movements of different directive character. With a tank of special construction which concealed from the fish all outside surroundings, and a pendulun which delivered regular blows upon one end of the tank, eight species were tested in numbers of five individuals each, their movements being carefully noted for fifty blows upon each end of the tank.

The fishes fell into three classes as follows: (1) Those which tended to retreat from the region of sound production; illustrated by the tautog (*Tautog onitis*), the scup (*Stenotomus chrysops*), young kingfish (*Menticirrhus saxatilis*), and young swellfish (*Spheroides maculatus*). (2) Those which were attracted by the sound, as the sea robins (*Prionotus carolinus* and *P. strigatus*). (3) Those which, though agitated, moved neither toward nor away from the sound; illustrated by the killifishes (*Fundulus heteroclitus* and *F. majalis*). Of all three classes it was observed that the influence of the sound was almost as short in duration as the stimulus. It is therefore improbable that sounds of brief duration can have much effect on the temporary distribution of fishes within their reach. That fishes should be attracted over any considerable area or repelled from that area by sound would seem to demand some more or less continuous source of sound production.

Ethel M. Smith.

ANTHROPOLOGY.—*Censers and incense of Mexico and Central America.* WALTER HOUGH. Proceedings U. S. Natural Museum, **42**: 109–137. Apri 17, 1912.

The paper is a study of ancient and modern censers and presents a classification of these interesting objects into communal censers, which are stationary, and special censers, which are classed as portable, gesture and swinging censers. It also discusses the use of incense in worship, the origin of incense materials, and the customs connected with the use of incense. The paper is illustrated with twelve plates and twelve text figures. W. H.

PHYSICAL ANTHROPOLOGY.—*The natives of Kharga Oasis, Egypt.* ALES HRDLICKA. Smithsonian Miscellaneous collect ons, **59**: no. 1. 1912.

This work is the result of the coöperation of the Smithsonian Institution with the Metropolitan Museum of New York. It presents geographical and historical notes on the Great Oasis and the recent data on the Kharga Oasis people. The writer has gathered numerous general observations and information on environment, social and medical records, vital statistics, physiological observations on the body and a large number of measurements on the people. This valuable and comprehensive study contains a bibliography and appendix of detailed measurements and is illustrated with thirty-eight plates and twelve figures. Dr. Hrdlicka concludes:

The type of the Kharga natives is radically distinct from that of the negro. It is according to all indications fundamentally the same as that of the non-negroid Valley Egyptians. It is in all probability a composite of closely related northeastern African and Southwestern Asiatic, or "hamitic" and "semitic" ethnic elements, and is to be classed with these as part of the southern extension of the Mediterranean subdivision of the white race.

Judging from the mummies of the Oasis inhabitants from the 2–5 centuries A. D., exhumed at El Baguat, the type of the present non-negroid Kharga natives is substantially the same as that of the population of the Oasis during the first part of the Christian era. The nature of the population of the Oasis in more ancient times can only be determined by skeletal material from the ancient cemetries.

W. HOUGH.

REFERENCES

METEOROLOGY.—Monthly Weather Review. **39**: No. 4, pp. 487–648, charts 8; No. 5, pp. 649–813, charts 7; No. 6, pp. 815–971, charts 7; No. 7, pp. 973–1134, charts 7; No. 8, pp. 1135–1300, charts 7; No. 9, pp. 1301–1466, charts 7; No. 10, pp. 1467–1631, charts 7; No. 11, pp. 1633–1790, charts 8.

TECHNOLOGY.—Technological papers of the Bureau of Standards: (1) *Effect of preliminary heat treatment upon the drying of clays*, A. V. Bleininger; (2) *The strength of reinforced concrete beams*—results of tests of 333 beams (First Series), R. L. Humphrey and L. H. Losse; (3) *Tests of the absorptive and permeable properties of Portland cement mortars and concretes, together with tests of damp-proofing and water-proofing compounds and materials*, R. J. Wig and P. H. Bates; (4) *The effect of added fatty and other oils upon the carbonization of mineral lubricating oils*, C. W. Waters; (5) *The effect of high pressure steam on the crushing strength of Portland cement mortar and concrete*, R. J. Wig; (6) *The determination of chromium, and its separation from vanadium, in steels*, J. R. Cain; (7) *The testing of clay refractories, with special reference to their load carrying ability at furnace temperatures*, A. V. Bleininger and G. H. Brown; (8) *A rapid method for the determination of vanadium in steels, ores, etc., based on its quantitative inclusion by the phospho-molybdate precipitate*, J. R. Cain and J. C. Hostetter; (9) *The density and thermal expansion of linseed oil and turpentine*, H. W. Bearce.

TECHNOLOGY.—Reports issued by the Bureau of Mines:

Coals available for the manufacture of illuminating gas. A. H. White and Perry Barker. Bulletin 6, pp. 77. 1911. Results of experiments with 6 typical coals. Gives analyses of the coals and the percentages of gas, ammoniacal liquor, etc., obtained by distilling in a standard horizontal retort.

Résumé of producer-gas investigations, October 31, 1904, to June 30, 1910. R. H. Fernald and C. D. Smith. Bulletin 13, pp. 393. 1911. A detailed account of results obtained in gas-producer tests made by the United States Geological Survey. Gives analyses of producer gas from different classes of coals. Discusses the chemical reactions involved in the gasification of fuel in a producer and the factors that affect the economical operation of a gas-producer plant.

Investigation of the explosives used in coal mining, with a chapter on the natural gas used at Pittsburgh. Clarence Hall, W. O. Snelling, S. P. Howell and G. A. Burrell. Bulletin 15, pp. 197. 1912. Discusses the nature, composition and thermochemistry of explosives, with particular reference to permissible explosives. Among the subjects considered are the thermochemistry of carbon dioxide and carbon monoxide, the formation of carbon dioxide and carbon monoxide in the presence of water, the maximum temperature of explosion of various explosive substances; the specific heats of solid substances at high temperatures; practical methods of reducing the flame temperatures of explosives; and tables of use in thermochemical calculations.

The bulletin contains an account of an investigation of the natural gas used in the tests of explosives by the Bureau of Mines with the methods used in the exact determination of the constituents of this gas and the bearing of the results on the use of the gas in testing the relative safety of explosives. The bulletin also contains a description of apparatus and methods used by the bureau for physical tests of explosives and gives results of tests with permissible explosives, dynamite, black powder and 4 permitted explosives.

The uses of peat for fuel and other purposes. C. A. Davis. Bulletin 16, pp. 214. 1911. Contains a discussion of the distribution of peat in the United States, the climatic and surface conditions that govern the accumulation of peat beds, the various types of plants that contribute to peat deposits; also discusses the physical and chemical properties of peat in relation to its fuel value, and the methods of utilizing peat for fuel both in this country and in Europe. The bulletin also contains a review of the other uses of peat, proximate and ultimate analyses and calorific value of a large number of samples of peat from different States, and a selected bibliography of the more important publications on the uses of peat.

A primer on explosives for coal miners. C. E. Munroe and Clarence Hall. Bulletin 17, pp. 70. 1911. This bulletin is a revised reprint of U. S. Geological Survey Bulletin 423. Among the subjects treated are combustion and explosion, the composition of explosives, igniting devices, and the proper methods of storing and using explosives.

Physical and chemical properties of the petroleums of the San Joaquin Valley of California, with a chapter on analyses of natural gas from the oil fields of Southern California. I. C. Allen and W. A. Jacobs and G. A. Burrill. Bulletin 19, pp. 60. 1911. Gives a brief description of the methods used in examining a large number of samples of petroleum from the Kern River, Coalinga, McKitrick, Midway, and Sunset oil fields; a tabular statement of the results of the examination and a detailed description of an electric still designed for the exact fractionation of petroleums in the laboratory. Also contains a brief description of the methods used in determining the constituents of natural gas.

Alaskan coal problems. W. L. Fisher. Bulletin 36, pp. 32. 1911. Briefly summarizes the salient economic features of the Matanuska and Bering River coal fields, and discusses the probable markets for the coal and the advantages and disadvantages of having the coal mined under government leases.

Specifications for the purchase of oil by the government, with directions for sampling oil and natural gas. I. C. Allen. Technical Paper 3, pp. 13. 1911. Contains specifications based on physical properties and heating value, and gives the methods used by representatives of the Bureau of Mines in sampling petroleum or fuel oil and in sampling natural gas.

The electrical section of the Bureau of Mines, its purpose and equipment. H. H. Clark. Technical Paper 4, pp. 12. 1911. Gives a brief statement of the purposes for which electricity is used in mines and the dangers from electrical equipment; mentions the equipment of the electrical laboratory of the Bureau of Mines experiment station at Pittsburgh, Pa., and summarizes briefly the results of an investigation of the safety of enclosed cartridge fuses.

The rate of burning of fuse as influenced by temperature and pressure. W. O. SNELLING and W. C. COPE. Technical Paper 6, pp. 28. 1912. The results of a careful investigation of the influence of pressure, temperature, moisture and mechanical injury on the rate of burning of ordinary blasting fuse, with attention to the bearing of the results on the use of explosives in mines.

Investigations of fuse and miners' squibs. CLARENCE HALL and S. P. HOWELL. Technical Paper 7, pp. 19. 1912. Among the subjects investigated were the characteristics of different brands of miners' fuse, the quantity of powder used per foot in miners' fuse, the size of the powder grains, the gases produced by combustion, and the relative safety and efficiency of fuse for use in mines.

Methods of analyzing coal and coke. F. M. STANTON and A. C. FIELDNER. Technical Paper 8, pp. 21. 1912. Gives in detail the analytical methods used in the Pittsburgh laboratory of the Bureau of Mines for analyzing samples of coal and coke and determining their heating value. The methods are essentially those recommended by the American Chemical Society, with modifications that have been found desirable.

Liquefied products from natural gas, their properties and uses. I. C. ALLEN and G. A. BURRELL. Technical Paper 10, pp. 23. 1912. Briefly discusses early attempts at liquefying natural gas; describes experiments made by the authors; gives analyses of those types of natural gas yielding the largest proportion of liquefied products; and discusses the properties and industrial uses of these products.

ECONOMIC GEOLOGY.—*Contributions to economic geology* (short papers and preliminary reports) 1909: Part II, *Mineral Fuels.* MARIUS R. CAMPBELL. Bulletin U. S. Geological Survey No. 431. Pp. 254, maps and sections. 1911. This volume comprises the following articles: *Natural gas in North Dakota,* A. G. LEONARD; *The San Juan oil field, San Juan,* Utah, H. E. GREGORY; *Gas and oil prospects near Vale, Oreg., and Payette, Idaho,* C. W. WASHBURNE: *Gas prospects in Harney Valley, Oreg.,* C. W. WASHBURNE; *Preliminary report on the geology and the oil prospects of the Cantua-Panoche region, California,* ROBERT ANDERSON; *The southern part of the Cahaba coal field, Alabama,* CHARLES BUTTS; *The Powell Mountain coal field, Scott and Wise counties, Va.,* M. R. CAMPBELL and E. G. WOODRUFF; *The eastern part of the Bull Mountain coal field, Montana,* C. T. LUPTON; *Preliminary report of the Coos Bay coal field, Oregon,* J. S. DILLER and M. A. PISHEL; *The Black Mesa coal field, Arizona,* M. R. CAMPBELL and H. E. GREGORY; *Coal Deposits near Pinedalle, Navajo Country, Ariz.,* A. C. VEATCH; *Coal in San Benito County, Cal.,* M. R. CAMPBELL.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. II, JUNE 19, 1912 No. 12

PHYSICS.—*A note on the standard scale of temperatures between 200° and 1100°.* L. H. ADAMS and J. JOHNSTON, Geophysical Laboratory.

The original measurements recorded in this note were made over a year ago in connection with another investigation; they determine the freezing points of the four metals, tin, bismuth, cadmium and lead, in terms of the boiling points of naphthalene and benzophenone. The agreement of these results with the best resistance thermometer measurements of the same fixed points shows that the thermocouple is not inferior to the resistance thermometer as an accurate temperature measuring device within the temperature range in question. In addition, it is shown that the most thorough and most extensive series of resistance thermometer measurements—those of Waidner and Burgess, made at the Bureau of Standards—are also in remarkable agreement over the whole range of temperature (up to 1100°) with the gas thermometer measurements of Day and Sosman, when they are expressed in the same scale. At the same time, this comparison shows that, if we consider all of the points,[1] excepting sulphur, to be fixed by the gas thermometer work, and on this basis set up an interpolation formula and calculate therefrom the boiling point of sulphur, the resistance thermometer measurements lead to a value (444°.56) identical with the gas thermometer determinations.

The calibration of the thermoelements has already been described[2] but the account there given must be amplified by the following additions and corrections, which are rendered necessary by the slight changes

[1]Namely, the boiling points of naphthalene and benzophenone, and the freezing points of tin, cadmium, zinc, antimony, silver and copper.

[2] Am. J. Sci. 31: 501–17. 1911.

in the temperature scale resulting from the new and more accurate gas thermometer determinations at temperatures up to 500.°

Too much reliance can not be placed on the readings of copper-constantan thermoelements at the zinc-point (419°.4), for some diminution of electromotive force sets in, not serious, but sufficient to preclude the most accurate measurement; for this reason we have ceased to make use of the zinc point as a calibration temperature.

The calibration temperatures, expressed in the corrected scale, together with the corresponding values of electromotive force of the standard element, are given in Table I.

TABLE I

CALIBRATION TEMPERATURES

t	e IN MICROVOLTS		DIFFERENCE	
	Observed	Calculated	In microvolts	In degrees
0	0	0	0.0	0.0
25.00	979	980.0	−1.0	−0.025
50.00	2012	2012.7	+0.7	+0.016
75.00	3096	3095.8	+0.2	+0.005
100.00	4227	4226.1	+0.9	+0.019
217.95	10119	10119.3	−0.3	−0.005
306.1*	15007	15007.0	0.0	0.0

* The benzophenone used was from Merck, which melts at (46°.9) 0°.3 lower, and boils 0°.2 higher, than that obtained from Kahlbaum (Waidner and Burgess, Bull. Bur. Standards, 7: 3–11; 1910). The f. p. of our Merck benzophenone was also 46°.9; consequently we have added 0°.12 to the accepted b. p. (305°.9) of Kahlbaum benzophenone.

To reproduce the above data, a quadratic equation is insufficient, except over a very short range, and so is the cubic equation[3] of the form $t = A\,e + B\,e^2 + C\,e^3$; but they can, as we found, be fitted very closely by the inverse form of function, $e = A\,t + B\,t^2 + C\,t^3$. Accordingly, on this basis a least square solution for all the points in Table I was made; this resulted in the equation

$$e = 38.105\ t + 0.04442\ t^2 - 0.00002856\ t^3,$$

from which the figures in the third column of Table I have been computed. The agreement is excellent; it can not, however, be used as a valid argument in favor of the accuracy of either the temperature scale or of the measurements, as anyone can readily convince himself by working with a number of similar cubics. By computation from this equation, a table giving t in terms of e was constructed.[4]

[3] This was tried because its use would have saved so much trouble in calculating the most convenient form of table—that giving t for round values of e.

[4] This table is presented in full in the more complete paper in Am. Jl. Sci.

The identity of the readings of the thermoelement and the resistance thermometer at boiling points and melting points. The initial series of measurements gave differences between the freezing point of tin and the naphthalene point on the one hand and between the freezing point of cadmium and the benzophenone point on the other,—using our own apparatus and materials—which were 0°.2 higher than the corresponding differences obtained by Waidner and Burgess at the Bureau of Standards. This lack of agreement disappeared[5] when we determined all the points on the identical samples of material used by Waidner and Burgess, which they were kind enough to lend us.

In Table II we present our results. In the boiling point experiments, three forms of apparatus were used; one (B in the table) of glass[6]—with an aluminium shield for the thermo-couple; the second (A) of brass with an inner tube of thin copper to prevent radiation; and the third (S) similar to the second, but of slightly different dimensions. Four different elements were used, one (E) of platinum—platin-rhodium, the other three (C_1, C_2, C_3) of copper-constantan (No. 30 wire = 0.25 mm. diam.)

The electromotive forces at the freezing points were reduced to degrees with the aid of the table; the boiling points were reduced to normal pressure by means of this table and the formulae: for naphthalene, $T_{760} = T - 0.058\ (p - 760)$; for benzophenone, $T_{760} = T - 0.063\ (p - 760)$. The freezing points have been given to hundredths of a degree, as relative values for purposes of comparison only; their absolute accuracy is of the order of 0°.1.

This table shows that the boiling points are independent of the apparatus and sample of material employed, and that the freezing points can be reproduced satisfactorily on different days and with varying set-up; e.g., the results are independent of the size and kind of tube—glass or porcelain—used to protect the thermo-couple from the metal, and of the size of the charge.

In order to make the data of Waidner and Burgess more truly comparable with our own, we have reduced them to the scale of temperature on which our own values are based (cf. *postea*, Table IV), and present these reduced values in the last column of Table II. The differences between the values for the adjacent freezing and boiling points are compared in Table III with the analogous differences derived from our thermoelectric measurements.

The differences, therefore, as determined by us with platin-rhodium and copper-constantan thermoelements in various forms

[5] The divergence was due to slight impurities in our tin and to the fact that the benzophenone used was from Merck (cf. footnote, to Table I).

[6] Lent to us by the Bureau of Standards.

of apparatus on the one hand, and with resistance thermometers at the Bureau of Standards or at the Reichsanstalt on the other, agree very satisfactorily. This proves conclusively, that there is no systematic deviation whatever, within the range of these measurements, between the readings of these two kinds of thermometers—either at boiling points or at melting or freezing points—when both are calibrated with reference to the same temperature scale. This position is confirmed by a direct comparison of the series of measurements by Waidner and Burgess of the resistances of platinum thermometers with the recent gas thermometer measurements of Day and Sosman,[7] transferred by means of thermoelements to the same fixed points.

So far we have dealt with temperatures less than about 330°; but the comparison just referred to enables us to extend the same conclusion to the copper point (1083°), beyond which the readings of the usual form of resistance thermometer are no longer trustworthy.

TABLE II

Boiling Points of Naphthalene and Benzophenone

Substance	Source	Apparatus	Thermocouple*	From thermoelectric measurements (Adams & Johnston)		From resistance thermometer measurements (Waidner & Burgess)	
				Microvolts	Degrees	As given by them†	When reduced to our scale§
Naphthlene	Merck	A	E	1585.7¶			
	Kahlbaum	B	E	1585.3			
		B	C_1	10119.0	(217.95)	218.0	217.97
	Merck	A	C_3	10119.0¶			
		A	C_3	10118.5			
		A	C_2	10120.0			
Benzophenone.....	Merck (b)	A	E	2366.2¶			
	Merck (a)	A	E	2366.3			
		S	C_1	15008.0	(306.1)	306.2	306.11
		A	C_1	15007.0¶			
		S	C_2	15010.0			
		A	C_3	15004.0			
	Merck (b)	A	C	15005.5¶			

[7] Am. J. Sci., 29: 93–161. 1910; Carnegie Institution of Washington, Publication No. 157. 1911. cf. also J. Wash. Acad. Sci. 2: 167–76. 1912.

TABLE II—Continued

FREEZING POINTS OF METALS

METAL	SOURCE	QUANTITY OF METAL	THERMOCOUPLE*	FROM THERMOELECTRIC MEASUREMENTS (ADAMS & JOHNSTON)		FROM RESISTANCE THERMOMETER MEASUREMENTS (WAIDNER & BURGESS)	
				Microvolts	Degrees	As given by them‡	When reduced to our scale§
		grams					
		1500	C_1	10861.0	231.75		
		1500	C_1	10859.0	231.71		
		1500	C_3	10863.0	231.79		
		200	C_3	10856.0	231.67		
Sn	Kahlbaum					231.92	231.88
		200	E	1706.0	231.9		
		200	E	1706.0 ※	231.9		
		1500	E	1706.0	231.9		
		1500	E	1706.0	231.9		
Bi	J. T. Baker		C_1	13020.0	270.99		
			C_1	13015.0	270.90		
Cd	Kahlbaum		C_1	15860.0	320.92		
			C_3	15858.0	320.92		
						321.01	320.92
			E	2502.5	320.9		
Pb	Kahlbaum		E	2560.5	327.2		
						327.27	327.19
			C_1	16227.0	327.28		
			C_3	16226.0	327.30		

* Couple E is of Pt—PtRh; C_1, C_2, C_3 are of copper-constantan.

† Bull. Bur. Standards, **7**: 3–11. 1910. (Reprint No. 143.)

‡ Ibid. **6**: 150–230. 1910. (Reprint No. 124).

¶ The values given in the last column have been reduced from those in the column to the left by means of the differences between the scales as determined in a way to be described later (p. 280); i.e., these values are on the basis that the b. p. of sulfur is 444°56.

§ Mean of two or more determinations often separated by a month or so in time. The maximum deviation from the mean in any of these cases was 0°03.

※ Melting point.

Comparison of the series of resistance thermometer measurements (Waidner and Burgess) *with gas thermometer determinations* (Day and Sosman) *at the same fixed points.* For a fair comparison it is essential that the results be expressed in the same scale of temperatures; for this we have adopted the thermodynamic scale. We have accordingly applied the appropriate corrections, taking

a mean of the correction numbers collated by Buckingham,[8] to the results of Day and Sosman, which were determined on the constant volume scale. The uncertainty of the gas thermometer determinations is indeed comparable with the magnitude of these corrections; nevertheless we have, for the sake of definiteness, considered it advisable to apply them.

TABLE III

COMPARISON OF TEMPERATURE INTERVALS AS MEASURED BY THERMOELEMENTS AND BY THE RESISTANCE THERMOMETER

INTERVAL	TEMPERATURE DIFFERENCE AS DERIVED BROM MEASUREMENTS WITH				
	Thermoelements			Resistance Thermometer	
	E*	C_1	C_3	Waidner & Burgess	Holborn & Henning
Sn – naphthalene	13.9	13.78	13.78	13.91	13.87
Cd – benzophenone, Merck	14.8	14.82	14.82	14.81	
Cd – benzophenone, Kahlbaum	15.0	15.02	15.02	15.01	15.03
Pb – Cd	6.3	6.36	6.38	6.43	

* When reading only to 1 microvolt, as we were, it is illusory to give the readings of the platin-rhodium element closer than the nearest tenth of a degree.

The results as given by Waidner and Burgess[9] were derived by means of the Callendar formula,[10] the third calibration temperature being the sulfur boiling point taken as 444°.70. In order to refer these values to the comparison scale, it seemed simplest to substitute in the Callendar equation the simultaneous values of the thermodynamic temperature (t) and the platinum temperatures of a single resistance thermometer[11]

[8] Bull. Bur. Standards, **3**: 288–9. 1907; (reprint No. 57).

[9] Ibid, **6**: 150–223. 1910; (reprint No. 124); **7**: 1–11. 1910; (reprint No. 143).

[10] The Callendar formula is $t - p = \delta \left(\frac{t}{100} - 1\right) \frac{t}{100}$, where is the true temperature, and pt (the so-called platinum temperature) is defined by the relation

$$pt = \frac{100\,(R_t - R_o)}{R_{100} - R_o}\,.$$

(R_t is the resistance at $t°$). δ is a deviation constant derived by means of the formula from the third calibration temperature (usually the sulfur boiling point); for pure platinum δ, as thus obtained, is close to 1.50. The formula is essentially a simple quadratic relation of the form

$$R_t = R_o + at - bt^2.$$

[11] No. 1787C; this instrument was used over the widest range and appears to be the most satisfactory of those used at the Bureau of Standards.

as measured by Waidner and Burgess, and to compute in this way the corresponding values of δ'. These values vary irregularly at the lower temperatures, as might be expected, since the influence of variation of δ is small when t is small; but at the higher temperatures they show a distinct upward trend, and can be represented very fairly by the relation $\delta' = 1.489 + 0.000015\ t$. These values of δ' were combined with the respective platinum temperatures to give new values of the temperature, which were then subtracted from the temperatures as given by Waidner and Burgess;[12] thus giving the differences between the two scales at these points. These differences were applied to the average values

TABLE IV

COMPARISON OF THE "CORRECTED" TEMPERATURES (MEASURED BY THE RESISTANCE THERMOMETER) WITH DETERMINATIONS BY THE GAS THERMOMETER AND WITH THERMOELEMENTS. THERMODYNAMIC SCALE

	TEMPERATURE BASED ON GAS THERMOMETER MEASUREMENTS (D. & S.) I	"CORRECTED" TEMPERATURES FROM RESISTANCE THERMOMETER MEASUREMENTS (W. & B.) II	DIFFERENCES II−I
Nph., b.p.	217.95	217.97	+0.02
Sn., f.p.	231.73*	231.88	+0.15
Bnz., b.p.	305.90†	305.91	+0.01
Cd., f.p.	320.92*	320.92	0.00
Pb., f.p.	327.39*	327.35	−0.04
Zn., f.p.	419.4†	419.24	−0.16
S., b.p.	444.55‡.	444.55	0.00
Sb., f.p.	630.0†	630.36	+0.36
Ag., f.p.	960.4†	960.7	+0.3
Cu., f.p.	1083.2†	1082.8	−0.4

* From the thermoelectric measurements of Table III above.

† Temperatures transferred from gas thermometer measurement to fixed point by thermocouples.

‡ Direct gas thermometer determination.

given by Waidner and Burgess, giving the "corrected" average temperatures presented in Table IV, column I. Alongside of this we have tabulated (in column II) the temperatures on the thermodynamic scale as derived from the work of Day and Sosman, and (in column III) the differences between these two sets of measurements.

The differences at the tin and zinc points are no doubt due to the fact that in these two cases the determinations were made on different samples of metal; with these two slight exceptions the agreement is all that

[12] That is, the temperatures as derived from a fixed δ, obtained by calibration at 0°, 100°, and the S.B.P. taken as 444°70.

could be desired. This concordance shows further that if we derive an interpolation formula for the resistance thermometer based on all of the points excepting sulfur, and calculate by means of this formula the boiling temperature of sulfur, we obtain a result identical with the direct gas thermometer determination of this fixed point.

If we recalculate the above temperatures using a fixed value of δ based on the newer determinations of the sulfur point, we obtain results which are practically identical with those of column II (Table IV) except at the silver and copper points, which would on this basis be lower by 0°.6 and 0°.9 respectively. This silver point would still be within the limits of accuracy of the gas thermometer measurements at that point, but the divergence at the copper point (1°.3) is somewhat greater than the probable error.

This raises the question of the range through which the simple, and very convenient, Callendar formula is applicable in accurate work. It does not hold for impure platinum or for palladium;[13] nor does it hold for pure platinum at all temperatures below 0°C. Indeed Travers and Gwyer say: "A standard scale of temperature, based on Callendar's three fixed points, using standard wire, and taking 1.5 for the value of δ, would obviously lead to absurd results at low temperatures; and the converse may be said of our own observations;"[14] and conclude that the Callendar formula cannot be made use of except for interpolation. There is thus ground for believing that the accuracy of the results calculated from the change of resistance of *pure* platinum by means of the simple Callendar formula is to some extent fortuitous. The small variation of δ introduces uncertainties which would appear to be too great for the most accurate work except over the temperature range included between the fixed calibration points (0°–444°.55), and a short region beyond (perhaps to 750°).[15] On the other hand it must be admitted that the cubic term (which expresses the variation of δ with the temperature) is very small—so small that its effect is scarcely greater than the uncertainty in the gas thermometer determinations at the higher temperatures.

[13] Waidner and Burgess, Bull. Bureau Standards, **6**: 176, 183. 1910.

[14] Proc. Roy. Soc. London, **74**: 538. 1904–5.

[15] The effect of slight changes of δ on the calculated temperatures may be gauged from the following: that a change of 0°.2 in the boiling point of sulfur changes δ by 1 per cent (and proportionally for other small changes); this in turn affects temperatures of 300° or lower by 0°.1 or less, but affects the antimony point by 0°.5 and the copper point by 1°.6.

In this connection one point remains to be noted—namely the accuracy of the Reichsanstalt scale in the region 1000–1100°. Holborn and Valentiner state in one place[16] that the uncertainty at 1000° amounts to 2 to 3°; in another place,[17] in discussing the reliability of their newer measurements at high temperatures, they state that there is a difference amounting to 5° between the older (1900) and the newer (1906) Reichsanstalt determinations at 1100°, and continue: "The deviation from the mean would still fall within the limits of error of the earlier determinations. We consider it better however to attach greater weight to the former measurements, because the temperature gradient in the gas thermometer bulb was much smaller in the earlier measurements." This may well be, for they give figures[18] which show that in the 1906 determinations at 1124° there were differences of temperature from one point of the bulb to another of as much as 346 microvolts, or about 29°.

Summary. In this note a new calibration curve for copper-constantan thermo-elements, extending from 0° up to 360°, is given, together with a series of independent measurements of the temperature differences between the boiling points of naphthalene (217°.95) and benzophenone (305°.9) on the one hand, and the freezing points of tin, bismuth, cadmium and lead on the other. These measurements lead to the following values of the freezing points: Sn, 231°.8; Bi, 271°.0; Cd, 320°.9; Pb, 327°.3. The concordance of these values with those obtained by other measurements show that the thermoelement is not inferior to the resistance thermometer within this range of temperature (0 to 360°). Moreover, a comparison of the results obtained with these interpolation instruments (thermoelement, resistance thermometer, etc.) which measure not temperature independently but a well-defined physical property which changes continuously with the temperature, affords an excellent opportunity, *through this continuity,* for the discovery of inconsistencies in the gas thermometer measurements. The remarkable concordance of the present

[16] Sitzungsber. Akad. Wiss. Berlin **44**: 414. 1906.
[17] Ann. Physik. **22**: 19. 1907.
[18] loc. cit. p. 8.

series of thermoelectric measurements and the most extensive recent series of resistance thermometer measurements (Bureau of Standards) on the one hand with the recent gas-thermometer determinations made in this laboratory on the other, serves therefore as an efficient and independent check upon the trustworthiness of the present gas thermometer scale between 0° and 1100°.

PHYSICS.—*The expansion coefficient of graphite.* ARTHUR L. DAY and ROBERT B. SOSMAN, Geophysical Laboratory. To appear in the Journal of Industrial and Engineering Chemistry.

As a basis for the measurement of the specific volumes of silicates at high temperatures we found it necessary to know approximately the expansion coefficient of Acheson artificial graphite up to 1600°. The published data on graphite were so inconsistent and covered so small a temperature range, that we redetermined this constant over the range from 0° to 1500°; the results obtained from the material of the present paper.

The expansion was measured directly on a bar 3 mm. by 5 mm, by 700 mm. long, with a comparator which has been used in this laboratory for measuring the expansion coefficient of alloys of platinum with rhodium and iridium.[1] The comparator consists of two micrometer microscopes held at a fixed distance of 500 mm. apart by invar bars, and having mounted upon the system another invar bar by which any changes in this fixed distance amounting to 0.001 mm. or more can be detected.

Two points on the graphite bar, 500 mm. apart, were marked by flattened pieces of platinum wire bound around it, each having a fine line cut at the middle of the wire. The bar was heated by sending a heavy current through it, and a uniform temperature along its length was obtained by slightly adjusting its thickness. It was surrounded by a tube of Marquardt porcelain, and this again by a wide glass tube, each free to expand independently of the bar. The space within the tube was kept filled with carbon monoxide.

In the reducing atmosphere a thermoelement could not be used. The temperature was, therefore, found by noting the melting point of small

[1] Day and Sosman, Am. J. Sci. 26: 425–436. 1908. 29: 111–114. 1910. Carnegie Pub. No. 157; 27–36, 61–63. 1911.

fragments of aluminum (658°), silver (960°), copper (1083°) and the mineral diopside (1391°) lying upon the bar. Intermediate temperatures were read by means of a Holborn-Kurlbaum optical pyrometer, which thus served simply as a device for interpolating between the melting points. It was not necessary to obtain great accuracy in the temperature measurement, as the expansion is small.

Below 700° the expansion is so small that we found it necessary, in order to obtain accurate measurements of the coefficient, to use the method which we had previously employed for the platinum alloys: namely, to heat the bar in a narrow tubular resistance furnace, and read the expansion on a series of very fine lines 0.2 mm. apart, drawn with a dividing engine. These lines were drawn upon the polished ends of small plugs of silver or platinum set into the graphite at points 500 mm. apart. Up to the red heat of 700° the bar could be protected fairly well from oxidation, and contamination of the thermoelement could be prevented by enclosing it in Jena glass capillaries.

Table I contains the data. In the first two columns are given the date and the temperature at the time of the measurement. In the third column is the initial distance at 0°, between two reference lines on the silver or platinum markers on the graphite bar, in mm.; this distance was frequently changed slightly by resetting the silver or platinum markers. The fourth column contains the expansion from 0°, in mm., and the fifth, the mean linear expansion on coefficient $\frac{\Delta l}{l_o t}$ from 0° to t°.

The coefficient is seen to be very small, though increasing rapidly with rising temperature. The total expansion up to 1000° is only about one-fifth of that of platinum. Two samples were used, but no systematic difference exceeding the error of measurement was observed.

The greatest uncertainty arises from changes in length of the bar after heating. In every case where the change was measurable, the bar was longer than before heating, as if this somewhat porous material had failed, after expanding, to entirely pull itself together again. The largest change noted was 0.046 mm., which is 0.009 per cent on the total length, and therefore quite negligible when the total length or volume is being considered.

Within the limits of error, the results may be expressed by the formula $10^6 \beta = 0.55 + 0.0016\, t$ in which β is the mean linear coefficient $\frac{\Delta l}{l_o t}$ from 0°. The "true coefficient" α, or rate of expansion, $\left(\frac{1}{l_o} \cdot \frac{dl}{dt}\right)$ at any temperature t would be therefore;

$$10^6 \alpha = 0.55 + 0.0032\, t.$$

If this equation continues to hold below 0°, the true coefficient would become zero at about − 170°; in other words this

TABLE I

OBSERVED EXPANSION OF ACHESON GRAPHITE

DATE	t	l_0	EXPANSION	$\beta \times 10^6$
I. Self-heating bar				
1910				
December 2	658	499.94	0.60	1.82
	658		0.58	1.77
December 5	970	500.16	1.04	2.14
	1085		1.21	2.23
December 6	960	500.11	0.98	2.05
	1085		1.19	2.20
	1175		1.42	2.41
	1255		1.56	2.49
December 7	960	500.13	0.97	2.02
	1090		1.25	2.29
	1190		1.42	2.40
	1335		1.77	2.65
	1410		1.98	2.82
	1495		2.25	3.02
II. Platinum resistance furnace				
1911				
January 6	198	500.974	0.090	0.91
	396		0.265	1.34
January 8	202	501.020	0.075	0.74
	401		0.228	1.13
January 10	304	501.016	0.145	0.95
January 23	401	501.433	0.229	1.14
	602		0.467	1.55
January 31	403	501.279	0.274	1.35
	604		0.514	1.69
February 12	413	501.291	0.272	1.31
	616		0.506	1.64

would be the temperature of maximum density. According to Fizeau's measurements, diamond has a similar point of maximum density or zero expansion at $-42°$.

The published figures on the expansion coefficient of graphite vary widely. We do not know of any previous determinations on Acheson graphite, nor have the manufacturers a record of any. The following data have been obtained on natural graphites:

SOURCE	OBSERVER	RANGE	$\beta \times 10^6$
"Batongol" (Siberian) graphite	Fizeau*	10° to 85°	$7.45 + 0.0051t$
"Siberian" graphite	Muraoka†	Not given	3.8
"Cumberland" graphite	Dewar‡	−190° (from 17°)	24.4

* Compt. rend. **68**: 1125–1131. 1869. Pogg. Ann. **138**: 26–31. 1869. Fizeau's values are for α, the true coefficient; the mean coefficient from 0° has been calculated from the original values.

† Ann. Phys. **13**: 307–318. 1881.

‡ Proc. Roy. Soc. **70**: 237–246. 1902.

For pencil-graphite, Muraoka found the value 0.95×10^{-6} But as this is a mixture containing only 52 per cent of graphite, it is hardly comparable with data on pure materials.

The wide range of these data is striking, especially when taken in comparison with the expansion coefficients of other forms of carbon, and of carbon compounds. It will be seen from the table below that from the expansion coefficient of diamond to that of anthracite we have an increase of forty-fold.

FORM	OBSERVER	RANGE	$\beta \times 10^6$
Diamond	Fizeau*	10° to 85°	$0.60 + 0.0072t$
Arc carbons (of coke)	Muraoka	Not given	0.32
Arc carbons	Muraoka	Not given	1.5
Arc carbons	Muraoka	Not given	2.05
Arc carbons	Muraoka	Not given	3.0
Gas carbon (retorts)	Fizeau†	10° to 85°	$4.96 + 0.0055t$
Anthracite (Pennsylvania)	Fizeau†	10° to 85°	$24.02 - 0.0408t$
Coal (Charleroy)	Fizeau	10° to 85°	$26.63 + 0.0148t$
Woods, various kinds	Villari‡	43°	24 to 42

* Pogg. Ann. **128**: 583. 1866.

† Compt. rend. **68**: 1125–1131. 1869.

‡ Landolt-Börnstein-Meyerhoffer Tab. p. 202. Figures are mean linear, or one-third of cubical.

A rough parallelism is immediately evident between the temperatures of formation and the expansion coefficients of the different varieties of carbon in the two tables above. The highest coefficient is possessed by bituminous coal, which is followed closely by anthracite. The Cumberland (Borrowdale, England) graph-

ite investigated by Dewar stands next in order, and very near anthracite. This graphite has been formed in company with intrusions of igneous rock into clay-slates containing organic matter. The Batongol graphite, with a lower coefficient, occurs in veins in granite and syenite.[2] Various samples of arc light and retort carbon, all of which have probably been heated in the process of manufacture to a higher temperature than any of the natural graphites, stand next in the order of decreasing expansion. Lowest of all (excepting one sample of arc carbon made of coke) come diamond and Acheson artificial graphite. The formation temperature of diamond is unknown. The artificial graphite is made by heating anthracite, petroleum coke, etc., to a temperature above 2200°.[3]

The view has been repeatedly expressed, by Moissan,[4] Luzi,[5] and others, that none of the three forms of carbon as at present distinguished, not even diamond, can be looked upon as a substance of fixed and reproducible properties, comparable for instance to the monoclinic and rhombic forms of sulfur. In the case of graphite, there are wide variations in such physical properties as density and electrical conductivity, as well as in chemical properties such as combustibility and the formation of "graphitic acids" of widely varying composition when different kinds of graphite are treated with nitric acid and potassium chlorate.

If we look upon natural graphites as products of metamorphism from organic matter, we may imagine the complicated carbon chains and rings of the cellulose and resin compounds of bituminous and anthracite coal as persisting after the removal of the hydrogen and oxygen, giving a whole series of "graphites" whose properties change progressively as the molecules become simpler. Berthelot[6] held this view as regards amorphous carbon.

Arsem,[7] as a result of this studies on the graphitization of different forms of "amorphous" carbon, and the densities of the result-

[2] Donath, "Der Graphit," 1904.
[3] Gillett, Journ. Phys. Chem. **15**: 302, 1911.
[4] Chimie Minérale, 1905, II, 222.
[5] Donath, "Der Graphit," 1904, p. 11.
[6] Ann. Chim. Phys. (4) **9**: 475. 1866.
[7] Jl. Ind. and Eng. Chem. **3**: 799–804. 1911.

ing products, reaches this tentative conclusion: "Graphite in the most restricted sense of the term is an allotropic form of carbon having a definite and perhaps not very complex molecular configuration. . . . . When an organic compound is decomposed, there results a mixture of substances constantly increasing in complexity until finally carbon is obtained. This carbon need not be regarded as a simple substance, but may be considered to be a mixture of many varieties of carbon each with a different number and arrangement of atoms in the molecule. . . . . In a given sample of amorphous carbon some of the molecules will be capable of easily undergoing rearrangement under the influence of heat to form graphite molecules, while others will not, and the proportion of molecules capable of such change will determine the character of the final product."

Arsem's definition is as follows: "Graphite is that allotropic form of carbon having a specific gravity of 2.25 to 2.26." This is the specific gravity of Acheson graphite, and all the graphites made by Arsem were equal to or less than this. "Those varieties of carbon which have some of the physical properties of graphite, such as color, softness, and streak, but a lower specific gravity, may perhaps be regarded as impure graphites; that is to say, mixtures of graphite with other forms of carbon."

Against the view set down in preceding paragraphs, that so-called graphite is not a simple and reproducible substance, we have the recent work of LeChatelier and Wologdine. They found that the density of Acheson and of five natural graphites after purification to remove ash and compression to drive out air, was 2.255, and conclude that this property defines graphite as a simple and reproducible substance. But the wide divergence in expansion coefficient which we have noted above seems quite beyond the range of possible experimental error, and indicates some fundamental difference between these graphites.

[8] Compt. rend. **146**: 49–53. 1908.

CHEMISTRY.—*A theory of the mercury ammonia compounds.* EDWARD C. FRANKLIN, Hygienic Laboratory, U. S. Public Health and Marine Hospital Service. To appear in full in the American Chemical Journal.

The large number of products which have been prepared by the action of ammonia on mercuric oxide and mercuric salts constitute an obscure group of substances which has never received adequate theoretical treatment. In the dictionaries and handbooks of chemistry these products are for the most part described as mercuriammonium compounds, that is to say, they are assumed to be ammonium oxide, ammonium hydroxide or ammonium salts in which ammonium hydrogen is to a greater or less extent substituted by mercury, or they are complex compounds containing mercury substituted ammonium salts.

According to the theory proposed by the writer the mercury ammonia compounds, instead of being mercury substituted ammonium salts and bases, are, as a matter of fact, either (1) mercuric salts with ammonia of crystallization; (2) ammonobasic salts; (3) mixed aquobasic ammonobasic salts or (4) mixed aquo ammono bases.

An attempt will be made here to give the results arrived at by the author as applied to a few of the better known representatives of the large class of mercury ammonia compounds leaving the proofs of the inadequacy of the mercuriammonium theories together with the detailed arguments in support of the writer's theory of the nature of the mercury ammonia compounds to be found in the longer paper.

The fusible white precipitate. Over sixty years ago Kane gave this compound the formula $HgCl_2.2NH_3$, expressed in terms of modern nomenclature, and recognized it as a compound in which ammonia plays a part analogous to that of water in salts with water of crystallization. Since that time the compound has been variously formulated as mercuridiammonium chloride, $Hg\begin{cases}NH_3\text{-}Cl\\NH_3\text{-}Cl\end{cases}$ that is, as ammonium chloride in which one hydrogen of each of two molecules of ammonium chloride is replaced by

the divalent mercury atom; as a compound of the infusible white precipitate and ammonium chloride as represented by the formula $NH_2HgCl.NH_4Cl$; and especially in recent years in accordance with the widely accepted Rammelsberg-Pesci theory as a double salt of dimercuriammonium chloride and ammonium chloride as represented by the formula $NHg_2Cl.3NH_4Cl$.

Now there are no known experimental facts which require the formulation of the fusible white precipitate in accordance with any of the mercuriammonium theories and since every thing known of the behavior of the fusible white precipitate indubitably places it in the class of ammonated salts, it follows that the formula given it by Kane must be accepted.

The infusible white precipitate. In accordance with the prevailing ammonium theories this compound is assumed to be either ammonium chloride in which one-half of the hydrogen is replaced by mercury as represented by the formula $Hg{:}NH_2Cl$, or as a double salt of dimercuriammonium chloride and ammonium chloride of the formula $Hg_2NCl.NH_4Cl$. The writer has shown that this compound results from the ammonolysis of normal mercuric chloride either in liquid ammonia solution or in water solution and that to it must accordingly be ascribed the formula NH_2-Hg-Cl, which represents it as an ammonobasic salt.

Millon's base. This substance has been assigned a bewildering number of formulas depending upon the view to be expressed concerning its empirical composition, for even this is uncertain, and its constitution. The prevalent views are perhaps best expressed by the formula $Hg_2NOH.nH_2O$, which represents it as dimercuriammonium hydroxide with more or less water of hydration. The writer has shown that the compound is a mixed aquo ammono base to which the formula HO-Hg-NH-Hg-OH or any one of a number of other formulas representing it as a compound, basic at the same time to both water and ammonia, may be given.

The chloride and iodide of Millon's base. When the fusible white precipitate is thoroughly washed with water, or when Millon's base is treated with a limited quantity of dilute hydrochloric acid, a compound is formed which was formerly called the chloride of Millon's base but which more recently has come to be

known as hydrated chloride of dimercuriammonium as represented by the formula $Hg_2NCl.H_2O$. The iodide of Millon's base, or Nessler's precipitate, is obtained without the presence of the elements of water and is consequently given the formula Hg_2NI, which represents it as anhydrous dimercuriammonium iodide. It is shown in the longer paper that Nessler's precipitate is an ammono basic mercuric iodide formed by the ammonolysis of normal mercuric iodide in accordance with the reversible equation

$$2HgI_2 + 4NH_3 \rightleftarrows Hg : N\text{-}Hg\text{-}I + 3NH_4I,$$

and that the chloride of Millon's base is a mixed aquo basic ammono basic salt resulting from the simultaneous hydrolysis and deammonation of the ammonobasic salt NH_2HgCl as represented by the equation

$$2NH_2\text{-}Hg\text{-}Cl + H_2O = HO\text{-}Hg\text{-}NH\text{-}Hg\text{-}Cl + NH_4Cl$$

A very large number of products are described in the literature as having been obtained by the action of aqua ammonia on mercuric salts. Many of these products are certainly not definite compounds but are basic mixtures which happened to approximate in composition the formulas assigned them. Such as are definite chemical individuals belong to one of the three classes of compounds described above, that is, they are mercuric salts with ammonia of crystallization, ammonobasic salts or aquobasic ammonobasic salts.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 461st Regular and 33d Annual Meeting of the Society was held April 30, in the New National Museum, with the president, Mr. F. W. Hodge, in the chair. The following officers were elected: President, G. R. Stetson; vice-president, Francis LaFlesche; secretary, William H. Babcock; treasurer, J. N. B. Hewitt; additional members of the board of managers, G. C. Maynard, Felix Neumann, E. T. Williams, E. L. Morgan, and John R. Swanton.

Several amendments to the by-laws were adopted.

Truman Michelson, *Retiring Secretary.*

THE BOTANICAL SOCIETY OF WASHINGTON

The 81st meeting was held May 7, 1912. The following papers were read:

Further studies on the pecan "rust": F. V. Rand. A preliminary report on the fungus causing this pecan leaf disease was published in *Phytopathology*, August, 1911, under the name *Mycosphaerella convexula.* Since that time the fungus in question has been obtained from a number of other sources and several strains known to have orignated from single two-celled ascospores have been under study. In the course of one and one-half year's growth in culture, strains originally producing a majority of apparently two-celled ascospores have gradually changed until now most of the ascospores are distinctly non-septate. Furthermore a typical Gloeosporium form was developed in culture and also obtained from the host. A large number of colonies known to have originated from single ascospores or single conidia all gave cultures producing both perithecial and conidial forms, showing the two to be different phases in the life cycle of the same fungus. Inoculations on Jonathan and Yellow Newton apples gave a decay similar to bitter-rot, with production of conidia and immature perithecia on the latter. Inoculations on young pecan leaves under greenhouse conditions gave negative results but infections together with production of conidia and mature perithecia readily occurred on living leaves in damp chamber. The latter case approximates conditions in the field, since the disease has been found largely on mature leaves late in the season and under damp conditions near the ground. From the studies summarized above it would appear that the fungus is closely related to if not identical with *Glomerella rufomaculans,* and that it is not a very active parasite on the pecan.

Distribution of pigment in the seed-coat of the cowpea: ALBERT MANN. The question of the arrangement of pigments in the seed-coat of the cowpea was studied because of the bearing of certain phenomena upon questions of heredity now being studied by Prof. W. J. Spillman. Transverse sections of the seed-coat disclose three principal layers of cells, the outer one being a palisade layer with long axis vertical to the surface and with the cell cavity club-shaped and having the larger end at the lower extremity of the cell, the upper end of the cavity being often reduced to a mere thread. Second, a heavy-walled layer below this of empty cells; and third, a layer of considerably compressed cells with long axis parallel to the surface of the cowpea.

It was found that the colorations in the cowpea are the result of pigments deposited in two of these layers. In all colored cowpeas there is a basal color or practically uniform tint and invariably to be found in the lowest of the three layers, to which is therefore given the name of the basal color layer. This is a melanin compound and is of an orange-yellow tint, grading into lemon-yellow and pale buff. The changes in intensity are probably not due to a difference in the character of the pigment, but to a difference in the quantity. All other colors are obtained by superposing upon this basal color layer various pigments, and these are uniformly deposited in the palisade cells, and as a rule in the lower and larger third of the cell cavity. The colors to be found here are of practically three kinds: first, a black to blue-black, or sometimes purple tint which is an anthocyanin. Secondly a yellow or brassy-brown pigment which is some melanin compound; and third, an intense black pigment which is also a melanin compound. By various arrangements of these three superposed tints in the palisade cells, or by the absence of any pigments in these cells, the various schemes of coloration in the cowpea are obtained; the marbling, blotching, dotting, as well as the uniform colors of some cowpeas being produced by the basal color plus such superposed arrangements of color in the palisade cells as are characteristic of the different varieties.

In the case of the few cowpeas having white or colorless seed-coats, the result is obtained by the suppression of all pigments both in the basal color layer and in the palisade layer.

A wild cowpea secured from North Nigeria, Africa, is of particular interest, in that upon the same cowpea all the elements of color, as well as all the schemes of coloration are to be found. This cowpea, which is from one-seventh to one-eighth the size of the average cultivated cowpea, has a seed-coat that morphologically is identical in structure with that of cultivated cowpeas; the methods of pigment deposit are found to be also identical with those seen in the cultivated varieties.

The purpling chromogen of the Hawaiian bitter yam: H. H. BARTLETT.

Illustrations of the phytogeography of the North American Continent: JOHN W. HARSHBERGER (by invitation). The speaker displayed to the Society an album of twelve volumes of photographs and illustrations of North American vegetation collected during the preparation of his recently published work on the phytogeography of North America. The

sources of the material, and method of preparation and classification were discussed, and the general plan and scope of the work were explained in detail.

W. W. STOCKBERGER, *Corresponding Secretary.*

CHEMICAL SOCIETY OF WASHINGTON

A special meeting was held at the Cosmos Club Friday, March 1. Dr. R. B. MOORE of the Bureau of Soils gave a lecture on *Radioactivity,* illustrated by diagrams, specimens, experiments with the electroscope, and demonstration of spectra of the rare gases.

The 214th regular meeting was held at the Cosmos Club on March 14. The following papers were read:

Relations of the two sulfides of zinc: J. L. CRENSHAW, Geophysical Laboratory. Discussion by Allen.

Beet sugar manufacture: W. L. BADGER, Bureau of Standards. Illustrated with lantern slides and specimens. Discussion by Franklin.

A note was presented by DR. BLUM of Bureau of Standards on *Permanency of oxalate standards.* His experiments with coarse and fine samples showed a maximum absorption of 0.04 per cent of moisture under the most unfavorable conditions.

A special meeting was held at the Cosmos Club, March 22. DR. A. M. COMEY, director of the Eastern Laboratory of the E. I. duPont de Nemours Powder Company at Chester, Pa., delivered an illustrated lecture on *The testing of high explosives.* A smoker followed the meeting.

The 215th regular meeting was held on April 11. The following papers were read:

Relation of the chemical and physical properties of the alkali feldspars: H. E. MERWIN, Geophysical Laboratory. Discussion by Allen, who called attention to the usefulness of the petrographic microscope to the chemist.

The thermal expansion of graphite: R. B. SOSMAN, Geophysical Laboratory. Discussion: Hillebrand inquired as to the purity of the natural graphites; Wells inquired as to the effect of gases on the expansion coefficient.

Benzoic acid as an acidimetric standard: G. W. MOREY, Geophysical Laboratory. Discussion: Seidell inquired as to availability of purchasable benzoic acid for analytical use. Mr. Morey replied that high grade commercial acid should not vary more than 0.1 per cent from the pure acid, and that this variation disappears after one crystallization.

J. JOHNSTON and L. H. ADAMS exhibited crystals of calcium hydroxide and barium sulfate. Dr. Johnston explained the diffusion method for obtaining such crystals.

The first meeting of the Baltimore Branch of the Chemical Society was held in Hopkins Hall, Baltimore, on April 27. The following papers were read:

On the possibility of determining gelatin quantitatively when contained in milk and similar liquids: CHARLES GLASER.

Osmotic pressure determinations at higher temperatures (25° to 70°): PROF. H. N. MORSE. Discussed by W. Simon, W. W. Murray, E. C. Franklin, W. N. Berg.

Determination of sulfite when used as a preservative in meat. W. W. RANDALL and W. B. D. PENNIMAN.

Preliminary report on the solid acids separated from fats by means of the ammonia method: H. B. DISNEY and W. B. D. PENNIMAN. These last two were read by Dr. Randall. Discussion by C. Caspari, W. W. Murray, H. N. Morse.

A special meeting, arranged by Professor Munroe, in celebration of the centenary of the gas industry, was held at the Institute of Industrial Research on May 1. The following papers were read:

The gas centenary, its origin and meaning: PROF. CHARLES E. MUNROE, of George Washington University.

Gas appliances: WALTER R. ADDICKS, Vice-President of the Consolidated Gas Company, of New York. Discussion: In reply to a question by Sosman, Mr. Addicks outlined the possibilities of house heating by artificial gas. LeClerc inquired about the danger to life from faulty gas apparatus. Munroe brought out the point that over-enrichment may be a cause of danger by causing flames to "strike back." McBride mentioned the work being done by the Bureau of Standards on standard gas ordinances for cities.

Internal operation of the Lowe process: Illustrated. W. H. GARTLEY, Engineer of Works, United Gas Improvement Company, of Philadelphia.

Inspection of gas meters: With exhibits of apparatus. E. G. RUNYAN, Inspector of Gas and Meters for the District of Columbia. Discussion: McBride, Munroe, and Johnston brought out different phases of the specification of pressure, as well as the degree of constancy of pressure, as a municipal regulation not now in common use but of considerable importance.

Liquefied natural gas: With exhibit of apparatus. Dr. W. O. SNELLING, Chemist of the Bureau of Mines. Discussion: The relative heating values, temperatures obtainable with oxygen, and usefulness for cutting and welding, of this gas as compared with acetylene and with hydrogen were discussed by Cushman, C. O. Bond, and Crawford.

The 216th regular meeting was held on May 9 at the Cosmos Club. Dr. H. W. WILEY spoke on *The value of chemistry to the medical profession.*

ROBERT B. SOSMAN, *Acting Secretary.*

GEOLOGICAL SOCIETY OF WASHINGTON

The 252d meeting was held in the Cosmos Club, February 14, 1912, and the following papers were given:

A continually rising base level and its results: SIDNEY PAIGE.

Color photography in petrographic work. Illustrated. F. E. WRIGHT.

Undescribed glaciers of Mt. Rainier. Illustrated. F. E. MATTHES.

In his classic report on "The Glaciers of Mount Rainier," the late I. C. Russell described only six of the eleven principal ice streams of that mountain. The other five, situated on its west and southwest flanks, he did not have an opportunity to visit; and, as no one else has thus far given any description of them, they have virtually remained unknown. Last summer (1911), happily, these glaciers were mapped in the course of the topographic survey of the Mount Rainier National Park, and some data regarding them are consequently now at hand.

The interest that attaches to these glaciers arises chiefly from the fact that they are associated with the two subsidiary summits of the mountain, Peak Success and Liberty Cap. These are the two largest remnants of the rim of the main crater, and so extensive are their slopes that several large ice streams originate upon them. Indeed, of the five glaciers in question, only two, the Kautz and Tahoma glaciers, come from the summit névés of the mountain and are therefore true "primary" glaciers in the sense in which Russell used that term. The other three, the Wilson, Puyallup, and Edmunds glaciers, head in cirques situated at a level some 4000 feet lower than the summit. They are strictly speaking "secondary" or "interglaciers," to follow out Russell's classification to its logical end; but such is their size that they may easily be considered as ranking with the "primary" glaciers, and the term "secondary" scarcely seems appropriate to them. Should it be found desirable, however, to retain the distinction between primary and secondary glaciers as suggested by Russell, then it will become necessary to reclassify two of the glaciers described by him and classified by him as "primary," namely, the Carbon and Willis glaciers. Both of these ice streams originate in cirques on the sides of the Liberty Cap massif and belong to the same type as the Wilson, Payallup, and Edmunds glaciers. Of especial interest is the case of the Carbon Glacier which is perhaps the second largest ice stream on Mount Rainier. Russell sought to explain the evolution of its huge cirque as the result of the eroding action of a primary glacier cascading from the summit regions. All primary glaciers, according to him, normally tend to produce such cirques, only Carbon Glacier, owing to especially favorable circumstances, has been able to develop its cirque in advance of the other glaciers and to give it a maturely rounded form. Indeed, so far has the recession of the headwall already progressed that but little now remains of the upper névé area that formerly alimented the glacier from above. As a consequence, Russell thought, the glacier "is now destroying the very conditions on which its existence depends," and with the diminishing of the snow supply from above, will gradually decrease in size.

This interpretation, in the light of recent studies on cirque development, seems scarcely admissible. Cirque glaciers do not require tributary upper névés for their alimentation, but are capable of developing, and ordinarily do develop, independently from such névés. The wind is their chief alimenter, and the prime reason that cirques are capable of collecting such large quantities of snow is that they are the most capacious *windschatten* in the relief. All the cirque glaciers on Mount Rainier are to be conceived as having been initiated primarily by the accumulation of windblown snow in depressions already existing in the mountain's flanks. These depressions they have progressively enlarged into cirques through the eroding effect chiefly of their own mass movements. The enormous size and the mature character of the Carbon Glacier cirque are due, first, to the great capacity of the original depression which gave it birth, and second, to the superior eroding power of the huge ice masses it has from the beginning contained. The part played by snow descending from the summit regions has never been more than a subordinate one. The cirque, to begin with, does not head in the summit névés, but in the rocky platform surrounding Liberty Cap. What névé bodies gather on the platform are quite limited in extent, and can at no time have supplied, in the form of avalanches, more than a fraction of the total bulk of ice filling the cirque.

The Carbon Glacier, like the other glaciers mentioned, is a true cirque glacier and not a "primary" glacier in a senescent stage. Its cirque, instead of a sequential feature that is threatening to extinguish the glacier's source of alimentation on the summit, is to be regarded, rather, as the evergrowing generator of the ice mass.

The 253d meeting was held in the Cosmos Club February 28, 1912, and the following papers were presented:

Age of the Worcester (Massachusetts) phyllite: David White. See this Journal, **2**: 115. 1912.

The Chattanooga shale and its equivalent in the Ohio section: E. O. Ulrich.

The Chattanooga shale problems in the Southern Allegheny region: E. M. Kindle.

Ralph W. Richards, *Secretary.*

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. II, JULY 19, 1912 No. 13

MATHEMATICS.—*A table of the circular functions to radian argument.* C. E. VAN ORSTRAND, U. S. Geological Survey.

With the exception of a few tables containing values of the circular sine and cosine to a small number of decimals, there appears to be no satisfactory table to radian argument of these most important and fundamental of mathematical functions. Not only is it frequently necessary to use the higher values in the usual laboratory computations, but they are also needed for the construction of tables of the requisite accuracy in which circular functions are involved in trigonometrical equations or appear in simple relations which are derivatives of other functions. Important examples of such cases are:

$$\sinh(x \pm iy) = \sinh x \cos y \pm i \cosh x \sin y$$
$$\cosh(x \pm iy) = \cosh x \cos y \pm i \sinh x \sin y$$
$$gd^{-1}(x) = \int \sec x \, dx.$$

Instances of this kind arise from time to time as new applications of mathematical theory are gradually introduced into the various sciences.

The evaluation of the circular sine and cosine, and many other functions, is readily accomplished by repeated applications of Taylor's series. As a means of forming a basis for the application of the series in the present instance, 16 values of $\sin x$ and $\cos x$ between the limits 0.0 and 1.6 were computed roughly to 20 places of decimals by direct substitution in the respective

series. This computation is not a difficult task for the reason that tables of the factorials[1] have been published, and a table of the successive powers from 2 to 20 of the first 20 natural numbers may be readily formed and checked by comparing the 20th difference with $\underline{|20}$. The computation of terms of the form $x^n \div \underline{|n}$ is then easily made and checked by differences. The summation of these terms need not be checked independently for the 10th interpolation must agree with the value obtained by direct substitution in the series.

If the interpolation formulas are written in the forms,

$$\sin(x + \Delta x) = \sin x + \frac{\Delta x}{\underline{|1}} \cos x - \frac{(\Delta x)^2}{\underline{|2}} \sin x - \frac{(\Delta x)^3}{\underline{|3}} \cos x + \ldots,$$

$$\cos(x + \Delta x) = \cos x - \frac{\Delta x}{\underline{|1}} \sin x - \frac{(\Delta x)^2}{\underline{|2}} \cos x + \frac{(\Delta x)^3}{\underline{|3}} \sin x + \ldots,$$

it will be noted that the two series together contain terms of the forms $(\Delta x)^n \sin x \div \underline{|n}$ and $(\Delta x)^n \cos x \div \underline{|n}$ where n assumes successive values of the natural numbers beginning with unity. We thus have two series of terms,

$$\frac{1}{\underline{|2}} \sin x, \quad \frac{1}{\underline{|3}} \sin x, \quad \ldots\ldots \quad \frac{1}{\underline{|n}} \sin x,$$

$$\frac{1}{\underline{|2}} \cos x \quad \frac{1}{\underline{|3}} \cos x, \quad \ldots\ldots \quad \frac{1}{\underline{|n}} \cos x,$$

which may be evaluated by dividing the sine or cosine, as the case may be, first by 2, this quotient by 3, the last by 4, and so on, thus avoiding the use of one large factor. The only effect of the factor $(\Delta x)^n$ is to shift the decimal point, and this may be determined once for all. The following details illustrate the method:

[1] J. W. L. Glaisher, Tables of the exponential function. Camb. Phil. Soc., Trans. 13: 246–247. 1883.

x	sin x				cos x			
0.380	sin x =	0.37092	04694	12983	cos x =	0.92866	46355	76510
	c	0.00092	86646	35577	3s	0.00000	00000	61820
	4s	0.00000	00000	00015	4c	0.00000	00000	00039
	Σ	0.37184	91340	48575	Σ	0.92866	46356	38369
	−2s	0.00000	01854	60235	−s	0.00037	09204	69413
	−3c	0.00000	00001	54777	−2c	0.00000	04643	32318
	$-\Sigma$	0.00000	01856	15012	$-\Sigma$	0.00037	13848	01731
0.381	sin x =	0.37184	89484	33563	cos x =	0.92829	32508	36638

In the preceding notation, ns is used to represent $(\Delta x)^n \sin x \div \lfloor n$ and similarly nc represent $(\Delta x)^n \cos x \div \lfloor n$. The constant quantity Δx is here equal to 0.001.

The above method has been used in the preparation of a table consisting of 1600 values of sin x and cos x between the limits 0.000 and 1.600 with an accuracy of about 8 or 10 units in the 20th place of decimals. This table, a portion of which appears in the present paper, is to be published in full during the coming year. Further interpolations are being made for the purpose of obtaining a complete 10-place table which will also include values of tan x and cot x to the same degree of accuracy. All of the computations have been made by Messrs. William J. Ahern and Alfred G. Seiler, graduates of the McKinley Manual Training School of Washington, D. C.

The tabular error of the values in the following table is less than 5 units in the 16th place of decimals.

TABLE OF CIRCULAR FUNCTIONS TO RADIAN ARGUMENT

x	sine x	cosine x
0.00	0.00000 00000 00000	1.00000 00000 00000
0.01	0.00999 98333 34167	0.99995 00004 16665
0.02	0.01999 86666 93333	0.99980 00066 66578
0.03	0.02999 55002 02496	0.99955 00337 48988
0.04	0.03998 93341 86634	0.99920 01066 60978
0.05	0.04997 91692 70678	0.99875 02603 94966
0.06	0.05996 40064 79445	0.99820 05399 35204
0.07	0.06994 28473 37533	0.99755 10002 53280
0.08	0.07991 46939 69173	0.99680 17063 02619
0.09	0.08987 85491 98011	0.99595 27330 11994
0.10	0.09983 34166 46828	0.99500 41652 78026
0.11	0.10977 83008 37175	0.99395 60979 56697
0.12	0.11971 22072 88919	0.99280 86358 53866
0.13	0.12963 41426 19695	0.99156 18937 14788
0.14	0.13954 31146 44236	0.99021 59962 12637
0.15	0.14943 81324 73599	0.98877 10779 36042
0.16	0.15931 82066 14246	0.98722 72833 75627
0.17	0.16918 23490 66996	0.98558 47669 09561
0.18	0.17902 95734 25824	0.98384 36927 88121
0.19	0.18885 88949 76501	0.98200 42351 17270
0.20	0.19866 93307 95061	0.98006 65778 41242
0.21	0.20845 98998 46100	0.97803 09147 24148
0.22	0.21822 96230 80869	0.97589 74493 30605
0.23	0.22797 75235 35188	0.97366 63950 05375
0.24	0.23770 26264 27135	0.97133 79748 52030
0.25	0.24740 39592 54523	0.96891 24217 10645
0.26	0.25708 05518 92155	0.96638 99781 34513
0.27	0.26673 14366 88831	0.96377 08963 65891
0.28	0.27635 56485 64114	0.96105 54383 10771
0.29	0.28595 22251 04836	0.95824 38755 12697
0.30	0.29552 02066 61340	0.95533 64891 25606
0.31	0.30505 86364 43444	0.95233 35698 85713
0.32	0.31456 65606 16118	0.94923 54180 82441
0.33	0.32404 30283 94868	0.94604 23435 28387
0.34	0.33348 70921 40814	0.94275 46655 28346
0.35	0.34289 78074 55451	0.93937 27128 47379
0.36	0.35227 42332 75090	0.93589 68236 77935
0.37	0.36161 54319 64962	0.93232 73456 06034
0.38	0.37092 04694 12983	0.92866 46355 76510
0.39	0.38018 84151 23161	0.92490 90598 57313
0.40	0.38941 83423 08650	0.92106 09940 02885

TABLE OF CIRCULAR FUNCTIONS TO RADIAN ARGUMENT—Continued

x	sine x	cosine x
0.40	0.38941 83423 08650	0.92106 09940 02885
0.41	0.39860 93279 84423	0.91712 08228 16605
0.42	0.40776 04530 59570	0.91308 89403 12308
0.43	0.41687 08024 29211	0.90896 57496 74885
0.44	0.42593 94650 66000	0.90475 16632 19963
0.45	0.43496 55341 11230	0.90044 71023 52677
0.46	0.44394 81069 65520	0.89605 24975 25525
0.47	0.45288 62853 79068	0.89156 82881 95329
0.48	0.46177 91755 41483	0.88699 49227 79284
0.49	0.47062 58881 71158	0.88233 28586 10121
0.50	0.47942 55386 04203	0.87758 25618 90373
0.51	0.48817 72468 82907	0.87274 45076 45751
0.52	0.49688 01378 43737	0.86781 91796 77650
0.53	0.50553 33412 04847	0.86280 70705 14761
0.54	0.51413 59916 53113	0.85770 86813 63824
0.55	0.52268 72289 30659	0.85252 45220 59506
0.56	0.53118 61979 20883	0.84725 51110 13416
0.57	0.53963 20487 33969	0.84190 09751 62269
0.58	0.54802 39367 91874	0.83646 26499 15187
0.59	0.55636 10229 12784	0.83094 06791 00163
0.60	0.56464 24733 95035	0.82533 56149 09678
0.61	0.57286 74601 00481	0.81964 80178 45480
0.62	0.58103 51605 37305	0.81387 84566 62534
0.63	0.58914 47579 42270	0.80802 75083 12152
0.64	0.59719 54413 62392	0.80209 57578 84293
0.65	0.60518 64057 36040	0.79608 37985 49056
0.66	0.61311 68519 73434	0.78999 22314 97365
0.67	0.62098 59870 36560	0.78382 16658 80849
0.68	0.62879 30240 18469	0.77757 27187 50928
0.69	0.63653 71822 21968	0.77124 60149 97107
0.70	0.64421 76872 37691	0.76484 21872 84488
0.71	0.65183 37710 21537	0.75836 18759 90508
0.72	0.65938 46719 71473	0.75180 57291 40895
0.73	0.66686 96350 03698	0.74517 44023 44870
0.74	0.67428 79116 28145	0.73846 85587 29588
0.75	0.68163 87600 23334	0.73168 88688 73821
0.76	0.68892 14451 10551	0.72483 60107 40905
0.77	0.69613 52386 27357	0.71791 06696 10943
0.78	0.70327 94192 00410	0.71091 35380 12277
0.79	0.71035 32724 17608	0.70384 53156 52236
0.80	0.71735 60908 99523	0.69670 67093 47165

TABLE OF CIRCULAR FUNCTIONS TO RADIAN ARGUMENT—Continued

x	sine x	cosine x
0.80	0.71735 60908 99523	0.69670 67093 47165
0.81	0.72428 71743 70143	0.68949 84329 51747
0.82	0.73114 58297 26896	0.68222 12072 87614
0.83	0.73793 13711 09963	0.67487 57600 71267
0.84	0.74464 31199 70859	0.66746 28258 41308
0.85	0.75128 04051 40293	0.65998 31458 84982
0.86	0.75784 25628 95277	0.65243 74681 64052
0.87	0.76432 89370 25505	0.64482 65472 40001
0.88	0.77073 88788 98969	0.63715 11441 98580
0.89	0.77707 17475 26824	0.62941 20265 73697
0.90	0.78332 69096 27483	0.62160 99682 70664
0.91	0.78950 37396 89950	0.61374 57494 88812
0.92	0.79560 16200 36366	0.60582 01566 43463
0.93	0.80161 99408 83777	0.59783 39822 87298
0.94	0.80755 81004 05114	0.58978 80250 31098
0.95	0.81341 55047 89374	0.58168 30894 63883
0.96	0.81919 15683 00998	0.57351 99860 72457
0.97	0.82488 57133 38450	0.56529 95311 60354
0.98	0.83049 73704 91970	0.55702 25467 66217
0.99	0.83602 59786 00521	0.54868 98605 81588
1.00	0.84147 09848 07897	0.54030 23058 68140
1.01	0.84683 18446 18015	0.53186 07213 74355
1.02	0.85210 80219 49363	0.52336 59512 51650
1.03	0.85729 89891 88603	0.51481 88449 69955
1.04	0.86240 42272 43338	0.50622 02572 32778
1.05	0.86742 32255 94017	0.49757 10478 91727
1.06	0.87235 54823 44986	0.48887 20818 60528
1.07	0.87720 05042 74682	0.48012 42290 28534
1.08	0.88195 78068 84947	0.47132 83641 73740
1.09	0.88662 69144 49487	0.46248 53668 75301
1.10	0.89120 73600 61435	0.45359 61214 25577
1.11	0.89569 86856 80048	0.44466 15167 41707
1.12	0.90010 04421 76505	0.43568 24462 76712
1.13	0.90441 21893 78826	0.42665 98079 30157
1.14	0.90863 34961 15883	0.41759 45039 58358
1.15	0.91276 39402 60521	0.40848 74408 84157
1.16	0.91680 31087 71767	0.39933 95294 06273
1.17	0.92075 05977 36136	0.39015 16843 08230
1.18	0.92460 60124 08020	0.38092 48243 66882
1.19	0.92836 89672 49167	0.37165 98722 60533
1.20	0.93203 90859 67226	0.36235 77544 76674

TABLE OF CIRCULAR FUNCTIONS TO RADIAN ARGUMENT—Continued

x	sine x	cosine x
1.20	0.93203 90859 67226	0.36235 77544 76674
1.21	0.93561 60015 53386	0.35301 94012 19330
1.22	0.93909 93563 19068	0.34364 57463 16047
1.23	0.94248 88019 31698	0.33423 77271 24503
1.24	0.94578 39994 49539	0.32479 62844 38776
1.25	0.94898 46193 55586	0.31532 23623 95269
1.26	0.95209 03415 90516	0.30581 69083 78289
1.27	0.95510 08555 84692	0.29628 08729 25319
1.28	0.95801 58602 89225	0.28671 52096 31956
1.29	0.96083 50642 06073	0.27712 08750 56558
1.30	0.96355 81854 17193	0.26749 88286 24587
1.31	0.96618 49516 12734	0.25785 00325 32670
1.32	0.96871 51001 18265	0.24817 54516 52373
1.33	0.97114 83779 21045	0.23847 60534 33723
1.34	0.97348 45416 95319	0.22875 28078 08459
1.35	0.97572 33578 26659	0.21900 66870 93042
1.36	0.97786 46024 35316	0.20923 86658 91419
1.37	0.97990 80613 98614	0.19944 97209 97573
1.38	0.98185 35303 72360	0.18964 08312 97834
1.39	0.98370 08148 11277	0.17981 29776 72999
1.40	0.98544 97299 88460	0.16996 71429 00241
1.41	0.98710 01010 13850	0.16010 43115 54831
1.42	0.98865 17628 51720	0.15022 54699 11686
1.43	0.99010 45603 37178	0.14033 16058 46737
1.44	0.99145 83481 91686	0.13042 37087 38145
1.45	0.99271 29910 37588	0.12050 27693 67367
1.46	0.99386 83634 11645	0.11056 97798 20070
1.47	0.99492 43497 77581	0.10062 57333 86932
1.48	0.99588 08445 37640	0.09067 16244 64310
1.49	0.99673 77520 43143	0.08070 84484 54801
1.50	0.99749 49866 04054	0.07073 72016 67703
1.51	0.99815 24724 97548	0.06075 88812 19386
1.52	0.99871 01439 75583	0.05077 44849 33579
1.53	0.99916 79452 71476	0.04078 50112 41591
1.54	0.99952 58306 05479	0.03079 14590 82466
1.55	0.99978 37641 89357	+0.02079 48278 03092
1.56	0.99994 17202 29966	+0.01079 61170 58267
1.57	0.99999 96829 31835	+0.00079 63267 10733
1.58	0.99995 76464 98740	−0.00920 35432 68808
1.59	0.99981 56151 34291	−0.01920 24929 01693
1.60	0.99957 36030 41505	−0.02919 95223 01289

CHEMISTRY.—*Benzoic acid as an acidimetric standard.* GEORGE W. MOREY. Communicated by W. F. Hillebrand. To appear in the Bulletin of the Bureau of Standards.

The study of the suitability of benzoic acid as a primary standard in acidimetry and alkalimetry was suggested by experience gained in the purification of benzoic acid to be used as a calorimetric standard. During that work it was found that benzoic acid could be titrated with standard alkali to a high degree of accuracy and that this titration afforded the most rapid and accurate method of comparing the purity of various samples. Since pure benzoic acid has been furnished for some time by the Bureau of Standards as a calorimetric standard, it would of course be advantageous to use it also for a standard in acidimetry if found suitable.

Wagner,[1] in a report presented to the Fifth International Congress of Applied Chemistry, in 1903, mentioned benzoic acid among a number of other possibilities for the purpose named; and Phelps and Weed[2] included it in a short study of the availability of several organic acids and acid anhydrides.

The method used in studying this problem was that of standardizing a hydrochloric acid solution by several well known and standard methods, and comparing the results so obtained with those obtained by standardizing the same hydrochloric acid against benzoic acid. The methods chosen for the work were the distillation method of Hulett and Bonner, the gravimetric silver chloride method, comparison with a sulfuric acid solution standardized gravimetrically by the barium sulfate method, and comparison with the same sulfuric acid standardized volumetrically by the sodium oxalate method. All the materials used were prepared with the greatest care, and were carefully protected from the carbon dioxide of the air by suitable guard-tubes. Great care was taken to prepare and keep all solutions free from carbon dioxide, and each solution was tested from time to time for the presence of carbonate. All operations were con-

[1] Proc. Fifth Internat. Cong. Applied Chemistry, Berlin, 1: 323. 1903.
[2] Am. Jour. Sci. 26: 141. 1908.

ducted so to be as free from error as possible. Weight burettes were used for all titrations, which were made in a 300-cc. flask thru which passed a stream of air free from carbon dioxide. A one-per cent solution of phenolphthalein was used as indicator in all the titrations.

Direct standardizations of hydrochloric acid. The hydrochloric acid was first standardized in its preparation, having been prepared by the method of Hulett and Bonner,[3] which is based on the constancy of composition, at a definite atmospheric pressure, of the constant boiling mixture formed by hydrochloric acid and water. From the data given by Hulett and Bonner, the resulting solution was calculated to contain 0.0036396 gram HCl per gram solution, corresponding to a 0.1N factor of 0.9980.

The next standardization was by the silver chloride method with a 50-gram sample. The hydrochloric acid in the filtrate and washings was determined with the nephelometer and the amount found added to that calculated from the weight of silver chloride. Four concordant determinations by this method gave the value 0.0036611 gram HCl per gram solution, corresponding to a 0.1N factor of 0.9984.

The hydrochloric acid was standardized from the sulfuric acid by comparing the two solutions thru a solution of sodium hydroxide. The mean of six determinations of the ratio HCl: NaOH was 1.0464; of four determinations of the ratio H_2SO_4, 0.8454; the ratio H_2Cl: H_2SO_4 was therefore 1.2378. For the gravimetric standardization of the sulfuric acid a 50-gram sample was taken. After igniting and weighing in the usual manner the precipitates were tested for occluded barium chloride by the method of Hulett and Duschak,[4] but the amount found was always less than 0.1 milligram, a negligible quantity. The 0.1N factor for the HCl calculated from these determinations was 0.9984.

The standardization by means of sodium oxalate was made after a series of experiments made to compare various samples of sodium oxalate. While concordant results were obtained by strict adherence to a certain procedure in the transformation

[3] Hulett and Bonner: Jour. Am. Chem. Soc., **31**: 390–393. 1909.

[4] Zeits. anorg. Chem., **40**: 196. 1904.

of the oxalate to the carbonate, it was found that slight variations in the rate or manner of heating might produce very discordant results. The 0.1N factor calculated from the determinations with sodium oxalate was 0.9982.

Standardization of hydrochloric acid by benzoic acid. Because of the bulkiness of the sublimed benzoic acid, it was found convenient to fuse or compress it before weighing. Fusion has the advantage of diminishing the possibility of large surface effects. A platinum dish was filled with the sublimed benzoic acid and the covered dish placed in an oven heated to about 140°. When melted, the liquid was poured into a test tube, and after solidifying the stick so obtained was broken into pieces of convenient size and preserved in a glass stoppered bottle. Samples so prepared can be kept indefinitely and used without preliminary drying.

About a gram of this material was weighed and placed in a 300-cc. flask which had been swept free from carbon dioxide; 20 cc. of alcohol were added, the flask was stoppered and let stand until the sample had dissolved. Three drops of a 1 per cent solution of phenolphthalein were then added and the solution titrated directly with 0.1N alkali, a current of air free from carbon dioxide bubbling through the solution until the titration was completed. The end point chosen was that of a 7 per cent transformation of the indicator added, that being the end point which should give the best results.[5] The effect of the alcohol on the end point was determined in a blank experiment and the titrations corrected by this amount. This blank ranged from 0.06 to 0.08 cc.

In the first series of experiments a solution of barium hydroxide was used, this being the most convenient alkali to use when exclusion of carbon dioxide is necessary. The mean of four concordant determinations of the ratio HCl: $Ba(OH)_2$ was 1.3790. The mean of fifteen determinations, whose maximum difference was 1 part in 1600, gave the value 0.9984 for the 0.1N factor of the HCl. In a second series of experiments the

[5] Noyes: Jour. Am. Chem. Soc., **32**: 857. 1910.

sodium hydroxide solution used in comparing the hydrochloric and sulfuric acids was used, for which the ratio HCl:NaOH was 1.0464. The mean of four concordant determinations was 0.9981.

Summary and conclusion. The results of the foregoing standardizations are summarized in the following table:

SUMMARY OF STANDARDIZATIONS

Method	0.1 N *factor for* HCl
Direct by Hulett and Bonner	0.9980
Direct by AgCl	0.9984
H_2SO_4–$BaSO_4$–NaOH–HCl	0.9984
H_2SO_4–$Na_2C_2O_4$–NaOH–HCl	0.9982
$C_6H_5CO_2H$–Ba $(OH)_2$–HCl	0.9984
$C_6H_5CO_2H$–NaOH–HCl	0.9981

The close agreement of these results proves the accuracy of the benzoic acid method. Moreover, benzoic acid has many advantages. Its high molecular weight permits the use of large samples, thus reducing the error of weighing; its stability and lack of hydroscopicity make it very convenient; and the method is rapid, since a single weighing and a titration are all the operations involved. These considerations, combined with the ease of obtaining it in a high state of purity, make benzoic acid an excellent material to use as a standard in acidimetry and alkalimetry.

ZOÖLOGY.—*The homologies of the so-called anal, and other plates in the pentacrinoid larvæ of the free crinoids.* AUSTIN HOBART CLARK, National Museum.

In the course of my studies upon the recent crinoids I have been able to examine many hundreds of pentacrinoid larvæ belonging to numerous species distributed in several families, and many points hitherto involved in obscurity have been made clear.

Unfortunately all of the work previously done upon the developing crinoid has been based upon one or other of the species of the genus *Antedon,* one of the most specialized of the genera in the group to which it belongs, and hence one of the least satisfactory for purposes of phylogenetic investigation.

In *Antedon* the so-called anal plate is formed at about the period of development of the IBr_2, between the two posterior radials; but it is noticeable that while the radial to the left of it is of normal shape, that to the right has its left side more or less cut away for its reception. When the anal is lifted out from the circlet of radials just previous to its resorption it is noticeable that it keeps to the right of the posterior interradial area, remaining more or less in contact with the right hand radial and first primibrach, instead of being drawn directly upward as would be expected; also the right radial is asymmetrical, more convex on the right side than on the left (adjoining the anal) though after the withdrawal of the anal this asymmetry quickly disappears.

The general tendency of the anal plate of the young *Antedon* to keep to the right of the posterior interradial area, though very strongly marked, does not appear ever to have attracted attention; but it is nevertheless a fact of the very highest importance.

In more primitive species, in which the five infrabasals are large and equal in size, the anal appears to be formed before any of the radials, occupying a position in the rhombic area between the corners of the basals and orals. Soon afterward the radial appears, just to the right of and in line with it, between the basal and oral of that side and to the right of the vertical line dividing the basals and the orals. The radial grows much faster than the anal, which it gradually surrounds so that the latter comes to lie in a deep concavity in the side of the radial to the right of it and to the right of the posterior interradius, well to the right of the midline of the posterior basal. Later this right hand radial extends itself beneath the anal and the concavity becomes straightened out and disappears, the anal concurrently being shoved diagonally forward (toward the left) and disappearing by resorption.

In certain fossils groups there may be traced a progessive variation in the position of the radianal from a primitive position directly under the right posterior radial to an oblique position under the lower left hand corner of the radial, and finally to complete elimination. The position of the so-called anal in the larvæ of the more primitive comatulids, lying within a concavity in the lower left hand portion of the radial to the right of the posterior

interradius and its migration upward and toward the left leave no room for doubt that the so-called anal of the pentracrinoid larvæ is nothing more nor less than the radianal of the fossil forms.

Since the radianal is represented in the larvæ of the comatulids we should expect also to find a representative of the plate known as anal *x*. Now in forms in which the radianal is present anal *x* lies directly over the posterior basal, always to the left of the radianal and always maintaining a closer relation with the radial to the left of the posterior interradial area than with that to the right, with which the radianal is associated. Whereas the radianal is always a single plate, anal *x* commonly forms the base of a short series of more or less similar plates.

In the so-called *Thaumatocrinus renovatus* the posterior interradial area is occupied by a large interradial plate bearing upon its distal edge a conical process composed of a series of calcareous rings; this process lies to the left of the base of the anal tube, and therefore presumably to the left of the recently vanished radianal.

The free arms of the crinoids are composed of an extension of the boundary between the primarily skeleton forming dorsal surface and the perisomic ventral surface. Although phylogenetically very complicated, ontogenetically they arise as a linear (or double) series of ossicles, each new ossicle being added at the extremity of the series; none of the phylogenetic processes by which they originated are recapitulated. In short a crinoid arm in all the forms we know is nothing but a double or single series of ossicles supporting an extension of the ventral perisome—a series of simple braces of long forgotten origin.

The fixity of the crinoid arm as an individual structure entirely distinct from the crinoid arm as a phylogenetic complex—the conception of the crinoid arm as a structure with an identity of its own and with an ontogenetically completely obliterated phylogenetic origin—must constantly be kept in mind; for when we are able to grasp this idea we see at once that *any* series of ossicles arising on the border between the dorsal skeleton forming and ventral perisomic surfaces, and being composed in equal parts of each, will assume the structure common to all the processes arising in the same region, and will take on from the beginning the struc-

ture of the crinoid arm, exactly as every process from the centrodorsal will become a cirrus and every one arising on the distal corner of a brachial will become a pinnule.

Thus while a plate if situated below the ventral edge of the perisomic surface may give rise to a simple series of more or less similar plates running up to the edge of the ventral surface, and possibly continued further along the anal tube, the same plate if situated just at the ventral surface will give rise to an arm or a group of arms exactly like those arising from the radials. The character of the ossicles following a plate is not determined so much by the character of the plate itself as by its position in reference to the boundary between the dorsal and ventral surfaces of the animal.

I have examined pentacrinoids in which both the radianal and anal x are present, the former dwindling, the latter increasing in size. They are situated side by side between the two posterior radials.

In some thirty six-rayed specimens which I have studied the supernumerary ray is in all cases but two inserted behind the left posterior; that is, between the two posterior radials, and receiving its ambulacra from the groove trunk to the left.

It is thus clear that in *Thaumatocrinus renovatus* we have a young comatulid just after the resorption of the radianal with anal x fully developed and bearing a rudimentary arm which eventually will increase in size and become indistinguishable from the other arms.

This establishes the identity of the supposed species. Since anal x has given rise to an additional arm it is only reasonable to suppose that all the other interradial plates, which are exactly like it, will do the same thing. There will therefore result a ten-rayed form with ten undivided arms from which IBr series will be absent. Such a condition characterizes the genus *Decametrocrinus*, one species of which, *D. abyssorum*, was the only other crinoid dredged with *Thaumatocrinus renovatus*, and *Decametrocrinus* and *Thaumatocrinus* have since been found similarly associated.

Anal x in the fossil forms may be reduplicated in the form of a series of interradials, one in each of the other interradial areas; and it therefore does not surprise us to see the same thing in the recent comatulids.

Sir Wyville Thomson notes that in one or two cases he observed about the time of the first appearance of the anal (radianal *mihi*) a series of five minute rounded plates developed interradially between the lower edges of the oral plates and the upper edges of the basals. These are strictly homologous with the interradials of the so-called *Thaumatocrinus*, and that in the posterior interradius is anal x.

In this connection it is most interesting to examine the figure published by Mr. Frank Springer (Journ. Geology, **14**: No. 6, 1906, pl. 5, fig. 9; explanation p. 493) to show the probable primitive structure of the anal interradius and adjacent parts of the calyx in the whole Flexibilia type, both fossil and recent. If we should carry backward to its probable inception the course indicated by the migration of the radianal plate in the young of the recent comatulids we should arrive at a calyx structure identical with that shown by Mr. Springer and deduced from the study of the fossil forms; with the possible trivial difference that we should be inclined to assume the reduplication of anal x in the shape of interradials in all the other interradial areas, though from the data acquired from the study of six-rayed forms it would seem that we would be justified in considering these four additional interradials as a later development.

Mr. Springer has shown (Journ. Geology, **14**: 496. 1906) that in the Flexibilia there is a very pronounced tendency shown by all the radial structures to turn toward the right; the radianal originates under the right posterior radial; from this position it migrates upward until it disappears, always to the right of the median line; if the arms have an asymmetrical distortion it is toward the right, never toward the left; the vertical series of plates arising from the anal x is affected by this tendency, which persists long after the radianal has disappeared.

In the comatulids the radianal follows the same course as in a succession of fossil genera; the anal tube is always to the right

of the median line of the posterior interradius; that the supplementary arm arising on the anal x of *Thaumatocrinus renovatus* does not turn to the left is to be interpreted purely as a secondary condition, the result of its origin on the edge of the disk and its free extension outward from the body. Were this series of ossicles following anal x in *Thaumatocrinus* incorporated in the perisome we cannot doubt but that it would have followed the anal tube in its migration to the right, and would therefore have come into complete correspondence with the conditions seen in the fossil Flexibilia.

In *Thaumatocrinus renovatus* the disk between the margin and the orals is completely enclosed by a pavement of small plates which later disappear, and the same is true in certain other forms. This heavy plating of the disk in the very young of species of which the adults have naked disks must be of very profound significance, and, when taken in connection with the occurrence of the radianal and anal x, and with various other features, strongly indicates that it is the transient vestige of the forerunner of the dome of the Camerata.

SUMMARY

1. The so-called anal in the pentacrinoid larvæ of the recent comatulids is in reality the radianal of the fossil forms.

2. Anal x is represented in the pentacrinoid larvæ of the comatulids by a posterior interradial which gives rise to an additional post-radial series, as in *Thaumatocrinus renovatus* and in six-rayed specimens of other species, or by a minute plate which is quickly resorbed; in the recent forms it is repeated in all the interradial areas.

3. *Thaumatocrinus renovatus* is merely the young of *Decametrocrinus abyssorum* (P. H. Carpenter).

4. The solid plating of the disk which appears in the young of certain forms concurrently with the disappearance of the orals, quickly to be resorbed, is the transient vestige of the condition which developed into the solid dome of the Camerata.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

METEOROLOGY.—*Free air data, sounding balloon ascensions at Indianapolis, Omaha, and Huron.* Wm. R. Blair. Bulletin of the Mount Weather Observatory, 4: 183–304. 1911.

Four series of sounding balloon ascensions, giving 79 good records, were made by the U. S. Weather Bureau at the above places during the years 1909, 1910 and 1911. One of these ascensions, the one made at Huron, S. Dak., Sept. 1, 1910, is the highest on record, 30,486 meters.

The data obtained from all these ascensions, temperature, pressure, humidity, height, wind velocity and wind direction, are given in detail in a number of tables and diagrams and the final summary and discussion include 59 additional ascensions made at St. Louis, Mo., and at Pittsfield, Mass by the Blue Hill Meteroological Observatory.

Among the conclusions reached are:

a. Rapid changes of condition with altitude seem to occur at elevations of about 1.2, 3.5, 10.5, 15.5, and 28.0 kilometers. That is to say, at the upper limit of diurnal convection, upper level of the lower condensation layer, average level of the upper condensation layer, upper limit of condensation, and a much higher level, respectively.

b. The first and second of the above levels and the third over rising air pressure at the earth's surface are at greater elevations in summer than in winter; the fourth level is highest in spring and lowest in autumn.

c. The change in temperature with altitude is increased, with a rising barometer, up to the first level; decreased from the first to the second, and at higher levels not much affected.

d. At the third level the temperature decreases slowly with altitude, at the fourth it increases and at the fifth it again decreases.

e. Air temperatures are lower above the third level and higher below it with a falling than they are with a rising barometer.

f. The wind velocity seems to decrease above the fourth level; its mean direction is west-northwest. In the lower levels, however, the wind distribution, as already known, is largely controlled by the distribution of surface pressure.

In explanation of the observed phenomena it is suggested that the peculiarities of temperature distribution, including the "latitude effect" and the upper inversion of temperature, may be due to the influence of convection on the distribution of the constituent gases, vapors and dust of the atmosphere. W. R. B.

METEOROLOGY.—*Free air data at Mount Weather for July, August, and September,* 1911. Wm. R. Blair. Bulletin of the Mount Weather Observatory, **4**: 342–395. 1911.

During this period 112 kite and captive balloon records were obtained of pressure, temperature, relative humidity, wind direction and wind velocity, the details of which are given in tables and charts. Besides this the surface temperatures of the mountain kite station and of two adjacent valley stations are given in diagram.

Two series of 8 ascensions each were made, August 16–17, and Septtember 12–13, for studying the diurnal changes that take place in the various elements observed. Clear weather was chosen for both series and observations were obtained at all altitudes up to 3 kilometers above sea level. The results show that on these dates the 1.5 kilometer level was one of transition at which the hourly departures of the temperature from the mean for the day were least; that below this elevation the diurnal maximum temperature occurred at about 3 to 5 p.m., and the minimum at 1 to 2 p.m.

In the discussion it is pointed out that the diurnal convection currents probably rose to the 1.5 kilometer level, or a little higher, on the days in which the observations were made, and it is therefore suggested that the contributions to and the distribution of the constituents of the lower atmosphere by these currents probably were responsible for the peculiar temperature distribution observed. W. R. B.

METEOROLOGY.—*The upper atmosphere.* W. J. Humphreys. Bulletin of the Mount Weather Observatory, **4**: 402–408. 1912.

This paper is a critical examination of our present knowledge of and inferences concerning the atmosphere above the level of the highest clouds. The conclusions reached are as follows:

Sources of information: (1) Records of sounding balloons, (2) Obser-

vations of meteors, (3) Observations of twilight phenomena, (4) Observations of auroras, (5) Observations of noctilucent clouds,

Chief facts of observation: (1) At and beyond 11 kilometers up to the greatest elevation yet reached, about 30 kilometers, the temperature is substantially constant at any given time and place, (2) The humidity of the upper atmosphere is vanishingly small, (3) The upper atmosphere consists in part of hydrogen and helium, (4) The atmosphere is sufficiently dense at an elevation of 150 kilometers to fire meteors, (5) The atmosphere at 70 kilometers elevation still scatters a perceptible amount of light.

Chief inferences: (1) The temperature of the upper atmosphere is substantially constant with respect to elevation far beyond the limits yet reached by sounding balloons, (2) The upper atmosphere is practically free from vertical convection, (3) The volume percentages of the gases at the beginning of the isothermal region are the same as those of dry air at the surface of the earth, (4) Above this level the lighter gases gain in percentage with increase of elevation, (5) Above 75 kilometers, mass-density and light-intensity soon decrease very slowly with increase of elevation, while below this level they soon increase rapidly with decrease of elevation, (6) Above 75 to 80 kilometers dust falls comparatively rapidly, while below this level it settles more and more slowly, (7) There is no level at which either mass-density or light-intensity changes in any sense abruptly with changes of elevation.

W. J. H.

METEOROLOGY.—*Echelon clouds.* W. J. Humphreys. Bulletin of the Mount Weather Observatory, **4**: 409–411. 1912.

Under certain conditions a great many small cumulus clouds appear with flat bases, and all at substantially the same elevation. When viewed from a point to one side and at a lower level such a cloud formation appears in perspective like a series of inverted terraces, or like an extensive inverted flight of steps.

The meteorological meanings of the cloud phenomena just described are, among others: (*a*) That the cloud bases are all on about the same level, (*b*) That the vertical distribution of water vapor is essentially the same over all the region covered by the clouds in question, (*c*) That the change of temperature with altitude above any given place in this region is substantially the same as it is above any other, (*d*) That the amount of humidity is rather large, (*e*) That vertical convection is occurring in many separate places, but nowhere violently. W. J. H.

PHYSICS.—*The spectroscopic determination of aqueous vapor.* F. E. Fowle. Astrophysical Journal, April 1912, p. 149.

By laboratory experiments on the transmissibility of radiation through long columns of air containing known amounts of water vapor the dependence of transmission on the water-vapor content has been determined for the intra-red bands Φ and Ψ. The direct determinations cover quantities of water vapor up to a depth of 0.5 centimeters of precipitable water. Beyond this the determinations have been extended by aid of solar observations made on Mount Wilson. This extension does not require assumptions as to the actual quantities of water vapor in the solar beam, but only as to the relative quantities as fixed by the length of path of the beam. As the purity of the spectrum enters into the results it has been necessary to determine the dependence of transmission on water vapor for different values of combined slit- and bolometer-width. While the experiments have been made only at atmospheric pressure, a computation is given which shows that the results are probably applicable with slight correction to the actual pressures at which water vapor occurs in the atmosphere. Accordingly, a method has been established by means of which the total quantity of water vapor between the observer and the sun may be easily determined by spectro-bolometric observations. It is proposed in subsequent papers to give applications of the method. F. E. F.

AGRICULTURAL PHYSICS.—*The effect of soluble salts on the physical properties of soils.* R. O. E. Davis. Bulletin 82, Bureau of Soils.

The addition of small amounts of soluble salts affect the physical properties and therefore the structure of the soil. No predictions can be made regarding the specific direction or the amount of the action of salts on particular soils. The effect of salts is more pronounced in a soil containing a large percentage of fine soil particles and this leads to the conclusion that colloid-like clay particles are affected most by soluble salts and in turn effect most the structure of the soil. The actual nature of the condition produced in the smallest soil particles is not known beyond the fact that flocculation and deflocculation may be produced.

M. X. Sullivan.

AGRICULTURAL CHEMISTRY.—*The distribution of organic constituents in soils.* Oswald Schreiner and E. C. Lathrop. Journal Franklin Institute, August. 1911.

Twenty-six samples of soils from eleven different states were examined for known organic soil constituents which had previously been isolated

from one soil or another. From the data obtained it would appear that pentosans, pentose sugars, histidine, cytosine, xanthine, hypoxanthine and dihydroxystearic acid are rather common soil constituents and are likely to be encountered in soils everywhere. Although agroceric acid, lignoceric acid, paraffinic acid, α-monohydroxystearic acid, as well as agrosterol, phytosterol, and hentriacontane were only found in one or two soils, no general statement covering their frequency or infrequency of occurrence is warranted. Arginine, a common cleavage product of protein, was found in only two soils and it is probably a soil constituent which persists in the soil only a short time. E. C. L.

AGRICULTURAL CHEMISTRY.—*Studies in organic soil nitrogen.* E. C. Lathrop and B. E. Brown. Journal Industrial Engineering Chemistry, **3**: 657-660. 1911.

The largest part of the N in the soil exists in complex organic forms, and this paper deals with an analytical attempt to determine in what combination this N exists. Five soils, Hagerstown loam, from the plats of the Pennsylvania State College Experiment Station, which had been under treatment since 1881 were examined. The soil was heated with HCl and in the acid solution total N, Ammonia N, mono and diamino acid N and "Humin" N were determined by the method of Hausmann as modified by Osborne and Harris. The NH_3 liberated and the amount of soluble organic nitrogenous compounds caused by heating the soil with water under pressure from 1 to 10 atmospheres was also studied. By the latter method it was shown that the organic N in the lime-treated plats was in different combination from that of the other plats. There was a wide variation in the amounts of mono and diamino acid N and there seemed to be no agreement between amino N and plat treatment. The ammonia and amino acid N will be directly available for plant use and, in these plats, these two together, form 40–60 per cent of the total N in the soils. The "Humin" N is not considered to be directly available and these soils would yield on decomposition 40–60 per cent of such compounds. Since these 5 soils are really the same soil under long continued treatment of different kinds, the work shows that different decomposition of the nitrogenous matter has taken place and probably will continue to take place under such different conditions imposed in the field. E. C. L.

AGRICULTURAL CHEMISTRY.—*A beneficial organic constituent of soils: Creatinine.* Bulletin 83, Bureau of Soils. Introduction: Importance of beneficial constituents. O. SCHREINER. I. The isolation of creatinine from soils. E. C. SHOREY. II. The origin of creatinine in soils. M. X. SULLIVAN. III. The effect of creatinine on growth and absorption. J. J. SKINNER.

In this bulletin, the presence in soils of a constituent decidedly beneficial to growing crops is emphasized. This soil constituent is creatinine, a nitrogenous compound. The first paper deals with the isolation, identification, and chemical properties of the compound. The relation of creatinine to other organic compounds is pointed out and observations are made regarding the possible connection between creatinine and other organic soil constituents. Creatinine is a frequently occurring and probably a normal constituent of soils in amounts comparable to the quantities of nitrates normally present. Like the nitrates, it is probably a fluctuating quantity. The presence of creatinine in stable manure and cowpea vines is also pointed out. In the second paper, the occurrence of creatinine in plants and cropped soil is shown. Of samples of the same soil, planted and unplanted, kept side by side in the greenhouse, the planted soil gave larger amounts of creatinine. Creatinine was also found in the water in which wheat seedlings had grown, and was demonstrated for the first time in plants, wheat seeds, wheat seedlings, and wheat bran, in seeds of rye, clover, and alfalfa, in mature cowpea vines, and in potatoes. In the third paper it is shown that creatinine and creatine have beneficial effects on plant growth. Plants grown in solution cultures containing only potash and phosphate have shown increased growth when creatinine or creatine is added. When large amounts of nitrates are present in the solution, creatinine and creatine produce no appreciable effect on the growth. In the presence of these compounds, the plants absorb less nitrate, while the absorption of potash and phosphate is normal. It appears that creatinine and creatine can replace the nitrate in solution cultures. M. X. SULLIVAN.

AGRICULTURAL CHEMISTRY.—*Organic compounds and fertilizer salts.* Bulletin Bureau of Soils 77. OSWALD SCHREINER and J. J. SKINNER.

The action of fertilizer salts in restraining the harmful influence of certain organic compounds was studied as well as the effect of the compounds on absorption. The effect of cumarin, vanillin and quinone was tested on wheat in soil and water cultures. The culture solutions

comprised all possible ratios of the three principal fertilizer elements, phosphate, nitrate, and potassium in 10 per cent stages. The various fertilizer salts acted differently in overcoming the respective harmful effects of the toxic compounds. The mainly phosphatic fertilizers were the most efficient in overcoming the cumarin effects; the mainly nitrogenous in overcoming the vanillin effects; the mainly potassic in overcoming the quinone effects.

Cumarin affected plants have characteristic stunted tops, broad distorted leaves; vanillin affected plants are less characteristic, but show decreased growth of tops and strongly inhibited root growth. Quinone affected plants are tall and slender with thin narrow leaves in strong contrast to the cumarin affected plants. The cumarin depressed potash and nitrate removal from the nutrient solution more than it did phosphate removal; the quinone on the other hand depressed phosphate and nitrate more than it did potash. The effect of vanillin was not determined in this regard. Dihydroxystearic acid which appears to act much as vanillin did, depressed phosphate and potash more than nitrate. The conclusion is drawn that different toxic substances produce definite effects in their action on plants and that the effects are modified differently by the different fertilizer salts. J. J. S.

AGRICULTURAL CHEMISTRY.—*Origin of creatinine in soils.* M. X. SULLIVAN. Science **35**: 390. 1912.

Of samples of the same soil planted and unplanted kept side by side in the greenhouse, the water and glycerine extracts of the planted soils gave larger amounts of creatinine by the creatinine zinc chloride method. It would seem that the increase in the amount of creatinine was connected in some way with plant growth. Creatinine was found in small amounts in the water in which wheat seeding had grown, in wheat seeds, wheat seedlings, wheat bran, rye, clover, alfalfa, cowpeas and potatoes. Besides the possible production of creatinine by microorganisms and the introduction into the soil in the animal excreta of stable manure, the creatinine of soils has its origin in vegetable matter. M. X. S.

AGRICULTURAL CHEMISTRY.—*The action of nucleic acid and its decomposition products on soils and plants.* O. SCHREINER and J. J. SKINNER. Science **35**: 390. 1912.

Nucleic acid as well as some of its decomposition products occur in soils and the effect of some of these compounds has been studied with

wheat seedlings. Mineral nutrient solutions with phosphate, potash, and nitrate in varying proportions were used, and to these were added 50 parts per million of the compound tested. The neutralized nucleic acid as well as its nitrogenous decomposition products, hypoxanthine and xanthine, had a beneficial action on the plants, promoting growth and decreasing the nitrate absorption. The plants appear to be able to utilize these compounds directly in their metabolism and require under these circumstances less nitrate for maximum growth.

M. X. SULLIVAN.

AGRICULTURAL CHEMISTRY.—*Nucleic acids in soils.* E. C. SHOREY. Science **35:** 390. 1912.

Nucleic acids have been obtained from soils by extraction with dilute sodium hydroxide, neutralizing and concentrating under reduced pressure, acidifying with acetic acid and addition of several volumes of alcohol as a light colored amorphous body which on hydrolysis gave pentose sugars, purine bases, pyrimidine compounds, levulinic acid and phosphoric acid. Xanthine and hypoxanthine were identified among the purine bases and cytosine among the pyramidine compounds.

M. X. SULLIVAN.

AGRICULTURAL CHEMISTRY.—*Examination of soils for organic constituents, especially dihydroxystearic acid.* O. SCHREINER and E. C. LATHROP, Bulletin 80, Bureau of Soils. Journal American Chemical Society **33:** 1412–17. 1911.

This investigation covers a partial survey of the nature of organic matter in the soils of the United States. Soils from eighteen different states, and of widely different origin, topography, texture, climate, drainage, and cropping, varying from soils of the highest productivity to soils incapable of producing profitable crops were examined for different soil constituents. In the soils, pentsans, pentose, sugar, histidine, cytosine, xanthine, hypoxanthine, and dihydroxystearic acid were frequently encountered. Arginine, agroceric acid, lignoceric acid α-monohydroxystearic acid, agrosterol, phytosterol, and hentriacontane were only ocassionally found. The frequent occurrence of dihydroxystearic acid is of special interest and significance because of its known harmful action on plants One-third of all the soils examined contained this compound, virgin soils as well as soils long under cultivation; soils continually cropped as well as soils under permanent sod; soils from the Atlantic coast, the Pacific coast and the Gulf states. It is likely to be

encountered in soil anywhere. Its formation or accumulation is doubtless due to local conditions which may obtain in any region. Of 25 good soils examined, only two contained dihydroxystearic acid, and they were of moderate productivity. Of 35 poor soils examined 51 per cent contained it. Of the soils which had a record for infertility, the dihydroxystearic acid was found in every case. It is either a direct or an indirect factor in low productivity, direct because of its harmful effects and indirect as arising and accumulating under poor soil conditions. The determination of this one constituent leads to a recognition of the kind of infertility in the soils examined and is, therefore, a readily recognized symptomatic factor of poor soil conditions. M. X. SULLIVAN.

FISHERIES.—*Fishes from Bering Sea and Kamchatka.* CHARLES HENRY GILBERT and CHARLES VICTOR BURKE. Bulletin of the Bureau of Fisheries, **30**: 31–96. 1910. 37 text fig. Issued May 6, 1912.

This paper, based upon collections by the United States Fisheries Steamer *Albatross* during her cruise in the northwest Pacific in the summer of 1906, "serves again to emphasize the bewildering richness of the northern Pacific in cottoid and liparid forms. Genera like *Triglops*, *Icelus*, *Artediellus*, and *Gymnocanthus*, which are represented in the north Atlantic by one, or at most two, species, contain in the northwestern Pacific numerous forms, some of which may be widely divergent. Such facts are usually accepted as conclusive evidence of the original home and the center of dispersal of the group thus richly represented."

"On the basis of the hasty reconnaissance which the *Albatross* was able to make in passing, no sharply defined faunal lines are indicated in the region here considered. In passing from the eastern end of the Aleutian chain westward to Attu and Agattu only minor changes seem to occur. There is no perceptible break between the Aleutians and the Commander Group. The best defined division appears to coincide with the deep channel which separates the Commander Islands from Kamchatka. This is indicated by the failure of certain species to cross this barrier, and by the presence on the two sides of incipient species—representative forms which have only slightly diverged, as though under the influence of prolonged isolation."

These collections were found to contain 121 species of fishes, of which 35 are described as new, 8 of the genera also being new.

ETHEL M. SMITH.

FISHERIES.—*Studies on the reproduction and artificial propagation of freshwater mussels.* GEORGE LEFEVRE and WINTERTON C. CURTIS. Bulletin U. S. Bureau of Fisheries, **30:** 105–202, pl. vi–xvii, 4 text fig. 1910.

The extended biological researches reported upon in this paper are the basis upon which the U. S. Bureau of Fisheries, through its station at Fairport, Iowa, is undertaking to propagate the commercially valuable species of pearl mussels in the interests of the pearl button manufacturing industry, which derives its raw materials from unionid shells found in waters of the Mississippi basin.

A large preliminary portion of the paper relates to the Unionidae from the historical biological standpoint, but their mode of reproduction, structure, and the development and parasitism of the larvae are naturally given chief and most detailed consideration and lead to an extended account of the experiments and observations made for the purpose of economic application of the facts. Messrs. Lefevre and Curtis confirm previous investigators in their findings as to breeding seasons of the Unionidae, the short and long periods of gravidity being generic characters; and they also find the two well-marked types of glochidia, those with hooks, which attach themselves chiefly to the fins of fishes, and those without hooks, which are found in the gill filaments. A third type, of ax-head shape, was also found in a few closely related species. One genus, *Strophitus,* was found to develop without a parasitic stage.

As it proves upon experiment that the species of fish most satisfactory as hosts for the larval mussels are the black basses and sunfishes so numerous in Mississippi waters and collected yearly by the U. S. Bureau of Fisheries in great quantities from the overflows, it was found comparatively easy to contrive means for wholesale infection of young fish before distributing them for the regular fish-cultural purposes, and the Fairport station at once entered upon such operations. But altho the feasibility of mussel culture has been amply demonstrated, many problems connected with it remain unsolved, and the investigators expect to continue their researches with especial reference to conditions of growth of the mussels, their food, enemies, diseases, and the very interesting question of pearl formation. ETHEL M. SMITH.

MINERAL RESOURCES.—*A reviewe of the phosphate fields of Florida.* W. H. WAGGAMAN. Bulletin 76, Bureau of Soils.

The author describes the classes of Florida phosphate which are at present commercially important. These are the hard rock phosphate occurring along the west coast of the Florida peninsula and the land pebble phosphate which is mined to the south of the hard rock fieldsin Polk and Hillsboro Counties. The geological occurrence physical properties and their relation to the chemical composition of the rock are described, the methods of mining and preparing the rock for the market are described, and the cost of production and percentage of waste material are estimated. Possible means of utilizing this waste are suggested. The present output and conditions in these fields and the future outlook of the industry are discussed. W. H. W.

MINERAL RESOURCES.—*A report on the natural phosphates of Tennessee, Kentucky and Arkansas.* W. H. WAGGAMAN. Bulletin 81, Bureau of Soils.

The geological occurrence, physical properties and chemical composition of the different varieties of rock in the phosphate fields of Tennessee, Arkansas and Kentucky, are described together with the methods of mining and treating the material for the market. In Tennessee there are three types of phosphate which are commercially important, namely the brown rock of ordovicean age, the blue rock or devonian phosphate, and the white rock which has been laid down at a later period.

The former wasteful methods of mining in these fields are being rapidly supplanted by more modern and economical methods. Many of the old dumps and waste heaps are being worked over and valuable phosphate rock thus recovered. The cost of preparing the brown and blue rock for the market is approximately $2.50 per ton. The white rock is not being mined at present.

The deposits of phosphate in northern Arkansas are not generally regarded as of much economic importance but they are being worked to a considerable extent and are well situated to supply the demand for fertilizers west of the Mississippi. The rock is mined like the blue rock of Tennessee and belongs to the same Geologic period. The grade of the rock is lower but the average cost of mining it is probably not as great.

The phosphate deposits of Kentucky have not as yet been exploited. They occur in the blue grass regions near Lexington and are probably

of greater extent than they are popularly supposed to be. The rock is very much like the brown rock phosphate of Tennessee and belongs to the same geologic epoch. Some specimens of Kentucky phosphate show a very high content of phosphoric acid but the material will have to be washed and graded before it can be used for the manufacture of acid phosphate. W. H. W.

GEOLOGY.—*The Bonnifield region, Alaska.* STEPHEN R. CAPPS, Bulletin U. S. Geological Survey No. 501. 1912. Pp. 62, with maps, views, and sections.

The Bonnifield region lies on the north slope of the Alaska Range and is bordered on the east by Delta River and on the west by the Nenana, and includes both the rugged mountains of the main range and the foothills belt.

The northern part of the area is occupied by Birch Creek schist composed of highly-contorted and fissile mica and quartz schists and phyllites. The Totatlanika schist lying north of the Birch Creek schist in the western part of the region is characteristically a porphyritic schist or augen gneiss, with phenocrysts of feldspar and quartz in a fine-grained groundmass composed chiefly of mica and quartz derived from rhyolites or rhyolite porphyries, with perhaps some tuffs. Associated with these altered igneous rocks are carbonaceous shales, schists, limestones, and conglomerates of sedimentary origin. The Totatlanika schist is provisionally assigned to the Silurian or Devonian.

Eocene coal-bearing beds occupy warped basins in the schists and underlie more recent deposits in the lowlands.

The coal-bearing series is succeeded by the thick Nenana gravels. These in places are conformable with the coal series but in other localities there was a period of deformation and erosion between the two. The gravels are believed to be Tertiary.

The two schist series are cut by extensive bodies of intrusive rocks, chiefly granites and diorites, and the intrusive masses were important in causing the mineralization of the schists. Placer gold, derived originally from the schists, and scattered in small quantities through the Tertiary gravels has in places been reconcentrated into workable placers.

S. R. C.

REFERENCES

PHYSICS.—*Recent progress in calorimetry.* WALTER P. WHITE, Geophysical Laboratory. I. *The real vs. the supposed errors.* Met. Chem. Eng., 9: 202. 1911. II. *Details of apparatus and method.* Met. Chem. Eng., 9: 296. 1911. III. *Temperature measurement and corrections.* Met. Chem. Eng., 9: 448. 1911.

AGRICULTURE.—*Publications of the Bureau of Plant Industry since July 1, 1911:* Farmers' Bulletin, 454, *A successful New York farm,* M. C. BURRITT; Circular 36, *Emergency forage crops,* DAVID A. BRODIE; B. P. I. 676, *The relation of handling to decay in California navel oranges; season of 1910–11,* A. V. STUBENRAUCH; Y. B. Separate 540, *Increased yields of corn from hybrid seed,* G. N. COLLINS; Y. B. Separate 541, *The utilization of crop plants in paper making,* CHARLES J. BRAND; Bulletin No. 215, *Agriculture in the central part of the semi-arid portion of the Great Plains,* J. A. WARREN; Bulletin No. 214, *The timber rot caused by Lenzites sepiaria,* PERLEY SPAULDING; Bulletin No. 206, *The blister rust of white pine,* PERLEY SPAULDING; Circular No. 38, *Suggestions to Settlers on the Belle Fourche irrigation project,* BEYER AUNE; Bulletin No. 224, *Timothy rust in the United States,* EDWARD C. JOHNSON; Farmers' Bull. 458, *The best two sweet sorghums for forage,* A. B. CONNER; B. P. I. 692, *Farm fertilizers,* W. B. MERCIER and H. E. SAVELY; Bulletin No. 220, *Relation of drought to weevil resistance in cotton,* O. F. COOK; Y. B. Separate 530, *Nitrogen-gathering plants,* KARL F. KELLERMAN; Circular No. 86, *Preliminary report on the klamath marsh experiment farm,* CARL S. SCOFIELD and LYMAN J. BRIGGS; Y. B. Separate 546, *Coöperation in the handling and marketing of fruit,* G. HAROLD POWELL; Bulletin No. 216, *The rusts of grains in the United States,* E. M. FREEMAN and EDWARD C. JOHNSON; Y. B. Separate 550, *The precooling of fruit,* A. V. STUBENRAUCH and S. J. DENNIS; Farmers' Bulletin 455, *Red clover,* J. M. WESTGATE and F. H. HILLMAN; Y. B. Separate 551, *Camphor cultivation in the United States,* S. C. HOOD and R. H. TRUE; Bulletin No. 225, *A spot disease of cauliflower,* LUCIA MCCULLOCH; Circular No. 82, *Crop plants for paper making,* CHARLES J. BRAND; Farmers' Bulletin 460, *Frames as a factor in truck growing,* W. R. BEATTIE; Farmers' Bulletin 464, *The eradication of quackgrass,* J. S. CATES; Circular No. 87, *Description of the comprehensive catalogue of botanical literature in the libraries of Washington,* ALICE C. ATWOOD; Farmers' Bulletin 462, *The utilization of logged-off land for pasture in western Oregon and western Washington,* BYRON HUNTER and HARRY THOMPSON; Y. B. Separate 549, *Promising new fruits,* WM. A. TAYLOR; Vol. xxvii, *Bulletins of the bureau of plant industry Nos. 206 to 212, inclusive, 1911,* CONTENTS AND TITLE PAGE; Circular No. 80, *Forage crops for the sand-hill section of Nebraska,* H. N. VINALL; Bulletin No. 222, *Arrangement of parts in the cotton plant,* O. F. COOK and ROWLAND M. MEADE; Circular No. 88, *The picking and handling of peanuts,* W. R. BEATTIE.

AGRICULTURE.—*Soil surveys* (Advance sheets—Field operations of the Bureau of Soils, 1909–1910) as follows:

Baldwin County, Ala. W. E. THARP, H. JENNINGS, and C S. WALDROP,

Department of Agriculture, and W. L. Lett, P. H. Avary, and L. Cantrell, Alabama Department of Agriculture and Industries. Pp. 74. Map.

Dale County, Ala. Lewis A. Hurst and R. W. Rowe, Department of Agriculture, and A. D. Cameron, Alabama Department of Agriculture and Industries. Pp. 39. Map.

Pike County, Ala. W. E. Tharp, Department of Agriculture, and W. L. Lett and W. E. Wilkinson, Alabama Department of Agriculture and Industries. Pp. 67. Map.

Livermore area, Cal. H. L. Westover and Cornelius Van Duyne. Pp. 64. Map.

Madera area, Cal. A. T. Strahorn, H. L. Westover, L. C. Holmes, E. C. Eckmann, J. W. Nelson, and Cornelius Van Duyne. Pp. 43. Map.

Marysville area, Cal. A. T. Strahorn, W. W. Mackie, H. L. Westover, L. C. Holmes, and Cornelius Van Duyne. Pp. 56. Map.

Jacksonville area, Fla. Grove B. Jones and James E. Ferguson. Pp. 26. Map.

Bulloch County, Ga. Charles N. Mooney, R. B. Hardison, David D. Long, and W. C. Byers. Pp. 52. Map.

Sumter County, Ga. J. C. Britton and F. S. Welsh. Pp. 47. Map.

Walker County, Ga. W. E. McLendon. Pp. 42. Map.

Rockcastle County, Ky. R. T. Avon Burke, Frank Bennett, and Clarence Lounsbury. Pp. 36. Map.

Concordia Parish, La. Charles J. Mann, E. B. Watson, Percy O. Wood, and Risden T. Allen. Pp. 35. Map.

Adams County, Miss. W. J. Geib, Department of Agriculture, and A. L. Goodman, Mississippi Geological Survey. Pp. 32. Map.

Noxubee County, Miss. Howard C. Smith and W. J. Geib, Department of Agriculture, and A. L. Goodman, E. M. Jones, and W. M. Spann, Mississippi Geological Survey. Pp. 46. Map.

Cooper County, Mo. A. T. Sweet, Department of Agriculture, and E. S. Vanatta and B. W. Tillman, University of Missouri. Pp. 37. Map.

Marion County, Mo. J. C. Britton, Department of Agriculture, and E. S. Vanatta, University of Missouri. Pp. 26. Map.

Fallon Area, Nevada. T. Strahorn and Cornelius Van Duyne. Pp. 44, 4 Pls. 2 Maps.

Cabarrus County, N. C. Risden T. Allen, Department of Agriculture, and E. W. Thornton and Hubert Hill, No. Carolina Department of Agriculture. Pp. 47. Map.

Granville County, N. C. R. B. Hardison and David D. Long. Pp. 44. Map.

Marshfield area, Oregon. C. W. Mann and James E. Ferguson. Pp. 38. Map.

Erie County, Pa. Gustavus B. Maynadier, Department of Agriculture, and Floyd S. Bucher, Penn. State College. Pp. 52. Map.

Washington County, Pa. F. S. Welsh and Floyd S. Bucher, Department of Agriculture, and D. K. Sloan, Penn. State College. Pp. 34. Map.

Central Gulf Coast area, Texas (Reconnoissance.) William T. Carter, Jr., and Party. Pp. 75. Pls. 8. Map.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE WASHINGTON ACADEMY OF SCIENCES

The 78th meeting of the Washington Academy of Sciences was devoted to an exhibit, 8–11 p.m., March 28, 1912, in the New National Museum, of new apparatus, methods, and results from various government bureaus and other scientific institutions of Washington. Over twenty bureaus and scientific institutions took part in the exhibit, and together rendered it one of the most instructive and enjoyable occasions the Academy has ever had. Over 600 persons, members of the Academy and their friends, attended this meeting, and everyone saw interesting apparatus and valuable results he had never even heard of before. Indeed this exhibit was so entirely successful that a similar exhibit probably will be given again in a year or two.

The 79th meeting was held jointly with the Philosophical Society, Saturday evening, May 4, 1912, at the Cosmos Club. Prof. DAYTON C. MILLER of the Case School of Applied Sciences, Cleveland, Ohio, gave an illustrated and experimental lecture on *Sound-waves; how to photograph them and what they mean.*

Both the synthesis and the analysis of sound-waves were shown and explained, and, to the delight of everyone present, many musical notes produced by tuning forks, by the flute, and by the speaker's voice, were made to trace upon the screen, as by a moving master hand, their wonderful curves of harmonic complexity.

It is not often that an audience finds itself really instructed on a difficult scientific question and at the same time so charmed and delighted as to wish the lecture twice as long, but this was one of those rare occasions. W. J. HUMPHREYS, *Recording Secretary.*

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 708th meeting was held on April 6, 1912, Vice-President Burgess in the chair. One paper was presented:

Evolution of the aeroplane; its fundamental features of English origin: A. F. ZAHM.

Two informal papers were presented, one on *Earth light* and one on *Holes in the air,* each by W. J. HUMPHREYS, of the U. S. Weather Bureau.

709th meeting, April 20, 1912, Vice-President Burgess in the chair. One paper was presented.

Account of researches in the algebra of physics: ALEXANDER MACFARLANE.

170th meeting, May 4, 1912, was a joint meeting with the Washington Academy of Sciences, and at which Prof. DAYTON C. MILLER of the Case School of Applied Science spoke on *Sound waves; how to photograph them and what they mean.*

711th meeting, May 18, 1912, Vice-President Fischer in the chair. Two papers were read:

Some problems in wireless telegraphy: F. A. KOLSTER, of the Bureau of Standards.

Present flame standards of candle power: E. C. CRITTENDEN, of the Bureau of Standards.

R. L. FARIS, *Secretary.*

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. II, AUGUST 19, 1912 No. 14

MATHEMATICS.—*Account of researches in the algebra of physics.*[1] I. A. MACFARLANE.

As these researches extend over thirty years and the results have appeared in a variety of publications, I am glad to accept the invitation of the Philosophical Society to give a connected account of the principal results, more especially because I have reason to believe that I have solved the main difficulties of the problem investigated.

Note on plane algebra. Proc. Roy. Soc. Edinb., 1883, pp. 184–186. I began by studying plane algebra as a logical generalisation of ordinary algebra. The algebraic symbol used was a small Roman letter, which denoted a length combined with an angle: thus $\mathrm{a} = a \,.\, \alpha$ $\mathrm{b} = b \,.\, \beta$ $\mathrm{c} = c \,.\, \gamma$ $\mathrm{r} = r \,.\, \theta$. In this notation $\sqrt{-1}\, r = r \,.\, \pi/2$ and $-r = r \,.\, \pi$. The sum was obtained by the parallelogram construction. The product ab was defined as the product of the lengths combined with the sum of the angles; that is $\mathrm{ab} = ab \,.\, \alpha + \beta$, giving $\mathrm{b}^2 = b^2 \,.\, 2\beta$. The quotient $\frac{1}{\mathrm{a}}\,\mathrm{b}$ was defined as the quotient of the lengths combined with the difference of the angles; thus

$$\frac{1}{\mathrm{a}}\,\mathrm{b} = \frac{b}{a} \cdot -\alpha + \beta; \text{ giving } \frac{1}{\mathrm{b}}\,\mathrm{b} = 1 \cdot 0$$

The product of three quantities $\mathrm{abc} = abc \,.\, \alpha + \beta + \gamma$, giving

[1] Read before the Philosophical Society of Washington, April 20, 1912.

$b^3 = b^3 . 3\beta$ and generally $b^n = b^n . n\beta$. Again since $db = d(b . \beta) = db . \beta + bd\beta . \beta + \pi/2$ it follows that $db^2 = 2bdb$, and generally $db^n = nb^{n-1} db$. Also $d(ab) = adb + bda$. As the fundamental properties of the symbol are the same in form as those of the ordinary algebraic symbol, I concluded that the theorems of line algebra remained true generally without change of form in plane algebra. The principle was applied to produce problems in series for examination papers, and some were propounded in the columns of the *Educational Times* (*e.g.*, Reprint, **45**: 28). I asked Professor Tait what he thought of the principle; to which he replied that it was a pretty bold step to take. But if we take conjugate powers and products, no such easy generalisation is possible. The conjugate product of a and b has the product of the lengths, but the difference of the angles, $ab . -\alpha + \beta$, giving for the conjugate square $bb = b^2 . 0$. Also the conjugate of $abc = abc . \alpha - \beta + \gamma$ giving $bbb = b^3 . \beta$. It was from this point of vantage that I began to study the space-generalisation of algebra.

Physical arithmetic. Macmillan and Company, 1885. The original title of this book was *Arithmetic of Physics.* In it I attempted a thoro-going application of the following principle, enunciated by Maxwell (*Heat*, p. 75).

> Every quantity is expressed by a phrase consisting of two components, one of these being the name of a number, and the other the name of a thing of the same kind as the quantity to be expressed, but of a certain magnitude agreed on among men as a standard or unit.

In the book each quantity is analysed into unit, numerical value, and where necessary, descriptive phrase. This descriptive phrase often has reference to the direction of a line unit. A compound unit is expressed in terms of its elementary units by means of "by" and "per." Originally all the reasoning in working out examples was done by means of the expression for the complex unit involved; at the suggestion of Professor Tait I introduced an equivalence method, which I do not now think is an improvement. Equivalences are treacherous, especially in space-analysis. The above analysis afterwards led to the idea of analysing each space quantity into modulus and vector-unit, simple or compound.

Principles of the algebra of physics. Proc. Amer. Assoc. Adv. of Science, **40**: 65–117. I thus enunciated the problem as it appeared to me then (p. 65):

> I am convinced that the notation of quaternions can be improved; that the principles require to be corrected and extended; that there is a more complete algebra which unifies quaternions, Grassmann's method, and determinants, and applies to physical quantities in space. The guiding idea in this paper is generalization. What is sought for is an algebra which will apply directly to physical quantities, will include and unify the several branches of analysis, and when specialised will become ordinary algebra.

The fundamental rules of quaternions were investigated by considering (1) the product of two quadrantal versors, (2) the product of a quadrantal versor and a unit vector, (3) the product of two unit-vectors.

Let h, j, k (fig. 1) be a righthanded system of orthogonal axes, and let $h^{\pi/2}$ denote a quadrant round h. Then if we take the quadrants in the cyclical order

$$h^{\pi/2}\, j^{\pi/2} = k^{\pi + \pi/2}.$$

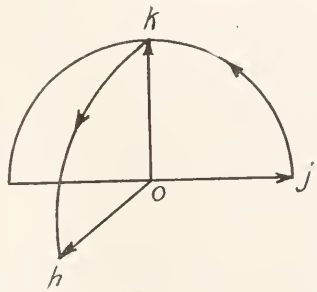


Fig. 1.

Why do we take the angle greater than π, not the smaller angle? Because the equivalent rotation round k which will bring j into coincidence with h must be righthanded, and therefore amounts to $3\pi/2$. But when we take the anti-cyclic order, we get

$$j^{\pi/2}\, h^{\pi/2} = k^{\pi/2}$$

The rules are thus expressed in tabulated form

	$h^{\pi/2}$	$j^{\pi/2}$	$k^{\pi/2}$
$h^{\pi/2}$	h^{π}	$k^{3\pi/2}$	$j^{\pi/2}$
$j^{\pi/2}$	$k^{\pi/2}$	j^{π}	$h^{3\pi/2}$
$k^{\pi/2}$	$j^{3\pi/2}$	$h^{\pi/2}$	k^{π}

Consider next the product of a quadrantal versor and a unit-vector. From the diagram it is evident that $h^{\pi/2}\, j = k$ but $j^{\pi/2}\, h = -k$; also $h^{\pi/2}\, h = h$. Hence we have the table:

	h	j	k
$h^{\pi/2}$	h	k	$-j$
$j^{\pi/2}$	$-k$	j	h
$k^{\pi/2}$	j	$-h$	k

Consider finally the product of two unit-vectors. From considerations of projection I derived the table

	h	j	k
h	$+$	k	$-j$
j	$-k$	$+$	h
k	j	$-h$	$+$

This table is implicitly assumed by vector-analysts; but there is an evident difficulty in reconciling it with the principle of dimensions and in harmonizing it with the products of quadrants, which are in a sense imaginary unit vectors. To overcome the former difficulty I adopted the following theory (p. 79):

> In such an expression as xi it is more philosophical and correct to consider the x as embodying the unit, while i denotes simply the axis. I look upon the magnitude as containing the physical unit, to be arithmetical ratio and unit combined, and different vectors have different physical units. An axis is not a physical quantity but merely a direction.

In pursuance of this theory I considered the types of compound

axes of the first four orders. These are given in the first place by the homogeneous products:

α	α^2	α^3	α^4
	$\alpha\beta$	$\alpha^2\beta$	$\alpha^3\beta$
		$\alpha\beta^2$	$\alpha^2\beta^2$
		$\alpha\beta\gamma$	$\alpha^2\beta\gamma$
			$\alpha\beta^3$
			$\alpha\beta^2\gamma$
			$\alpha\beta\gamma^2$
			$\alpha\beta\gamma\delta$

and in the second place by inserting the conjugate forms. At that time I supposed these expressions to denote compound axes and the elements to be orthogonal. It was only after much subsequent study that I discovered the true nature of these expressions as compound units.

In connection with this I used a *pole* notation; $\overline{\alpha\beta}$ was used to denote the axis which is perpendicular to α and to β, or with greater truth the conjugate axis of their plane. As the vinculum is inconvenient to print, it is better to use a special form of bracket as $[\alpha\beta]$. This notation expresses unambiguously any complex pole, such as $[[\alpha\beta]\gamma]$ or $[[\alpha\beta]\,[\gamma\delta]]$.

A quaternion was defined, not as the ratio of two vectors simply, but as the ratio of two vectors when they are free to rotate in their own plane. The former definition—the ratio of two vectors—was held to be the true definition of Gibb's dyad. A quaternion was analysed into tensor, axis, and amount of angle, and the relation of these elements was expressed, for example, by

$$q_1 = a_0\,\alpha^a \qquad q_2 = b_0\,\beta^b$$

The axis was supposed to be defined by two elements, and in contrast to Hamilton (Elem. Bk. II, Art. 130) the angle was not restricted to being less than π, but on the contrary might have any magnitude.

As a consequence the square of a quaternion was defined by $q^2 = a_0{}^2\alpha^{2a}$, which Hamilton could not logically do, because if a were greater than $\pi/2$, then $2a$ would be impossible. Similarly the square-root was defined *definitely* by

$$q^{\frac{1}{2}} = \sqrt{a_0}\,.\,\alpha^{a/2}$$

It was shown that a quaternion could be reduced to the sum of two homogeneous components, by writing

$$a_0\alpha^a = a_0 \quad \{\cos\ a\ .\ \alpha^0 + \sin\ a\ .\ \alpha^{\pi/2}\};$$

and it was pointed out that the righthand member was not a full equivalent of the lefthand member, as all the complete turns had been dropped.

It was shown that the fundamental principle in the composition of quaternions is

$$\beta^{\pi/2}\ \gamma^{\pi/2} = -\cos\ \beta\gamma - \sin\ \beta\gamma\ [\beta\gamma]^{\pi/2} = [\beta\gamma]^{\pi+<\beta\gamma}$$

This principle makes both terms negative, in contrast to the Hamiltonian principle which makes the latter term positive, in order apparently that the angle may be less than π. When both terms are negative, it is much easier to pass to the analogous principle for unit vectors. The principle is proved as follows:

Choose the standard case where the angle between the planes is less than $\pi/2$ (fig. 2). The order from β to γ (by short way) together with the righthanded screw determine the pole $[\beta\gamma|$. Then $\beta^{\pi/2}\ \gamma^{\pi/2}$ is the resultant of the quadrants AB and BC. The positive angle round OB which will take OA into the position OC is not the angle which takes the shortest way but the angle which is determined by the screw rule, namely $\pi + <\beta\gamma$; hence

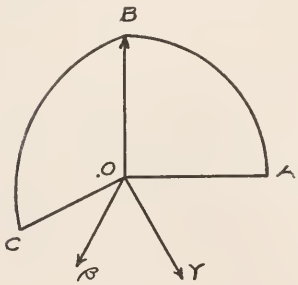


Fig. 2.

$$\beta^{\pi/2}\ \gamma^{\pi/2} = -\cos\ \beta\gamma - \sin\ \beta\gamma\ [\beta\gamma]^{\pi/2}$$

According to Gibbs the dyad AL is a kind of symbolic product in which A is the antecedent and L the consequent. I pointed out that according to the use which he makes of the dyad, it is not a product but a quotient, and expresses the ratio of the consequent to the antecedent. And in the expression for ∇ it seemed plain that to express a rate, $d_x u\ \dfrac{1}{dxh}$ or $\dfrac{du}{dx}\ \dfrac{1}{h}$ was more correct than $\dfrac{du}{dx}\ h$.

In the proof which was given that $\beta^b = e^{b\beta^{\pi/2}}$, a method was introduced which afterwards proved effective in demonstrating the Exponential Theorem. It consists in restoring the original powers from which a reduced expression was derived:

$$\begin{aligned}\beta^b &= \cos b \cdot \beta^0 + \sin b \cdot \beta^{\pi/2} \\ &= \left\{1 - \frac{b^2}{2!} + \frac{b^4}{4!} - \right\}\beta^0 \\ &+ \left\{b - \frac{b^3}{3!} + \frac{b^5}{5!} - \right\}\beta^{\pi/2} \\ &= 1 + b\beta^{\pi/2} + \frac{b^2}{2!}\beta^{\pi} + \frac{b^3}{3!}\beta^{3\pi/2} + \frac{b^4}{4!}\beta^{2\pi} + \\ &= e^{b\beta^{\pi/2}}\end{aligned}$$

PHYSICS.—*The melting points of fire bricks.* C. W. KANOLT. Communicated by C. W. Waidner. To appear in the Bulletin of the Bureau of Standards.

We are accustomed to thinking of a melting point as a temperature at which a substance changes from a rigid to a fluid condition, but a melting point can be precisely and rationally defined only as the temperature at which a crystalline or anisotropic phase and an amorphous or isotropic phase of the same composition can exist in contact in equilibrium. While this definition is satisfactory for pure substances, so complex a mixture as an ordinary fire brick usually has no single definite melting point according to this definition, since several anisotropic phases may be present, all differing in composition from the isotropic phase produced by fusion. We can then only select the temperature at which the transition from a rigid to a fluid state seems most distinct, and can call this the melting point only by apology. In the case of fire bricks, the transition temperatures so found are fortunately sufficiently distinct. I have taken as the melting point the lowest temperature at which a small piece of the brick could be distinctly seen to flow.

The experiments were conducted in an Arsem graphite resistance vacuum furnace. The samples were usually inclosed in a refractory tube made of a mixture of kaolin and alumina in the

proportions to form sillimanite, to protect them from the small amount of reducing gas in the furnace, altho the action of this gas was slight. The samples were observed thru a glass window in the top of the furnace.

The temperatures were determined by means of a Morse optical pyrometer of the Holborn-Kurlbaum type, which was sighted vertically downward thru the glass window. The carbon-filament pyrometer lamp was calibrated by two methods. In the first calibration it was sighted into a platinum resistance furnace in which black-body conditions were obtained, and the temperature of which was measured by platinum platinum-rhodium thermocouples. These thermocouples had been calibrated against the freezing points of pure metals. In the second calibration the lamp was calibrated against the freezing points of metals directly, without the intermediation of thermocouples. The metals used were copper, silver and the copper-silver eutectic, which freeze at 1083°, 961°, and 779° respectively. The metals were melted in the vacuum furnace in graphite crucibles, the pyrometer being sighted into a thin-walled graphite tube inserted in the metal. The pyrometer readings corresponding to the freezing points were determined by means of cooling curves. With silver and copper, heating curves were also obtained.

As the melting points to be measured were above the working limit of the pyrometer lamp, an absorption glass was interposed between the pyrometer and the furnace.

The true temperatures were then found from the apparent temperatures measured thru the glass, by means of the equation

$$\frac{1}{T_2} - \frac{1}{T_1} = A$$

where T_1 is the absolute temperature of the furnace, T_2 is the apparent temperature observed thru the glass, and A is a constant. The value of A was determined by calibrations at various temperatures. A small correction was also applied for the absorption and reflection of the glass window of the furnace.

The samples, which were from 1 to 2 cm. in diameter, were heated at the rate of about 10° per minute when near the melting

point. It was found that in the case of certain bricks made of heterogeneous material of relatively low melting point, the melting points were slightly higher after six hours heating to 1550°, apparently as the result of the gradual running together of dissimilar particles to form a mixture having a higher melting point than the most fusible of the original materials.

The results are summarized in the following table:

MELTING POINTS OF FIRE BRICKS

MATERIAL	NUMBER OF SAMPLES	MELTING POINT CENTIGRADE
Fire clay brick	41	1555 to 1725 mean 1649
Bauxite brick	8	1565 to 1785
Silica brick	3	1700 to 1705
Chromite brick	1	2050
Magnesia brick	1	2165
Kaolin	3	1735 to 1740
Bauxite	1	1820
Bauxite clay	1	1795
Chromite	1	2180
Pure alumina		2010
Pure silica		1750

The value 1750° given for silica is not the true melting point, but represents approximately the temperature at which the silica flows distinctly. It was found that silicon carbide does not melt below 2700°; it becomes unstable at much lower temperatures.

CHEMISTRY.—*Notes on chemical stability.* F. W. CLARKE, Geological Survey.

The term chemical stability is one of those qualitative expressions which convey a definite idea to the mind, even tho they cannot be formulated quantitatively. One substance is easily formed and difficultly decomposable; it is therefore said to be stable. Another is made with much trouble and decomposes readily, and is described as unstable. The distinction is clear, but the conditions of formation and decomposition are due to various agencies which may reinforce or oppose one another.

Molecular saturation, molecular symmetry and simplicity of constitution are favorable to stability; unsaturated compounds or highly complex substances are less likely to be permanent. Stability is also a function of temperture, for one compound may decompose below 100°, while another can be heated to 2000° without breaking down. At the absolute zero all compounds should be equally stable. Furthermore, stability is conditioned by association or environment. Two substances, each stable by itself, may form, when brought together, an unstable system. That is, they react chemically, to generate a new system of greater stability. Here again, temperature is a controlling factor, and pressure also may exert an influence. At very low temperatures, chemical activity ceases, and at very high temperatures all compounds are dissociated. Each reaction is possible only within its own range of temperature, which may be low or high. At ordinary temperatures sodium sulfate and silica can remain in contact indefinitely; at a full red-heat they react, the sulfate is decomposed and a silicate is formed. Stability, then, is a purely relative term, and must always be considered with reference to specific conditions. A substance which is stable under one set of conditions becomes unstable under another.

The foregoing observations are obvious and commonplace, but they serve as a preface to something which is less evident and which seems to have received little attention so far. When two elements unite in equal or nearly equal masses, the compound produced is more likely to be stable than when the masses widely diverge. For example, sulfur dioxide, in which the masses of sulfur and oxygen are practically the same, is more stable than the trioxide. When the latter compound is decomposed by heat the dioxide is one of its products, and when sulfur burns in air, the dioxide alone is formed. In carbon monoxide the elements are combined in the ratio 12 to 16; and this substance, despite the fact that it is unsaturated, is more stable than the dioxide with the ratio 12 to 32. Among the oxides of nitrogen the same relation holds, and the compound NO, with the simplest ratio between the masses, is the most stable of all. Other good examples are furnished by cyanogen, 12 to 14, boron nitride, 11

to 14, and sulfur monochloride, 32 to 35.5. Sulfur tetrachloride, 32 to 142, is very unstable. In short, stable equilibrium seems to be most easily established when the combining masses approach equality; even though the rule may be modified or apparently abrogated in some cases by other conditions. Such conditions are sufficiently indicated in my prefatory remarks.

The influence of what, for want of a better name, may be termed mass equilibrium, can be illustrated in many ways. Consider, for example, the several series of normal hydrides; in each series the lowest member is the most stable. Hydrogen combines with fluorine in the cold, and forms a stable compound. With chlorine the product is also stable, but formed less energetically. Hydrobromic acid is not so stable, and hydriodic acid, which can only be prepared by indirect methods, decomposes with great ease. The same rule holds for the series from NH_3 to SbH_3, and the series H_2O to H_2Te, with a stable member at one end, and an unstable one at the other. Even the hydrides of the alkaline metals show a similar relation; that of lithium, with the smallest ratio between its components being the most stable. In methane, with the ratio 4 to 12 or 1 to 3 we have a very stable compound, perhaps the most stable or least reactive, chemically, of all the normal hydrides. Among the alkaline oxides that of lithium, ratio 14 to 16, is the one most easily prepared and preserved. Examples like these might be multiplied almost indefinitely; provided that the comparisons are made between similar compounds in strictly definite series. When different series are compared other influences may come into play and modify the mass relations.

A study of solubilities also reveals some regularities which seem to indicate mass relations like those already considered. In many series of compounds the solubility is least when the combined masses most nearly approach equality. The alkaline chlorides and iodides, for instance, show this regularity clearly, as follows: The solubilities represent grams of salt in 100 grams of water at 0°.

COMPOUND	SOLUBILITY	ATOMIC WEIGHT DIFFERENCE
LiCl	63.7	28.5
NaCl	35.6	12.5
KCl	*28.5*	*3.6*
RbCl	77.0	50.0
CsCl	161.4	97.3
LiI	152.0	120.0
NaI	159.0	104.0
KI	126.1	87.9
RbI	137.5	41.5
CsI	*38.3*	*5.8*

The bromide series is less complete and is inconclusive. Rubidium bromide should be the least soluble, but the existing data give this place to the potassium salt. The series needs further investigation. As for the fluorides, the slight solubility of the lithium and sodium salts is well known, and emphasizes the present argument. To the nitrates of the alkalies the rule seems not to apply; but in the sulfates, if we compare the metals with the radicle SO_4, the regularity appears.

COMPOUND	SOLUBILITY	DIFFERENCE, M TO SO_4
Li_2SO_4	35.5	82.0
Na_2SO_4	19.6	50.0
K_2SO_4	*7.35*	*17.8*
Rb_2SO_4	36.4	75.0
Cs_2SO_4	167.1	169.6

Here, as the masses of the radicles approach each other, the solubility is lowered. The rule, however, as I have already indicated, is not universal. Solubility is affected by various conditions, such as hydrolysis, the formation of hydrates, etc.; but in general it seems as if a stable compound is less easily dissociated into ions than a comparatively unstable substance, and therefore, dissolves less freely. This subject is one which deserves careful investigation. The agreements shown are something more than mere coincidences.

If we study the occurrence of compounds in the mineral kingdom, we shall find many illustrations of the influence of mass equilibrium. Among the oxides, corundum is noted for its stability and inertness towards solvents, and in it aluminum and oxygen are combined in the ratio 54 to 48. Quartz, 28: 32, is also remarkably stable. Among sulfides, pyrite, with the ratio 56 to 64, is characteristic, and the fluoride, fluorspar, 40 to 38, is equally so. The fluorides of strontium and barium are as yet unknown as natural minerals, and these metals combine preferably to form sulfates in which the ratios of metal to SO_4 are simpler. Of the three fluorides, moreover, that of calcium is the least soluble, while calcium sulfate dissolves in water quite perceptibly.

When silica and alumina are combined magmatically, that is in dry fusion, only one silicate, sillimanite, Al_2SiO_5, is formed. This is the one compound, among the several which are theoretically probable, in which the ratio Al to Si + O is the simplest, 54 to 108 or 1 to 2. The silicates which contain aluminum with other metals are too complex in their ratios to admit of accurate comparison; but it is noteworthy that the relatively simple anorthite, nephelite and leucite are easily crystallized from fusion, while the more complicated albite and orthoclase are not so readily synthesized.

There is one more general relation in the mineral kingdom which is most suggestive. The elements of low atomic weight, exclusive of the halogens, are chiefly found as oxidized compounds. Sulfides appear first with calcium, as the mineral oldhamite, found only in meteorites. Sulfides of vanadium and manganese are rare, but from iron upwards they are abundant. Selenium and tellurium are chiefly combined with elements of high atomic weight, and their few oxidized compounds are merely the products of secondary alterations. Arsenic and antimony, in their primary minerals, also seek companions in the higher portions of the atomic weight scale, that is, from iron upwards. Heavy atoms seem to choose heavy partners, altho the rule is by no means universal.

To sum up: Chemical stability is favored by various conditions, but equality or approximate equality between the combining masses is one of them. This is clearly an important condition of stability, but it may be modified by any of the others. In many instances the effect of mass equilibrium is conspicuous and cannot be disregarded. The molecules of the diatomic elements, H_2, O_2, Cl_2, N_2, etc., in which two equal masses are combined, may be regarded as typical stable compounds.

BOTANY.—*Clastotypes, clonotypes and spermotypes, means for multiplying botanical type specimens.* WALTER T. SWINGLE, Bureau of Plant Industry.

In a recent number of this Journal I called attention to the possibility of multiplying type material by the use of merotypes,[1] i. e., additional herbarium specimens collected from the plant that furnished the original type specimen.

In case of the types which now exist in herbaria one cannot usually decide with certainty from what individual plant they were taken, even in the case of recently described species. It is often possible, however, to distribute to other herbaria fragments of existing types and these, even if very small, often have a high value. Such parts of types may be called clastotypes.[2]

If a photograph be taken of the type specimen before any fragments are detached, it is easy to mark on a photographic print the location of the clastotype cut away. A print so marked and preserved with the type serves to indicate its original condition, while one sent with the clastotype shows its postion on the type specimen.

So valuable are types pecimens that every portion no matter how small should be preserved. If a fragment is boiled and studied it should afterwards be added to the alcoholic collection; if examined under the microscope a permanent mount should be made. Both the alcoholic specimens and the microscopic

[1] Swingle, Walter T. Merotypes as a means of multiplying botanical types. This Journal **2**: 220–222, no. 9, May 4, 1912.

[2] Clastotype (κλαστός broken; τύπος type). A part or fragment of the type specimen of a species.

mounts should be kept in some easily accessible place, preferably in the herbarium itself, and a reference to them should be made on the sheet to which the type specimen is attached.

Frequently the same type specimen is studied by many botanists, each of whom removes a fresh portion to soak up in boiling water. If the first fragment removed for study were mounted in permanent form and properly indexed, it would often suffice for the observations of subsequent students and thus further unnecessary mutilation of the type specimen would be avoided.

Besides making merotypes and clastotypes there are other ways in which one may add to authentic type specimens.

Cuttings or buds taken from the plant that furnished the type specimen can be indefinitely multiplied by vegetative methods. Specimens cut from such plants may be called *clonotypes*.[3] They are usually very similar to merotypes but of course are subject to greater variation, since plants propagated by clones are often exposed to widely differing conditions of climate and soil, to say nothing of the profound effects produced by the different stocks upon which they may be grafted. Then, too, there are occasional bud variations or mutations in such vegatatively propagated plants.

Many plants that cannot be grafted or propagated from cuttings can nevertheless be made to yield clonotypes; for example, herbaceous perennials that propagate vegetatively by rhizomes, offshoots, or tubercules, as well as monocotyledons that reproduce by means of bulbs or bulbils.

Still another method of multiplying typical material is the sowing of seeds collected from the individual plant that furnished the type specimen. Specimens cut from the seedlings may be called spermotypes.[4] Of course the plants grown from seeds of the individual that yielded the type specimen are still more liable to vary than are vegetatively propagated cuttings or buds. Not only

[3] Clonotype (κλών, a young shoot, a twig; τύπος, type). A specimen taken from a vegetatively propagated part of the individual plant from which the type specimen was obtained.

[4] Spermotype (σπέρμα, ατος seed; τύπος type). A specimen taken from a representative plant grown from seed of the type plant.

are young seedlings more subject to new-place effects because of exposure to unusual environmental conditions, but there is also a much more serous liability to variation thru pollination of the flowers from some other species resulting in hybrid offspring. Nevertheless spermotypes frequently, in fact usually, do reproduce the parent plant almost identically and if properly compared with the type by a competent botanist yield type material of great value. An unchecked spermotype has, of course, little value. One great advantage of spermotypes is that they can be secured from the seedlings of short-lived plants which could not yield many merotypes and few or no clonotypes.

A little attention by collectors in securing seed from plants likely to become the types of new species will in many cases enable representative spermotypes of new species to be distributed in large numbers.

What with clastotypes taken from the type itself, clonotypes from vegetatively propagated parts of the type plant, and spermotypes from seedlings of it, there is certainly a possibility of distributing authentic material much more widely than has been customary in the past.

BOTANY.—*Phototypes, a means for wide distribution of type material.* MAUDE KELLERMAN, Bureau of Plant Industry. Communicated by Walter T. Swingle.

Altho the use of the camera in a museum by the visiting botanist is not a new thing the value of photography in herbarium work has not as yet been adequately realized.

Even very full notes cannot compare in value to actual photographic reproductions of the specimens themselves. The point of view of monographers changes with increasing knowledge and a character regarded as of little or no importance and hence neglected at the time notes are made may come to be considered of paramount importance later on. The camera, however, records with unfailing accuracy and without prejudice all the visible characters.

Photographs of type specimens are, of course, of the greatest

value. Indeed the importance of such a photograph is sufficient to warrant giving it a special name, *phototype*.[1]

It would be desirable for the larger herbaria to maintain a collection of phototypes in connection with that of the types themselves. The use of phototypes would enable a small herbarium to have a complete collection of the type material of those groups of which it makes a specialty.

Phototypes would be valuable for exchange and once widely distributed would cause type collections to become better known and more generally used.

The student would often find it of great convenience to be able to consult phototypes of the group he is studying when it is impossible for him to visit the various herbaria containing the type specimens themselves; these of course, should never by sent out as loans.

Where type specimens are kept separately in fireproof cases, preferably mounted in type boxes,[2] phototypes may take the place of these specimens themselves in the regular herbarium.

The prints should conform as far as possible to the size of the standard herbarium sheet. Bromide enlargements can be made from small negatives or photostat prints ($11\frac{1}{2}$ x 15 inches) can be made directly on sensitized paper without the intervention of a negative.

In connection with clastotypes[3] the phototype becomes important in indicating the exact location of the former on the type specimen. Phototypes of the more important parts of types and of clastotypes taken exactly natural size are very convenient and finer details of structure can be shown with a magnification of a few diameters.

When the type specimen is taken from a well-known and easily located tree it is often possible to identify the type plant with

[1] The word in this shorter form is used in preference to the cumbrous photographotype.

[2] Kellerman, Maude. A method of preserving type specimens. This Journal, **2**: 222–223, no. 9, May 4, 1912.

[3] Swingle, Walter T. Clastotypes, clonotypes and spermotypes, means of increasing type material. This Journal, **2**: 344–346, no. 14, Aug. 19, 1912.

certainty and sometimes photographs of it taken before the type specimen was collected may be in existence. Such anticipatory phototypes may be of great interest.

The highest value from a botanical standpoint must be given to synchronous phototypes taken of the fresh type specimens before they have been dried or placed in preserving fluid. If another photograph be taken at the same time showing the exact position on the type plant of the particular branch selected as the type specimen, the photographic record attains an even greater degree of perfection.

The more usual case, however, is that of the photograph taken from the dried type specimen as it exists in the herbarium. Such a subsequent phototype tho giving less information as to the nature of the species it represents than does a synchronous phototype taken in the field, has nevertheless one important advantage in that it shows the original label, thereby preventing any possible error or confusion.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

MINERALOGY.—*Mineralogical notes, Series 2.* WALDEMAR T. SCHALLER. Bulletin U. S. Geological Survey, No. 509. 1912. Pp. 115, plate and sections.

The papers included in this bulletin are as follows: *A study of the rutile group; Barbierite, monoclinic soda feldspar; Crystallized turquoise from Virginia; Crystallized variscite from Utah; Hinsdalite from Colorado; The alunite-beudantite group; Some minerals from Beaver County, Utah; Note on minerals from gabbro of Waimea Canyon, Hawaii; Cuprodescloizite from California; Mineralogy of the French phosphorites; The probable identity of podolite with dahlite; The composition of the phosphorite minerals; Natramblygonite from Colorado; The properties of mosesite; Thaumasite from Beaver County, Utah; The identity of stelznerite with antlerite.* W. T. S.

GEOLOGY.—*Headwater regions of Gulkana and Susitna rivers, Alaska, with accounts of the Valdez Creek and Chistochina placer districts.* F. H. MOFFIT. Bulletin U. S. Geological Survey No. 498. Pp. 82, with maps, views, and sections.

The headwater regions of the Gulkana and Susitna rivers include a high mountainous belt on the north, constituting a part of the Alaska Range and the northern margin of the Copper River basin. Between the provinces is a belt of low foot-hills rising above the plateau level, and paralleling the main range. Except in the high mountains, the rivers occupy broad alluvium-filled valleys. The region has been intensely glaciated in recent times, and the remnants of the former ice sheet are found in the several large glaciers found in the high range on the north.

The Birch Creek schists (pre-Ordovician?), the oldest rocks, occur in the northeastern part of the area and are separated by a fault from a series of quartzite tuffs and limestones lying to the south. The limestones carry Carboniferous (Mississippian?) fossils. A series of greenstones and schists occurring in the southernmost belt of foot-hills are assigned to pre-Carboniferous age. The Mesozoic is represented by basaltic lava flows and tuffs, with some shale (Triassic?), limestones (Triassic), by slate, tuffs, arkoses, etc. (Triassic), locally highly metamorphosed, and by very extensive intrusions of diorite (Jurassic?). There are also some areas of shales, with coal-beds, conglomerate and gravels, assigned to the Kenai (Upper Eocene). The Quaternary is represented by the high gravels, sands, and silts which make up the plateau, and by terrace deposits, both assigned to the Pleistocene, and by the alluvium of the present water courses. All of these rocks strike approximately east and west, and the prevailing dips are to the south. Some evidence was obtained of extensive faulting.

The gold placers of the region are in part reconcentrations from the auriferous gravels of old Quaternary deposits. It appears that the bedrock source of the gold is in the altered phases of the Triassic slates, and the mineralization is probably due to the influence of the dioritic intrusions. F. H. M.

GEOLOGY.—*The New Madrid earthquake.* MYRON L. FULLER. Bulletin U. S. Geological Survey No. 494. 1912. Pp. 119, with maps, views and sections.

The succession of shocks designated collectively the New Madrid earthquake occurred in an area of the central Mississippi Valley including southeastern Missouri, northeastern Arkansas, and western Kentucky and Tennessee. Beginning December 16, 1811, and lasting more than a year, these shocks have not been surpassed or even equaled for number, continuance of disturbance, area affected, and severity by the more recent and better-known earthquakes at Charleston and San Francisco. The earthquakes began a little after 2 a.m. on December 16 and continued the next day at short intervals, but gradually diminished in intensity. They occurred at long intervals until January 23, when there was another shock, similar in intensity and destructiveness to the first. This shock was followed by about two weeks of quiescence, but on February 7 there were several alarming and destructive shocks, the last equaling or surpassing any previous disturbance, and for several days the earth was in a nearly constant tremor.

For fully a year from this date small shocks occurred at intervals of a fews days, but as there were no other destructive shocks the people gradually became accustomed to the vibrations and gave little or no further attention to them.

There is geologic evidence of earthquakes in this region long antedating that of 1811. Cracks as large as any of those caused by the last great disturbance have been seen covered by trees fully 200 years old. Nor is the action apparently altogether recent, for post-Lafayette but pre-Iowan faults (antedating the deposition of the loess), and apparently being either a cause or accompaniment of earthquakes, have been observed in Crowley Ridge, and Glenn has described sandstone dikes filling old earthquake cracks in the Porters Creek formation of the Eocene Tertiary.

The area affected by the New Madrid earthquake may be subdivided into an area of marked earth disturbances, an area of slight earth disturbances, and an area of tremors only. The total area characterized by disturbances of the first type is from 30,000 to 50,000 square miles; of the second type, of over a million square miles.

Godfrey Le Sieur, who witnessed the shock, described it as follows: "The earth was observed to roll in waves a few feet high, with visible depressions between them. By and by these swells burst, throwing up large volumes of water, sand, and coal." The movement in the area of principal disturbance was from the southwest.

The tectonic effects of the earthquake were fissures, faults, landslides, uplifts, domes, and depressions. There were also extrusions of gas, water, and of various rock-making materials. The general trend and shape of the affected area, taken in connection with the direction of the earth waves, points to a centrum of the original shock along a northeast-southwest line extending from a point west of New Madrid to a point a few miles north of Parkin, Ark. The centrum of the heavier subsequent shocks seems also to have been along essentially the same line. The location of the centrum of some of the later and lighter shocks may have been elsewhere. Inasmuch as the center of activity of the primary shocks is within the embayment area of the Mississippi Valley and well removed from the surrounding areas of consolidated rocks, it seems clear that the ultimate cause lies in forces operating beneath the embayment deposits. The action may be associated either with the processes of folding or warping or be incident to a depression and deepening of the basin.

A. H. Brooks.

GEOLOGY.—*The Devonian and Mississippian formations of northeastern Ohio.* CHARLES S. PROSSER. Bulletin 15, Fourth Series, Geological Survey of Ohio. 1912.

This bulletin contains a description of the Devonian and Mississippian formations as followed from Rocky River Valley west of Cleveland eastward across northern Ohio into the western part of Pennsylvania. A large number of sections are described and some of the most striking outcrops or formation contacts are illustrated by half-tones.

The formations of the area described are classified as follows:

SYSTEM	SERIES	FORMATION	MEMBER
Carboniferous	Pennsylvanian...	Pottsville formation	Sharon conglomerate
	Mississippian	Royalton formation	Sharpsville sandstone
		Orangeville formation	Brecksville shale Aurora sandstone Sunbury shale
		Berea grit	
		Bedford formation	Sagamore sandstone Euclid sandstone
Devonian		Cleveland shale Chagrin formation	

In the above table the Euclid and Sagamore members are merely two sandstone lentils of the Bedford and they do not represent the thickness of the entire formation. The Sunbury shale, Aurora sandstone and Brecksville shale represent the entire thickness of the Orangeville formation, while the Sharpsville sandstone and Sharon conglomerate represent only the lower part respectively of the Royalton and Pottsville formations. The Orangeville formation of the Second Pennsylvania Survey has been adopted for the Ohio classification with the same limits that Dr. I. C. White gave it near the Ohio-Pennsylvania State line, viz., from the top of the Berea grit to the base of the Sharpsville sandstone.

The Cuyahoga terrane of Newberry in the Cuyahoga Valley, which is its typical region, may readily be divided into two formations, the lower one about 125 feet thick consisting largely of blackish shales which

is correlated with the Orangeville formation of Pennsylvania and this name is adopted for it. The upper formation of the Cuyahoga terrane consists of alternating blue sandstones and shales, the latter predominating in thickness, and this one has been named the Royalton from the outcrops in that township to the southwest of Cleveland. The disconformity between the Bedford and Berea formations is described and illustrated. This disconformity has been followed from near the Grand River in eastern Ohio west and southwest into central Ohio to the south of Columbus.

It is shown that the fauna of the Chagrin consists of Chemung species which extend as far west as the western tributaries of the Cuyahoga River, south of Cleveland. For example, in Ashtabula County, which is the northeastern one of Ohio, 29 species and varieties have been identified from the Chagrin, of which 6 are confined to the Ohio formation, leaving 23 for consideration in reference to correlation. Seventeen, or nearly 74 per cent of the above list, are confined to the Chemung formation and every one of the list occurs in the Chemung formation of either New York or Pennsylvania. Ten additional forms are either identified with a ? mark or compared with a species and these are also found in the Chemung, so that 84.5 per cent of the total Chagrin fauna of this county is found in the Chemung formation of New York and Pennsylvania. Consequently the fossiliferous portion at least of the Chagrin formation is regarded as the western continuation of the Chemung formation of New York.

The bulletin contains a chapter on correlation devoted principally to the formations of the upper Devonian and lower Mississippian. The evidence and literature relating to the line of division between the Devonian and Carboniferous systems in northern Ohio is summarized, a question that has recently become one of the most controverted points in the geology of Ohio. The final chapter is devoted to the paleontology of the Chagrin formation, in which a part of its brachiopod fauna is described and illustrated. C. S. P.

BOTANY.—*Le genre Balsamocitrus et un nouveau genre voisin, Æglopsis.* WALTER T. SWINGLE. Bull. soc. bot. de France, (1911), 58 (Mém 8d): 225–245, Figs. A–B, Pls. 1–5, (2 Mar. 1912), (in Chevalier Aug., Novitates floræ africanæ fasc. **4**: 225–245). Reprinted in Chevalier, l.c., and separately with original pagination.

A study of the material from tropical Africa in Paris, resulted in bringing to light two additional species of *Balsamocitrus* as well as a new

monotypic genus, *Aeglopsis*. Both of these genera are hard-shelled citrous fruits related to the Indian *Aegle* [Belou] *marmelos*.

The genus *Balsamocitrus* is divided into two sections: *Eubalsamocitrus*, having a small disk and twice as many stamens as petals; and a new section, *Afraegle* having a larger, lobed disk and four times as many stamens as petals.

The type species of the genus, *B. Dawei*, Stapf, from the Budongo Forest of Uganda, belongs to the first of these sections.

The new section, *Afraegle*, is created for *B. paniculata* (Schum.) Swingle. This plant was first collected by Thonning and published by Schumacher in 1827 or 1828 as *Citrus Paniculata*. The original description of Thonning given by Schumacher is sufficient to show that the plant must be allied to *Balsamocitrus*.

There is a cotype of this species in the Jussieu herbarium in Paris which is identical with *Aegle Barteri*, Hook, and *Limonia Warneckei* Engl., as proved by comparison with the types of these latter species preserved at Kew and Berlin.

Citrus paniculata Schum., which has been a puzzle to botanists for more than a century, is therefore the oldest name for the plant in question.

The third species, *B. gabonensis*, Swingle, n. sp., cannot yet be definitely placed in either of the section given above, as its flowers are not known. The fruits, which are used as powder flasks by the natives of French Congo and Kamerun, are large ($3\frac{1}{4}$ inches in diameter), slightly pyriform, with numerous seeds.

In 1907 M. Chevalier found at Sassandra, Côte d'Ivoire, a shrub or small tree much resembling *Balsamocitrus*, but which is in reality a new genus, *Aeglopsis*. It differs from *Balsamocitrus* principally in the structure of the ovary, which is only 6-locular The cortex of the fruit is much thinner and the cells are large and triangular, with thin walls. The leaves are simple, short-petioled, with numerous glands. This new genus is founded on *A. Chevalieri*, Swingle, n. sp., which occurs at Sassandra and at Tabu, near the eastern frontier of Liberia.

Aeglopsis has a special interest for trial as a stock for *Citrus*, since it is said to resist more or less salt in the soil.

All the species mentioned above are figured in the two text cuts and four plates. A half tone plate is also given of *Aegle glutinosa* (Blanco) Merrill, a related plant from the Philippines.

MAUDE KELLERMAN.

REFERENCES

ECONOMIC GEOLOGY.—*Contributions to Economic Geology* (short papers and preliminary reports) 1910: Part 1, *Metals and nonmetals except fuels.* C. W. HAYES and WALDEMAR LINDGREN. Bulletin U. S. Geological Survey No. 470. Pp. 558, maps and sections. 1912.

This volume comprises the following articles: *The auriferous gravels of the Trinity River basin, Cal.*, J. S. DILLER; *The economic geology of Carson camp, Hinsdale County, Colo.*, E. S. LARSEN; *Geology and mineralization of the upper St. Joe River basin, Idaho*, J. T. PARDEE; *Gold-bearing ground moraine in northwestern Montana*, F. C. SCHRADER; *Geologic relation of ore deposits in the Elkhorn Mountains, Mont.*, R. W. STONE; *Notes on the economic geology of the Ramsey, Talapoosa, and White Horse mining districts, in Lyon and Washoe counties, Nev.*, J. M. HILL; *The ore deposits near Pinos Altos, N. Mex.*, SIDNEY PAIGE; *Metalliferous ore deposits near the Burro Mountains, Grant County, N. Mex.*, SIDNEY PAIGE; *Preliminary report on the mineral deposits of Ducktown, Tenn.*, W. H. EMMONS and F. B. LANEY; *Notes on lead and copper deposits in the Bear River Range, Idaho and Utah*, R. W. RICHARDS; *Lead and zinc deposits in the Metaline mining district, northeastern Washington*, HOWLAND BANCROFT; *The arsenic deposits at Brinton, Va.*, F. L. HESS; *Iron ores in the Montevallo-Columbiana region, Alabama*, CHARLES BUTTS; *Variegated marble southeast of Calera, Shelby County, Ala.*, CHARLES BUTTS; *Supplementary notes on the commercial granites of Massachusetts*, T. N. DALE; *Clay near Calhan, El Paso, County Colo.*, G. B. RICHARDSON; *Clay resources of the Murphysboro quadrangle, Illinois*, E. W. SHAW; *Notes on some clays from Texas*, ALEXANDER DEUSSEN; *Gypsum deposits in Eagle County, Colo.*, E. F. BURCHARD; *Preliminary report on a portion of the Idaho phosphate reserve*, R. W. RICHARDS and G. R. MANSFIELD; *Rock phosphate near Melrose, Mont.*, H. S. GALE; *A reconnaissance of the phosphate deposits in western Wyoming*, ELIOT BLACKWELDER; *Paint shales of Pennsylvania*, B. L. MILLER; *Sulphur deposits, near Soda Springs, Idaho*, R. W. RICHARDS and J. H. BRIDGES; *The types, modes of occurrence, and important deposits of asbestos in the United States*, J. S. DILLER; *Dolomite for flux in the vicinity of Montevallo, Shelby County, Ala.*, CHARLES BUTTS; *Graphite near Dillon, Mont.*, A. N. WINCHELL; *Fluorspar near Deming, N. Mex.*, N. H. DARTON and E. F. BURCHARD.

Mineral resources of the United States. Calendar year 1910: Part 1, *Metals.* U. S. Geological Survey. Pp. 796, map and sections. 1910.

AGRICULTURE.—*Soil surveys* (Advance sheets—Field operations of the Bureau of Soils, 1909–1910) as follows:

Ellis County, Texas. FRANK BENNETT, R. T. AVON BURKE, and CLARENCE LOUNSBURY. Pp. 34. Map.

Panhandle Region Texas. (Reconnaissance.) WILLIAM T. CARTER, JR., and Party. Pp. 59. Pls. 6. Map.

Point Pleasant area, W. Va. W. J. LATIMER and CHARLES N. MOONEY. Pp. 50. 2 Maps.

Marinette County, Wis. (Reconnaissance.) S. WEIDMAN, Wisconsin Geological and Natural History Survey, and Percy O. WOOD, U. S. Department of Agriculture. Pp. 39. Pls. 4. Map.

HYDROLOGY.—*Surface water supply of the United States, 1909.* Part I, *North Atlantic Coast.* H. K. BARROWS, C. C. COVERT, and R. H. BOLSTER. Water-Supply Paper U. S. Geological Survey No. 261. Pp. 309, with views. Part III, *Ohio River basin, 1909.* A. H. HORTON, M. R. HALL, and R. H. BOLSTER. No. 263. Pp. 192. Pls. 6. 1911. Part V, *Hudson Bay and upper Mississippi River basins, 1909.* ROBERT FOLLANSBEE, A. H. HORTON, and R. H. BOLSTER. No. 265. Pp. 231. Pls. 5. 1911. Part VI, *Missouri River basin.* W. A. LAMB, W. B. FREEMAN, and F. F. HENSHAW. No. 266. Pp. 291. Pls. 5. Part IX, *Colorado River basin.* W. B. FREEMAN and R. H. BOLSTER. No. 269. Pp. 247. Pls. 9. Part XI, *California.* W. B. CLAPP and F. F. HENSHAW. No. 271. Pp. 256. Pls. 6. 1911. Part VIII, *Western Gulf of Mexico.* W. B. FREEMAN and J. G. MATHERS. No. 288. Pp. 149. Pls. 3. 1911.

ENGINEERING.—*Results of spirit leveling in Alabama, Georgia, North Carolina, South Carolina, and Tennessee, 1896, to 1909.* R. B. MARSHALL. Bulletin U. S. Geological Survey No. 441. Pp. 145. 1911. *Retracement of the boundary line between Idaho and Washington from junction of Snake and Clearwater rivers northward to the International Boundary.* R. B. MARSHALL. No. 466. Pp. 39, map and sections. 1911. *Results of spirit leveling in North Dakota, 1897 to 1910.* R. B. MARSHALL. No. 469. Pp. 22. 1911. *Results of spirit leveling in Kansas and Nebraska, 1896 to 1909.* R. B. MARSHALL. No. 473. Pp. 42. 1911. *Results of spirit leveling in California, 1907 to 1910.* R. B. MARSHALL. No. 481. Pp. 115. *Results of spirit leveling in Colorado, 1896 to 1910.* R. B. MARSHALL. No. 486. Pp. 107. *Results of spirit leveling in Idaho, 1896 to 1909.* R. B. MARSHALL 487. Pp. 43. 1911. *Results of spirit leveling in Montana, 1896 to 1910.* R. B. MARSHALL. No. 482. Pp. 154. 1911. *Results of spirit leveling in Nevada, 1897 to 1909.* R. B. MARSHALL. No. 488 1911. *Results of spirit leveling in Illinois, 1909 and 1910.* R. B. MARSHALL. No. 493. Pp. 109. 1911.

LAW.—*Mining laws of Australia and New Zealand.* A. C. VEATCH. Preface by Walter L. Fisher, Secretary of the Interior. Bulletin U. S. Geological Survey No. 505. Pp. 180. 1911.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY OF WASHINGTON

The 254th meeting was held in the Cosmos Club March 13, 1912, President Stanton being in the chair. The following informal communications were presented:

Mr. David White brought up the question of the formation of limestone near tide level thru the agency of calcareous algae and called attention to the very important as well as striking data on the subject published in the 18th part of the "Siboga-Expeditie," and to the work of Rothpletz and other paleontologists on limestones of various ages in Europe. Expressing the opinion that many of the limestones of the American coalfields were formed very close to tide level and under climatic conditions shown by the associated land plants to be favorable for great development of coralline algae, the speaker hoped that this branch of paleontology, almost untouched in America, might engage the interest of some of our young paleontologists.

Mr. K. D. Burling described the reëxamination by Mr. J. A. Allan and himself of the Mount Bosworth (British Columbia) section described by Dr. Charles D. Walcott in 1908, in an attempt to determine the position in that section of a series of 2500 feet of Cambrian shales and limestones measured by Mr. Allan in the Ice River Region, and announced the finding of typical Upper Cambrian (Sherbrooke) fossils in the "Ordovician" beds forming the top of the exposed section, a discovery which enabled them to place the Ice River beds in the interval between the Sherbrooke and the true Ordovician.

Mr. F. E. Matthes briefly called attention to the introduction by French topographers of two new terms, "topology" and "topometry," expressing concepts related to that of "topography," but different from it. He gave the definitions, as laid down by Berthaut, and discussed the desirability of the wider adoption of these terms, and the value of the more precise differentiation between the respective concepts which would ensue.

REGULAR PROGRAM

The development of a typical bolson in the Southwest: O. E. Meinzer. The Spanish term "bolson," is used to designate constructional detritus plains occupying structural troughs in arid regions. A good example of a plain of this type is afforded by Sulphur Springs Valley in southeastern Arizona. The northern part of this valley is a completely closed bol-

son, one that holds the surface water, with its mechanical sediments, and the underground water, with its dissolved solids. This closed basin is, on the whole, being aggraded but is suffering stream erosion (1) on the upper parts of the slopes, and (2) near the playa. The high-level erosion results in part from the normal development of the gradational cycle, the large canyons having been cut deeper than the smaller ones, and all of them having been progressingly lowered. The basin held an ancient lake of 120 square miles with 30 miles of beach ridge. Inside the ancient strand is a playa covering 51 square miles. Northeast of the playa is a dune area produced by southwest storm winds. Search for ancient shore features in any bolson in this region should begin on the southwest side of the playa, where such features are not covered by wind deposits.

A completely closed bolson has two surfaces: a débris surface and an underground-water surface. The base-levels of the two generally coincide. The débris base-level is gradually raised by débris from the mountains. Since the water supply is much larger than the débris supply the water base-level is kept up to the débris base-level, and were it not for evaporation the water-level would be raised indefinitely. As long as the water-level does not rise above the playa the débris surface is a self-developed unit, but when it rises above the playa, the submerged part of the débris surface is placed under new conditions and the part remaining above water adjusts itself to the lake-level, which is the new base-level accidentally imposed upon it. In Sulphur Springs Valley the débris surface has not yet readjusted itself since the disappearance of the Pleistocene lake, as is shown by the erosion near the playa.

In a completely closed bolson the soluble minerals are concentrated in the central area of evaporation, and as the valley is aggraded they are carried upward and reconcentrated at the surface. The very shallow waters in the area of evaporation are generally more highly mineralized than the deeper waters and the waters below the slopes. The waters below the slopes adjacent to igneous mountains contain less mineral matter than those below the slopes adjacent to mountains of sedimentary rock. Also the mineral matter is of a different kind, the soluble material in the soil derived from the igneous mountains being largely sodium carbonate.

The fill of the Gila Valley has been eroded and this erosion has extended to Sulphur Springs Valley, capturing several of its arroyos. Hence this bolson, with its delicate gradational adjustments, is an ephemeral feature.

Certain deposits in Sulphur Springs and adjacent valleys that indicate deposition in lakes or seas lie beneath the stream deposits and represent an older submergence than do the beaches.

The magmatic sulfide ore body at Elkhorn, Montana: Adolph Knopf. The Golden Curry Mine at Elkhorn, Montana, has produced 50,000 tons of iron ore carrying $4 a ton in gold, which has been used mainly as a flux for the lead smelters. One of the sources of this iron ore was a lens of sulfide ore occurring in quartz monzonite 250 feet from the contact

with metamorphosed limestone. This ore body is elliptical in plan; it is 100 feet long, 20 feet wide, and has been stoped upward to a height of 10 or 12 feet. From it were extracted 2000 tons of ore carrying $4 in gold, 35 per cent excess iron, and 2 per cent in copper.

The ore consists of a mixture of pyrrhotite and chalcopyrite in a gangue of augite. Surrounding the sulfide mass and grading into it is a body of dark heavy rock of fresh appearance and of even-grained granitic texture, which proves upon microscopic examination to be a pyrrhotite augite diorite. This rock in turn grades laterally outward into quartz monzonite composed of plagioclase, orthoclase, quartz, biotite, and hornblende, which is the normal country rock. The facts pointing to the primary igneous origin of the sulfides are the following: (1) The lack of evidences of hydrothermal alteration in the ore and wall rocks; (2) the textural relation of the sulfides to the augite as shown by the tendency of the pyroxene to develop idiomorphic boundaries against the sulfides; and (3) the marked differentiation that has taken place in the magma concurrently with the segregation of the sulfides, expressed mineralogically by the decrease of the othoclase, quartz, and biotite, and the concurrent increase of the ferromagnesian minerals, as the ore body is approached.

The mineral composition of the primary ore as a factor determining the vertical extent of the secondary sulfide zones: W. H. Emmons. It is generally supposed that waters descending from the surface in sulfide ores rapidly lose acidity. Two samples taken from the same column of water in a shaft in a body of pyrrhotite ore at Ducktown, Tennessee, indicate a decrease of acidity of more than one-half at a depth only 37 feet below the top of the body of standing water.

At Ducktown, Tennessee, and in many other copper deposits containing abundant pyrrhotite, the chalcocite zones are restricted to a few feet in vertical extent, whereas they may be hundreds of feet in vertical extent in pyritic ores containing little or no pyrrhotite. With a view to ascertaining the effect of dilute acid sulfate waters on several sulfides Dr. R. C. Wells carried out the following experiments. Equal volumes of ground sulfides similarly sized were treated separately with dilute ferric sulfate and acid sulfate solutions, and also with acid sulfate solutions about 1/20 normal. The rate of attack with acid sulfate was in the following order: Pyrrhotite, sphalerite, galena, chalcopyrite and pyrite. The action with pyrrhotite was about 25 times as rapid as with sphalerite and with sphalerite at least 4 times as rapid as with pyrite or chalcopyrite. The generation of hydrogen sulfide was proved in the action on pyrrhotite, sphalerite and galena.

Since hydrogen sulfide precipitates copper, gold, silver and some other metals from acid solutions, it would not be supposed that these metals would be carried far below the zone where hydrogen sulfide was being generated by the action of acid on sulfides. They could probably be carried to greater depths in ore composed of pyrite and chalcopyrite without pyrrhotite or sphalerite than in sphalerite ores, and to greater depths in sphaleritic ores containing no pyrrhotite than in ores contain-

ing abundant pyrrhotite. A statistical review of a number of ore deposits classified with respect to the mineral composition of the primary ore appears to lend some support to this hypothesis, since chalcocite zones in ores containing abundant pyrrhotite are generally limited vertically while those containing sphalerite pyrite, and chalcopyrite extend to greater depths.

The 255th meeting was held in the Cosmos Club March 27, 1912, with President Stanton in the chair.

REGULAR PROGRAM

An occurrence of emeralds in North Carolina: D. B. STERRETT. Emeralds are found in several types of deposits. In Columbia they occur in calcite veins in bituminous limestone; in Upper Egypt and in the Ural Mountains, in dark mica schist interfoliated with talc schist; in the Salzburg Alps, in a greenish-brown mica schist interbedded with chlorite and hornblende schist; in Maine, Connecticut, and on Crabtree Mountain, Mitchell County, North Carolina, in pegmatite; at Hiddenite in Alexander County, North Carolina in cavities in veins cutting biotite gneiss, associated with quartz, calcite, dolomite, muscovite, rutile, black tourmaline, pyrite, monazite, and hiddenite.

At a new locality in Cleveland County, North Carolina, $4\frac{3}{4}$ miles S.30°W. of Shelby, emeralds occur in pegmatite cutting hornblende hypersthenite and olivine gabbro. Some of the hypersthenite contains olivine and grades into gabbro. The two rocks are probably genetically related. Both have been intruded and surrounded by biotite granite. The granite has acted on the basic rock both absorbing and altering the composition of part to less basic variety. Pegmatite, probably genetically associated with the granite, has filled fissures in the basic rocks. In one of these pegmatites emeralds have been found. It is suggested that the agencies which formed the pegmatite contained the necessary elements of the formation of beryl. The absorption of some of the basic rock by the granite magma supplied the oxide of chromium necessary to impart an emerald green color to the beryl. Analyses by Dr. R. C. Wells, of the Geological Survey, showed the presence of 0.16 per cent Cr_2O_3 in the hornblende hypersthenite and of 0.17 per cent in the olivine gabbro. This is practically the same percentage of oxide of chromium contained in emerald. Beryl found in other pegmatites inclosed in granite and mica gneiss in this region are pale aquamarine green, yellowish, or white.

Some emeralds of fine color have been found at the new locality. The best one was found on the surface in a cotton field. It is about half of a crystal, split parallel with its length, and measures about 1 by $\frac{3}{4}$ by $\frac{1}{2}$ inch. The color is a fine deep green. About a quart of emeralds have been found in all and the color and quality of these are about equal to the average emeralds from Columbia. The best gem so far cut from this North Carolina locality weighs 0.83 carats and has been valued at

$200 per carat. Other crystals that have not yet been cut will probably yield equally fine stones.

The salt and gypsum deposits of southwestern Virginia: GEORGE W. STOSE. The deposits described are in the valley of North Holston River in the vicinity of Saltville and are associated with a soft shaly formation (Pulaski) of upper Mississippian age, 1000 feet thick. This formation overlies the Price sandstone, which represents the Pocono of Pennsylvania, and underlies the Newman limestone, which represents the Greenbrier of that region.

The gypsum was formerly considered to have been derived from limestone by the action of sulfuric acid solutions derived from oxidizing pyrite in the associated black shales, but more recently has been described by Eckel as sedimentary in origin. The fact that the deposits are found only close to a great fault which overthrusts Cambrian dolomite from the southeast upon the Pulaski formation, leads to the present conclusion that the thick deposits of both gypsum and salt are due to concentration in the Pulaski formation, by meteoric waters circulating along the fault, of minerals originally disseminated in the same formation by sedimentation under salt-pan conditions. Further evidence in support of this view was presented.

Classification of metalliferous mineral lands: R. W. STONE. A great part of the work of the Metalliferous Board of the Land Classification Board of the Geological Survey has been the classification of land in the Northern Pacific Railroad grant. This grant made by Congress to the Northern Pacific in July, 1864, to aid in the construction of a railroad and telegraph line from Lake Superior to Puget Sound was a gift of 20 alternate square miles of non-mineral land on each side of the right of way for each mile of road in the territories, and 10 alternate square miles in the States. Two in lieu strips, each 10 miles wide, granted subsequently, made in the territories a strip of land 120 miles wide in which the railroad had a claim to all odd-numbered sections of non-mineral land. The first formal classification of these lands was provided for by Act of Congress, February 26, 1895, the work to be done by three commissioners in each of four land districts in Montana and Idaho. Many of the classifications made by these commissioners were protested and vacated as fraudulent. June 25, 1910, Congress made an appropriation to complete the examination and classification of lands within the Northern Pacific grant. This work was begun in July 1910 by Messrs. Calkins, McDonald, Pardee, and E. E. Smith in Idaho and Stone in Montana, all under the supervision of Mr. H. S. Gale, and was continued in 1911.

In the public domain and in Indian Reservations the classification as mineral or non-mineral is based on a consideration of relative values, agriculture, grazing, and timber possibilities being balanced against the probability of paying mineral deposits. In the Northern Pacific grant, "Is the land mineral or non-mineral?" is the whole question. The main point of contention between the government and the railroad is the interpretation of the law as to what constitutes evidence of mineral land.

The 256th meeting was held in the Cosmos Club April 10, 1912, President Stanton in the chair.

REGULAR PROGRAM

Discussion of the relation of forestation to streams and erosion: Led by Prof. Willis L. Moore, Dr. W J McGee, Dr. F. B. Laney.

The following members and guests also took part in the discussion: C. A. Davis, W. L. Hall, A. C. Spencer and G. O. Smith.

ROBERT ANDERSON,
RALPH W. RICHARDS,
Secretaries.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

VOL. II, SEPTEMBER 19, 1912 No. 15

MATHEMATICS.—*Account of researches in the algebra of physics.*[1] II. A. MACFARLANE.

The fundamental theorems of analysis generalised for space. Read before the New York Mathematical Society, May 7, 1892. Separately printed. First of all the generalised DeMoivre's Theorem was considered. Let α^a, β^b, γ^c denote three independent spherical angles; then:

$$\alpha^a\beta^b\gamma^c = (\cos a + \sin a \,.\, \alpha^{\pi/2})\ (\cos b + \sin b \,.\, \beta^{\pi/2})$$
$$(\cos c + \sin c \,.\, \gamma^{\pi/2}) = \cos a \cos b \cos c$$
$$+ \cos a \cos b \sin c \,.\, \gamma^{\pi/2} + \cos b \cos c \sin a \,.\, \alpha^{\pi/2}$$
$$+ \cos c \cos a \sin b \,.\, \beta^{\pi/2}$$
$$+ \cos a \sin b \sin c \,.\, \beta^{\pi/2}\ \gamma^{\pi/2} + \cos b \sin c \sin a \,.\, \alpha^{\pi/2}\ \gamma^{\pi/2}$$
$$+ \cos c \sin a \sin b \,.\, \alpha^{\pi/2}\ \beta^{\pi/2} + \sin a \sin b \sin c \,.\, \alpha^{\pi/2}\ \beta^{\pi/2}\ \gamma^{\pi/2}$$

The compound angles are expanded by means of the principle $\beta^{\pi/2}\ \gamma^{\pi/2} = -\cos\beta\gamma - \sin\beta\gamma\ [\beta\gamma]^{\pi/2}$. As the angles are independent of one another, the theorem has its general meaning in the composition of rotations.

The main object of the paper was the demonstration of the generalised Exponential Theorem; from it the other theorems follow as consequences. To prove that

$$e^{b\beta^{\pi/2}}\ e^{c\gamma^{\pi/2}} = e^{b\beta^{\pi/2} + c\gamma^{\pi/2}}$$

[1] Read before the Philosophical Society of Washington, April 20, 1912. See this Journal 2: 331–337. 1912.

$$\text{Since } e^{b\beta^{\pi/2}} = 1 + b\beta^{\pi/2} + \frac{b^2}{2!}\beta^{\pi} + \frac{b^3}{3!}\beta^{3\pi/2} + \cdots$$

$$\text{and } e^{c\gamma^{\pi/2}} = 1 + c\gamma^{\pi/2} + \frac{c^2}{2!}\gamma^{\pi} + \frac{c^3}{3!}\gamma^{3\pi/2} + \cdots$$

$$\begin{aligned} e^{b\beta^{\pi/2}}\, e^{c\gamma^{\pi/2}} &= 1 + c\gamma^{\pi/2} + \frac{c^2}{2!}\gamma^{\pi} + \frac{c^3}{3!}\gamma^{3\pi/2} + \\ &\quad + b\beta^{\pi/2} + bc\beta^{\pi/2}\gamma^{\pi/2} + \frac{bc^2}{2!}\beta^{\pi/2}\gamma^{\pi} + \\ &\quad + \frac{b^2}{2!}\beta^{\pi} + \frac{b^2c}{2!}\beta^{\pi}\gamma^{\pi/2} + \\ &\quad + \frac{b^3}{3!}\beta^{3\pi/2} + \\ &= 1 + b\beta^{\pi/2} + c\gamma^{\pi/2} + \frac{1}{2!}\left\{b^2\beta^{\pi} + 2bc\beta^{\pi/2}\gamma^{\pi/2} + c^2\gamma^{\pi}\right\} \\ &\quad + \frac{1}{3!}\left\{b^3\beta^{3\pi/2} + 3b^2c\,\beta^{\pi}\gamma^{\pi/2} + 3bc^2\beta^{\pi/2}\gamma^{\pi} + c^3\gamma^{3\pi/2}\right\} \\ &\quad + \text{etc.} \end{aligned}$$

The question now is: Is the quadratic expression within the brackets the square of $b\beta^{\pi/2} + c\gamma^{\pi/2}$? Hamilton answered in the negative, because it does not conform to the formula

$$(A + B)^2 = (A + B)\ (A + B) = A^2 + AB + BA + B^2.$$

I answer in the affirmative, because it conforms to the formula

$$(A + B)^2 = A^2 + 2AB + B^2.$$

The latter is the square of a succession of vectors A and B, the former is merely the square of the resultant of A and B. Observe also that the above method of multiplying gives only one $bc\beta^{\pi/2}\ \gamma^{\pi/2}$, and that the 2 is introduced to compensate for the factorial 2! placed outside; the multiplication gives no term in $b\ c\ \gamma^{\pi/2}\ \beta^{\pi/2}$ as is given by Hamilton's conjugate square. In a similar manner the terms within the next bracket give $\{b\beta^{\pi/2} + c\gamma^{\pi/2}\}^3$; hence the theorem is proved.

In this way the doctrine of successive vectors and of direct powers was introduced into space-analysis. The truth of the

Binomial Theorem, at least for n being a positive integer, became evident, namely,

$$(iA + iB)^n = (iA)^n + n\ (iA)^{n-1}\ (iB) + \frac{n\,(n-1)}{1\cdot 2}\,(iA)^{n-1}\,(iB)^2$$

$+$ etc.

where iA and iB denote two successive logarithmic vectors $a\alpha^{\pi/2}$ and $b\beta^{\pi/2}$; and it was inferred that the same would apply to a sum of successive simple vectors $A + B$ where $A = a\alpha$ and $B = b\beta$.

From the Binomial Theorem, the Multinomial Theorem follows; for example:

$(A + B + C)^2 = A^2 + B^2 + C^2 + 2AB + 2AC + 2BC$; where it is to be noted that the term which occurs is $2AC$ not $2CA$.

It was shown that the sum of successive vectors $A + B - A$ does not reduce to B, but is represented by the three sides of a parallelogram (fig. 3)

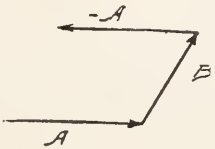


Fig. 3.

On the imaginary of algebra. Proc. A.A.A.S., **41**: 33–55. This paper contains the extension of the prosthaphaerisis theorems of plane trigonometry to spherical trigonometry; also an investigation of the logarithmic circular spiral $e^{b\beta^{\omega}}$, where ω is the constant angle between the radius vector and the tangent. The spiral is equivalent to $\exp\,(b \cos \omega + b \sin \omega\ .\ \beta^{\pi/2})$, $= \exp\, b \cos \omega \exp\, b \sin \omega\ .\ \beta^{\pi/2}$.

The expression, complementary to that for a circular angle, was sought for a hyperbolic angle in space, in the simplest case where the hyperbola is equilateral. The difficulty lay in the circumstance that the logarithm of the hyperbolic β^1 seemed to be β^{π}, whereas $\beta^{\pi/2}$ seemed to be needed to express the rectangular components. The difficulty was then only partially solved.

Definitions of the trigonometric functions. Read before the Mathematical Congress at Chicago, August 22, 1893. Separately printed. This paper treats of the triangular functions, the circular ratios, the equilateral hyperbolic ratios, the elliptic ratios, and the complex ratios.

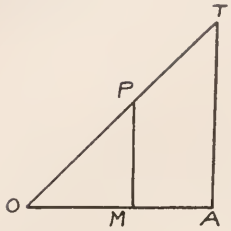


Fig. 4.

Under the first heading are considered two lines OA and OP (fig. 4) with the projections of OP along and perpendicular to OA, namely OM and MP, also certain other projections as AT drawn perpendicular to OA cutting off OT. It was shown that the geometric equation of the first degree

$$OP = OM + MP$$

leads to a geometric equation of the second degree

$$(OA)\ (OP) = (OA)\ (OM) + (OA)\ (MP);$$

that is, the parallelogram (OA) (OP) is equal to the scalar area (OA) (OM) plus the vector area (OA) (MP). This was stated to be the fundamental principle of vector-analysis. The complete product (whose existence is ignored by vector-analysts) is simply the parallelogram formed by the two given lines OA and OP. Its unit, on account of its obliquity partakes partly of the nature of the scalar unit, and partly of the nature of the orthogonal unit. The fundamental principle is expressed by

$$OA)\ (OP) = (OA)\ (OM) + (OA)\ (MP) \text{ (fig. 5.)}$$

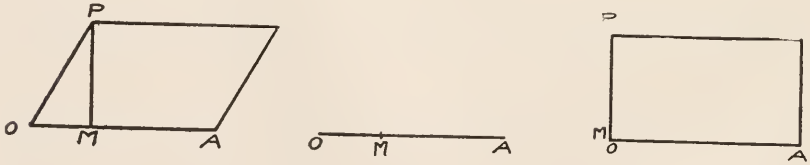


Fig. 5.

In a similar manner, as OA = OT − AT, it follows that

$$(OA)\ \ (OA) = (OA)\ \ (OT) - (OA)\ \ (AT)$$

It was pointed out that there is a variety of ways of defining the

circular ratios, differing principally in the line units chosen for the ratio; and that for the other curves these ratios, differing in conception, may cease to have equal numerical values. For example, PM is said to be drawn perpendicular to OA (fig. 6), or parallel to the tangent at A; and cos AOP is variously given by different authors as OM/OA or OM/OP; while sin AOP with still greater ambiguity is defined as

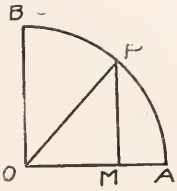


Fig. 6.

PM/OA MP/OA PM/OP MP/OP MP/OB PM/OB.

The simplest ratio is obtained where the two lines of the quotient have the same directed unit; thus OM/OA and MP/OB give pure numerical values, whereas OM/OP and MP/OA involve a difference of direction. In the above paper I defined cos AOP as OM/OA, but made the mistake of defining sin AOP as MP/OA. The simple principle mentioned allows definitions to be given of the circular ratios which apply without change to the more complex curves mentioned.

The principles of elliptic and hyperbolic analysis. Abstract read before the Mathematical Congress at Chicago, August 24, 1893. Separately printed. This paper investigates some of the fundamental principles of trigonometry on the surface of the exsphere, by which is meant the surface of the equilateral hyperboloid. Let AQ (fig. 7) be the positive equilateral hyperbola, A′Q′ the negative, and P″Q″ the conjugate; when the figure revolves about OA, the whole surface traced out by the three curves forms the exsphere. The angle AOP was defined as the ratio of the area of the sector AOP in square units to the area of the triangle AOB in square units; that is $u = A/\frac{a^2}{2}$ that is $2A/a^2$. All the radii from O to the bound-

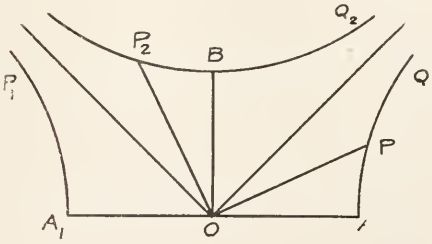


Fig. 7.

ing surface are in a sense unit axes, or unit lines, because the modulus is unity for each.

It was first shown that for a simple hyperbolic angle in a plane passing thru the axis of revolution, the expression is

$$\beta^{ib} \text{ or } \exp ib\beta^{\pi/2} \text{ where } \beta \text{ is a spherical axis.}$$

Let ρ denote any spherical axis; it is expressed quite generally by

$$\rho = \cos\theta \,.\, h + \sin\theta\,(\cos\varphi \,.\, j + \sin\varphi \,.\, k);$$

and if u denote the circular measure, any spherical angle with ρ for axis, that is, in the plane normal to ρ, is expressed by ρ^u or $\exp u\rho^{\pi/2}$.

In a similar manner any axis, as OP, to the double sheet can be expressed as $\rho = \cosh\theta \,.\, h + i \sinh\theta\,(\cos\varphi \,.\, j + \sin\varphi \,.\, \mathrm{k})$; and if u denote an angle of the circular kind, ρ^u or $\exp u\rho^{\pi/2}$ expresses an elliptic angle, that is a sector of the elliptic section made by the plane normal to ρ.

The axis OP″ at right angles to OP, terminated in the single sheet, has the form $i\rho$ and $i\rho = i\,\{\cosh\theta\,(\cos\varphi \,.\, j + \sin\varphi \,.\, k) - i \sinh\theta \,.\, h\}$. Consequently $i\rho^u = \rho^{iu} = \exp iu\rho^{\pi/2}$ expresses a hyperbolic angle; and the plane normal to $i\rho$ makes a hyperbolic section. The composition of two general exspherical angles was investigated.

In the investigation of the elliptic trigonometry, the simplest definitions were not chosen, the sine being defined with respect to OA instead of OB. One of the main difficulties was the want of an expression for the hyperbolic or elliptic arc, the solution of which difficulty I did not then perceive. The trouble is connected with the old difficulty of the rectification of such arcs.

On the analytical treatment of alternating currents. Proc. of the International Electrical Congress, Chicago, 1893, pp. 24–32. In this paper I pointed out that plane algebra was the proper analytical method for dealing with alternating currents. It was read before Section A, Professor Rowland in the chair. Mr. Steinmetz contributed to the same section an elaborate paper to the same effect, entitled "Complex quantities and their use in electrical engineering." Rowland stated that there was no

doubt about the importance of the subject in the then state of electrical science.

Application of hyperbolic analysis to the discharge of a condenser. Trans. Amer. Inst. Elec. Engineers, **14**: 163–174. The investigation of the discharge of a condenser leads to a differential equation, the solution of which depends on the solution of a quadratic equation. The author proceeded on the following theory of the quadratic equation. So far as line algebra is concerned the roots of a quadratic equation with real coefficients are either both real, or else conjugate complexes, the complex roots being scalar in both terms. But for plane algebra the roots of such an equation are either two conjugate hyperbolic roots or else two conjugate circular roots; in both cases the roots are planar. What is new in this theory is the treatment of the real roots as conjugate hyperbolic roots. The truth of this principle was made evident by the application to the discharge of a condenser.

Sur la résolution de l'équation du troisième degré. Association française pour l'avancement des Sciences. 1897. In this paper the rules of plane algebra were applied to Cardan's solution of the cubic equation $x^3 + qx - r = 0$; viz.

$$x = \left\{\frac{r}{2} + \sqrt{\frac{q^3}{27} + \frac{r^2}{4}}\right\}^{\frac{1}{3}} + \left\{\frac{r}{2} - \sqrt{\frac{q^3}{27} + \frac{r^2}{4}}\right\}^{\frac{1}{3}}$$

When the quantity under the radical sign is negative, that is in the irreducible case, the binomial expresses a circular complex quantity; and when the quantity under the radical sign is positive, the binomial expresses a hyperbolic complex quantity. The hyperbolic solution has two cases; if $\frac{q^3}{27}$ is negative, the hyperbolic vector belongs to the primary hyperbola; if that quantity is positive, the vector belongs to the conjugate hyperbola. In every case the values of x were deduced by plane algebra, circular or hyperbolic.

Differentiation in space-analysis. Read before the American Mathematical Society in 1895. Science **1**: 302. I stated that there were two distinct kinds of differentiation, and that only one of these was treated of in works on quaternions or vector-analysis.

The new more nearly resembled ordinary differentiation, gave a differential coefficient, and allowed Taylor's Theorem to be generalised without difficulty.

Brief of twelve lectures on space-analysis. University of Pennsylvania. University Bulletin, April, 1900. The imaginary expression $i\alpha$ is merely a convenient way of writing $\alpha^{\pi/2}$ and in reality means the same thing. Using this notation, the fundamental principle for quadrants is

$$(i\alpha)\ (i\beta) = -\cos\ \alpha\beta - \sin\ \alpha\beta\ .\ i\ [\alpha\beta].$$

By dividing out ii and the equivalent $-$ we derive

$$\alpha\beta = \cos\ \alpha\beta + \sin\ \alpha\beta\ .\ i\ [\alpha\beta]$$

which is the fundamental principle for vectors. This derivation explains the necessary presence of i in the second partial product; a point which is ignored by vector-analysts.

Vector differentiation. Read before the Philosophical Society of Washington. March 31, 1900. Bull. Philos. Soc. Wash. **14**: 73–92. The paper begins by referring to the two kinds of differentiation, depending on the two forms of multiplication. For the direct square

$$d(A^2) = 2AdA$$

and for the direct product

$$d(AB) = AdB + BdA.$$

But for the conjugate square

$$d(AA) = dA\ .\ A + AdA,$$

and for the conjugate product

$$d(AB) = dA\ .\ B + AdB.$$

The latter form is the only kind considered by quaternionists and vector-analysts, and is called differentiation *in situ*.

The application to the modulus and the unit was pointed out. For example, if $R = r\rho$, the direct square is $r^2\rho^2$; and $d(r^2) = 2rdr$, $d(\rho^2) = 2\rho d\rho$. But for the conjugate square $RR = r^2\rho\rho$; and $d(r^2) = 2rdr$ as before, but $d\ (\rho\rho) = d\rho\ .\ \rho + \rho d\rho = 0$. Again $d(\rho^3)$ is simply $3\rho^2 d\rho$; but $d(\rho\rho\rho) = d\rho\ .\ \rho^2 + \rho d\rho\rho + \rho^2 d\rho$.

The paper then proceeds to vector differentiation, by which is meant the theory of ∇. It was pointed out that the differential of a reduced expression is not equivalent to the differential of the primitive expression; and that if the axis ρ is variable, the reduction $\rho^2 = 1$ can be introduced only after the process of differentiation has been completed.

In the investigation of ∇ it is shown that

$$\nabla R = 3;\ \nabla r = 1/\rho;\ \text{and}\ \nabla\rho = 2/r.$$

The next step is to investigate $d(1/\rho)/d\rho$; it is found to be not $-\frac{1}{\rho^2}$ but $\frac{1}{\rho^2}$. The general conclusion was reached that when n is odd

$$\mathrm{d}\,(1/\rho^n)/\mathrm{d}\rho = n\,\frac{1}{\rho^{n+1}};$$

but when n is even, a minus is introduced. The latter statement was afterward found to be erroneous; in no case is there a minus. In this respect the differential of an inverse power of a unit differs from the differential of an inverse power of a modulus.

The rest of the paper was devoted to deriving ∇^2 from ∇ by direct operations of the calculus. For

$$\nabla = \frac{\partial}{\partial x}/h + \frac{\partial}{\partial y}/j + \frac{\partial}{\partial z}/k,$$

it was sought to deduce ∇^2 by means of the multiplication formula

$$\left(\frac{\partial}{\partial x}/h + \frac{\partial}{\partial y}/j + \frac{\partial}{\partial z}/k\right)\left(\frac{\partial}{\partial x}/h + \frac{\partial}{\partial y}/j + \frac{\partial}{\partial z}/k\right);$$

the result was

$$\nabla^2 = \frac{\partial^2}{\partial x^2}/h^2 + \frac{\partial}{\partial y^2}/j^2 + \frac{\partial^2}{\partial z^2}/k^2,$$

which reduces to

$$\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}.$$

As the above is the formula for conjugate multiplication, it is evident that what was obtained is the conjugate square of ∇.

It was shown that for a function of r, the spherical modulus,

$$\nabla = \frac{\partial}{\partial r} / \rho \text{ and } \nabla^2 = \frac{\partial^2}{\partial r^2} / \rho^2 + \frac{2}{r}\frac{\partial}{\partial r} / \rho^2.$$

For spherical coördinates,

$$\nabla = \frac{\partial}{\partial r} / \rho + \frac{\partial}{\partial \theta} / r \frac{\partial \rho}{\partial \theta} + \frac{\partial}{\partial \varphi} / r \frac{\partial \rho}{\partial \varphi};$$

and the conjugate square of ∇ was deduced by applying the formula for multiplication, and expanding the resulting terms.

METEOROLOGY.—*On the diurnal variations of atmospheric pressure.* W. J. HUMPHREYS, U. S. Weather Bureau. To appear in full in the Bulletin of the Mount Weather Observatory.

It has been known for nearly two and a half centuries that there are more or less regular daily variations in the height of the barometer, culminating in two maxima and two minima during the course of twenty-four hours; the maxima occurring at 10 o'clock, roughly, forenoon and evening, the minima at 4 o'clock, roughly, afternoon and morning.

Some of the observed facts in regard to this twelve-hour cyclic change of pressure are: (*1*) The amplitude is greatest in the tropics and decreases towards the poles, approximately as the square of the cosine of the latitude; (*2*) The amplitude is everywhere greatest at equinox and everywhere least at solstice; (*3*) The amplitude is greater at perihelion than at aphelion; (*4*) The amplitude is greater by day than at night; (*5*) The amplitude is greatest on clear days and least on cloudy; (*6*) The day amplitude is greater over land than over water; (*7*) The night amplitude is greater over oceans than over continents; (*8*) Over the tropical Pacific Ocean the forenoon barometric maximum is about 1 mm. above and the afternoon minimum 1 mm. below the general average.

Here and there through the voluminous literature on this meteorological mystery one may find an attempt to explain its origin.

The inertia of rising and of falling masses of atmosphere; the formation and evaporation of dew; the pressure due to radiation—"light pressure;" atmospheric tides and a number of other things have been advocated as actual and sufficient causes of the daily variations of the barometer. But a simple numerical test shows that nearly every one of the supposed causes is wholly inadequate to produce the observed pressure changes.

There are however three phenomena which, in the author's opinion, coöperate in such manner as to produce the barometric waves in question.

1. *Overflow of the atmosphere from the regions where it is warmest and most expanded towards those where it is coldest and most contracted.* The exact hour at which the atmosphere, top to bottom, of any given locality averages warmest and therefore, as a whole, is most expanded depends upon a variety of circumstances, but in general it is not very far from 4 o'clock in the afternoon. Hence at about this time, because of the overflow that the expansion produces, the amount of air overhead, counting from sea level, must be least; and therefore at this same hour a sea-level barometer must have its lowest average reading. Calculations, too long and tedious to include here, based on the average daily change in temperature and on the viscocity of the atmosphere, indicate that the atmospheric overflow resulting from the known thermal changes may fully account for the afternoon or 4 o'clock barometric minimum.

2. *Interference by vertical convection with free horizontal flow.* It is well known that in general the velocity of the wind increases with increase of elevation, and therefore that the free flow of the atmosphere must be disturbed to some extent by that vertical interchange of its parts which local temperature variations always induce.

We will consider this point a little closer: Let the mass of air m be near the ground and have the horizontal velocity v, and let the larger mass M be at a higher elevation and have, in the same direction, the greater velocity V. If now these two masses of air should mingle in such a manner as to be free from all disturbance, except their own mutual interference, the resulting final

velocity, U, in the same direction, would be given by the equation,

$$U = \frac{mv + MV}{m + M}$$

and there obviously would be no check in the total flow, no damming up and consequent increase of pressure. But this simple mixing of the two masses is by no means the whole story. The rise of the mass m is simultaneously accompanied by the descent of an equal amount from the larger mass M. Thus from a single interchange, due to vertical convection, the total momentum becomes

$$2mv + (M - m)V$$

Hence the total flow is reduced, through ground friction by the amount

$$m(V - v)$$

But as this is for a single interchange, it is obvious that the more active vertical convection becomes, the greater will be its interference with the flow of the atmosphere, the more the winds will be dammed up and the higher the resulting barometric pressure. In general, as convection increases, reaches a maximum and then decreases, so too will the resulting interference go through the same changes.

Now the general movement of the atmosphere is from east to west within the tropics and from west to east at higher latitudes. Hence in either case such damming up of the atmosphere as vertical convection may produce will be essentially along meridians, just as any given phase of vertical convection itself, which has to be substantially at right angles to the march of the sun, is also essentially along a meridian. In other words, convection and its attendant phenomena are functions of the time of day. But, in general, convection increases most rapidly during the forenoon, say 8 to 9 o'clock, is most active at 10 to 11 o'clock, and reaches its greatest elevation about 4 o'clock in the afternoon. Hence the damming up of the atmosphere, due to vertical convection, and the resulting increase of barometric pressure must

increase most rapidly during the forenoon, and come to a maximum about 10 o'clock. After this the convectional interference decreases, while at the same time the amount of atmosphere in a vertical column of fixed cross section also decreases as a result of expansion and overflow, till at about 4 o'clock in the afternoon the barometric pressure, as we have already seen, has reached a minimum.

To form some idea of the magnitude of the barometric change due to convectional turbulence, consider the atmosphere between two parallels of latitude near the equator. This limited quantity of the atmosphere may be regarded as a stream flowing around the earth, having its minimum velocity and maximum depth where convection is greatest, and maximum velocity with minimum depth where convection is absent.

Now the linear velocity of a point on the equator is approximately 28 kilometers per minute, while during the forenoon the rate of increase of the barometric pressure at the same place is roughly 0.2 mm. per hour. Hence a damming up, or check in the flow, of the given stream of atmosphere at the rate of 0.44 kilometer per hour would be sufficient of itself to account for the observed rise in the barometer. But if the average velocity of the wind, or flow of the stream in question, is 10 m. per second, which it may well be, the required change in the velocity could be produced by having, during the course of an hour, only one part in eighty of the whole superincumbent atmosphere in touch with the earth, an amount which, from the size of the cumulus clouds, seems altogether reasonable. Besides, the necessary velocity change is of the same order of magnitude as that observed to take place during, and as the result of, vertical convection.

The afternoon barometric minimum and the forenoon maximum, therefore, are regarded each as an effect of temperature increase; the minimum as due to expansion and consequent overflow; the maximum as mainly caused by vertical convection and consequent interference with the free circulation of the atmosphere.

The forced afternoon minimum would occur in an otherwise stagnant atmosphere, and substantially as at present; but not

so with the forced forenoon maximum since, so far as the interference or damming effect is concerned, it depends upon a flow or circulation of the atmosphere, parallel roughly to the equator.

It remains now to account for the night 10 o'clock maximum and 4 o'clock minimum.

3. Natural or free vibration of the atmosphere as a whole. This subject has been discussed by several mathematical physicists of great eminence. The latest and most complete of these discussions, and the one to which those interested in this phase of the barometric problem are especially referred, is by Lamb,[1] who concludes:

> Without pressing too far conclusions based on the hypothesis of an atmosphere uniform over the earth, and approximately in convective equilibrium, we may, I think, at least assert the existence of a free oscillation of the earth's atmosphere, of "semi-diurnal" type, with a period not very different from, but probably somewhat less than, 12 mean solar hours.

Hence any cause of pressure change, having a semidiurnal period, or harmonic of this, would, if of sufficient magnitude and proper phase, account for the twelve-hour barometric curve. Such a cause, many think, may be found in the irregular daily march of temperature, since the curve expressing this march is more or less approximately resolvable into a diurnal and semidiurnal sine curve. But the resolution is not perfect and besides there is no obvious cause for a temperature increase by night, and hence the reality of the semidiurnal component in the temperature curve is equally doubtful.

All that is needed, apparently, to give the semidiurnal pressure curve is a pressure impulse of the same period, twelve hours, as that of the free vibration of the atmosphere as a whole. And this, it seems, is furnished by the forced forenoon barometric maximum, followed, six hours later, at the same place, by the forced afternoon barometric minumum. In other words, taken together the forenoon and afternoon forced disturbances appear to occur with the proper time interval necessary to set up and maintain the twelve-hour free vibrations of the atmosphere.

[1]Proc. Roy. Soc., A, **84**: 551. 1911.

The course of events at each locality, affecting the height of the barometer, appears to be substantially as follows: (1) A forced forenoon compression of the atmosphere followed by its equally forced afternoon expansion; the two together forming one complete barometric wave, with a 10 o'clock maximum and a 4 o'clock minimum, in harmony with the free vibration of the entire atmospheric shell. (2) Non-disturbance thru the night, or during the period of a single free vibration. (3) Repetition the following day of the forced disturbances in synchronism with, and therefore at such time as to reinforce, the free vibrations.

The series of disturbances of course is indefinitely great, alternately forced and alternately free, but the resulting amplitudes of the barometric changes are limited, thru friction and thru the absence of perfect synchronism, to comparatively small values.

METEOROLOGY.—*Note on the influence of clouds on the distribution of solar radiation.* H. H. KIMBALL and E. R. MILLER. To appear in full in the Bulletin of the Mount Weather Observatory.

The Callendar pyrheliometer as ordinarily exposed gives a continuous record, on a drum revolved by clockwork, of the intensity of the vertical component of the radiation received from both sun and sky. It is a matter of common observation, subconscious in most cases, that with favorable relative position of clouds and sun the solar rays are concentrated. Records obtained by means of the Callendar pyrheliometer at Mount Weather, Va., and Madison, Wis., afford several interesting examples of increased radiation intensity due to such concentration of the sun's rays. A few of these records are reproduced in the more extended note that will appear in the Bulletin of the Mount Weather Observatory. They set forth more clearly than can words the results here given.

At Madison, on February 5, 1912, at 10.40 a.m., a glaringly bright sheet of alto-stratus cloud advanced from the northwest. The recording pen of the register rose as the cloud approached the sun; attained a maximum of 1.11 gram-calories per square centimeter per minute when the edge of the cloud reached the

sun, and then fell rapidly to a value somewhat lower than was recorded before the cloud came up. The record of February 3, 1912, a day without clouds, affords a good comparison curve, as apparently the atmospheric transmission was about the same on these two days, disregarding the effects due to clouds. The value of the sun and sky radiation on the 3d, at the time the peak was recorded on the 5th, was 0.79 calories, so that the radiation of the 5th, augmented by the cloud effect, was 41 per cent in excess of the radiation with the clear sky of the 3d. The cloud was a relatively thin sheet, and the temperature prevailing at the time, 12°F. at the surface, was low enough to make certain that the cloud was made up of ice particles. Its brightness was therefore doubtless due in part to light received upon the upper surface, and transmitted thru the cloud by refraction and reflection.

On July 28, 1912, shortly after 8 a.m., a similar sheet of alto-cumulus clouds formed rapidly over the Blue Ridge at Mount Weather. An imperfect solar corona was visible soon after the clouds covered the sun. The record made by a horizontally exposed Callendar pyrheliometer shows that as the edge of the cloud sheet approached the sun the concentration of the solar rays caused an increase in the recorded radiation of 13 per cent over what would have been recorded had the clear sky radiation curve been continued. After a short interval of clear sky, clouds again obscured the sun. At this time they were on all sides of it, and just before the sun was obscured the record shows an increase in radiation intensity of 20 per cent above what would have been received had the sky been clear.

At the same time a record was obtained from a Callendar pyrheliometer mounted equatorially in a diaframed tube, and kept pointed towards the sun by clockwork. The angular opening from the center of the pyrheliometric receiving surface to either side of the outer square diafram was about 4°. But little sky radiation could therefore be admitted to the pyrheliometer, and the record shows scarely a trace of increased radiation intensity as the clouds approached the sun. This seems to disprove the assumption made by some writers that the sky is exceptionally clear between clouds.

On May 17, 1912, a strato-cumulus cloud sheet formed over the Shenandoah valley to the west of Mount Weather, and at 9.15 a.m. advanced rapidly over the mountain. In the five minutes preceding the time at which the sun was obscured the recorded radiation intensity on a horizontal surface increased 12 per cent above the very regular curve that had been made with the clear sky previously prevailing.

At Mount Weather on June 9, 1912, cumulus clouds formed rapidly after 11 a.m., and between 11.03 a.m. and 11.19 a.m., the recorded radiation intensity increased 11 per cent. On July 8, at 10.00 a.m., a thin fracto-cumulus cloud that formed between the zenith and the sun increased the radiation intensity by 8 per cent.

In all these cases the zenith distance of the clouds was less than the zenith distance of the sun, and the clear sky that had preceded the clouds made possible rather definte measurements of the increase in radiation intensity due to the clouds. When these are in rather dense masses, such as cumulus or strato-cumulus formations, the condensation of the solar rays must be attributed to reflection from the cloud surfaces.

There are also many cases in which the cloud effects, while marked, cannot be accurately measured. A good example is the record obtained at Madison on June 3, 1912. The sky was clear until 9.30 a.m., when small cumulus clouds advanced from the northwest and covered the sky by 10.20 a.m. The alternate sunshine and shadow caused the recording pen to traverse the sheet rapidly, for the most part below the normal for that time of the day with a clear sky; but at 11.30 a.m. the relative distribution of clear sky and cloud was such that the unusual concentration of the solar rays caused a radiation intensity of 1.84 calories to be recorded.

Apparently the intensity at this time had the sky been clear would have been 1.12 calories, which gives an excess of radiation of 64 per cent due to reflection from cloud surfaces.

Another notable example of the effect of cloud reflection is the record for June 17, 1912, at Madison, when thin alto-cumulus or alto-stratus clouds prevailed thruout the day. The radiation

intensities fluctuated alternately above and below the highest clear sky records obtained at Madison during June.

By way of contrast, it may be stated that frequently during the prevalence of thunderstorms the dense cloud masses reduce the recorded radiation intensity to less than 1 per cent of clear sky intensities.

Summary. The records from Callendar recording pyrheliometers show that with favorable conditions of sun and clouds the intensity of the vertical component of the radiation received from the sun and sky may be at least 40 per cent in excess of what would have been recorded had the sky been free from clouds, and that an excess of 10 per cent is quite common. In consequence partial cloudiness may diminish but slightly the amount of radiation received at the surface of the earth.

BOTANY.—*Supplement to the Lichen flora of the Santa Cruz Peninsula, California.* ALBERT W. C. T. HERRE.

Some years ago in a paper on lichen distribution in the Santa Cruz peninsula, I expressed the belief that there were probably 200 species and subspecies of lichens in that region. Later in my lichen flora of the Santa Cruz peninsula I described in detail 307 species and subspecies, and diagnosed or mentioned 25 others which I did not deem worthy of very distinct separation. At the same time I stated that this number would be raised materially upon further investigation, and it is my present belief that the lichen flora of the Santa Cruz peninsula comprises not less than 400 good species and subspecies, generally recognized as true lichens. In this estimate no cognizance is taken of those forms (such as the parasitic *Buellias* of authors) usually described in lichen floras, but which in my judgment are true fungi. If in addition one were to include the lichens of the coast about Monterey, and those of the inner Coast Range near San José, including Mt. Hamilton and Alum Rock Park, the number would easily be raised to 500.

The greater number of my as yet undecipherable specimens belong to the genera *Buellia, Pannaria,* and *Rhizocarpon.* The

most of these are transition forms which are probably so modified by their habitat as to lose their typical characters and only physiological studies could place them properly.

This paper concludes my studies of the lichens of the Santa Cruz Peninsula as a separate unit. A work on the lichen flora of the Pacific Coast states is in preparation and the receipt of material from any state west of the Rocky Mountain divide would be greatly appreciated. The chief factor to be reckoned with now is that of geographical distribution, and it is therefore important to have as many divergent stations represented as possible. Specimens lent me for examination would be promptly returned, while exchanges would be gladly made and unidentified material named.

VERRUCAZIA NIGRESCENS Pers. in Ust. Ann. Bot. 14: 36. 1795. We may include here the two following Nylanderian species.

VERRUCARIA AQUILELLA Nyl. *Verrucaria aquilella* Nylander, Flora, 59: 237. 1876. The variety of *Verrucaria nigrescens* to which Nylander gave this name has been collected by me on sandstone at Devil's Cañon, at an altitude of 2400 feet. It has likewise been collected by Dr. Hasse in southern California. The asci are short-ventricose or saccate and measure 11 to 12μ in breadth by 23 to 24μ in length; when treated with I the thecium is bluish, then yellow or tawny in color; the spores are smaller than in *nigrescen* proper, being from 4.4 to 5.8μ in breadth and 11.7 to 17.5μ in length.

VERRUCARIA FUSCO-CINERASCENS Nyl. *Verrucaria fusco-cinerascens* Nyl. Flora, 59: 310. 1876. This obscure lichen, said by Leighton to be "apparently only a state or form of *V. nigrescens*," occurs on sandstone along the sea coast near Pigeon Point. The thallus is thin, effuse, of minute dark brown or reddish brown uneven areoles, which may be aggregated into a continuous crust or scattered and nearly disappear. The spores measure 12 by 28μ in our specimens. Not really separable, except in color, from *V. nigrescens*.

VERRUCARIA AETHIOBOLA Wahlenberg. *Verrucaria aethiobola* Wahlb. in Supplem. Ach. Meth. Lich. 17. 1803. Thallus thin, smooth, continuous, effuse, forming dark brown stains on the rocks; no chemical reactions. Apothecia very numerous, hemispherical, rather prominent, more or less immersed, black, minute, 0.3 to 0.1 mm. in diameter; perithecium black, dimidiate; paraphyses wanting; asci cylindrical, pyriform, or variously swollen and irregular, 10 to 14μ broad by 32 to 40μ long; hymenial gelatine blue with I, the spores vinous red, quickly fading to yellow; spores elliptical, 4 to 6.8μ broad by 12 to 15μ long. On rocks in the hills east of Los Gatos, at an elevation of 1500 feet and upward. A European lichen recorded by Dr. Hasse (who has kindly determined this specimen for me) from Santa Monica, California, but apparently not otherwise noticed by American authors.

ARTHOPYRENIA CERASI (Schrad.) Koerber. *Verrucaria cerasi* Schrader Cryptog. Exsicc. 1797. *Arthopyrenia cerasi* Koerber, Syst. Lich. 369. 1855. Thallus very thin, pale yellowish to brown, forming small, determinate, distinct, more or less shining spots which are irregular or more or less rounded in outline, their diameter 8 to 25 mm. Apothecia numerous, often crowded, minute, 0.3 mm. in diameter, convex, shiny black; perithecium black, dimidiate; paraphyses absent; asci tawny with I; spores quadrilocular, 5.75 to 6μ broad, by 20.5 to 27μ long. Rare with us; collected on smooth barked poplars at Stanford University. A fairly common European lichen.

ARTHOPYRENIA SPHAEROIDES (Wallr.) A. Zahlbr. *Arthopyrenia sphaeroides* A. Zahlbr. in Engler and Prantl, Natur. Pflanzenfam. I Teil, Abteil I*, 65. 1903. Thallus thin, uniform, effuse, whitish to greenish olive; darkened by KOH; $CaCl_2O_2$. Apothecia numerous, conspicuous, semi-immersed to sessile, hemispherical to sub-globose, black; ostiolum dot-like or more often not visible; perithecium black, dimidiate; paraphyses hair-like, twining; asci tubular, 8.7μ by 68 to 88μ long; spores 3 to 5.8μ wide by 9 to 13μ long; thecium—reddish brown with I. On *Quercus agrifolia* at Laguna Creek, elevation about 50 feet. Referred here with considerable doubt, rather than to call it new.

ARTHOTHELIUM ANASTOMOSANS (Ach.) Arn. *Arthonia astroidea anastomosans* Ach. Lich. Univ. 146. 1810. *Arthothelium anastomosans* Arnold, Verh. K. K. Zool. Bot. Gesell. Wien, **22**: 304. 1872. Thallus very thin, uniform, gray, forming more or less orbiculate, definite, but small and inconspicuous patches; no chemical reactions evident. Apothecia numerous, minute to small, 0.4 to 0.1 mm. across, black, more or less elevated; of many different shapes, rounded, elongate, and difform, simple, straight, or curved, stellate, and branched; thecium blue with I; asci pyriform or ventricose; spores 6 to 8 in the asci, colorless, with 6 transverse rows of cells and 2 longitudinal rows, 6 to 8.8μ broad by 14.6 to 19μ long. On twigs of *Cupressus macrocarpa* and *Pinus radiata* at Stanford University. By the spores this is *anastomosans*, but it does not agree very well in other respects. Apparently rare, but perhaps really passed over as *Arthonia radiata*; a microscopic examination is the only sure test. Recorded also by Dr. Hasse from Catalina Island. A European lichen of widespread distribution.

LECIDEA ATROBRUNNEA (Ram.) Schaerer. *Lichen atro-brunneus* Ramond in DC. Fl. Fr. **2**: 367. 1803. *Lecidea atro-brunnea* Schaerer, Spicilegia, 134. 1828. Tuckerman, Synopsis, **2**:74. 1888. Thallus of thick areoles or squamules which may be thinly scattered, closely set, or crowded, upon a conspicuous black limiting hypothallus; areoles from small and flat soon swollen and convex, with a thin black margin or abnormally with pale or white edges; circular or irregular in shape, finally with wavy and sculptured surface, the marginal areoles sometimes elongate and lobate; color brown, varying from pale and yellowish to copper, chestnut, and blackish brown, smooth and shiny to dull; medulla blue or violet with I. Apothecia small to medium, rarely large, 0.5 to 1.8 mm. in diameter; closely adnate, flat or slightly hollowed, black tho sometimes pruinose, with an entire, thick, elevated, concolorous margin; finally more or less flexuous with wavy or crenate margin, and the disk more or less swollen, and thru crowding or fusion forming irregular clusters, when the apothecia seem to be very large; hypothecium pale to brownish; epithecium thick, greenish black; paraphyses slender, straight, their slightly enlarged tips and upper portion greenish; thecium

blue with I; asci short, narrowly clavate, in our material usually without well developt spores; these often smaller than given by most authors, 2.8 to 3.5μ wide and 5.8 to 8μ long; in a specimen collected by Bolander in the Yosemite Valley and determined by Tuckerman I find the pruinose apothecia have spores 3.5 to 5μ wide by 9 to 11μ long. A lichen of granitic and schistose rocks in alpine and arctic regions. Occurring on Black Mountain, at an altitude of 900 meters. Common in the Sierra Nevada at 2000 meters and above and one of the most successful of lichens on the highest peaks. On Mt. Hamilton, near San José, at 1400 meters. Collected in southern California by Dr. Hasse at 1800 meters and above. Abundant in western Nevada. Recorded by Tuckerman from a number of Californian localities, Mt. Hood, Oregon, the Oregon coast, and from Washington. Found on all high mountains thruout the region west of the Missouri River.

LECIDEA SILACEA Ach. *Lecidea silacea* Ach. Meth. Lich. 48. 1803. *Lecidea lapicida* Tuck. Synopsis, **2**: 70. 1888. in part. Thallus indeterminate, thin or scanty, the areoles rather thickish, more or less tartareous, ashen gray in our specimens but also glaucous; KOH −; $CaOCl_2$ faintly reddish; KOH + $CaOCl_2$, red; medulla faint blue with I. Apothecia 0.3 to 1.3 mm. in diameter, closely adnate or sometimes somewhat immersed, numerous, often clustered; from circular becoming irregular by crowding, the flat black disc becoming slightly convex; margin thin, black, elevated, said to finally disappear tho not so in our material; the broad hypothecium black or very dark brown; epithecium greenish umber; thecium more or less greenish, becoming deep blue with I; paraphyses conglutinate, not very distinct, with enlarged darker tips; asci clavate; spores short ellipsoid, 4 to 6μ broad, and 9 to 12μ long. On sandstone in the Santa Cruz Mountains at from 600 meters (Bear Gulch road) to 1000 meters elevation (Castle Rock). Occurring also at Mt. Hamilton at 1400 meters. Undoubtedly the "Glaucous lichen" reported by Tuckerman from the mountains of California. A European lichen occurring also in various parts of North America and in New Zealand.

LECIDEA GLEBULOSA (E. Fries). *Biatora glebulosa* E. Fries, Lich. Europ. Reform. 252. 1831. Tuckerman, Synopsis, **2**: 16. 1888. Thallus of small, closely appressed scales which vary from crumb-like to lobed and crenate; dispersed, or crowded and forming an irregular uneven crust which is effigurate at the margin when well developt; dull whitish to gray in color. KOH −; $CaCl_2O_2$, red. Apothecia appressed, large, the flat or slightly convex disk usually black, but varying from reddish or pale flesh color to black; the thick, prominent, paler or whitish margin becoming irregular and finally deeply folded so that the disk is more or less dissected; hypothecium pale brown; spores broadly ellipsoid 5 to 6μ broad and 10 to 12μ long. On sandstone in the foothills near Stanford University, but rarely fertile. In the Oakland Hills it is not rare and is abundantly fertile. Recorded by Tuckerman from California, Oregon, and Washington.

LECIDEA ULIGINOSA (Schrad) Ach. *Lichen uliginosus* Schrader, Spic. Fl. Germ. 88. 1794. *Lecidea uliginosus* Ach. Meth. Lich. 43. 1803. *Biatora uliginosa* Tuckerman, Synopsis, **2**: 27. 1888. Thallus spreading indefinitely, of minute to microscopic granules which form a very thin and more or less continuous blackish, brown, or dusky crust; no reactions with the usual reagents. Apothecia of the same color as the thallus, small to very minute, 0.2 to 0.6 mm. in diameter, at first immersed but mostly adnate; with flat disk which is rarely convex; margin thin, elevated, at first pale but soon blackening and disappearing; hypo-

thecium dark blackish brown to brown; epithecium dark reddish brown; thecium brown, the paraphyses not distinct, coherent, simple, blue with I; asci cylindrical or narrowly clavate; spores ovoid or broadly ellipsoid, 4.9 to 7.5μ broad and 9.75 to 14.7μ long. On damp earth and moist shaly rock in the city of Santa Cruz, at an elevation of about 50 feet. Recorded by Tuckerman from Washington and from British Columbia by Macoun. Reported from most parts of North America and Europe, and also from Asia.

CATILLARIA LAURERI Hepp. *Catillaria laueri* Hepp in Arn. Exsic. No. 353. 1867. *Biatora laureri* Tuck. Synopsis, **2**: 30. 1888. Thallus very thin and scanty, or even disappearing, or at times roughened and contiguous to chinky, scurfy or smooth; effuse, forming small, irregular dusky ashen to ashy white patches; turning brown with KOH. Apothecia rather numerous, minute to small (0.4 to 1 mm. in diameter), the black, slightly roughened disk at first plane, but soon convex and swollen, when the thin entire margin disappears and the fruit is lecideine; epithecium thick, granulose, blackish or black violet; thecium pale or colorless; with a violaceous-reddish cast, becoming deep blue with I; hypothecium dusky, dusky reddish, and nearly clear, but when seen in thick sections it is of a dull greenish color; paraphyses thread-like, more or less capitate and dusky tipped, free, somewhat lax and twining; asci clavate, blue with I; spores bilocular, fusiform-ellipsoid, 3 to 5μ broad and 8.7 to 16μ long. Collected but once by me, on dead twigs along the sea coast near Pigeon Point. A bark lichen of Northern and Central Europe, reported by Tuckerman from New England, New York, California, Oregon, Alaska, and Canada.

THELOCARPON ALBO-MARGINATUM Herre, new species. Thallus composed of very small to minute (0.1 to 0.3 mm. in diameter), more or less circular and rather thick but flattened thalline warts, which lie rather thinly scattered over the substratum, or occasionally are grouped into small clusters; color a dark chestnut brown, with a distinct white margin surrounding each areole. One apothecium in each areole, its presence indicated by a minute pore; asci flask shaped; paraphyses free, thread-like, and more or less twining, not septate and rarely forked near the apex; thecium blue with I; spores very numerous, ellipsoid, 1 to 1.5μ broad, 2.5 to 4μ long. On a loose rock lying on earth near the summit of the west wall of Devil's Cañon, elevation about 2400 feet. Externally the plant much resembles a degenerate *Acarospora* and is very likely to be passed over as such.

ZAHLBRUCKNERELLA Herre. *Zahlbrucknera* Herre, Proc. Wash. Acad. Sci. **12**: 129. 1910, not Reicheub. 1832. As the name of *Zahlbrucknera* had already been applied to a genus of flowering plants, my use of the name was untenable; I therefore make the modification given above.

COLLEMA CRISPUM (Huds.) Hoffm. *Lichen crispus* Hudson, Fl. Ang. 447. 1762. *Collema crispum* Hoffm. Deutsch. Fl., **2**: 101. 1795. Thallus small, effuse, forming close or scattered greenish black or brownish black clumps, 6 to 20 mm. in diameter; the minute lobes outspread and flattish, or usually more or less erect and crowded, with crisped and intricate or dentate-granulate margins. Apothecia small to medium, 0.5 to 2 mm. in diameter, with concave reddish-black disk, which at last may become plane; margin thick, sub-entire or granulate; spores oblong ellipsoid, four-locular, colorless or faintly brown, measuring 7.3 to 11.7μ in breadth by 17.5 to 29μ in length; said to become more or less muriform, tho not so in our scanty specimens. Rare; on sandstone at Castle Rock, altitude

3000 feet. A European earth-dwelling lichen which is found across the northern half of the American continent.

LEPTOGIUM CRISTATELLUM (Tuck.) Herre. *Collema cristatellum* Tuck. Lich. Calif. 29. 1866. Herre, Proc. Wash. Acad. Sci. **7:** 378. 1908. A careful study of the thallus of this lichen shows it to be a true *Leptogium* and not a *Collema*, a well developed cortical layer being present. In addition to the stations previously recorded, I have found it growing on crumbling sandstone beside the road en route to the Lick Observatory in the inner Coast Range, at an altitude of about 1100 feet.

PLACYNTHIUM SONOMENSIS (Tuck.) Herre. *Pannaria sonomensis* Tuck., Proc. Am. Acad. **12:** 169 1877; Synopsis, **1:** 126. 1882. Thallus forming small to very small orbiculate or irregular dark dull brown patches, which appear to the naked eye as little more than dirty stains on the rocks; made up of very minute but distinct elongated, terete, linear and many cleft lobes; these more or less tangled and coralloid centrally, but somewhat expanded marginally; beneath white or pale, and smooth; upon a black hypothallus, which is usually obsolete; alga *Scytonema*. Apothecia minute, lecanorine, sessile; the flat disk soon convex and finally sub-globose, in which case the persistent entire whitish margin may be excluded; color reddish brown and blackening; margin enclosing algae which likewise form a layer beneath the colorless to very pale dusky hypothecium; epithecium broad, umber; thecium colorless, blue with I; paraphyses, thick, jointed, with enlarged tips; asci much shorter than the paraphyses, clavate, their contents usually not differentiated, 6 to 9μ broad by 35 to 41μ long; spores very slender, straight or slightly curved, simple, colorless, 1.5 to 3μ in breadth and 17 to 26μ in length; these measurements are somewhat smaller than those given by Tuckerman. I have collected only sterile specimens in the Santa Cruz Peninsula, at Castle Rock, altitude 3000 feet; on rocks at Alum Rock Park, inner Coast Range, near San José, at an altitude of 500 feet, it occurs abundantly fertile. Collected on various rocks in Sonoma County and also at Yosemite by Bolander. This plant does not agree with any of the genera as defined by Zahlbruckner, as it combines lecanorine apothecia, simple spores, and *Scytonema* algae. These characteristics do not occur together in any genus as defined, but as the separation of the genera of the *Pannariaceae* should be based primarily upon the alga enslaved rather than upon the spore characters or apothecial structure, I deem it best to call this plant a *Placynthium*.

PANNARIA LEUCOSTICTA (Tuck.) *Pannaria leucosticta* Tuckerman, Proc. Amer. Acad. **4:** 404. 1860. Cummings, Williams, and Seymour, No. 270, Decades. North Am. Lichens, Sligo Creek, Maryland. Thallus small to medium, appressed, the radiate lobes expanded marginally, their tips denticulate crenate, upturned; from sub-orbicular becoming effuse; centrally becoming reduced to minute denticulate squamules and passing into a granular crust; color whitish gray, changing centrally to brownish or greenish buff; margin of lobes and finally the whole upper surface except the peripheral lobes covered with minute, erect, denticulate, whitish, bluish, or concolorous granules; beneath white, and blackening; no chemical reactions. Apothecia numerous, of medium size; appressed, with dentate thalline margin, the flat disk soon strongly convex; color pale to dark red-brown; epithecium pale yellow; hypothecium brownish; thecium pale blue, then more or less tawny with I; spores simple, subglobose to broadly ellipsoid, often pointed at one

end, 9.5 to 10μ broad by 10 to 19.5μ long. Encrusting bark, mosses, and *Sticta anthraspis*, on the trunk of a scrub oak in the chaparral east of Los Gatos, at an altitude of about 2000 feet. Common thruout eastern North America and reported by Macoun from British Columbia, but not otherwise recorded west of the Rocky Mountains.

LECANORA BADIA (**Pers.**) **Ach.** *Lichenbadius* Persoon, Ust. Ann. Bot. **7**: 27. 1794. *Lecanora badia* Ach. Lich. Univ. 407. 1810. Tuck. Synopsis N. Am. Lich. **1**: 190. 1882. Thallus small, indeterminate, on a thin black hypothallus; of fissured areoles which pass into squamules with imbricate-areolate surface; color olive brown, usually more or less polished, but rather dull in our specimens; no reactions to chemicals. Apothecia small to minute, sessile; flat in our specimens tho said to become convex; disk blackish brown and reddish-black, with a thick, entire, persistent margin which is concolorous with the thallus, or more often blackens; paraphyses stout, their tips brownish; thecium bluish with I; spores broadly spindle shaped, 3 by 9μ; according to Tuckerman they measure 3 to 5μ in breadth by 10 to 14μ in length. A few obscure but well marked specimens were collected on rocks at Twin Peaks, San Francisco, at an elevation of about 700 feet. Recorded by Tuckerman from the White Mountains, Tadousac, Canada, and Arctic America. Beyond doubt occurring in the northern part of the Sierra Nevada and in the Cascade Mountains. Common enough in northern and central Europe in both alpine and maritime situations.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

PHYSICS.—*Circular dichroism and rotary dispersion of certain salt solutions.* L. B. Olmstead. Physical Review, **35**: 31–46. 1912.

The author investigated the rotation and ellipticity produced in plane polarised light by transmission thru solutions containing an optically active acid radical combined with an absorbing metallic ion; and, in connection with this, the extinction coefficients and refractive indices of the same solutions. Readings were made at intervals of $10\mu\mu$ to $30\mu\mu$ thruout the visible spectrum and the values obtained were plotted against wave-lengths. The colored compounds successfully used to give circular dichroism were chromium, copper, cobalt, and manganese; and the organic compounds were tartrates, malates, and lactates. The ellipticity is of the order of 10^{-3} to 10^{-2} for the concentrations used and is always a maximum in the region of maximum absorption. The rotation is anomalous in every case but the refractive index shows no anomaly. In the chromium compounds the absorption curves are of the same general shape with an absorption band in the yellow and one in the violet. At about $570\mu\mu$ the slope of the rotation curve is steepest and usually changes sign; and at this point the ellipticity reaches a maximum positive or negative value. In the copper compounds the ellipticity and absorption are maximum in the red, decreasing rapidly toward the blue. The cobalt compounds reach their maximum ellipticity and absorption in the green. The manganese tartrate solution shows an absorption band in the violet and a slight one in the green. The ellipticity changes rapidly from a negative value at $420\mu\mu$ to a maximum positive value at $540\mu\mu$, decreasing again to a small negative value in the red. L. B. O.

PHYSICS.—*The relation of the horsepower to the kilowatt.* Circular 34, Bureau of Standards, 1912.

A unit of power should not vary in magnitude from place to place, and hence the horsepower should be defined in such a way as to be equivalent to a fixed number of watts. The Standards Committee of the American Institute of Electrical Engineers in 1911 adopted the most frequently used equivalent, namely, 746 watts, as the precise value of the horsepower and this value is now recommended by the Bureau of Standards. The "continental horsepower," used in Europe, is similarly best defined as 736 watts. In accord with the trend of modern practice, particularly in electrical engineering, it is recommended that the kilowatt instead of the horsepower be used generally as the unit of power.

J. H. Dellinger

ELECTRICITY.—*Electric wire and cable terminology.* Circular 37, Bureau of Standards, 1912.

On account of the growing need for precise definitions in the field of conductor terminology, the Standards Committee of the American Institute of Electrical Engineers requested the Bureau of Standards to prepare a circular on the subject. As a result of extensive correspondence and consultation it was found possible to formulate a reasonably consistent body of definitions without introducing radical departures from existing general practice. Seventeen of the most important terms have been defined.

It was found necessary to give the most care and thought to the terms "strand" and "cable." In the strong preponderence of current opinion, "strand" implies a component part of a cable or stranded conductor, each part being either a combination of wires or a single wire. It fortunately happens that this is precisely in accord with the non-technical meaning of "strand." A "cable" is defined as either: (1) a stranded conductor, i.e., a conductor composed of a group of wires; or (2) a combination of conductors insulated from one another. The first kind of cable may be either bare or insulated. The component conductors of the second kind of cable may be either solid or stranded and the whole may or may not have a common insulating covering.

From the main terms defined, the minor germs should follow logically and most or all of the confusion which has existed in this subject should disappear.

J. H. Dellinger.

ELECTRICITY.—*The testing of instrument transformers.* P. G. AGNEW and F. B. SILSBEE. Proceedings American Institute Electrical Engineers. June, p. 1267. 1912.

This paper describes a new arrangement for testing instrument transformers, which has recently been developed at the Bureau of Standards. For current transformers the ratio is found as formerly by balancing the IR drops in two resistances, but the phase angle is measured by using the secondary voltage of a mutual inductance to balance the quadrature component of the voltage drops. A vibration galvanometer is used as a detector, and when a complete balance is obtained both ratio and phase angle can be computed from the values of the resistances and the mutual inductance.

For potential transformers a high resistance is connected across the primary side and the secondary voltage is applied through the galvanometer potentiometer fashion to a portion of this resistance. The phase relations are taken care of by inserting a large fixed self inductance in the low side of the resistance and then shunting a fixed condenser around a variable portion of the latter. This has the effect of neutralizing a portion of the inductance.

The vibration galvanometer used was of the Campbell type with a moving coil specially constructed to give high voltage sensitivity. The instrument could detect 0.5 microvolt at 25 cycles.

The advantages of this method are that only a single instrument is required for all ranges of transformers, but one observer is required, and neither a polyphase source, a phase shifting device nor a rotating commutator is required. P. G. A.

GEOLOGY.—*Coal near the Black Hills, Wyoming-South Dakota.* R. W. STONE. Bulletin U. S. Geological Survey No. 499, pp. 66, with maps, sections, and illustrations. 1912.

The salient features of the Black Hills uplift are: (1) a central area of crystalline Archean and Algonkian rocks; (2) a limestone plateau with in-facing escarpment; (3) a continuous trough, the Red Valley, completely encircling the plateau; and (4) an outer rim of flat-topped ridges sloping away from the central area. The formations of which it is necessary to take cognizance in connection with the occurrence of coal are the Spearfish formation (Triassic?), locally known as the "red beds;" the Sundance formation and Morrison shale (Jurassic?); and the Lakota sandstone, Fuson shale, Dakota sandstone, and Graneros shale (Cretaceous).

Coal is found on the west and south sides of the uplift at or near the base of the Lakota sandstone. All known occurrences are described and the conclusion is reached that Cambria is the only locality which will add to the record of coal produced in the Black Hills.

An interesting feature of the Cambria coal is the occurrence in it of gold, assays showing up to $2 a ton. Four kinds of coal are described: bituminous, cannel, splint, and "pine needle," all occurring in the same bed. The latter kind, resembling a mass of pine needles, is composed of fibers of resin, circular to elliptical in cross section, which may originally have filled some cylindrical vegetable cell. R. W. S.

BOTANY.—*Observations sur les quelques espèces indochinoises des genres Atalantia et Glycosmis.* WALTER T. SWINGLE. Notulæ systematicæ, H. Lecomte, **2**: 158–163, fig. 1^{1-6}, fasc. 5, 20 Dec. 1911, (p. 158–160) and fasc. 6, 25 Mar. 1912 (p. 161–163).

A study of the material from Indo-China in the Herbarium of the Muséum d'Histoire naturelle, Paris showed that the plant recently listed by M. A. Guillaumin in the Flore générale de l'Indo-Chine as *Atalantia disticha* (Blanco) Merrill, constitutes in reality a new species, *A. Guillaumini*, Swingle. The former plant, common in the Philippine Islands, is not yet known from the Asiatic mainland.

This new species differs decidedly from *A. disticha* in having large (nearly 1 inch in diameter) pulpless fruits containing very large seeds. It also has larger leaves with darker colored, less pubescent petioles. *A. Guillaumini* resembles *A. ceylonica* in having large seeds which almost completely fill the fruit, but the veins are not curved as in this latter species, nor are the stipules so large and foliaceous. This new species should be tested as a stock for *Citrus*.

A close study of the type material of *A. pseudoracemosa*, Guill., showed striking concordance with the characters of the genus *Glycosmis*, especially in the fine ferrugineous pubescence of the young leaves. Until the plants included in the genus *Glycosmis* are better known, the species in question should be called *Glycosmis pseudoracemosa* (Guill.) Swingle.

Glycosmis seems to include three types of species: (1), with compound leaves like *G. sapindoides*; (2), with simple leaves but long, slender petioles articulate at both ends, like *G. Bonii*; (3), with simple leaves and short petioles not articulate with the blade, like *G. pseudoracemosa*. These three groups are more or less united by the type species of the genus, *G. cochinchinensis*, which has polymorphous leaves.

MAUDE KELLERMAN.

BOTANY.—*New or noteworthy plants from Colombia and Central America* —3. H. PITTIER, in Contributions from the U. S. National Herbarium, vol. 13, pt. 12, pp. 42, text fig. **32** and plates **19**. 1912.

This is the third of a series of papers in which the author describes new materials collected during his travels, occasionally entering into critical examination of old genera and species or revising and complementing the descriptions of species that, altho long known, have more lately acquired some importance in economic botany. A thoro taxonomic investigation of the tropical American tribe of the Olmediae (Moraceae) brought to light the singular mistake made by suppressing the well-founded genus Naucleopsis, partly on account of a fantastic plate in the *Flora brasiliensis* and partly through the misplacing of an illustration in the *Pflanzenfamilien*.

With reference to the transfer of *Moquilea platypus* Hemsl. to the genus Licania, it should be stated that this had already been made by Dr. Fritsch in 1889 and therefore the new combination should read *Licania platypus* (Hemsl.) Fritsch. This is a tree that bears heavy crops of a fruit of excellent quality and it may, on that account, become of some economic importance. The same applies also to *Mammea americana* and several other Guttiferae; some of which are new and belong to the genus Rheedia. Of the Sapotaceae several new species are described, and the descriptions and synonymy of old ones revised and somewhat modified. H. P.

REFERENCES

METEOROLOGY.—Recent publications by the U. S. Weather Bureau: *Monthly Weather Review*, **39**: No. 12, pp. 1791–1949, charts 8, 1911; **40**: No. 1, pp. 1–161, charts 8, 1912; **40**: No. 2, pp. 163–320, charts 8, 1912; **40**: No. 3, pp. 321–486, charts 8, 1912; **40**: No. 4, pp. 487–658, charts 8, 1912; **40**: No. 5, pp. 659–813, charts 8, 1912.

The relation between the precipitation over the watershed of the Ohio River above and the stream-flow at Cincinnati. J. Warren Smith. **40**: pp. 40, charts 4, 1912.

Forecasting frost in the North Pacific States. Edward A. Beales. **41**: pp. 49, charts 6, 1912.

Summaries of climatological data by sections. Bulletin W: vol. i. *Sections west of the Mississippi River*, vol. ii. *Sections east of the Mississippi River.* The numerous charts and 600 pages, about, of each volume give, chiefly in tabular form, a vast amount of climatological data.

HYDROLOGY.—*Gazetteer of surface waters of California:* Part 1. Sacramento River Basin. Prepared under the direction of John C. Hoyt, by B. D. Wood. Water-Supply Paper U. S. Geological Survey No. 295. Pp. 99. 1912.

Surface water supply of the United States, 1910: Part II. *South Atlantic Coast and Eastern Gulf of Mexico.* H. R. Mall and J. G. Mathers. Water-Supply Paper U. S. Geological Survey No. 282. Pp. 109, views and sections. 1912. Part V. *Hudson Bay and Upper Mississippi River.* Robert Follansbee, A. H. Horton, and G. C. Stevens. Water-Supply Paper U. S. Geological Survey No. 285. Pp. 318, views and sections. 1912. Part VI. *Missouri River Basin.* W. A. Lamb, W. B. Freeman, Raymond Richards, and R. C. Rice. Water-Supply Paper U. S. Geological Survey No. 286. Pp. 308, views and sections. 1911. Part VII. *Lower Mississippi Basin.* W. B. Freeman and J. G. Mathers. Water-Supply Paper U. S. Geological Survey No. 287. Pp. 91, views and sections. 1911.

Water Resources of the Penobscot River Basin, Maine. H. K. Barrows and C. C. Babb. Prepared in cooperation with the Maine State Survey Commission. Water-Supply Paper U. S. Geological Survey No. 279. Pp. 285, maps, diagrams, and sections. 1912.

Gaging stations maintained by the United States Geological Survey, 1888–1910, and Survey publications relating to water resources. B. D. Wood. Water-Supply Paper U. S. Geological Survey No. 280. Pp. 102. 1912.

ENGINEERING.—*Results of triangulation and primary traverse for the years 1909 and 1910.* R. B. Marshall. Bulletin U. S. Geological Survey No. 496. Pp. 392, with map. 1912.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY OF WASHINGTON

The 257th meeting was held in the Cosmos Club April 24, 1912, Vice-President White in the chair. The following informal communications were presented:

Relation of the Sewanee conglomerate to the Bon Air sandstone: CHARLES BUTTS.

A zircon rock from Virginia: F. L. HESS.

Koenigsberger on geothermic gradients and petroleum: E. W. SHAW. Mr. Shaw reviewed a paper by Professor Koenigsberger which treats of the technique of measuring underground temperatures, of the temperature gradients in numerous borings, mines and tunnels for which data are given, and of the conclusions that may be drawn therefrom. In the computation of the gradients in mines and tunnels the observed temperatures are corrected for the effect of forced ventilation, water evaporation and movement, the shape of the surface and other factors which must be considered in working out the isogeotherms. Professor Koenigsberger also takes into account the difference in heat conductivity of different rocks, or of the same rocks in different directions with reference to the cleavage, and the effect of water in the rocks of nearby large bodies of water on the surface. He considers the age of the strata, their attitude, their degree of metamorphism, the presence or absence of evidence of vulcanism, the heat generated by the oxidation of iron sulfide and hydrocarbons, the hydration of anhydrite and other minerals, the depolymerization of bituminous substances, especially coal and oil, and, finally, radioactivity. After evaluating all these factors, he arrives at the conclusion that whereas the average rate of increase in temperature within the earth is about 1°C. for 30 m., in coal regions there is a higher gradient, in oil and gas fields still higher, and that this fact can be used in prospecting.

Professor Koenigsberger's observations seem to have been made with care and precaution, but there appear to be weak points. (1) The data from mines and tunnels are subject to so much correction for circulating air and water, and the arrangement of mountains and valleys at the surface, etc., that one hesitates to put much weight on them, especially as slight error would make a great difference in the conclusion. (2) Of the fifty or sixty measurements in excavations of all kinds, only a few were made by the author himself and none was made with instruments more accurate than the best maximum mercury thermometer, which is

only accurate to about 1°. (3) The given temperature gradients in oil fields are not uniformly high, but are of all degrees of steepness, and it is only true that of the gradients given the *average* for oil wells is higher than that for water wells. Perhaps if the gradients for fifty other wells were considered the opposite conclusion might be drawn. (4) The temperature of wells in the Appalachian and interior oil fields certainly does not increase nearly so rapidly as would be necessary according to Professor Koenigsberger for the existence of considerable pools of oil and gas. Measurements taken in western Pennsylvania indicate a rise of only about 1° for 75 to 100 feet. It is possible that chemical changes in oil and coal, especially those which lead to more stable compounds, may generate heat, but whether enough heat could be generated to warm up the outer mile or two of the earth perceptibly is perhaps open to question. Altho it may be to some degree true one feels a hesitancy about accepting without further confirmation the conclusion that the presence or absence of oil and other valuable minerals can be foretold by the temperature gradients within the earth.

REGULAR PROGRAM

Glacial deposits in Roxbury conglomerate: LAURENCE LA FORGE.
Soil movements in Alaska: B. L. JOHNSON.
Origin of freshwater lime deposits: CHARLES A. DAVIS.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. II, OCTOBER 4, 1912 No. 16

MATHEMATICS.—*Account of researches in the algebra of physics.*[1] III. A. Macfarlane.

Differentiation in the quaternion analysis. Read before the Royal Irish Academy, June 25, 1900. Proc. (3) VI: no. 2. The object of the paper was stated as follows: There are two places in the *Elements of Quaternions* where further investigation seems desirable. The quaternion analysis is intended to be applicable to space of three dimensions, but at these two places Hamilton restricts the analysis to the plane. The first place is in the treatment of logarithms. He says in Art. 316:

> In the present theory of diplanar quaternions we cannot expect to find that the sum of the logarithms of any two proposed factors shall be generally equal to the logarithm of the product; but for the simpler and earlier case of complanar quaternions that algebraic property may be considered to exist with due modification for multiplicity of value.

The other place is in the treatment of differentiation. He says in Art. 333.

> The functions of quaternions, which have been lately differentiated, may be said to be of algebraic form; the following are a few examples of differentials of what may be called, by contrast, transcendental functions of quaternions; the condition of complanarity being, however, here supposed to be satisfied, in order that the expressions may not become too complex.

I then proceeded to show that the source of the difficulty in both cases was one and the same, namely, the erroneous use of

[1] Read before the Philosophical Society of Washington, April 20, 1912. See this Journal 2: 331–337 and 363–372. 1912.

conjugate powers instead of the complete powers. For example, in the case of the square, the use of

$$A^2 + AB + BA + B^2$$

which gives merely the square of the resultant, instead of

$$A^2 + 2AB + B^2$$

which is the complete square of the complex $A + B$.

Hyperbolic quaternions. Read before the Royal Society of Edinburgh, July 16, 1900. Proc. **23**: pp. 169–180. In this paper the hyperbolic analogue to the spherical quaternion was further considered, the surface corresponding to the sphere being the equilateral hyperboloid comprising all three sheets. Lord Kelvin was in the chair; from his well known antipathy to the spherical quaternion it required some courage to attempt the elucidation of the hyperbolic one, even with the aid of models made of wire.

Application of space-analysis to curvilinear coördinates. Deuxième congrès international des mathématiciens, pp. 305–311. Paris, 1900. An expression is given for ∇ in the case of equilateral-hyperboloid coördinates. Let R denote a vector to the positive double sheet of such a surface; then $R = r\rho_1$, where r denotes the hyperbolic modulus and ρ_1 the hyperbolic unit.

Now $\rho_1 = \cosh\theta\cdot h + i\sinh\theta\,(\cos\varphi\cdot j + \sin\varphi\cdot k)$;

$$\rho_2 = \frac{\partial\rho_1}{\partial\theta} = \sinh\theta\cdot h + i\cosh\theta\,(\cos\varphi\cdot j + \sin\varphi\cdot k);$$

and $\rho_3 = -\sin\varphi\cdot j + \cos\varphi\cdot k$;

hence $\nabla = \dfrac{\partial}{\partial r}/\rho + \dfrac{\partial}{\partial\theta}/r\rho_2 + \dfrac{\partial}{\partial\varphi}/ri\sinh\theta\cdot\rho_3.$

On the square of Hamilton's delta. Atti del IV congresso internazionale dei matematici, **3**: pp. 153–157. Roma, 1908. The common way of forming the square of the sum of three successive vectors gives merely the scalar part of the complete square. Does, it was asked, a similar distinction hold in forming the square of Hamilton's operator ∇, which is well-known to be a kind of symbolic vector? In the case of rectangular coördinates

$$\nabla = \frac{\partial}{\partial x}/h + \frac{\partial}{\partial y}/j + \frac{\partial}{\partial z}/k;$$

and ∇^2 is said to be

$$\frac{\partial^2}{\partial x^2}/h^2 + \frac{\partial^2}{\partial y^2}/j + \frac{\partial^2}{\partial z^2}/k^2,$$

from which is derived by reduction

$$\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}.$$

But in the multiplication the vector part has been cancelled out due to an artificial order of the factors, whereas the real order is a cyclical order of the terms. When the parts cancelled are restored, the square has the additional term

$$2\left\{\frac{\partial^2}{\partial x \partial y}/hj + \frac{\partial^2}{\partial y \partial z}/jk + \frac{\partial^2}{\partial z \partial x}/kh\right\}.$$

It was shown also in the case of polar coördinates, that the restoration of the cancelled terms gave the complete square.

Unification and development of the principles of the algebra of space. Bulletin of the Quaternion Association. October, 1910, pp. 41–92. As regards unification the following position is held:

We have before us three forms of space-analysis: the *scalar*, founded by Descartes, which makes use of axes, but provides no explicit notation for directed quantities whether line or angle; the *quaternionic*, founded by Hamilton, which is characterized by a notation for versors or angles in space; the *vectorial*, founded by Grassmann, which is built on vector-units and compound units derived from them. For the past half century the masters of these several forms have been engaged in a triangular fight: much has been written on vectors *versus* quaternions; and we have heard of a thirty years' war between one who could bend the bow of Hamilton and one equally skilled in the more ancient weapon of Descartes. It will surely be admitted that each branch contains part of the truth; it is therefore highly probable that no one of them contains the whole truth, and that each has a part of the truth which the others have not. It has for long seemed to me that what is wanted is an analysis which will harmonize all three, and present itself as the space-generalization of algebra. As to this conception of the oneness of the algebra of space, I may quote Sylvester's declaration that he would as soon acknowledge a plurality of gods as a plurality of algebras. Likewise, Gibbs at the close of his address to the Mathematics Section of the American Association, said we begin with multiple algebras and end with multiple algebra.

Quaternions and vector-analysis are reconciled and unified by the complementary principles

$$(i\alpha)\ (i\beta) = -\cos\alpha\beta - \sin\ \alpha\ \beta\ .\ i\ [\alpha\beta]$$

and

$$\alpha\beta = \cos\alpha\beta + \sin\alpha\beta\ .\ i\ [\alpha\beta].$$

Both are unified with algebra and the Cartesian analysis by the development which is given of the line complex of vectors, and the cyclic complex of vectors.

Line complex of vectors. Let A, B, C, D be a number of line-vectors of which B is applied at the end of A, C at the end of B, D at the end of C (fig. 8). Let this complex be denoted by $\mathfrak{R}$ and the common resultant by R. As the complex is a broken line with its parts in a definite order, but the resultant merely a straight line from the initial point to the final point, the powers of the complex are very different from those of the resultant. Nothing but confusion results from not distinguishing between the complex and the resultant. We have seen this already in expanding a complex logarithm.

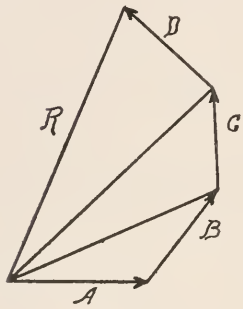


Fig. 8.

Let $\mathfrak{R} = A + B + C + D$. The square of $\mathfrak{R}$ is the algebraic square of the quadrinomial, with the proviso that the natural order of the vectors be preserved in each term; that is A prior to B, B prior to C, C prior to D. Hence

$$\begin{aligned}\mathfrak{R}^2 = A^2 + B^2 + C^2 + D^2 \\ + 2\ \{AB + AC + AD \\ + BC + BD \\ + CD\}\end{aligned}$$

and the same is true for any number of terms. Let the sum of the scalar terms be denoted by Cos $\mathfrak{R}^2$; then

$$\begin{aligned}\text{Cos}\ \mathfrak{R}^2 = A^2 + B^2 + C^2 + D^2 \\ + 2\text{Cos}\ \{AB + AC + AD\} \\ + 2\ \text{Cos}\ \{BC + BD\} \\ + 2\ \text{Cos}\ CD\end{aligned}$$

which gives the square of the resultant.

But there is a complementary part which may be denoted by Sin $\mathfrak{K}^2$; and it is

$$\begin{aligned} &2 \operatorname{Sin} \{AB + AC + AD\} \\ &\qquad + 2 \operatorname{Sin} \{BC + BD\} \\ &\qquad\qquad + 2 \operatorname{Sin} CD \end{aligned}$$

This vector part by reading the columns is seen to be 4 times the directed area of the triangles AB, $(A+B)\ C$, $(A+B+C)\ D$; and the resultant is 4 times the maximum projection of these areas.

The third power of the complex is formed after the same algebraic principle, giving, for a trinomial,

$$\begin{aligned} \mathfrak{K}^3 = A^3 + B^3 + C^3 + 3\{A^2B + A^2C + B^2C\} \\ + 3\{AB^2 + AC^2 + BC^2\} \quad + 6ABC. \end{aligned}$$

The conjugate third power is much more complex, viz:

$$\begin{aligned} \mathfrak{K}\mathfrak{K}\mathfrak{K} = A^3 + B^3 \quad + C^3 \\ + A^2B \ + A^2C \ + B^2C + AB^2 + AC^2 + BC^2 \\ + BA^2 \ + CA^2 \ + CB^2 + B^2A + C^2A + C^2B \\ + ABA + ACA + BCB + BAB + CAC + CBC \\ + ABC + ACB + BCA + BAC + CAB + CBA \end{aligned}$$

The last six terms form a determinant in vectors.

Cyclic complex of vectors. In a cyclic complex the vectors have a common point of application, and the order is determined by the order in which the free extremities occur in a cycle. Let R denote such a complex; for example $R = A + B + C$ (fig. 9). The square is formed from the algebraic square by inserting cyclic order: thus

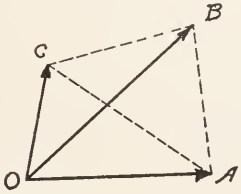


Fig. 9.

$$\begin{aligned} R^2 = A^2 + B^2 + C^2 \\ + 2\ AB + 2BC + 2\ CA. \end{aligned}$$

This differs from the corresponding line complex in having CA instead of AC. Hence

$$\begin{aligned} \operatorname{Cos} R^2 = A^2 + B^2 + C^2 \\ + 2 \operatorname{Cos} AB + 2 \operatorname{Cos} BC + 2 \operatorname{Cos} CA. \end{aligned}$$

So far as unit is concerned, these terms break up into the three pairs

$$A^2 + 2 \operatorname{Cos} AB, \qquad B^2 + 2 \operatorname{Cos} BC, \qquad C^2 + 2 \operatorname{Cos} CA.$$

Again $\text{Sin } R^2 = 2 \text{ Sin } AB + 2 \text{ Sin } BC + 2 \text{ Sin } CA$ that is, four times the directed areas of the three faces; the resultant of which is equal and opposite to the directed area of the fourth face ABC.

The Cartesian coördinates involve a cyclic complex. For example $R = xh + yj + zk$; the square of which is

$$R^2 = x^2h^2 + y^2j^2 + z^2k^2 + 2\,xy\,.\,hj + 2\,yz\,.\,jk + 2\,zx\,.\,kh.$$

Application to dyadic Φ. A dyadic is a sum of dyad quotients $L/A + M/B + N/C$, of which the antecedents A, B, C, are cyclic, as also the consequents L, M, N. Hence the dyadic is a cyclic complex of dyads, and may be treated as a cyclic complex. For example, the direct square of Φ (not the one commonly treated which is formed after the conjugate multiplication) is

$$\Phi^2 = L^2/A^2 + M^2/B^2 + N^2/C^2 + 2\,LM/AB + 2MN/BC + 2NL/CA.$$

Hence $\text{Cos } \Phi^2 = L^2/A^2 + M^2/B^2 + N^2/C^2$
$+ 2\text{Cos } LM/\text{Cos } AB + 2 \text{ Cos } MN/\text{Cos } BC + 2 \text{ Cos } NL/\text{Cos } CA$

And $\frac{1}{2} \text{ Sin } \Phi^2 = \text{Sin } LM/\text{Sin } AB + \text{Sin } MN/\text{Sin } BC + \text{Sin } NL/\text{Sin } CA$, and this last is the invariant commonly designated by Φ_2.

Application to delta. Suppose f to be a function of r, θ, φ. Then ∇f may be defined as the cyclic complex formed of the quotients of simultaneous differentials, namely

$$\begin{aligned}\nabla f &= \partial_r f / \partial_r R + \partial_\theta f / \partial_\theta R + \partial_\varphi f / \partial_\varphi R;\\ &= \partial_r f / \partial r\rho + \partial_\theta f / r\frac{\partial\rho}{\partial\theta}\partial\theta + \partial_\varphi f / r\frac{\partial\rho}{\partial\varphi}\partial\varphi\\ &= \frac{\partial f}{\partial r} / \rho + \frac{\partial f}{\partial\theta} / r\frac{\partial\rho}{\partial\theta} + \frac{\partial f}{\partial\varphi} / r\frac{\partial\rho}{\partial\varphi}.\end{aligned}$$

Hence this expression is simply a dyadic in differentials.

The complete square of ∇. According to the result obtained in the previous paper

$$\nabla^2 = \frac{\partial^2}{\partial x^2} / h^2 + \frac{\partial^2}{\partial y^2} / j^2 + \frac{\partial^2}{\partial z^2} / k^2$$

$$+ 2\frac{\partial^2}{\partial x \partial y} / hj + 2\frac{\partial^2}{\partial y \partial z} / jk + 2\frac{\partial^2}{\partial z \partial x} / kh.$$

But this supposes that h j k are constant. When they are variable we have the additional terms

$$\frac{\partial}{\partial x} / h^2 \times \left\{ \frac{\partial h}{\partial x}\frac{1}{h} + \frac{\partial h}{\partial y}\frac{1}{j} + \frac{\partial h}{\partial z}\frac{1}{k} \right\}$$
$$+ \frac{\partial}{\partial y} / j^2 \times \left\{ \frac{\partial j}{\partial x}\frac{1}{h} + \frac{\partial j}{\partial y}\frac{1}{j} + \frac{\partial j}{\partial z}\frac{1}{k} \right\}$$
$$+ \frac{\partial}{\partial z} / k^2 \times \left\{ \frac{\partial k}{\partial x}\frac{1}{h} + \frac{\partial k}{\partial y}\frac{1}{j} + \frac{\partial k}{\partial z}\frac{1}{k} \right\}$$

This formula still applies when the antecedent units have a modulus attached, as in the case of spherical coördinates.

Axial units. The principle that a parallelogram is equal to the scalar product plus the orthogonal product when applied to two line units α and β may be written

$$\alpha\beta = \cos\ \alpha\beta\ .\ \alpha^2 + \sin\ \alpha\beta\ .\ \alpha\ [\alpha\beta]^{\pi/2}\alpha$$

By dropping the alphas in the latter term, and supposing the dimensions placed in the axis $[\alpha\beta]$ we pass to the corresponding axial unit, and write

$$\alpha\beta = \cos\alpha\beta\ .\ \alpha^2 + \sin\alpha\beta\ .\ [\alpha\beta]^{\pi/2}$$

The index $\pi/2$ remains, or, what means the same thing, an i is attached to $[\alpha\beta]$ as $i\ [\alpha\beta]$. Consider next the unit $\alpha\beta\gamma$. We have

$$\begin{aligned}\alpha\beta\gamma &= \{\cos\ \alpha\beta\ .\ \alpha^2 + \sin\ \alpha\beta\ .\ i\ [\alpha\beta]\}\ \gamma \\ &= \cos\ \alpha\beta\ .\ \alpha^2\gamma + i \sin\alpha\beta \cos[\alpha\beta]\gamma\ .\ [\alpha\beta]^{3/2} \\ &\qquad - \sin\alpha\beta \sin[\alpha\beta]\gamma\ .\ [[\alpha\beta]\gamma].\end{aligned}$$

The second term has a scalar unit, but it is different in kind from α^2; because $[\alpha\beta]$ has two dimensions and the projection of γ along it only one. Hence the unit is $[\alpha\beta]^{3/2}$. It also involves an i. The third term reduces to

$$-\cos\ \gamma\alpha\ .\ \gamma^2\beta + \cos\ \beta\gamma\ .\ \beta^2\alpha;\ \text{hence}$$
$$\begin{aligned}\alpha\beta\gamma &= \cos\ \alpha\beta\ .\ \alpha^2\gamma - \cos\ \gamma\alpha\ .\ \gamma^2\beta + \cos\ \beta\gamma\ .\ \beta^2\alpha \\ &\qquad + \sin\alpha\beta \cos[\alpha\beta]\gamma\ .\ i\ [\alpha\beta]^{3/2}\end{aligned}$$

an equation which satisfies the principle of dimensions.

METEOROLOGY.—*The dense haze of June 10–11, 1912.* H. H. KIMBALL. To appear in full in the Bulletin of the Mount Weather Observatory.

General meteorological conditions. From June 8 to 12, 1912, the atmospheric conditions at Mount Weather were dominated by an area of high pressure that slowly advanced during the five days from the upper Mississippi valley to the South Atlantic Coast, and was nearly central over Mount Weather on the 10th and 11th.

Temperature and humidity conditions. Kite observations show that a decided fall in temperature occurred on the 7th and 8th, which extended to a height of at least 3 kilometers above sea level; and that the low temperature of the 8th was accompanied by a low water vapor content of the atmosphere. On the 9th the temperature of the air up to a height of at least 3 kilometers was rising. There was not sufficient surface wind for kite flights on the 10th and 11th, but the flight on the 12th showed considerably higher temperatures than on the 9th to a height of at least 4 kilometers, and also a considerable increase in the absolute humidity of the atmosphere.

Haze and clouds. On the 8th and 9th the atmosphere was unusually clear for June, but cumulus clouds formed before oon non both days. There were practically no clouds from the morning of the 10th to noon of the 11th, and the lower atmosphere was still clear, so that mountains 30 miles distant were distinctly visible; but the upper atmosphere was filled with a dense white haze. A cirrus cloud sheet covered the sky during the afternoon of the 11th. On the morning of the 12th the haze in the upper atmosphere had become light, but in the lower atmosphere it was dense, so that mountains 16 miles distant were completely obscured. Clouds covered the sky before noon.

Pyrheliometer observations. From pyrheliometric measurements of the intensity of solar radiation it appears that the atmospheric transmission coefficient, a, decreased in value from 0.756 shortly before noon of the 9th to 0.586 at the same hour on the 10th. Its value increased to 0.751 at 5.10 p.m. on the 10th, but was

very low during the morning of the 11th, and markedly higher again on the morning of the 12th.

On the 8th and 9th, shortly before noon, the radiation received diffusely from the whole sky was about 10 per cent of the vertical component of direct solar radiation, while on the 10th at about the same hour it was 30 per cent of this component.

Sky polarization observations. Measurements with a Pickering polarimeter of the polarization of sky light at the point of maximum show that the polarization decreased from 67 per cent at 9 a.m. of the 9th to 14 per cent just before noon of the 10th. It increased to 42 per cent at 5.10 p.m., and to 64 per cent at sunset, on the 10th, but was low during the morning of the 11th, and again higher on the morning of the 12th.

Measurements of the anti-solar and the solar distances of the neutral points of Arago and Babinet, respectively, showed a slight increase in the anti-solar distance of Arago's point of the 10th as compared with the 8th, while the increase in the solar distance of Babinet's point was more than two degrees.

Conclusions. The decrease in the percentage of polarization of skylight, and in the value of the atmospheric transmission coefficient, a, between June 9 and 10, and also the increase in the solar distance of Babinet's neutral point between June 8 and 10, are attributed to the increased haziness of the atmosphere on the latter date.

While increased haziness at the center or in the rear of an area of high pressure is a common occurence at Mount Weather, the haze of June 10 and 11 was of unusual density. The winds thruout the five-day period, June 8 to 12, were generally from some point between north and west, and were light on the 10th and 11th. We must therefore attribute the increased haziness of these two days to processes taking place in the atmosphere, rather than to changes in the constituents of the atmosphere due to air currents from a direction differing from that which had prevailed.

The most active process during this period appears to have been convection, which must have carried considerable quantities of dust and moisture from the surface to at least the top of the cumulus cloud layer, or to about 3 kilometers above sea level.

On account of the light winds that prevailed, both dust and moisture accumulated in the atmosphere on the 10th and 11th, but were swept away by the higher winds of the 12th.

In addition, innumerable little whirls would be established in a body of stagnant air that was being heated rapidly and unequally from point to point on account of variations in the character of the surface below. At the boundary surfaces of these whirls heat and light waves would be both reflected and refracted, whereby adding to the haziness attributable directly to dust or moisture particles. These whirls would be most numerous at the time of the most rapid rise in temperature, or from shortly after sunrise to shortly before noon, and would cease before sunset. The air would also be relatively drier in the afternoon than in the morning, on account of its increased temperature, and in consequence the dust particles would have less hazing effect.

It appears, therefore, that the dense haze of June 10 to 11, 1912, may be attributed to the effects of convection in quiescent air prevailing at the center of a nearly stationary center of high pressure, and that the unusual diurnal variation in atmospheric transparency on the 10th was the result of diurnal temperature changes.

A rapid diminition in the solar distance of Babinet's neutral point occurred on both the 8th and 10th when the sun was about 3 degrees below the horizon, being especially well marked on the 10th. It therefore seems probable that the upper limit of the haze on the 10th was at about the height of the top of the cumulus cloud layers of the two preceding days, or approximately at 3 kilometers above sea level. This conclusion is in accord with the results of recent studies by Suring and Humphreys.[1]

PHYSICS.—*A new reflection ocular.* P. G. NUTTING, Bureau of Standards.

The reflecting ocular here described was devised as a substitute for the well known Gauss ocular to give increased illumination

[1] Humphreys, W. J., Dust layers in the atmosphere and changes in the neutral points of sky polarization. Bull. Mt. Weather Observ., **4**: 397.

and sensibility. The same device serves as a most excellent photometric ocular.

In the ordinary Gauss ocular, an unsilvered glass plate, set at an angle of 45° with the axis, throws light from the side forward along the axis. The cross hairs are illuminated by this beam passing forward while the field is illuminated by light reflected back from the objective. The reflected image of the cross hairs is a shadow on a bright ground, brightly or faintly illuminated according to the aperture of the reflected beam. The setting is a superposition of the hairs on their shadows, both on a moderately illuminated field, conditions unfavorable to high precision particularly if the reflected beam be narrow. The reflected image is further very difficult to pick up under unfavorable conditions.

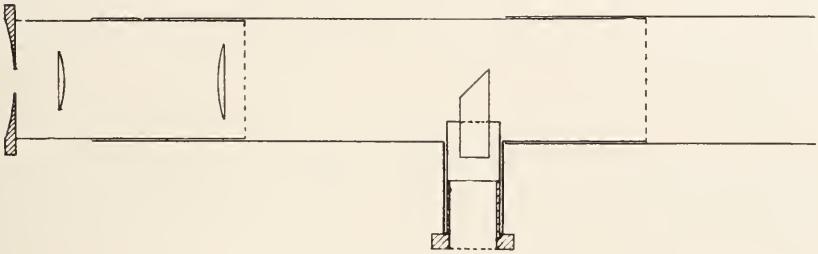


Fig. 1. New reflecting ocular

In the improved form of ocular, figure 1, a thin elongated reflecting prism is introduced in front of the ocular as shown in the diagram. This reflecting prism is of microscope cover glass 0.15 to 0.20 mm. thick, about 5 mm. wide, and 15 mm. long. Such prisms are easily prepared 50 at a time by grinding a pile of cover glasses clamped together. The sleeve into which the ocular slides is provided with a short side tube. Into this fits a metal plug with a knurled head, half the plug being cut away. To the remaining half the reflecting prism is attached with soft wax.

This ocular gives a brilliant reflected image easily seen in any part of the field of view. Owing to the smallness of the entering beam the field illumination is low. The setting is a superposition of the black rear face of the prism on its bright reflected image.

This setting can be made with a precision fully equal to that of the Gauss ocular under the most favorable conditions. When the plane surface to be set upon is but a few square millimeters and the Gauss ocular cannot be used at all, the new form gives excellent results.

The new ocular is used for photometry by simply rotating the reflecting prism 180° so that it faces toward the eye instead of the objective. Uniform illumination is secured by placing a fragment of opal glass over the outer end where the light enters. This arrangement has been used considerably at the Bureau of Standards in the measurement of diffuse reflection and transmission but it has not yet been tried on extra focal star images.

This thin form of reflecting prism has been used with great success in microscopes for illuminating the object viewed. It has the advantage over other forms of illumination of interfering but slightly with the visual beam and resolving power of the instrument.

The form of ocular described above was devised and used by the author at the Bureau of Standards about two years ago. It has proven so serviceable that it was thought advisable to publish a description of it.

GEOLOGY.—*Fall of volcanic ash on Seward Peninsula, Alaska, in 1907.* PHILIP S. SMITH.

The renewed interest in volcanic phenomena caused by the recent eruptions in southwestern Alaska warrants a statement concerning a fall of volcanic ash in Seward Peninsula in 1907, that has hitherto been unrecorded in scientific journals.

The ash is reported to have begun falling at Nome in the evening of November 24 and to have continued until the morning of November 28. The ash was reported from all parts of Seward Peninsula and even from places as far east as the Yukon. Samples were collected and have been preserved by the Geological Survey from the following localities: Nome, Solomon, Teller, Alder Creek in the Bluestone Basin, Lost River, York, Kingegan, Cheenik, Candle, Nulato, and Unalakleet. All of the material is dark

brown and very fine-grained. The largest grains in a specimen examined by Dr. Albert Johannsen are reported to have been from 0.02 mm. to 0.06 mm. in diameter. The material consists chiefly of fine volcanic glass but there are also a few grains that show polarization colors, tho they are too small for mineralogical identification. Dr. Johannsen reported that there is no magnetite in the ash collected near Nome but certain of the specimens from the western part of the peninsula, notably those from York and Lost River, show a little of this mineral.

The amount of ash that fell is variously estimated by different observers but many of the stories are evidently exaggerated and there seems to be no marked difference in quantity in the different parts of the region. The most trustworthy estimate was furnished by Arthur Gibson of Nome, who is the local observer for the Weather Bureau. He weighed the ash that collected in the official rain gage and found that 11 grains fell per square foot of surface. If this is correct, it follows that nearly 22 tons of ash fell on each square mile in the vicinity of Nome.

Nothing definite is known of the location of the volcano from which the ash came. Natives at Candle are said to have reported "Big mountain peluk (gone), smoke!" and to have signified a location to the north of Kotzebue. There are no recent volcanoes known in that region and considerable doubt is felt of the accuracy of this story. The records of the Weather Bureau at Nome show that the winds were prevailingly from the west and north during the shower. This suggests a Siberian or northwestern Alaskan location for the volcanic outburst, possibly in so sparsely inhabited a region that the eruption was not observed. The well-known difference in direction of upper and lower air currents, however, makes the wind direction an unsatisfactory criterion, especially as eruptions are known to have been in progress in the Bogoslof Islands to the south at least as late as October, 1907.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*The gabbros and associated rocks at Preston, Connecticut.* G. F. Loughlin. Bulletin U. S. Geological Survey No. 492. 1912. Pp. 158, with maps and sections.

The Preston region, a quadrangular area of about 102 square miles, lies in the southeastern part of Connecticut, a few miles north of Stonington on Long Island Sound. The pre-glacial formations comprise metamorphic sedimentary rocks, gabbro and granite intrusions, and an immense mass of quartz. The metamorphic sedimentary rocks, assigned provisionally to the Cambrian and Carboniferous, include quartzite, quartz-biotite schist, hornblende schist, black pseudoporphyritic schist (kinzigite), and dolomite, all, so far as local evidence shows, conformable. The gabbro, comprising two principal and several minor varieties, forms a main mass of oval outline, a few outliers, and some intrusive sheets. The granite, comprising three varieties, is represented by numerous intrusive sheets.

In the schists derived from sedimentary rocks the schistosity, so far as observed, is coincident with original bedding. Major folds are not clearly marked, but overturned synclines are indicated in the eastern and western parts of the area. During folding the central gabbro mass acted, with respect to the schists, like a large resistant pebble in the relatively plastic matrix of a mashed conglomerate. The secondary strains induced by its deformation in conjunction with the primary folding of the region, tended to develop abnormal crumpling locally and were sufficient to determine the paths of the granite intrusions. The intrusion of this granite completed the local deformation.

Both the main mass and the outliers of the Preston gabbro appear to be sills. Consideration of the effects of regional metamorphism indi-

cates that the gabbro had been intruded and had cooled at the period of compression. The varieties of gabbro are probably due to magmatic segregation.

The chief varities of Sterling granite gneiss are normal granite occurring as a batholith, porphyritic and alaskite phases intruded as sills, and pegmatite dikes. The intrusion of the main masses was accompanied by a thoro granitic injection of the neighboring biotitic schist accompanied by some pneumatolysis.

The quartzite includes minor variations containing lime-magnesia silicates and labradorite. The quartz-biotite schist, with its hornblendic, calcareous, and feldspathic variations, is regarded as an altered arkosic sandstone. The hornblende schist, chemically similar to gabbro, is believed to be a metamorphosed basaltic tuff. The black pseudoporphyritic schist has the mineral composition of kinzigite, but differs from the type in its pseudophenocrysts of albite-oligoclase and garnet, and is interpreted as the metamorphic form of a previously altered basaltic tuff.

In the porphyritic gabbro the order of crystallization was (1) feldspar, (2) diallage accompanied or closely followed by ilmenite. Pyrite appears to be contemporaneous with magnetite. In the norite the order of crystallization was (1) bronzite, (2) labradorite, (3) diallage, (4) titaniferous magnetite and pyrite. The olivine gabbro crystallized similarly but with olivine in place of bronzite. The pyroxenite merely represents a segregation of the ferromagnesian portion of the gabbro magma and is cut by complementary dikes of plagioclase pegmatite. The gabbro outliers and amphibolite sheets are gradational between porphyritic and quartz-hornblende gabbro.

The conclusion is reached that the two principal varieties of the gabbro are due to an incomplete differentiation prior to crystallization but that the minor phases are due to local segregation.

The Sterling granite gneiss is fairly typical of gneissoid biotite granite in general. Study of the granulation of their feldspar and quartz indicates that the normal and porphyritic granites were intruded and crystallized during the height of the compression period, the alaskite during the closing stages, and the pegmatite in the alaskite after compression and movement had practically ceased. The time of intrusion is supposed to be that of the Appalachian revolution.

The Lantern Hill quartz in North Stonington is believed to represent replacement of alaskite by quartz during the pneumatolytic stage of granite intrusion.

The correlation of the granites of this area with those of the Narragansett Basin is a problem for the future. Shaler, Woodworth, and Foerste regard the granite of the Narragansett Basin as older than the Carboniferous sediments while the Sterling granite gneiss of the Preston area is intrusive into them. C. E. SIEBENTHAL.

GEOLOGY.—*Pawpaw-Hancock, Md., W. Va., Pa., folio.* G. W. STOSE and C. K. SWARTZ. Geologic Atlas of the United States, No. 179. 24 folio pp., with maps, views and sections. U. S. Geological Survey, Washington, D. C. 1912.

The rocks exposed in the area range from Cambrian to Carboniferous and comprise, from the base up, Conococheague limestone, Beekmantown limestone, (Stones River and Chambersburg limestones absent at surface by reason of faulting), Martinsburg shale, Juniata formation, Tuscarora formation, Clinton shale, McKenzie formation, Wills Creek shale, Tonoloway limestone, Helderberg limestone, Oriskany sandstone, Romney shale, Jennings formation, Catskill formation, Rockwood formation, Purslane sandstone, Hedges shale, Myers shale, Pinkerton sandstone.

The beds are rather strongly folded, the axes striking northeast-southwest, the Cambrian rocks appearing only at the southeastern corner of the area, the Carboniferous in three narrow synclinal bands. The folds are not as continuous as in most parts of the Appalachian province, many of them terminating in the area by plunging or branching. Many complete arches and synclines are exposed in stream banks and in artificial cuts, and are illustrated by half-tone cuts. In the eastern part of the area the folds are overturned, broken, and extensively overthrust.

The area is crossed from west to east by the Potomac River whose channel is deeply cut in the surrounding upland and is bordered by a series of gravel-covered terraces recording stages of uplift of the land. The highest gravels found are 250 feet above the river level. The upland is an early Tertiary planation surface on which were developed the great meanders of the Potomac. The Jurassic-Cretaceous peneplain is preserved only on the tops of the highest mountains. Changes in the drainage of the area are discussed.

The only products of economic importance in the area are glass sand from the Oriskany, extensively mined in the vicinity of Berkeley Springs, W. Va., and natural cement rock, formerly quarried at Roundtop, Md.

G. W. S.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. II, OCTOBER 19, 1912 No. 17

METEOROLOGY.—*Solar radiation intensities at Madison, Wis.* H. H. Kimball and E. R. Miller. To appear in full in the Bulletin of the Mount Weather Observatory.

Since July 19, 1912, measurements of the intensity of the solar radiation received upon a surface normal to the direction of the incident solar rays have been made at the Weather Bureau office, Madison, Wis., on days when the sky was free from clouds.

A Marvin pyrheliometer, standardized by comparison with a Smithsonian silver disk pyrheliometer, has been employed in making the measurements. A brief description of this pyrheliometer will be found in the *Bulletin of the Mount Weather Observatory*, volume 3, page 81. The instrument has been exposed on shelves outside the office windows at an elevation of 974 feet above sea level. The latitude of Madison is 43° 05′ north.

The monthly means of a.m. and p.m. measurements are given in table I, each mean being the average of measurements obtained on not less than three different days.

The monthly means of a.m. and p.m. measurements made at Washington, D. C., with an Angstrom pyrheliometer, have been published in the *Bulletin of the Mount Weather Observatory*, volume 3: pages 86 to 91, inclusive. To facilitate comparison, these have been reduced to the Smithsonian standard by dividing by the factor 0.95, and the results are given in table II.

It will be seen from these tables that while the monthly averages of radiation intensities for Washington and Madison differ

but little during the warm months of the year, or from May to October, inclusive, the excess of the averages for Madison over those for Washington during the cold months is pronounced.

This excess cannot be attributed to a difference in the vapor content of the atmosphere at the two stations. The average difference in their respective water vapor pressures in winter does not exceed two millimeters, and as has been shown by one of us,[1] this would account for a difference in radiation intensities of only

TABLE I

MONTHLY MEANS OF SOLAR RADIATION INTENSITY AT MADISON, WIS., FOR THE TWO YEARS JULY, 1910, TO JUNE, 1912, INCLUSIVE, EXPRESSED IN GRAM-CALORIES PER MINUTE PER SQUARE CENTIMETER OF NORMAL SURFACE.

MONTH		AIR MASS								
		1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
January	a.m.			1.44	1.44	1.34			1.12	
	p.m.				1.42	1.33	1.24			
February	a.m.		1.56	1.49	1.42	1.39	1.26	1.18	1.08	1.15
	p.m.			1.51	1.45	1.38	1.26			
March	a.m.		1.48	1.40	1.33	1.26	1.17	1.09	1.06	
	p.m.		1.44	1.38	1.29	1.22				
April	a.m.		1.38	1.30	1.21	1.18	1.10			
	p.m.		1.40	1.31	1.19	1.11				
May	a.m.	1.36	1.21	1.08	0.97					
	p.m.		1.16							
June	a.m.	1.26	1.19	1.11						
	p.m.									
July	a.m.	1.25	1.18	1.08	0.93					
	p.m.									
August	a.m.	1.33	1.22	1.14	1.07	0.96	0.93	0.86		
	p.m.		1.12	0.99	0.82	0.72				
September	a.m.		1.23	1.10	1.03	0.96	0.89	0.86		
	p.m.		1.24	1.10	1.04	0.95	0.83	0.76	0.74	
October	a.m.		1.28	1.17	1.10	1.03	0.92	0.90	0.73	
	p.m.			1.21	1.16	1.08				
November	a.m.			1.36	1.30	1.26	1.21	1.15	1.05	
	p.m.				1.31	1.27				
December	a.m.				1.31	1.21	1.15	1.13		
	p.m.					1.25				

NOTE:—The air mass is approximately the secant of the sun's zenith distance.

[1] Jour. Franklin Inst., **171**: 339. April, 1911.

about 0.02 calories when the sun is at zenith distance 60°, and the air mass = 2.

The excess can only be attributed in part to difference in atmospheric pressure at the two stations, since their respective averages, 29 inches of the barometer at Madison and 30 inches at Washington, would account for a difference of only about 1 per cent in the atmospheric transmission coefficients for the two stations, or to a difference of about 0.05 or 0.06 calories in the radiation intensities when the air mass = 2.

TABLE II

MONTHLY MEANS OF SOLAR RADIATION INTENSITIES AT WASHINGTON, D. C., FOR THE FIVE YEARS MAY, 1905, TO APRIL, 1910, INCLUSIVE, EXPRESSED IN GRAM-CALORIES PER MINUTE PER SQUARE CENTIMETER OF NORMAL SURFACE.

MONTH		AIR MASS								
		1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
January	a.m.			1.20	1.05	1.05				
	p.m.			1.24	1.12	1.04	0.94	0.88	0.83	0.76
February	a.m.			1.29	1.16	1.10				
	p.m.		1.38	1.23	1.12	1.01	0.95	0.93	0.83	
March	a.m.		1.20							
	p.m.		1.32	1.14	1.04	1.01	0.91	0.82		
April	a.m.	1.41	1.19	1.08	1.02	1.00				
	p.m.	1.39	1.20	1.05	0.95	0.88				
May	a.m.	1.41	1.17	1.13	0.99					
	p.m.	1.26	1.16	1.01	0.87					
June	a.m.									
	p.m.	1.26	1.08	1.06	0.99	0.88				
July	a.m.	1.35	1.21	1.15	1.03	0.95				
	p.m.		1.01	0.90						
August	a.m.	1.24	1.08							
	p.m.		1.04	0.95						
September	a.m.		1.30	1.19	1.05	0.95				
	p.m.		1.19	1.05	1.01	0.95	0.85			
October	a.m.		1.26	1.15	1.06	0.93				
	p.m.		1.23	1.14	1.03	0.93	0.84	0.81	0.74	0.65
November	a.m.		1.44	1.29	1.20	1.11	0.91			
	p.m.		1.45	1.22	1.11	1.02	0.92	0.84	0.82	0.79
December	a.m.			1.21	1.15	1.07	1.01	0.97		
	p.m.			1.24	1.14	1.05	0.97	0.89	0.88	0.77

NOTE:—The air mass is approximately the secant of the sun's zenith distance.

These two causes combined therefore account for less than one-half the difference between the radiation intensities measured at Madison and Washington in winter.

There remains to be considered the relative effect of the dust content of the atmosphere at the two stations, with respect to which no data are available. These pyrheliometric measurements lead to the conclusion, however, that on clear days in winter, when the northern part of the United States is generally covered with snow, the atmosphere at Madison contains much less dust than the atmosphere of Washington, a difference that does not exist during the summer months.

ELECTRICITY.—*Constancy of wire resistance standards.* FRANK WENNER, Bureau of Standards. Communicated by E. B. Rosa.

On account of the convenience and of the high sensitivity readily attainable, electrical methods are being used more and more in various kinds of physical measurements. The numerical values obtained then are in terms of electrical units and the reliability of the results depends on the reliability of the electrical standards used.

In most of the more precise measurements of energy or heat and power as well as in primary electrical measurements with mercury resistance standards and the silver voltameter, and in absolute measurements of resistance and current the results obtained usually involve the resistance of one or more wire resistance standards. In all such and many other measurements the reliability of the results depends upon the constancy, over a longer or shorter time, of the resistance standards used.

It is therefore highly desirable that our standards should be so constructed as to have as nearly a constant resistance as it is possible to obtain, and that the small changes taking place be known as definitely as it is possible to obtain them.

At the Bureau of Standards ten 1-ohm resistance standards of the sealed type[1] in which the resistance material is manganin, were selected for use as a reference set. Whenever the resistance

[1] Rosa, Bull. Bureau Standards. 4: 413. 1908.

of one of these standards changes appreciably it is replaced by another whose resistance is known to be more constant. In March, 1909, values were assigned to the standards of the reference set, and since that time it has been assumed that their mean value has remained constant. The values assigned to all the standards belonging to the Bureau and to the standards submitted for test all involve this supposition. In May, 1910, certain standards from the national laboratories of England, Germany, France and the United States were compared, and considering all the data available the most probable value in International Ohms was assigned to the various standards. This resulted in an addition of 7 parts per million to the mean value of the reference set. Values obtained from measurements made before May, 1910, have had this correction applied so that all are on the same basis. That is, all values are based on the supposition that the mean value of the ten 1-ohm standards constituting the reference set has remained constant since March, 1909.

Values on different dates and at a temperature of 25° C. of a number of 1-ohm standards of the sealed type are given in table I. Here the identification number of the standard is given

TABLE I

1-Ohm Standards—Sealed Type

Excess of resistance above one ohm, on different dates at 25°C, and change in 2½ years in millionths of an ohm

NUMBER	MARCH, 1909	OCTOBER, 1909	MARCH, 1910	AUGUST, 1910	MARCH, 1911	JANUARY, 1912	CHANGE IN 2½ YEARS
3	53	56	59	61	63	66	+13
4		31	32	30	31	29	− 2
7	61	62	63	64	65	65	+ 4
8	69	69	69	69	69	69	0
11		63	61	54	53	53	−10
12		61	59	57	54	54	− 7
13	90	92	95		106	106	+16
19	127	144	153	158	163	165	+38
3939	97	96	98	99	99	97	0
3940	98	95	96	98	99	98	0

This table shows that during 2½ years the resistance of only one of these standards changed by more than 0.002 per cent and that the average change was less than 0.001 per cent.

in the first column and the amount in parts per million by which its resistance exceeded its nominal value is given in the succeeding columns. It will be observed that for most of the standards the values on different dates are very nearly the same. As most of these standards belong to the reference set we cannot assume that these figures give anything more than the relative constancy of a number of standards selected because of their small changes as compared with each other.

With the older or Reichsanstalt type of standards the relative changes were usually considerably more, especially in standards having resistances of 1000 ohms or above, where the changes in two or three years have sometimes amounted to 0.1 per cent or even more. When, however, the standards of the higher denomination are of the sealed type the changes are much smaller. The values of all the 10,000-ohm standards of the sealed type belonging to the Bureau of Standards are given in table II and it will be

TABLE II

10,000-Ohm Standards—Sealed Type

Excess in resistance above nominal value, on different dates at 25° C., and change in 2½ years in parts per million

NUMBER	FEBRUARY, 1909	JULY, 1909	FEBRUARY, 1910	MAY, 1910	APRIL, 1911	JANUARY, 1912	CHANGE IN 2½ YEARS
1		−142	−124	−128	−118	−124	+18
2		− 63	− 50	− 59	− 36	− 55	+ 8
3		131	136	131	134	134	+ 3
4	177	178	182	174	177	174	− 4
5	161	161	145	138	142	144	−17
6		145	154	147	152	149	+ 4
7		133	158	156	182	186	+53
3931		143	163	159	172	151	+ 8
3932		117	111	103	112	99	−18

This table shows that during 2½ years only one of the standards changed in resistance by as much as 0.005 per cent.

observed that the resistance of only one of the nine changed in comparison with the reference set by more than 20 parts per million during two and one-half years. The actual changes as compared with the reference set may be somewhat more or somewhat

less than that indicated by the table since the error in comparing a 10,000-ohm standard with a 1-ohm standard, as formerly made, may have amounted to several parts per million.

To what extent the mean value of the reference set has remained constant and may be expected to remain constant, or the mean value of any other reference set may be expected to remain constant, is a matter of prime importance. The history of a standard or set of standards giving the resistances on different dates should in most cases indicate the further changes to be expected.

The standards constituting the reference set were made at different times, by different persons using wire made under different conditions. Therefore, when we find their relative values and their mean values as compared with a large number of standards of different denominations remaining remarkably constant, it is reasonable to suppose that their mean value is also remaining very constant. This supposition, however, is not entirely justifiable since the resistance of most of the standards may conceivably be changing at an approximately uniform rate, and if so the intercomparisons made between the various standards furnish no means of detecting such a change. We are therefore desirous of knowing more about the constancy of the mean value of the reference set than can be obtained by comparing standards, in all of which the resistance material is manganin. It is therefore desirable to construct additional standards using other resistance materials. If two or three sets of standards each of a different resistance material are found to remain relatively constant, then there is much more justification for assuming the mean value of a selected set of standards as constant.

In this a beginning has been made in that a few standards in which the resistance material is the new alloy "therlo" have been under observation for more than a year.

The alloy is one of a number developed by Wilbur B. Driver and has many advantages for use as a resistance material in standards and various kinds of resistance apparatus. The indications are that standards in which it is used will be found fully as reliable as those in which manganin is used. In such standards the resistance increases for a few months following the annealing but

seems to become very constant within a year. Where manganin is used a very similar increase in resistance takes place while the standard is new. In order to make further test of the material and to determine what the heat treatment should be, coils have recently been constructed of hard-drawn wire and of wire annealed before insulating and these have been annealed at different temperatures after winding.

As a further means of determining the changes in the mean values of the standards of the reference set, certain standards have been sent abroad and measured at the national laboratories of England, Germany and France. Since May, 1910, a number of measurements have been made of the resistance of seven different standards. The 23 values assigned were usually each the mean of the values found by a number of different measurements. As compared with the values assigned to the same standards in the Bureau of Standards the mean difference, taken without regard to sign, is less than one part in one hundred thousand. This shows that the unit used in each of the laboratories continues to be very nearly the same.

Ultimately we depend for our unit of resistance on an arbitrary standard such as the mercury ohm or on an absolute measurement of some particular resistance.

Mercury resistance standards are sufficiently reproducible so that different laboratories agree to within two or three parts in a hundred thousand. Absolute measurements have not as yet been made as close as this. Wire standards are now so constant that a reference to mercury ohms need be made much less often than formerly, and international uniformity is maintained chiefly by the use of wire standards.

ABSTRACTS

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ELECTRICITY.—*A tubular electrodynamometer for heavy currents.* P. G. Agnew. Bulletin Bureau of Standards, 8: — 1912.

The field "coil" of the instrument consists of two coaxial copper tubes, thus giving a circular magnetic field in the space between the tubes. On direct current the distribution of the current is assumed to be uniform over the cross section of the tubes, but on alternating current, as is well known, the current is crowded toward the outside of the inside tube and toward the inside of the outside tube, and the amount of this change of distribution depends upon the frequency. But if we have axial symmetry the magnetic field at any point is independent of the current distribution. For there is no magnetic field between the tubes due to the outside tube, and the field at any point due to the current in the inside tube symmetrically distributed about the axis depends only on the distance of the point from the axis, and therefore the total effect is independent of the distribution of current, so long as it is symmetrical with respect to the axis.

There are two moving coils astatically placed between the tubes, one above and one below the inner tube, and suspended by a phosphor bronze strip. The common axis of the tubes is placed in a horizontal position in order to permit the use of a vertical suspension. While the distribution of the current is not the same on alternating as on direct current, the magnetic field in the space between the tubes and hence the torque is the same.

With water passing thru the inner tube, the instrument will carry continuously 5000 amperes, and without water cooling, 1200 amperes. The current-carrying capacity of the moving coils is 0.06 ampere.

Difficulties were at first encountered, due to distortion of the inside tube by differential thermal expansion, and by magnetic impurities in the moving coil, but these were finally overcome.

It is of first importance to determine whether the instrument is affected by residual distribution errors. It has been found that a purely electrical test can be used for the exact centering of the inside tube, so that any such residual errors due to imperfections of workmanship can be removed.

At commerical frequencies no error whatever could be detected, due to eddy currents being set up in the tubes by the current in the moving coils.

Measurements of large currents by means of a current transformer whose ratio had been carefully determined were in substantial agreement with the indications of the tubular dynamometer. It is believed that the instrument is accurate to 0.05 per cent. P. G. A.

ELECTRICITY.—*The testing and properties of electric condensers.* Circular Bureau of Standards, no. 36. 1912.

In the testing of condensers over a period of years, much information has been collected, only a part of which is at present available to the public. Also, a large amount of work has been done elsewhere, which has appeared in various publications. It is the purpose of this circular to collect together the important facts concerning condensers and to present them as a connected whole. The different kinds of condensers are described and their properties discussed, and the most satisfactory methods of testing indicated. H. L. Curtis.

CHEMISTRY.—*The standardization of potassium permanganate solution by sodium oxalate.* R. S. McBride. Bulletin Bureau of Standard, **8**: 612–643. 1912.

It was desired to determine the effect of the variation of the following factors upon the result obtained in the standardization of potassium permanganate by sodium oxalate, viz: temperature, acidity, volume of solution, rate of addition of the permanganate, access of air, presence of added manganous sulfate, and in connection with these, the corrections necessary upon the apparent end-points. In order to accomplish such determination the factors were varied one at a time and the effect, if any, produced upon the apparent value of the permanganate noted. Each of the factors was found to have a definite, though small, influence upon the result.

The effects were undoubtedly due to a variation of the reaction from the normal course as usually given. Such variations might tend to cause the use of an excess of either permanganate or oxalate; or both

sorts of influence might operate at the same time, in equal or unequal degree. The nine possible sources of variation are: (a) loss of oxalic acid by volatilization, (b) decomposition of oxalic acid by water, (c) decomposition of oxalic acid by sulfuric acid, (d) oxidation of oxalic acid by the air, (e) incomplete oxidation of the oxalic acid, (f) liberation of oxygen during the reaction, (g) incomplete reduction of the permanganate to the manganous state, (h) presence of impurities in the oxalate of either greater or less reducing power, and (i) formation of other products of the oxidation than carbon dioxide and water. Of these only two appeared to be at all probable, viz: loss of oxygen and atmospheric oxidation of the oxalic acid, and furthermore, only the first of these two could be held in the light of all the experiments reported.

If the main source of error is due to an oxygen loss the higher values obtained in the various series must be taken as correct. On this basis the following method of titration is recommended: in a 400 cc. beaker dissolve 0.25 to 0.3 gram of sodium oxalate in 200 to 250 cc. of hot water (80 to 90°) and add 10 cc. of 1:1 sulfuric acid. Titrate at once with $\frac{N}{10}$ $KMnO_4$ solution, *stirring the liquid vigorously and continuously.* The permanganate must not be added more rapidly than 10 to 15 cc. per minute and the last 0.5 to 1 cc. must be added dropwise with particular care to allow each drop to be wholly decolorized before the next is added. The solution should not be below 60° by the time the end-point is reached The excess of permanganate used to cause the end-point color must be estimated by matching the color in another beaker containing the same bulk of acid and hot water.

Under the above condition the agreement of duplicates should be at least 1 part in 2000; and the variation from absolute accuracy of average values is probably not greater than 0.05 per cent. Under other conditions than those described it is possible to obtain correct results; but by using the procedure recommended the difficulties of the titration are reduced to a minimum. R. S. M.

GEOLOGY.—*The earthquakes at Yakutat Bay, Alaska, in September, 1899.* RALPH S. TARR and LAWRENCE MARTIN. Professional Paper U. S. Geological Survey No. 69. 1912. Pp. 135, with maps, views, and sections.

In September, 1899, the region around Yakutat, Alaska, was shaken by a series of severe earthquakes, attended by great changes in the level of the land and remarkable changes in the adjacent glaciers.

The changes of level are the greatest recorded in historical times, the

maximum uplift amounting to over 47 feet. The changes in the glaciers include a rapid retreat of Muir Glacier, 150 miles to the southeast, and a general advance of several glaciers near Yakutat Bay. Muir Glacier, which hundreds of travelers had visited annually up to 1899, became inaccessible to tourist vessels in that year and remained so till 1907. By 1903 it had retreated from $2\frac{1}{2}$ to 3 miles, and by 1907 from $7\frac{1}{2}$ to 8 miles, perhaps in part as an indirect result of this earthquake, and had lost much of its scenic interest. The advance of the glaciers near Yakutat Bay included the eastern or Marvine lobe of the great Malaspina Glacier and rendered that highway of glacier travel inaccessible thru intricate crevassing.

The shocks lasted twenty-seven days—September 3 to 29, 1899—and included four or five world-shaking disturbances and hundreds of minor shocks. During four weeks there was almost constant palpitation of this part of the earth's crust. The shocks were most severe on September 3, 10, and 23, and were great on the 15th, 17th, 26th, and 29th. On the 10th there were over fifty small shocks and two world-shaking disturbances. The greatest faulting took place on September 10.

The phenomena accompanying the shocks were observed at distances of 5 to 730 miles, and perhaps raised water waves on Lake Chelan, in Washington, over 1200 miles away. The minimum land area shaken was 216,300 square miles, the water area being as much more, while distant observations suggest that the shocks may have been sensible over 1,539,000 square miles. These earthquakes seem to have originated in or near Yakutat Bay, which lies close to the bend of the St. Elias Range, near latitude 140 degrees west and longitude 60 degrees north.

The physical changes brought about by the earthquakes are correlated with the growth of the St. Elias Range and evidence of older faulting, changes of level, and glacial oscillations are recognized. A. H. Brooks.

TOPOGRAPHY.—*Topology, topography and topometry.* Francois E. Matthes. Bulletin American Geographical Society, vol. xliv, May, 1912.

Topology, topography and topometry are three terms now current among French topographers, and used to denote three distinct though allied concepts. In this country no attempts have as yet been made to clearly differentiate these concepts, and the single term "topography" is still employed, more or less loosely and inaptly to designate different classes of work.

In the first place the French have learnt to appreciate the fundamental difference that exists between maps on relatively large scales, such as 1 : 20,000, 1 : 10,000, 1 : 1,000 and larger, and maps on relatively small scales, such as 1 : 50,000, 1 : 100,000, 1 : 200,000 and smaller. Upon maps of the former class, most often prepared as a basis for drainage, irrigation and other engineering works, the surface of the land is rendered feature for feature, down to the merest minutiae and the contour lines are frequently run out individually by instrumental survey. "Eye-sketching" plays but an insignificant part in the make-up of such maps, and their main asset lies in their quantitative accuracy. For this reason they are designated "topometric maps" and the art of making them is styled "topometry."

Maps of the latter kind, on the other hand, by virtue of the limitations set by their scales can give only a generalized protrayal of the land. They are not replicas of the relief in miniature—rather, they partake of the nature of abstracts or condensed statements serving to bring out essentials, at the sacrifice, purposely, of irrelevant detail. Such maps are properly termed "topographic," and the art of making them is called "topography."

That the two classes of maps grade into each other is evident, at the same time there is great value in drawing the distinction. For, while the preparing of topometric maps involves only surveying and skilled drafting, the preparing of topographic maps is a complicated and subtle art, requiring besides skill in surveying and drafting, trained judgment in the condensing of topographic facts and in their intelligent portrayal in generalized form. Topographic mapping is essentially interpretative and synthetic in its nature, and for its best results demands from the topographic delineator insight into the significance of land forms as well as schooling in the principles of topographic "abstracting." This is a fact that appears to be as yet little appreciated by the geographers, topographers and engineers of this country. In France the desirability of the topographer having an intelligent understanding of the land forms with which he deals has long been recognized, and the analytical study of those land forms (detail forms mostly) has become known by the name "topology." A two-volume work entitled *Topologie*, by General Berthaut, Chief of the Service Topographique de l'Armée, recently published, has served to formally usher in the new science. It is to be hoped that some day a similar work may appear in this country for the guidance of American topographers, and if so, that it may go one step further than Berthaut's treatise and undertake to lay down the cardinal

principles that should underlie all condensing and generalizing of topographic facts on reduced scales. Until these principles are formulated and have become a fundamental part of every topographer's equipment, the signal lack of uniformity in topographic portrayal that characterizes our maps today must continue to prevail, and the topographer's art will not be able to lay claim to that economy of high grade production which only a scientific foundation can secure. F. E. M.

ZOOLOGY.—*A review of the cephalopods of western North America.* S. Stillman Berry. Bulletin of the U. S. Bureau of Fisheries, vol. 30, 1910, p. 267–336, pls. xxxii–lvi. Issued July 24, 1912.

The purpose of this paper is not to present a monograph, nor even a complete catalogue of the species now living within the area indicated, but, as stated by its author, is rather

to bring out of chaos and present under one cover a résumé of such work as has already been done, making the necessary corrections wherever possible, and adding accounts of such novelties as have been brought to my notice.

Descriptions are given of all the species known to occur or reported within our limits, and these have been made as full and accurate as the facilities available to me would allow. I have hoped to do this in such a way that students, particularly in the Western States, will find it unnecessary to have continual access to the widely scattered and often unavailable literature on the subject. In a number of cases, however, the attitude adopted must be understood as little more than provisional in its nature, and more or less extensive revision is to be expected later, especially in the case of the large and difficult genus *Polypus*, which here attains a development scarcely to be surpassed anywhere.

In dealing with genera or higher groups I have nowhere endeavored to give complete diagnoses, but mention is made of such of their more salient characteristics as may serve for at least their temporary recognition by the student unfamiliar with cephalopods.

The material upon which the paper is based consists of some 600 specimens, contained in collections of the U. S. Fisheries Steamer *Albatross* in Alaska and off the California coast; miscellaneous series in collections at Stanford University; a small collection possessed by the department of zoology of the University of California, and a small series of octopods received from the Marine Biological Laboratory at La Jolla, California, besides the private collection of the writer. The region covered embraces the western shores of North America between Bering Strait on the north and the Coronado Islands on the south, together with the immediately adjacent waters of Bering Sea and the North Pacific

Ocean. Twenty-two species of cephalopods are represented, among them a fair number of novel forms,

the interest of which, however, is mainly zoogeographical and as a rule throwing little light upon the broader problems of morphology and interrelationship.

To the paper is appended a bibliography of 137 titles, with reprints of several of the earlier and more inaccessible papers having a direct bearing on the teuthology of the west American region and containing the original descriptions of several species. ETHEL M. SMITH.

ZOOLOGY.—*Some hydroids of Beaufort, North Carolina.* C. MCLEAN FRASER. Bulletin of the U. S. Bureau of Fisheries, vol. 30, 1910, pp. 337–388, 52 text figures. Issued July 23, 1912.

Altho Beaufort had not been expected to yield large collections of hydroids, two weeks devoted to the purpose by Dr. Fraser in August and September, 1911, with facilities of the U. S. Fisheries Laboratory at his disposal, produced material of much interest and surprising abundance for so limited a period. The sources were the piles and rocks at low water, floating gulfweed, and dredgings, chiefly in Bogue Sound and, by the U. S. Fisheries Steamer *Fish Hawk*, some 23 miles outside the harbor.

Of the 51 species obtained but one is new, though several are new to this part of the coast and four gonosome descriptions are new. Much of the material was in such good condition and contained so many good specimens, that many interesting points were made out and it was possible to add much new matter to the regular descriptions of species.

The locality is of very great interest because it is less than 100 miles from Cape Hatteras, which has been considered somewhat of a rival of Cape Cod as a divisional point for different groups of marine forms. A study of the distribution of even the few species collected is illuminating, and, altho what may be true of hydroids is not necessarily true of other forms and in some cases might seem to be necessarily untrue of them, the comparisons afforded warrant some generalizations.

In the first place, when 31 species out of a total of 51 have been reported from the east coast of North America farther north, there is no evidence, so far as hydroids are concerned, that Cape Hatteras with its storms is any decisive barrier. In the second place, what little evidence there is on this question goes to sustain the conclusion that many of the hydroids have been distributed from a circumpolar area, southward

along meridional lines. When out of 51 species collected as far southward as Beaufort there are included as many as 12 species that have been found on the west coast of Europe and also on the west coast of North America, it seems scarcely possible to come to any other conclusion. In the third place, there is further evidence of the relationship of the hydroid fauna of Beaufort and the Bermudas, 9 out of the 11 species common to both localities being forms that would likely be carried on the sargussum with the Gulf Stream. Finally, there is added evidence, if such be needed, that there is no limit to the distribution of hydroid forms, Beaufort, in low latitude, being connected by hydroid distribution with such distant places as Australia, Chile, Bering Sea, and the White Sea, all in high latitudes, and having not one but several species in common with Beaufort. ETHEL M. SMITH.

BOTANY.—*The North American species of Nymphaea.* GERRIT S. MILLER, JR. and PAUL C. STANDLEY. Contribution U. S. National Herbarium, **16**: 63–108, pls. **35–47**, figs. **2–40**. 1912.

This is a monograph of the species of Nymphaea, the yellow-flowered pond lilies, of North America. Heretofore about half a dozen forms have been recognized within this area, but the number is here increased to 19, of which 10 are described as new. The study was based principally upon a large series of fresh specimens, obtained during a period of several years, but in addition the herbarium material of all the larger collections was examined. The genus has a wide distribution in North America, occurring in all of the divisions of the United States except two, and ranging north to Alaska, and as far south as Mexico and Cuba. Most of the new species are from the region bordering the Gulf of Mexico, but one is from the Ozark plateau of Missouri and Arkansas, and one from the coastal plain of New Jersey. All the species are illustrated with half-tones or line drawings, or both. P. C. S.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

GEOLOGICAL SOCIETY OF WASHINGTON

The 258th meeting was held May 8, 1912, President Stanton in the chair. The following informal communication was presented: *The General Custer Vein in Idaho*, J. B. Umpleby.

REGULAR PROGRAM

Some phases of Philippine geology (illustrated by lantern slides): Warren D. Smith, Chief of Division of Mines, Philippine Islands. For our present knowledge of the geology of the Philippine Islands we are indebted chiefly to four men—Abella, former chief of the Spanish Mining Bureau; Becker, first American geologist to visit the islands; McCaskey, the second chief of the American Mining Bureau, and Iddings, who has worked on Philippine rocks and who visited the islands in 1910. The igneous rocks are mainly diorite, representing the plutonic type, and pyroxene andesite the extrusive type. Leucite-bearing rocks have been found in one locality, Masbate, but this is an unusual development. Metamorphic rocks are represented by schists and gneisses, which are probably metamorphosed sedimentary and igneous formations of Tertiary or Mesozoic age. Of the sedimentary rocks there are none that we know positively to be older than Eocene. Most of the sediments are Miocene and later. Coral and orbitoidal limestones are wide-spread. Some red cherts containing uncertain fragments of sponges and radiolaria, and possibly to be correlated with similar material of Jurassic age in the Moluccas have been found in northern Luzon.

Coal, oil, iron, gold and copper are the principal economic deposits of the islands. Coal of a sub-bituminous grade, in which the fixed carbon is usually less than 50 per cent, is widespread. One seam $1\frac{1}{2}$ feet thick having 82 per cent of fixed carbon has been found in Mindanao. What appear to be large deposits of bessemer iron ore exist in Luzon, and pig iron is being produced by crude processes by the natives. A long-known and fairly good deposit of copper ore (largely enargite) occurs in northern Luzon, but fuel and transportation difficulties delay development. A deposit of the native metal exists in Masbate, but this is also undeveloped. There are several stamp mills and gold dredges operating now in the islands and the industry has a bright future. Oil seepages to the number of at least half a dozen have been found on Cebu, Leyte, and Tayabas Peninsula, some of the oil being paraffin oil of light gravity. The possibility of the existence of commercial quantities has not been tested.

Problems of oil and gas accumulations in the Appalachian Region: M. J. Munn. The oil and gas fields generally included within the Appalachian region are situated in southern New York and the western parts of Pennsylvania and West Virginia, the eastern parts of Ohio and Kentucky, middle Tennessee, and northern and western Alabama.

Structurally this part of the region is a broad flat geosyncline, roughly coincident with the Appalachian Plateau. The deepest part of this great structural basin is in the western part of West Virginia about 10 miles southwest of the corner of Pennsylvania. The general dip of the rocks toward the center of this basin is broken by a series of minor, open, irregular folds most of which trend northeast-southwest. The pitch of the axis of this trough has not been determined thruout its length but from the vicinity of Pittsburg southward to the center of the basin, a distance of about 125 miles, it is approximately 2400 feet. At the center of the basin the rocks consist of probably about 5000 feet of Devonian sandstone and shale and thin beds of limestone, overlain by about 3000 feet of Carboniferous rocks of Mississippian, Pennsylvanian, and Permian series, consisting of shale, sandstone, limestone, clay, and—in the Pennsylvanian and Permian—many coal beds. The Permian rocks are exposed over several hundred square miles in the center of the basin and successively older formations outcrop in going from the axis of the fold both east and west.

The special points brought out in this paper were as follows: (1) By far the largest number of oil and gas pools and also the largest pools are grouped along the axis of this geosyncline, in areas where the rocks have dips of less than 200 feet to the mile and rarely more than 75 feet to the mile. (2) On the west side of the axis of this geosyncline oil pools predominate, though a number of large gas fields occur. East of this axis only a few small oil fields have been found; this part of the region containing many of the greatest gas fields yet discovered, in areas where the rocks have in general a somewhat greater dip than in the oil fields on the west side of the axis. (3) The oil and gas pools which occur near the outer edges of this productive region farthest from the center of the basin are found at relatively shallow depths in sandstones which show considerable quantities of salt water closely associated with the oil. When these sandstones are traced toward the center of the basin the volume of salt water appears to increase in each sandstone up to a certain distance from the outcrop and depth from the surface. Beyond this, down the dip of the beds, and therefore at greater depths from the surface, the amount of salt water decreases, until, at the center of the basin many of the sandstones that furnish salt water somewhere up the slopes are found to contain no water when penetrated by the drill. (4) Many large gas fields in flat-lying rocks near this axis show little or no water in the producing sand in and immediately surrounding the gas field, the sand being continuous over large areas and the closed pressure of the gas ranging up to over 1000 pounds per square inch.

One of the objects of the paper was to show that the general regional conditions accompanying the occurrence of oil and gas in these fields

is such as to discourage the idea that accumulation has been accomplished solely through difference in gravity of oil, gas and water inclosed in a porous bed.

The last meeting for the spring, the 259th, was held May 22, President Stanton presiding. The following informal communications were given:

E. G. Woodruff on *A bituminous black shale in the Debeque Quadrangle, Colorado;* L. C. Graton on *Primary chalcocite ore from British Columbia;* and F. L. Hess on *A new roscoelite vein near Placerville, Colorado.*

REGULAR PROGRAM

Structure of the foothills of the Front Range, Central Colorado: G. B. Richardson. The speaker directed attention to a series of strike faults. which heretofore have escaped notice, in the foothills in the Castle Rock quadrangle, Colorado. Stratigraphic evidence of the dislocations is concealed for long distances by outwash deposits, but locally there is proof of profound faulting parallel to the general trend of the Front Range. Six miles south of Palmer Lake, at the base of the mountains just north of Deadmans Creek, a narrow belt of strata of Colorado age standing on edge lies between low-dipping beds of the Fountain formation (Pennsylvanian) on the west and perpendicular Dawson arkose (Eocene) on the east. These relations are due to parallel faults striking north and south. The major portion of Perry Park, 10 miles southeast of Castle Rock, is included between two parallel curved faults. At the eastern end of the park a fault causes the formations from the Fountain to the Colorado inclusive to strike into and abut against the Pierre shale. On the eastern side of the fault the Pierre strikes north and south and is almost vertical; on the western side the strike is northwesterly with dips ranging from 10 to 45 degrees.

Along the western boundary of the Perry Park block another fault, in general parallel to that just outlined, causes the Fountain formation, dipping 10 to 15 degrees northward, to abut against the Pikes Peak granite in the southern part of the Park, while farther north this fault cuts across the Fountain and forms the boundary between that formation and the Lyons(?) sandstone, the former dipping at an angle of about 15 degrees and the latter standing almost vertical. At the northwestern end of Perry Park, the westward continuation of the zone of faulting just described (actual tracing being prevented by a cover of Quaternary wash) apparently causes strata of the Colorado group to lie in close proximity to the Lykins formation (Permian?). These relations heretofore have been considered due to erosional unconformity developed on the so-called Castle "arch."[1] The question was raised whether similar relations at the Golden and Boulder "arches," which in the Denver Monograph are accounted for by unconformities, may not have been caused by a series of longitudinal faults.

[1]Lee, W. T., Areal Geology of the Castle Rock region, Colorado: American Geologist **29**: 96–109. 1902.

The Front Range, at least in the Castle Rock region, is not a simple monoclinal uplift, but strike faulting along the base of the mountains has played a more important part than has been supposed.

The Lewis overthrust, Glacier National Park: M. R. Campbell.

The Bannock overthrust, southeast Idaho: R. W. Richards.

Robert Anderson,
R. W. Richards,
Secretaries.

THE BOTANICAL SOCIETY OF WASHINGTON

A special meeting of the Society was held September 18, 1912, in honor of Prof. Hugo De Vries, of Amsterdam.

Professor De Vries spoke on *The future of plant breeding as related to agricultural production.* The speaker advanced a modified view of the Malthusian doctrine and emphasized the necessity for developing means whereby the productiveness of food plants can be greatly increased, and the desirability of producing new forms of plant life which may be utilized as a source of food materials. This is necessary if the increase in food production is to keep pace with the increase in population. Up to the present time this has been possible but unless some means is found of obtaining a greater yield than is possible today, future generations must face the problem of an insufficient food supply.

We are rapidly approaching the limits beyond which the further combination and selection of our best strains of plants will give no increased advantage. There is need of securing entirely new forms of plant life and experimental plant breeding is now laying a firm foundation for the production of such new forms. As this work is extended it will be necessary to study the various forms of plant life in order to discern the natural course through which the better strains have come into existence; then by following this course under experimentally controlled conditions it may be possible to produce new forms which will far exceed in productiveness those with which we are familiar at the present time.

At the close of the address brief appreciative talks were made by W. M. Hays, E. F. Smith, W. J. Spillman and F. V. Coville, on various aspects of Professor De Vries' work as a scientist.

W. W. Stockberger, *Corresponding Secretary.*

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. II, NOVEMBER 4, 1912 No. 18

GEOCHEMISTRY.—*Vanadium and chromium in rutile and the possible effect of vanadium on color.* Thomas L. Watson, University of Virginia. Communicated by F. W. Clarke.

Vanadium and chromium are rather widely diffused in very small quantity in a variety[1] of rocks and minerals, especially in igneous rocks. Clarke[2] computes the average of 87 determinations of V_2O_3 in igneous rocks analyzed in the laboratory of the U. S. Geological Survey to be 0.013 per cent, and for 256 igneous rocks 0.05 per cent of Cr_2O_3. In addition to its general presence in small amount in igneous rocks (shown by Hillebrand[3] to be smallest in persilicic rocks and highest in subsilicic rocks), vanadium occurs in many sedimentary and metamorphic rocks and in a variety of minerals.[4] It occurs in some hydrocarbons especially asphaltite from Peru and elsewhere[5] and in some coals (lignite and anthracite), and has been reported in some meteorites, in the

[1] A good summary of the reported distribution of vanadium in rocks and minerals with references is given by Clarke, F. W., Bull. U. S. Geol. Survey, No. 491, 672–678. 1912. See also Moissan, H., Traité de Chimie Mineralogie, **2**: 100. 1905; and Thorpe's Dictionary of Applied Chemistry, 1909; Vogt, J. H. L., Zeitschr. prakt. Geol., p. 274. 1899. For the distribution of chromium see Bull. U. S. Geol. Survey, No. 491, 664–666. 1912.

[2] Clarke, F. W., Loc. cit.

[3] Hillebrand, W. F., Amer. Jour. Sci. **6**: 209–216. 1898; also see Bull. U. S. Geol. Survey, No. 167, 49–55. 1900.

[4] Hayes, H. H., Proc. Amer. Acad. **10**: 294. 1875.

[5] Hewitt, D. F., Vanadium Deposits in Peru, Trans. A. I. M. E. **40**: 274–299. 1910.

ash of some plants, and in some natural waters. From available data it seems probable that chromium is more widely diffused than vanadium, Clarke's estimate in 1900 for the lithosphere being 0.01 per cent. It is common in some meteorites, but is most important in subsilicic rocks like peridotites and the serpentines derived from them, present in the form of the magmatic mineral chromite.

Both vanadium and chromium are not uncommon constituents in heavy ferric silicate minerals, such as some pyroxenes, amphiboles, and dark micas (biotite).[6] They have long been known in titaniferous magnetites.[7]

Altho vanadium was reported in rutile from St. Yrieux[8] in 1859 and chromium in a Swedish rutile from Käringbricka[9] as early as 1803, their presence in analyses of rutile and ilmenite are rarely indicated. Examination of the available analyses of rutile shows that with but few exceptions the oxides of titanium and iron, the latter usually reported as ferrous oxide, are the only constituents present. These to be sure are the chief constituents, but in light of recent investigations of rutile from various localities in the United States and Europe, vanadium is quite constantly present in variable small quantity, and in a majority of them chromium is also found.

By methods of spectrum analysis Hasselberg[10] in 1897 reported the presence of vanadium in 12 rutiles from localities in the United States, Spain, Germany, France, Switzerland, Russia, Norway, and Sweden. Vanadium was not detected in anatase from Switzerland. Hasselberg also reported the presence of chromium in 10 of the 12 rutiles examined, it being absent in anatase from Switzerland and Magnet Cove, Arkansas. It is a noteworthy fact that of the 22 analyses of rutile quoted by Hintze[11] neither

[6] Hillebrand, W. F., Loc. cit.

[7] Walz, Isidor, Amer. Chemist, **6**: 453–456. 1876; Kemp, J. F., 19th Ann. Rept. U. S. Geol. Survey, Pt. III, 387–397. 1897–98.

[8] Deville, H., Sainte-Claire, Comp. Rend., **49**: 301. 1859.

[9] Dana, E. S., A System of Mineralogy, p. 239. 1900.

[10] Hasselberg, B., Astrophysical Journal **6**: 22–26. 1897. Also Chem. News, **76**: 102–104. 1897; see also Giles, W. B., Chem. News, **67**: 137. 1897.

[11] Hintze, C., Handbuch der Mineralogie, p. 1622. 1907.

vanadium nor chromium is reported as being present in a single analysis. Of 100 analyses of ilmenites quoted by Hintze[12] Cr_2O_3, ranging from a trace to 0.56 per cent, is reported in 8, and vanadium is not listed in any.

In recent investigations of rutile by the Virginia Geological Survey accurate chemical analyses of several rutiles and ilmenite were made, and each analysis agreed in showing the presence of both vanadium and chromium in small and unequal but appreciable amounts. The results follow in the annexed tabular statement.

Partial chemical analyses of rutile and ilmenite

(Wm. M. Thornton, Jr., analyst)

	I	II	III	IV
V_2O_3	0.15	0.20	0.55	0.24
Cr_2O_3	0.02	0.07	0.39	0.07
FeO	2.35	1.68	0.81	

I. Red rutile from feldspathic facies of syenite, Roseland, Nelson County, Virginia.
II. Very dark rutile from nelsonite on Warwick tract, 1½ miles northwest of Rose's Mill, Nelson County, Virginia.
III. Nearly black rutile from Krageroe, Norway.
IV. Black ilmenite from same locality as II.

Attention is directed in the analyses to the predominance of vanadium over chromium. Hasselberg[13] found for the rutiles he examined that when vanadium was present in very appreciable amount chromium was also present, but when vanadium was present in very small amount chromium was present either in trace or entirely absent. Altho there are frequent exceptions vanadium is commonly tho but slightly in excess of chromium in the known analyses of titaniferous magnetites. The exact form or combination in which these two constituents are present in rutile is entirely conjectural. As Washington[14] remarks vanadium probably exists as V_2O_3, replacing Al_2O_3 and Fe_2O_3, in ferro-

[12] Hintze, C., Ibid., pp. 1876–1881. 1908.
[13] Hasselberg, B., Op. cit.
[14] Washington, H. S., Trans. A. I. M. E. **39**: 756. 1909.

magnesian silicate minerals, since it is essentially absent from such rocks as peridotites of which olivine is the chief mineral and the iron is ferrous oxide. It seems probable as has been suggested by Kemp[15] that V_2O_3 may be present in titaniferous magnetites replacing some of the ferric oxide, and he has remarked on the extremely sympathetic relations of Cr_2O_3 and V_2O_3 in the same ores.[16]

A second fact which at least is suggestive is that the chemical analyses of rutiles that have been made under the direction of the writer indicate that difference in depth of color is probably not to be attributed to iron oxide. On comparing the percentages of iron (FeO) with those of vanadium (V_2O_3) in the table above it will be observed that vanadium increases with decrease of iron, and the color increases in depth in the same direction. In other words the rutile (I) containing highest FeO and lowest V_2O_3 is red in color, while the rutile (III) showing lowest FeO and highest V_2O_3 is nearly black; II is intermediate in color and shows less FeO and more V_2O_3 than I.

No conclusions of course can be drawn for rutiles in general since complete analyses of the mineral are exceedingly few, but the above results are suggestive and it will be of interest to ascertain whether the possible relation holds in future analyses of rutile. Sufficient work has been accomplished by recent students, however, to indicate that in future analyses of rutiles careful search should be made for both vanadium and chromium.

BOTANY.—*Pomegranate flowers dimorphic.* O. F. Cook, Bureau of Plant Industry, U. S. Department of Agriculture.

The flowers of the pomegranate are of two forms that can be distinguished by the shape of the buds long before the time of opening. The buds that are to produce perfect flowers and set fruit appear more cylindrical than the others, because they have a larger base and are usually more abruptly rounded below. The other buds are shorter, with a narrower and more tapering base, and a general shape that may be described as obconic or turbinate.

[15] Kemp, J. F., Trans. A. I. M. E., **40**: 862. 1910.

[16] Kemp, J. F., 19th Ann. Rept. U. S. Geol. Survey, Pt. III, p. 396. 1897–98.

Such flowers do not set fruit, but soon fall off. In most cases it is very easy to assign a bud to the right class after the distinction has once been noticed.

Fig. 1. Pomegranate buds and flower, bisexual fruit-producing form (natural size).

Buds of the longer, more cylindrical form, shown in figure 1, produce perfect flowers, with well-developed, functional ovaries.

Fig. 2. Pomegranate buds and flower, staminate form, not producing fruit (natural size).

In such flowers the style is long and the stigma is carried out beyond the mass of stamens. This makes it possible for the stigma to be exposed as soon as the calyx opens, and while the stamens

are still completely covered by the infolded petals, an arrangement obviously favorable to cross-fertilization.

In the other type of flowers, with the narrow tapering base, shown in figure 2, the ovaries are poorly developed and have only minute rudimentary ovules that degenerate and shrivel, sometimes even before the flowers open, leaving the ovarial chambers apparently empty. A corresponding reduction appears in the styles, which are often less than half as long as in the perfect flowers and remain hidden under the stamens. This arrangement might be considered as favorable for self-fertilization, were it not that the short-styled flowers have lost all but the staminal functions, as shown by the reduced ovaries and abortive ovules. In the staminate flowers the whole surface of the ovary becomes bright red like the upper part of the calyx tube, but the perfect flowers often fail to show the bright color on the ovary.

The second or staminate form of flowers was much more numerous on most of the bushes and some of them had none of the perfect flowers, so that no fruit could be set. Thus the pomegranate may be considered as a polygamodioecious plant, to the extent that a large proportion of the flowers no longer produce functional pistils. On the other hand, the perfect flowers show no apparent tendency to lose the staminal function. It is as tho a simple dimorphism of short and long styles had been followed by a further reduction of the pistils and ovules of the shortstyled flowers, until the reproductive functions were lost.

The existence of ornamental varieties of the pomegranate that produce no fruits, but are propagated entirely from cuttings, may be taken to indicate a further dioecious tendency. In varieties that have double flowers sterility might be due to loss of function in the stamens, but it now appears that absence of perfect flowers with functional pistils may be another cause of unfruitfulness. At Bard, California, where these observations were made, several of the bushes with ordinary single corollas had only the staminate form of flowers and buds. But as this might not be true in another season, the extent of the dioecious tendency remains in doubt. The bushes were flowering abundantly at the middle of May, 1912, and the beauty of the floral display

attracted attention. A large series of seedlings is being raised at Bard for breeding purposes, under the direction of Mr. Thomas H. Kearney of the United States Department of Agriculture. The fact that the fruit-bearing possibilities of the buds could be determined before the flowers opened was noticed by Mr. G. B. Gilbert, and this led to a more detailed examination.

Tho it seems quite improbable that such a specialization should not have been described before, the existence of two forms of flowers in the pomegranate is not recognized in the chief works of reference. Knuth's *Handbook of Flower Pollination* describes the flowers of Punica as "homogamous or protandrous," which would be true of only the sterile or staminate flowers. On the authority of Schultz it is stated that "The style is very short, and may be either receptive during the dehiscence of the anthers or become so after their pollen is shed. Autogamy by means of pollen that remains in the flower is possible in both cases." Such a statement might be made if the observations were limited to an ornamental variety of the pomegranate that did not produce perfect flowers. The same limitation might be inferred from a statement by Niedenzu, in Engler and Prantl's *Natürlichen Pflanzen-Familien,* that the ovary is often abortive.

The bearing of the dioecious tendency upon the problem of breeding fruiting varieties of pomegranates is obvious. Failure to produce a sufficient number of the fertile flowers would render a variety unproductive, tho it might blossom abundantly. On the other hand, the possibility that some varieties require cross-fertilization should receive consideration.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

CHEMISTRY.—*Sodium oxalate as a standard in volumetric analysis.* Circular No. 40, Bureau of Standards. 1912.

This circular gives a resumé of the work done on sodium oxalate at the Bureau of Standards and elsewhere, which has led to its selection by this Bureau as a primary standard, which is now issued in a form similar to other standard analyzed samples. The methods of preparation, testing and use of sodium oxalate are described and discussed. This salt is recommended especially as an oxidimetric standard, tho directions for its use in acidimetry are also given. W. Blum.

GEOLOGY.—*The Alatna-Noatak region, Alaska.* Philip S. Smith. Bulletin U. S. Geological Survey No. 520 L. Pp. 26, with map. 1912.

The Alatna-Noatak region in northwestern Alaska receives its name from the two streams, the Alatna, which flows southward into the Koyukuk and thence into the Yukon, and the Noatak, which flows westward into Kotzebue Sound north of the Arctic Circle. Valley glaciers occur in the basins of both streams.

The geologic sequence from the base up is as follows: (1) Highly metamorphic schists of early Paleozoic age; (2) unconformably overlying them, intensely deformed limestones of undetermined age, in part probably Carboniferous, (3) a considerable thickness of complexly folded and faulted Mississippian sandstones, quartzites, and thin limestones containing molluscan remains; (4) a group of massive limestones overlying the sandstones and correlated with the Lisburne limestone of Mississippian age; (5) float of a cherty limestone containing Upper Triassic fossils; (6) Upper Cretaceous sandstones and conglomerates; and (7) unconsolidated deposits of marine, glacial, and fluviatile origin

ranging in age from Pleistocene to Recent. The igneous rocks are greenstones, intruding the metamorphic schists; gabbros, in stocks and dikes cutting the Mississippian sandstones; and granites, cutting the limestones of undetermined age in the upper part of the Alatna basin.

Many of the more striking present-day topographic features were produced by the agency of valley glaciers in the recent past.

Mineralization is confined mainly to the schists and pre-Mississippian rocks and is apparently not related to the igneous intrusives. There is no mining in the region, tho gold has been found in the gravels in the central part of the Alatna valley and in the headward portion of the Noatak, and veins of copper and gold have been reported in the same general region. P. S. S.

GEOLOGY.—*Reconnaissance of the Jarbidge, Contact and Elk Mountain districts, Nevada.* F. C. SCHRADER. Bulletin U. S. Geological Survey No. 497. Pp. 162, with maps, sections, and illustrations. 1912.

The districts described are in Elko County in northeastern Nevada, in a region occupied chiefly by Paleozoic sedimentary rocks, probably Carboniferous. These rocks, comprising quartzite, limestone, shale and slate, are folded and faulted and are intruded by Cretaceous (?) granodiorite. This series is capped by Tertiary eruptives, principally rhyolite, overlain by Tertiary lake beds and Quaternary deposits.

In the Jarbidge district the rocks are principally rhyolite flows with some Paleozoic sediments. The flows are separable into an older or Miocene (?) group and a younger or Pliocene group.

The principal rocks of the Contact district are granodiorite and the Paleozoic sediments which it intrudes. The granodiorite is surrounded by overlying, outward-dipping Paleozoic sediments with a known thickness of about 1600 feet. They are metamorphosed by the granodiorite and both they and the granodiorite are cut by dikes of various kinds.

The Tertiary lake beds occur chiefly in depressions in the Contact district where they have a known thickness of 400 feet and are mainly composed of volcanic tuff. In places they are tilted, flexed and gently folded. They are Pliocene and belong to the Humboldt formation. In the Jarbidge Mountains are some Pleistocene glacial accumulations.

The ores were deposited in at least two periods, one probably Cretaceous and the other post-Miocene.

The Cretaceous deposits are chiefly auriferous and argentiferous copper ores and occur mainly in the Contact district in the contact zone around

the granodiorite and in fissures. The contact metamorphic deposits contain axinite indicating deposition under pneumatolitic conditions. The fissure deposits are associated with the dikes and with contemporaneous or later quartz veins. They occur principally in the granodiorite.

The post-Miocene deposits are argentiferous gold ores. They occur in quartz-adularia veins in the older rhyolite of the Jarbidge district. The fissures are comprised mostly in two main systems which converge downward. The present gangue minerals were deposited by ascending thermal solutions that dissolved and replaced an older calcite gangue.

F. C. S.

GEOLOGY.—*Geology and mineral resources of the Peoria quadrangle.* J. A. Udden. Bulletin, U. S. Geological Survey No. 506. Pp. 103, with maps, sections and views.

The Peoria 30 minute quadrangle, in north-central Illinois, is located along the Illinois River and on the northwestward rise of the eastern interior coalfield, tho it is far within the border of the latter. The stratigraphy and economic geology are accordingly largely concerned with the Pennsylvanian coal measures and coals, the latter of Allegheny age being easy of access. Special attention is given to the overthrusts and faults exposed in the mines of the region and to the origin of the "white top" while some places overlies coal No. 6. The thrusts of the softer beds of the "coal measures" which are not very deeply buried, are attributed by Udden to the pressure and motion of a continental ice sheet in Pleistocene time. Considerable very interesting evidence is adduced in support of this view. The "white top," a mixture of shale, sand and limestone in a chalk-like groundmass, is conclusively explained as residual and inwashed material occupying solution channels cut in the base of the limestone which overlies the coal.

Other notable features of the bulletin are the discussion of the pre-Quaternary topography and the interpretation of the deep well records.

David White.

BOTANY.—*The grasses and grass-like plants of New Mexico.* E. O. Wooton and Paul C. Standley. New Mexico Agricultural Experiment Station Bulletin, **81**: 1–175, with numerous illustrations. 1912.

The introduction contains a discussion of life zones and grass societies in New Mexico, with maps illustrating each. Five grass societies are

outlined, (1) the blue grama (*Bouteloua oligostachya*), the most important, occupying the higher plains and much of the mountains; (2) the black grama (*Bouteloua eriopoda*) society, characteristic of the less elevated plains in the southern part of the State; (3) a society intermediate between nos. 1 and 2, best developed in the southeast corner of New Mexico; (4) the salt-grass (*Distichlis spicata*) society, characteristic of moist alkaline soils; and (5) the Arizona fescue (*Festuca arizonica*) society, confined to open parks in the higher mountains. The body of the work consists of an annotated list of the Poaceae, Cyperaceae, and Juncaceae of the State, with notes upon their economic importance. Keys are furnished for the identification of the genera and species.

P. C. S.

BOTANY.—*Three new club-mosses from Panama*, William R. Maxon. Smithsonian Miscellaneous Collection, **56**: no. 29, with 3 plates. January 6, 1912.

Lycopodium foliaceum, *L. stamineum*, and *L. watsonianum* are described, each being illustrated. All are from the humid forests of the Province of Chiriqui, Republic of Panama. P. C. Standley.

FORESTRY.—*Lightning in relation to forest fires.* Fred G. Plummer. Forest Service Bulletin 111. Pp. 41, with plates and diagrams. 1912.

Careful observations on the national forests have shown that lightning ranks second only to sparks from locomotives as a source of conflagration. From early times there has been a belief that certain trees are more likely to be struck than others. Experiments made, both in Europe by Du Moncel and in the United States by the Forest Service, show, however, that no kind of tree is exempt. Laboratory experiments prove that the electric conductivity of wood depends upon its water content. The moisture content of the wood in a tree is subject to great changes. Rain can so wet any tree that it will become, for the time being, an excellent conductor. Thus, tho the moisture content of wood, particularly within the outermost layer of growth in the living tree, favors conduction even the most resinous of trees, with the lowest moisture content, can in a heavy rain become good conductors in a moment's time.

Trees are the objects most often struck by lightning, because (a) they are numerous; (b) they extend upward and shorten the distance to a cloud, and (c) their spreading branches and roots present an ideal

form for conducting an electrical discharge to the earth. The greatest number of trees struck in any locality will be of the dominant species. The likelihood of a tree being struck is increased (a) if it is taller than surrounding trees, (b) if it is isolated, (c) if it is upon high ground, (d) if it is deeply rooted, (e) if it is the best conductor at the moment of the flash.

Only about 2 per cent of the trees struck by lightning on the national forests are ignited. While in general one species may be more inflammable than another, the degree of inflammability varies with the locality and season. The tree most often struck and ignited in the west is the yellow pine, which grows in open, park-like stands, where the fire hazard is small. It is probable that most forest fires caused by lightning are due to the presence of dry humus or litter at the base of the tree. There is a possibility that some forest fires are started by lightning striking the ground and igniting the soil cover. FINDLEY BURNS.

FORESTRY.—*Emory oak in southern Arizona.* FRANK J. PHILLIPS. Forest Service Circular 201. Pp. 15, with plates. 1912.

Emory oak (*Quercus emoryi*) forms one of the most important types in the open woodland forest of the southwest, and is the most common oak in the mountains of southern New Mexico and Arizona. It affords protection to watersheds, and has high value for fuel in a region where wood is scarce. Also, there is a possibility that its bark may become a source of tannic acid.

The emory oak ranges from western Texas to the western slopes of the Pajarito Mountains, Arizona, and from the south-central portion of Arizona to the south-central part of the Province of Chihuahua, Mexico. It is able to grow on a variety of sites, though it does best on deep alluvial soils with abundant water. The tree varies in form and size and in character of stand more than any other oak in its range. In broad, open valleys the tree reaches its maximum development, with breast-high diameters of from 2 to 3 feet and a total height of from 60 to 70 feet.

Altho emory oak produces seed abundantly, and much of this seed germinates to furnish the original seedlings from which subsequent sprouts develop, reproduction is due almost entirely to sprout growth. As with other broadleaf trees, the season of cutting has a marked influence on the sprouting capacity of the stump, and summer cutting is most likely to result in the death of the stump.

For the proper management of emory oak it is only necessary to keep

fire out and to prohibit cutting from July to September, and especially in August. The best results in securing coppice growth will accrue from a system which confines cutting to the period from November to April, inclusive. Clear cutting should never be practiced, and the wasteful pollarding practiced by the Mexican woodchoppers is even preferable, as a sort of rough selection system, to a clear cutting, which tends to lay bare a large area and render all unprotected young growth susceptible to injury. FINDLEY BURNS.

ZOOLOGY.—*Notes on a new species of flatfish from off the coast of New England.* WILLIAM C. KENDALL. Bulletin of the U. S. Bureau of Fisheries, vol. 30, 1910, pp. 389–394, pl. lvii. Issued August 13, 1912.

About April 18, 1912, the Bureau of Fisheries received from Mr. John R. Neal, of Boston, three specimens of flounders taken in an otter trawl on one of the offshore banks of New England. An examination of these specimens and comparison with known American and European flatfish indicated that they are a hitherto undescribed species. Later, additional specimens were received from Mr. Neal, by request, and examination supported the view that they were new to science. Dr. Kendall has accordingly published a description of this flounder, naming it *Pseudopleuronectes dignabilis.*

While the differences between this form and *P. americanus* are not very great, they appear to be collectively constant, although many of the characters individually approach *P. americanus* very closely. In fact, some of them, especially those exhibited by single specimens of each form examined, may disappear in an examination of larger series, particularly of fish of similar sizes, as the gillrakers and teeth of most fishes vary in number and character with the age of the fish. All of the differences, even, may be found to intergrade, but on the principle that a binomial name should represent what is known rather than what is not, it is believed that what is shown in the description entitles this fish to be considered a distinct species until complete intergradation shall have been proved. Should such an intergradation be discovered, the name will only be lengthened to a trinomial.

The most conspicuous differential characteristics of this species consist of a somewhat shorter head, a larger number of vertical fin rays, the coloration, and the large size attained; which, taken with its deep-water habitat and different spawning season from that of *P. americanus*, seem sufficiently distinctive.

Something over fifteen years ago Dr. Kendall was informed by a Georges Bank fisherman that occasionally flounders were taken on Georges Banks that were known to the fishermen as "lemon sole," owing to their prevailing yellow coloration. The identity of this fish was never definitely determined. The U. S. National Museum a number of years ago received from Fulton Market, New York, some large flounders taken in deep water off the New England coast which were then regarded as a deep-water form of *P. americanus*. The fish is thick and firm-meated, the flesh flaky and, when cooked, moist and of delicious flavor. ETHEL M. SMITH.

ZOOLOGY.—*The Bryozoa of the Woods Hole region.* RAYMOND C. OSBURN. Bulletin of the U. S. Bureau of Fisheries, vol. 30, 1910, pp. 203–266, pls. xviii–xxxi. Issued June 25, 1912.

The biological survey of the waters of Woods Hole, Mass., and vicinity, covering the years 1903 to 1909 and to be reported upon in a forthcoming extensive volume of the Bulletin of the Bureau of Fisheries, furnished so much bryozoan material that Dr. Osburn was led to prepare a special systematic discussion of this group. The region embraced in the survey includes Vineyard Sound between a line drawn from East Chop to Falmouth Heights and one from Gay Head to Sow and Pigs Reef, and Buzzards Bay above a line drawn from Sow and Pigs Reef to the Hen and Chickens Lightship.

In consequence of the fact that the Bryozoa of the American Atlantic coast have received comparatively little study, the collections of the recent survey have nearly doubled the number of known species from this region, bringing it up to 81, besides adding a number of varieties which have at times been classed as species. Only 5 of these species, however, are described as new, with 7 others known to occur only within this intermediate region between Florida and Canada. Of characteristic southern species there are almost no representatives. Fully one-half are characteristically northern or even arctic in their range. Another fourth is composed of species which have such wide distribution that they may be called cosmopolitan.

Within the region itself, 28 species found in the outer waters are not represented in the inner waters, and 12 species from the latter areas are not found in the others. This leaves more than one-half of the total number common to both inner and outer waters. Comparatively few of the species show a preference for any special habitat, and the majority

are rather small, though some of the erect chilostomes form bushy colonies several inches in height.

The author calls attention to the fact that while the Bryozoa yield no useful products and thus have no direct value in commerce, they, like most other small marine animals, play a part in furnishing food for fishes. He has seen large nodules of *Schizoporella* and *Smittia* taken from the stomachs of sharks, while among the edible fishes the examination of such species as the cunner and tautog indicates that the various Bryozoa often form no inconsiderable part of the diet.

To this paper is appended a bibliography of 73 titles.

ETHEL M. SMITH.

TECHNOLOGY.—*The preservation of mine timbers.* E. W. PETERS. Forest Service Bulletin 107. Pp. 27, with plates and diagrams. 1912.

In mining operations the cost of timber is a factor of much importance. In 1907, $10,000,000 was spent for round mine props alone, while additional outlay was necessary for lagging, planking, and other forms of lumber extensively used in mines. The life of mine timbers is in many cases very short, and as the supply of the better grades becomes depleted the less durable kinds must be used.

Altho decay, which in general is the agency most destructive to timber used in mines, may be retarded by peeling and seasoning, treatment with a suitable preservative is more effective.

The average life of green, unpeeled, and untreated loblolly pine gangway sets, under the conditions studied, was less than one and one-half years. Brush treatments with creosote and carbolineum increased this to three and four years, while impregnation with zinc chloride and creosote left from 70 to 90 per cent of the timbers sound at the end of four years.

Brush treatments are economical when the amount of timber to be treated will not warrant the erection of a small open-tank or pressure plant, or when only a short increase in service is required. The open-tank process is adapted to the treatment of small quantities of easily impregnated timber. When a large amount of material is to be treated, a pressure process should be used. Mine timbers impregnated with zinc chloride and creosote oils have shown the best results.

FINDLEY BURNS.

PROGRAMS AND ANNOUNCEMENTS

CHEMICAL SOCIETY

The annual election will be held at the 218th regular meeting, to be held at the Cosmos Club, at 8 p.m., Thursday, November 14. The usual smoker will follow the election.

BUREAU OF STANDARDS

The current meetings of the Physics Club of the Bureau of Standards are being devoted to the discussion of the application of the electron theory classes of phenomena. The papers in this series are as follows: October 14 and 21, *Determinations of* $\frac{e}{m}$ *and of e*, Dr. P. G. Agnew; October 28, *Conduction in gases*, Mr. A. Marcus; November 4, *The Zeeman effect*, Mr. L. B. Olmstead; November 11 and 18, *Metallic conduction and thermo-electric effects*, Dr. W. P. White, of the Geophysical Laboratory; November 25, *The index of refraction*, Mr. E. C. Crittenden; December 2, *Nature and properties of the electron*,————.

For the remaining meetings in December the following papers have been arranged: December 9, *Radiation pressure*, Mr. P. D. Foote; December 16, *Measurements of wave-length*, Mr. I. G. Priest.

The later dates are provisional since it is expected that a popular lecture will be given during November, in which case the regular program will be displaced one week.

The meetings are held in the lecture room of the Bureau of Standards from 4.30 to 5.30 and are open to anyone interested. Further information regarding them may be obtained from the secretary, Mr. E. C. Crittenden.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. II, NOVEMBER 19, 1912 No. 19

PHYSICS.—*The diffuse reflecting power of various substances.* W. W. Coblentz, Bureau of Standards. To appear in full in the Bulletin of the Bureau of Standards.

This paper gives an account of an investigation of the reflecting power of matte surfaces of various substances, for the spectral regions of 0.54, 0.60, 0.95, 4.4, 8.8, and 24μ. The diffusely reflected radiations were collected by means of a hemispherical mirror, and projected upon a surface thermopile of bismuth and silver, which was used to measure the intensity of the incident and reflected radiations.

The substances examined include lampblack, platinum black, pigments, white paints, green leaves, dyed cloth, and building material. The object of the investigation was to find the blackest and the whitest substances; the former to be used as absorbing surfaces of radiometers, the latter to be used as a covering for buildings exposed to intense sunlight.

Methods are given for preparing standard black surfaces; and quantitative data are given for the loss by reflection of the same. The blackest deposits of soot are obtained from an acetylene flame; the reflecting power being only about 0.6 per cent. Lampblack paint made by mixing the dry material with turpentine reflects about 3 per cent in the visible spectrum to 3.5 per cent in the extreme infra-red. Thick deposits of platinum black reflect about 1 per cent in the visible spectrum and 2 to 3 per cent in the extreme infra-red.

Bricks, granolith, dusty asphaltum pavements, and green leaves fall in the same group with a reflecting power about 25 per cent for green leaves. But there is a vast difference in their effect upon the surrounding atmosphere and consequently upon the comfort of the community. The building material continues to reradiate energy long after the sun has set, while in the growing leaf the absorbed energy is at once used in photo-chemical processes, with practically no rise in its temperature. It is evident that, until traffic demands the full width of it, a great portion of a street should be covered with grass and trees instead of granolith and asphalt, thus adding to the comfort of the community as well as decreasing the cost of maintenance. Observatories should be surrounded with grass and evergreen shrubbery which will absorb the solar rays without warming the atmosphere by reradiation.

As a covering for an observatory dome the problem is to find a white paint that reflects a maximum amount of visible rays and a minimum amount of infra-red rays of wave-lengths between 6 and 10μ. In this manner a large portion of the solar rays will be reflected into space; and the rise in temperature resulting from the solar rays that are absorbed will be prevented by reradiation, which is facilitated by a high emissivity (low reflectivity) at 6 to 10μ. Unfortunately the paint (zinc oxide) that fulfills the latter condition cannot be used for exterior work. The next best primary paint for exterior work is white lead. Radiometrically it would therefore be better to use a mixture composed of white lead and as high a proportion of zinc oxide as is permissible to form a good paint.

The carbonates, sulfates, and silicates have bands of strong metallic reflection in the region of 7 to 9μ, which suppresses reradiation of the absorbed solar rays. In binary mixtures, sulfates, and silicates are less desirable than carbonates; for their infra-red reflecting power is higher and the bands do not lie close to those of lead carbonate. This suppresses the emissivity over a wider range of the infra-red spectrum. Of course a few (5 to 8) per cent of silica or china clay which is said to improve white lead mechanically, cannot seriously affect the radiating

properties of the primary, viz., white lead. The combinations of calcium sulfate and of barytes with white lead appeared much darker than a similar combination with calcium carbonate.

The white paints examined quantitatively for reflection were samples which had been ground in linseed oil, under standard conditions.[1] There was no marked difference in the reflecting power of white lead made by different processes (American, Dutch, and French), the reflecting power of various samples varying from 74.3 to 76.0 per cent. Similarly the samples of zinc oxide paints reflected from 68 to 69 per cent. This agrees with previous observations on the dry pigments which show that lead carbonate has a higher reflecting power than zinc oxide. A mixture of equal parts of white lead and of zinc oxide reflected 71 per cent.

In view of the fact that the reflecting power of aluminum is high (69 per cent) in the visible and in the ultra-violet, it was of interest to determine whether sheet aluminum would be more satisfactory than white paint for protecting a building against warming by solar rays. The difference in reflecting power of aluminum and white paint is not so marked in the visible spectrum as in the infra-red. Both materials absorb considerable sunlight; but aluminum has the lower emissivity for radiations at 6 to 12μ. Hence it cannot radiate the absorbed energy as rapidly as the white paint and its temperature rises above that of white paint.

This conclusion is borne out by the following experiments in which the temperature of two similar plates of aluminum was observed before and after one plate was painted with white lead ground in pure linseed oil. Two sizes of sheet aluminum were tested; A = 46 by 48 by 0.718 mm., B = 68 by 69 by 0.245 mm. Thermocouples of copper and constantan wires were inserted and riveted in holes drilled thru the aluminum plates, and as a further attempt to obtain good contact the junctions were tightened with Wood's alloy. The constantan wire was 0.31 mm. and the copper wire was 0.40 mm. in diameter. The cold junctions

[1] Proc. Amer. Soc. for Testing Materials **11**: 226. 1911.

were kept in ice. The aluminum sheets were mounted side by side upon a board of yellow poplar, 20 by 19 by 0.18 cm. and exposed to direct sunlight. The temperature of the pairs of sheets, A and B, and the difference in temperature was measured by means of a potentiometer.

Sheets No. II of both A and B were given two coats of pure white lead paint and when dry they were exposed to sunlight. The sky was perfectly clear (10–7–1912) with only a slight breeze blowing. Without glass coverings, which is the test of most interest, the bare aluminum plate was the hotter. For A–I, the temperature of the unpainted aluminum sheet was 3°.0 to 3°.1 higher than the exactly similar sheet having two coats of white lead paint. The actual temperature of A–I was about 44°.7. Similarly, for B–I the temperature excess of the unpainted aluminum sheet was 2°.3 to 2°.4, the actual temperature being about 43°.7. The intensity of the solar radiation, Q, was about 1.16 gr. cal. cm^2. min.

These tests were repeated using three coats of paint. The weather was perfectly clear (10–10–1912) and no breeze blowing. The intensity of the solar radiation was 1.157 gr. cal. cm^2. min. The plates were exposed directly to the sun, i.e., no glass intervening. For A–I the temperature excess was 4°.1 to 4°.3 the actual temperature being about 45°C. Similarly for B–I (unpainted aluminum) the temperature excess was 3°.0 to 3°.2, the actual temperature being about 42°.7.

From these tests it is evident that a metal roof painted with several coats of white paint is far superior to one of bright metal. As already mentioned this is owing to the fact that white paint has a higher emissivity than metals in the infra-red.

The unpainted sheets of aluminum (A–I, B–I) were then given three coats of zinc oxide paint. When thoroly dry, the sheets containing the zinc oxide paint appeared to be at about the same (+0°.1) temperature as obtained in the white lead. Another coat of paint was then applied (making four coats in all) to each sheet. When exposed directly to solar radiation, the temperature excess of the zinc oxide paint for the thin sheets, B, was ±0°.1 and for the thick sheets it was about +0°.5. From this appears that, in

comparison with white lead, what is gained in higher emissivity in the infra-red in the zinc oxide paint, is lost by its higher absorption (lower reflecting power) in the visible spectrum, so that radiometrically it is no more efficient than white lead.

The white lead paint was removed from the sheets, A–II and B–II, which were then painted with a matte layer of the lampblack used in the experiments already described. When exposed directly to the sun the temperature of the lampblack sheet A–II was about 16° higher than the zinc oxide paint, A–I; the actual temperature of the lampblack being about 52°.2 for solar radiation of intensity, $Q = 1.16$. Similarly the temperature of the lampblack sheet, B–II was 17°.5 higher than the zinc oxide plate B–I, the actual temperature of the aluminum sheet covered with lampblack paint being about 53°.3 C. and the room temperature being about 23°.1 C. The infra-red reflecting at 8.8μ differs but little for these two substances, hence, there is no great difference in their emissivities for low temperatures. In the visible spectrum the absorptivity of the zinc oxide is only about 30 per cent and for lampblack it is 97 per cent. Hence, the lampblack must become the hotter; for it absorbs energy at three times the rate, and it emits energy (low temperature radiation) at practically the same rate, as does the zinc oxide paint.

ELECTROCHEMISTRY.—*The silver voltameter. I.* E. B. Rosa and G. W. Vinal, Bureau of Standards. To appear in the Bulletin of the Bureau of Standards.

The earliest use of electrochemical decomposition as a means for the measurement of electricity appears to have been by Gay Lussac and Thénard[1] about 1811, but it remained for Faraday to enunciate the conditions on which it may be used for the exact measurement of current. He declared his gas voltameter to be the "only actual measurer of voltaic electricity which we at present (1833) possess." Because of this, he named it a "volta-electrometer." The earliest use of the silver voltameter of which we are aware was by Poggendorff in 1847. Since then, about

[1] These and other references will be given more in detail in the full paper and also the places where they may be found.

sixty papers dealing with this instrument have appeared, but the diversity of opinions as to the causes of the anomalous results obtained has been so great, that the present authors undertook in 1909 a systematic research to discover, if possible, the best conditions under which the voltameter might be used as a primary standard for the measurement of electric current. Before describing their own work, the authors give a short historical review of the subject up to 1909.

The years 1880 to 1886 were important because of the first series of absolute determinations of the electrochemical equivalent of silver. The first to be published was by Mascart, who measured his current by means of an absolute balance and obtained (corrected value) 1.1156 mg. per coulomb. The work of F. and W. Kohlrausch was in terms of the horizontal intensity of the earth's magnetic field. With their tangent galvanometers and several forms of voltameter, they obtained the final result 1.1183 mg. per coulomb. Lord Rayleigh and Mrs. Sedgwick investigated carefully the purity of their materials, the inclusions of mother liquor in the deposit, the effect of size of platinum dish the effect of temperature, and finally designed a type of voltameter that has been much used nearly down to the present time. Their values for the electrochemical equivalent were obtained with an absolute current balance. They found 1.11794 mg. per coulomb.

Thomas Gray in 1886 made an extended investigation both of the silver and the copper voltameters, but his form of instrument (two parallel plates in a glass beaker) has not been used by later investigators. A comparatively unknown paper by Novak, published in Bohemian in 1892, was probably the first to suggest the formation of a complex ion at the anode which yielded an excess of silver deposit on reaching the cathode. The same idea was probaly independently put forward by Rodger and Watson several years later, and again proposed and emphasized by Richards, Collins, and Heimrod in 1899. The latter made no absolute determination of the electrochemical equivalent, but on the hypothesis of the heavy anode ion determined corrections as to be applied to previous determinations, obtaining

1.1175 mg. per coulomb as the mean. They originated the porous cup voltameter, which was very satisfactory and has been much used since.

Kahle, in 1899, published the results of his extended researches on the voltameter. He noted a characteristic striated appearance of the deposit when the solution was used several times. The liberation of acid he concluded accompanied the formation of oxidation products at the anode. His value for the equivalent, using Clark cells as reference standards, was the same as found by the Kohlrausches. Leduc (1902) believed that the anode current density ought to be very small, so that the quantity of acid produced should be a minimum. He thought also that the presence of AgOH, *if in solution*, is not detrimental, and recommended neutralizing the electrolyte with Ag_2O. Mylius, in 1902, called attention to the possibility of producing a red silver precipitate by the action of filter paper on $AgNO_3$. The significance of this observation was apparently not appreciated until recently.

The first work at the Bureau of Standards on the voltameter was by Dr. Guthe in 1904, who compared several different forms and particularly noted the difference between the porous cup and filter paper voltameters.

Van Dijk in 1906, compared the porous cup and filter paper forms of voltameter, and found the difference to be 0.023 per cent, which he ascribed to the complex ion yielding an excess deposit in the former. He gives as the electrochemical equivalent of silver, 1.1180 mg. per coulomb. Duschak and Hulett obtained a high degree of reproducibility, and made a careful analysis of their deposits, finding inclusions amounting to about 0.011 per cent.

The important recent investigations of the national laboratories of England, France, and Germany have been published by Smith, Mather, and Lowry; Janet, Laporte, and de la Gorce; Jaeger and von Steinwehr, respectively. Absolute balances were used to measure the current in the first two, and in the last the voltage of the cadmium cell was determined on the assumption that the electrochemical equivalent of silver is 1.118 mg. per

coulomb. The English and French work was based on the filter paper voltameter.

The work of the present authors, carried out in 1908–09, is described in the first of a series of four papers. In the other three, in which Dr. A. S. McDaniel is a joint author, the continuation of the work during the years 1909–12 will be described. The second paper of the series will deal with the chemistry of the voltameter, and the theory of striated deposits, the third will treat largely of the purification and testing of materials, and give the second series of quantitative results, while the fourth and last paper will give the results subsequent to the International Technical Committee's work.

In this investigation, ten platinum and two gold dishes have been used; four large dishes (350 cc.), four medium (175 cc.), and four small ones (125 cc.). All the dishes of one size were adjusted to the same weight to facilitate the weighings, which were made on three balances (one for each size of dish) mounted on piers in a special constant temperature room, so arranged that the balances could be read by telescope and scale from outside the room. For weighing the dishes, similar ones reserved for tare were used, and the silver was counterbalanced by special silver weights, gold plated. Buoyancy corrections were thus eliminated. The types of voltameters used were (1) the Rayleigh or filter paper form, (2) the Richards or porous cup form, (3) the Poggendorff form without septum, excepting a glass cup, hung under the anode, or with silk around the anode, (4) the siphon type.

The deposits were timed automatically by a chronograph, and the ticks of a standard Riefler clock. The circuit was so arranged that the current could, after adjustment, be thrown on to the voltameter circuit and maintained constant to usually better than 1 in 100,000 during the course of the experiment. Particular attention was paid to the insulation resistance. The reference standards were a Wolff manganin coil of 1 or 2 ohms in oil, and four standard cells in an oil bath maintained at a fixed temperature. The drop in potential across the standard resistance was made equal to the voltage of one of the cells and kept so by

regulating the current. As a further check, a potentiometer was also included in the circuit. Our reference standards were frequently compared with the standards of the Bureau, and suitable corrections made.

The porous cups were of Pukal ware made by the Königlich Porzellan Manufaktur of Berlin. They were prepared by filtering dilute HNO_3 thru the pores, and, after eliminating the acid by distilled water, the cups were soaked in pure electrolyte. Between experiments they were kept submerged in electrolyte. After washing the deposits and replacing any loose silver, they were dried in an electric oven at 150°C. After cooling, they were placed in the balance case for several hours before weighing.

The first experiments were with the Rayleigh voltameter. As a mean of 37 experiments, the value 1.01866 volts at 20°C. for the Weston normal cell was obtained, assuming the electrochemical equivalent of silver as 1.11800 mg. per coulomb, as defined by the London Conference of 1908. A difference of about 40 parts in 100,000 was found between this and the porous cup form, the latter giving the lower value. It occurred to the authors that if this excess were due to the filter paper letting thru a complex ion, as supposed by Richards, doubling or trebling the thickness of filter paper ought to decrease the discrepancy. But it was found that using two or three sheets of filter paper had just the opposite effect, and also increased the striations which were soon found to be a sure indication of a heavy deposit. It was found that the excess of deposit in the filter paper form over that in the porous cup form depended on the amount of filter paper present, and that the porous cup voltameter gave the same high values as the filter paper form if filter paper were wrapped around the outside of the porous cup, or if the electrolyte had previously been contaminated by soaking filter paper in it.

When solutions were repeatedly used in a filter paper voltameter, the deposits were increasingly heavy with each electrolysis, but a similar experiment with the porous cup voltameter always gave the same weight or slightly lighter. To further test the complex ion theory, we tried re-electrolyzing some of the elec-

trolytes saved from inside the porous cups; this is the anode liquid which should give too heavy a deposit, if Richard's theory is correct. It was found, however, that if the electrolyte was *free from filter paper* the deposit was perfectly normal.

Many of the deposits were examined under the microscope, and also photographed. From pure electrolytes, the deposits were always crystalline and non-striated, and, indeed, the appearance of the deposit was found to be a good criterion of the purity of the electrolyte.

It was found that to produce a heavy deposit, it was not necessary to bring the electrolyte and filter paper together, but merely to make up the electrolyte with water that had stood over filter paper for a short time. It was evident that important chemical changes were produced in the electrolyte by th filter paper, and, accordingly, Dr. McDaniels joined us in the summer of 1909 to study the chemistry of the voltameter.

With the porous cup form, the authors obtained 1.018287 volts for the Weston normal cell at 20°, and this is very close to the final result, which will be given in the last paper of the series.

ZOOLOGY.—*The occurrence of nodes in the bathymetrical distribution of the recent crinoids.* AUSTIN H. CLARK.

Among the recent crinoids the most important of the faunal areas, the one to which all the other faunal areas are subsidiary and of which they appear to be derivatives, has a somewhat peculiar geographical distribution. From the Moluccas and the Lesser Sunda Islands it extends eastward past New Guinea, then southeastward to New Caledonia, Fiji, Samoa, Tonga and the Kermadec Islands, near New Zealand; reappearing at Hawaii it extends thence westward to southern Japan and southward along the Kuril Islands to Formosa; westward from the Lesser Sunda Islands it extends, by way of the Andamans and Ceylon, to the Mascarene Islands, Madagascar and southeastern Africa. It has sent two very distinct branches into the Atlantic, a northern and a southern; the former, from the Bay of Bengal, has spread thruout the Mediterranean and along the east Atlantic Coasts from the Gulf of Guinea to Norway; the latter, from southeastern

Africa, inhabits the region from Morocco to the Bay of Biscay, thence westward to and thruout the Caribbean Sea.

One of the interesting points in the distribution of this fauna is that it is absent from the central East Indian region north of Sumatra, Java, the Lesser Sunda Islands and the Moluccas, and south of Formosa and Japan. The connection between New Zealand and Hawaii is probably by way of eastern Oceania, a region as yet unexplored.

In plotting the bathymetric ranges of the species of this fauna occurring in the Indian and Pacific Oceans certain bathymetric altitudes of maximum abundance are noticeable, and these occur in the same positions among the Japanese, Hawaiian and Indian Ocean species.

Corresponding nodes occur in the Caribbean Sea, but the intervals between them are not so great. These nodes are (in fathoms):

	1	2	3	4	5
Indian and Pacific Oceans	0–50	100–150	300–400	750–900	1600–2000
Caribbean Sea		100–150	250–300	400–450	700–800

On examining the nodes in the Indian and Pacific Oceans it is at once evident that there is a certain regularity in their occurrence. If we should take 50 fathoms as our unit (a) and arrange hypothetical nodes according to the ascending powers of 2 we should find nodes at:

$$50\ (a):\ 200\ (2^2a):\ 400\ (2^3a):\ 800\ (2^4a):\ 1600\ (2^5a).$$

What we actually find are nodes approximately at:

$$a:\ 2\left(a+\frac{a}{2^2}\right):\ 2^2\left(a+\frac{2a}{3}\right),\ \text{or}\ 2^3\left(a-\frac{a}{2^3}\right),\ \text{or}\ 7a:\ 2^4\left(a+\frac{a}{2^3}\right),$$

$$\text{or}\ 18a:\ 2^5\left(a+\frac{a}{2^3}\right),\ \text{or}\ 36a.$$

Considering the paucity of our records and our exceedingly imperfect knowledge of the true maximum range of the species involved we appear to be justified in calling attention to the curious and striking approximation between our hypothetical nodes calculated according to the ascending powers of 2 and the nodes as we actually find them.

It is also evident that there is a similar regularity in the distribution of the nodes in the Caribbean Sea. If we should take 50 fathoms as our unit (a) and arrange hypothetical nodes according to the ascending powers of 2, plus 2 itself, we should find nodes at:

$$50\ (a):\ 100\ (2a):\ 200\ (2^2a):\ 400\ (2^3a):\ 800\ (2^4a).$$

It will be noticed that this arrangement is not greatly different from what we actually find.

Taking the whole ocean into consideration, the difference in temperature between 200 and 400 fathoms is 8°.3 Fahrenheit; between 400 and 800 fathoms 4°.5; and between 800 and 1600 fathoms 2°.1. In other words, the decrease in temperature is roughly in inverse proportion to the distances between the nodes. As temperature is one of the chief factors governing the distribution of marine animals it is quite probable that the spacing of the nodes is dependent upon it.

But the temperature decrease in the sea is represented by a regular curve, so that it cannot account for the original existence of the nodes. Their origin is probably to be sought in the answer to the problem concerning the origin of the deep fauna.

The fauna of the central East Indian or Malayan region is a heterogeneous mixture of species which in their distribution fall into five more or less distinct groups. This fauna in its bathymetrical distribution shows no nodes.

BOTANY.—*Papualthia Mariannae, a new species of Annonaceae from the island of Guam.* WILLIAM EDWIN SAFFORD, Bureau of Plant Industry.

Among the unidentified trees growing on the island of Guam mentioned by Don Felipe de la Corte[1] was one called by the natives *paipay*, the wood of which is used in the construction of small buildings and for handles of garden tools. I saw no specimen of this tree during my residence on the island; but I afterwards obtained herbarium specimens, including leaves and flowers, from Mr. H. L. W. Costenoble, and very recently I received specimens of its fruit from the venerable Monsignor José Palomo, for many years priest of Agaña, to whom I am indebted for many favors. The tree in question proved to belong to the Annonaceae and to the recently described genus Papualthia, which is characterized by leaves somewhat asymmetrical at the base and by shortly peduncled or subsessile, 6-petaled flowers, with the petals in two series, valvate and connivent, the inner petals slightly smaller than the outer or nearly equal to them in size; stamens indefinite; carpels indefinite to 3; ovules many to 2; and carpidia subglobose.[2]

This genus shows an affinity in its vegetative characters and flowers to certain species which King has placed in the genus Popowia, and also to several Malaysian species of Polyalthia, especially to the 2-ovuled group to which *P. subcordata* Bl., *P. macrorhyncha* Miq., and *P. celebica* Miq. belong. All of these have a tendency to asymmetrical leaves. Their petals are polyalthoid, but show a tendency toward shortening and to the connivence of the inner series, forming a transition from the true Polyalthias to the present genus, as pointed out by Diels.

Papualthia Mariannae Safford. sp. nov.

An irregularly branching tree, its very young ultimate branchlets clothed with ferrugineous silky solitary hairs, soon becoming glabrate, the older ones grayish, slender, bearing numerous minute

[1] Felipe de la Corte, Memoria descriptiva e historica de las Islas Marianas. Madrid, 1875.

[2] See *Papualthia* Diels n. gen. Engler's Botan. Jahrb. **49**: 138. 1912.

Fig. 1. *Papualthia Mariannæ* Safford

whitish lenticels. Leaves alternate, 2-ranked, entire, short-petioled, rounded and usually asymmetrical at the base, the uppermost ones lanceolate, acute or acuminate, the lower ones near the base of the branches usually smaller and broader, often ovate and obtuse, the blades glabrous and glossy above with impressed midrib, and glabrate beneath except near the base of the midrib which usually bears a few scant hairs. Flowers small, subglobose or broadly conical in bud; peduncles solitary subterminal on small branchlets, 1-flowered, short and thick, bearing two broad clasping bracteoles, which together with the peduncle

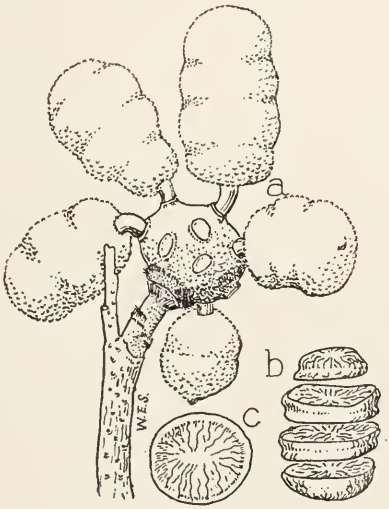

Fig 2. Fruit and seeds of *P. Mariannæ*

itself and the outer surface of the calyx are thickly covered with ferrugineous hairs; calyx 3-parted, the lobes broadly triangular; outer petals valvate, thick and coriaceous, broadly ovate, acute, appressed hirtellous on the outer surface, clothed with fine tomentum within; inner petals somewhat smaller, similar in shape and valvate like the outer ones, slightly clawed at the base, covered with fine dense tomentum. Receptacle (torus) convex or hemispherical, covered with fine stiff reddish hairs and bearing a large number of cuneate stamens closely crowded together, their

broadened connectives forming a continuous covering above the pollen sacs while the flowers are still immature; lower stamens shorter and relatively broader than the upper, subtriangular, the pollen sacs similar to those of other Annonas, adnate to the back of the broad filament and opening extrorsely by a longitudinal slit; the expanded connectives glabrous; carpels about 12, distinct, forming a cluster in the center of the mass of stamens, densely covered with appressed rufous hairs, and terminating in a short truncated stigma; fruit consisting of 8 to 12 shortly stipitate carpidia, globose to oblong, ovoid, or obovoid in shape, containing 1 to 4 seeds, granular on the surface, rounded or obtusely apiculate at the apex, and more or less constricted between the seeds; seeds of 1-seeded carpidia subglobose, those of 2-seeded carpidia hemispheroid, the inner ones of 3-seeded and 4-seeded carpidia discoid, with the circumference marked with a shallow groove, somewhat like that of a pulley, and the surface wrinkled, indicating the enclosed ruminate endosperm; mature torus spheroid borne on a short thick peduncle, its base bearing the remains of minute short stiff hairs and stamen scars.

Type material: In the United States National Herbarium no. 653784. Leaves and flowers collected on the Island of Guam, the southernmost of the Marianne Islands, on the Pago Road, east side of the island, by H. L. W. Costenoble, June, 1906 (Herb. W. E. Safford no. 1180). Fruit from the same locality received from Rev. José Palomo, September, 1912.

The thin, smooth, glossy leaves, are only slightly asymmetrical at the base. The petioles, which are hairy at first but at length become glabrate, are 4 mm. long, the blades of the larger leaves are 10 cm. long and 3.5 cm. broad, with 12 fine but distinctly marked lateral nerves on each side the midrib, more or less anastomosing before reaching the margin, with reticulating veins between them. The small cone-shaped flower-buds, which resemble those of *Annona glabra* in shape, are 8 mm. long and 7 mm. broad; the outer petals 8 mm. long and 5.6 mm. broad, and the inner ones 7.5 mm. long and 4.5 mm. broad. The lowermost stamens are 1.3 mm. long with the dilated connective 1 mm. broad, the upper stamens are 2.3 mm. long with the connective of the same

width as the lower ones. The carpels are about 2.3 mm. long and 1 mm. broad, and the stigmas, which are somewhat flattened and constricted at the base are about 0.5 mm. square. The mature carpidia owe the variation in their shape to the abortion or imperfect development of one or more of their ovules. Those with a single seed and globose in shape are about 1 cm. in diameter; the largest containing 3 to 4 seeds are 22 to 25 mm. long and 10 to 13 mm. in diameter.

Papualthia Mariannae is named in honor of Maria Anna of Austria, wife of Philip III of Spain, the patron and protector of the natives of Guam, for whom the Marianne Islands were named.

EXPLANATION OF FIGURES

Fig. 1. *Papualthia Mariannae* from type material, showing branches and leaves and a single flower natural size. *a*, flower with one outer petal removed, showing the 3 inner valvate petals covering the genital parts, with a few stamens visible between the somewhat unguiculate bases; *b*, subterminal flower, showing the two bracteoles on the peduncles; *c*, short stamen from the base of the androecium, *d*, longer stamens from the upper or inner part of the androecium, ventral and dorsal views, showing the two pollen sacs dehiscing by a longitudinal slit and capped by the transversely expanded connective; *e*, carpel, clothed with appressed hairs and terminating in a short broad truncated stigma. *a*, *b*, scale about 2.5; *c*, *d*, *e*, scale 10.

Fig. 2. The fruit of *Papualthia Mariannae*. *a*, spheriod torus bearing 5 carpidia and marked with scars made by the pedicels of fallen carpidia; *b*, seeds from a 4-seeded carpidium; *c*, discoid seed seen from above; all natural size.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

CHEMISTRY.—*The atomic weight of bromine.* H. C. P. WEBER, Bureau of Standards. Bulletin of the Bureau of Standards, in Press.

A considerable amount of work has been done in order to determine the atomic weight of bromine, and the oft-repeated comparison of the atomic weights of silver and bromine makes it seem that this ratio is known with considerable accuracy. The value accepted for bromine, however, rests almost entirely upon that of silver, and it is of interest and importance to obtain a ratio between it and some other element. For chlorine a number of determinations of the ratio of hydrogen to chlorine in hydrochloric acid have been made, both by purely physical and by chemical methods. For bromine similar comparisons have not been made. Since the determination of the ratio chlorine: hydrogen was carried out with reasonable ease, it seemed probable that the method might be advantageously applied for the purpose of determining the ratio between hydrogen and bromine.

The method which was employed by Noyes and Weber[1] was found to give good results in this case. The initial difficulties to be overcome were somewhat greater, which was rather unexpected. They were largely due to the physical properties of hydrobromic acid gas and were eliminated after the method had been studied for some time and slight alterations in the method of manipulation had been introduced.

The results obtained are given in Table I. The column headed "discrepancy" gives the differences between H + Br and HBr. The remainder of the table is self-explanatory.

[1] Bulletin, Bureau of Standards, **4**: 345. 1908.

TABLE 1

EXPERIMENT	H	Br	HBr	DISCREPANCY	H : Br	H : HBr
	grams	*grams*	*grams*	*mg.*		
1	0.77300	61.28837	62.06052	−0.85	79.2863	80.2853
2	0.86060	68.25033	69.11144	+0.54	79.3055	80.3061
3	0.77607	61.54733	62.32198	−1.42	70.3064	80.3046
4	0.96927	76.88221	77.85135	−0.15	79.3197	80.3195
5	1.07545	85.29562	86.37092	−0.15	79.3114	80.3114
6	0.99689	79.06834	80.06424	−0.99	79.3150	80.3140
7	0.74966	59.45275	60.20500	+2.59	79.3063	80.3097
8	0.98161	77.85554	78.83758	+0.43	79.3141	80.3145
9	1.00131	79.39533	80.39658	−0.06	79.2915	80.2914
10	0.81983	65.02140	65.83867	−2.56	79.3108	80.3077
	9.00369	714.05722	723.05828	−2.63	79.3067 ±0.0022	80.3064 ±0.0018
					Combined	
					79.3066	±0.0014

In the 10 experiments 9.00369 grams of hydrogen were combined with 714.05722 grams of bromine and yielded 723.05828 grams of hydrobromic acid. The value obtained from these two sums is respectively 79.307 (1) and 80.306 (9).

The final ratio obtained from these figures for H : Br is 79.306 (7), with a probable error of 0.0022. The ratio found from H : HBr is 80.306 (4), with a probable error of 0.0018. Combining the two the value is 79.306 (6) ± 0.0014. The numerical value of the probable error is somewhat larger than that of the chlorine ratio obtained in a similar manner. Relatively it is approximately the same or even somewhat smaller.

Taking the atomic weight of hydrogen[2] as 1.00779, the value for bromine on the oxygen basis becomes 79.924, as against the value 79.920 given by the International Commission for 1912.

H. C. P. W.

[2] Clarke: Recalculation of Atomic Weights, p. 41, 1910.

REFERENCES

AGRICULTURE.—*Publications of the Bureau of Plant Industry, Department of Agriculture*, from January 1 to June 30, 1912, as follows:

Suggestions on growing Egyptian cotton in the Southwest. CARL S. SCOFIELD, Document 717. Pp. 10.

Distribution of cotton seed in 1912. LEON M. ESTABROOK and O. F. COOK. Document 716. Pp. 11.

Memorandum of information concerning official cotton grades. N. A. COBB. Document 720. Pp. 3.

Grain-sorghum production in the San Antonio Region of Texas. CARLETON R. BALL and STEPHEN H. HASTINGS. Bulletin 237. Pp. 30, figs. 4.

Suggestions to potato growers on irrigated lands. L. C. CORBETT. Circular 90. Pp. 6.

A preliminary study of the forced curing of lemons as practiced in California. ARTHUR F. SIEVERS and RODNEY H. TRUE. Bulletin 232. Pp. 38, figs. 4.

The pear and how to grow it. G. B. BRACKETT, Farmers' Bulletin 482. Pp. 31, figs. 30.

The cultivation and manufacture of tea in the United States. GEORGE F. MITCHELL. Bulletin 234. Pp. 40, pls. 2, figs. 11.

Crossbreeding corn. C. P. HARTLEY, ERNEST B. BROWN, C. H. KYLE, and L. L. ZOOK. Bulletin 218. Pp. 72, fig. 1.

Cooperative grain investigations at McPherson Kans., 1904–1909. VICTOR L. CORY. Bulletin 240. Pp. 22.

The thornless prickly pears. DAVID GRIFFITHS. Farmers' Bulletin 483. Pp. 20, figs. 4.

Sweet clover. J. M. WESTGATE and H. N. VINALL. Farmers' Bulletin 485. Pp. 39, figs. 16.

Diseases of cabbage and related crops and their control. L. L. HARTER. Farmers' Bulletin 488. Pp. 32, figs. 7.

Two dangerous imported plant diseases. PERLEY SPAULDING and ETHEL C. FIELD. Farmers' Bulletin 489. Pp. 29, figs. 3.

The profitable management of the small apple orchard on the general farm. M. C. BURRITT. Farmers' Bulletin 491. Pp. 22, figs. 8.

The more important insect and fungous enemies of the fruit and foliage of the apple. A. L. QUAINTANCE and W. M. SCOTT. Farmers' Bulletin 492. Pp. 48, figs. 21.

Lawn soils and lawns. OSWALD SCHREINER, J. J. SKINNER, L. C. CORBETT, and F. L. MULFORD. Farmers' Bulletin 494. Pp. 48, figs. 19.

Alfalfa seed production. J. M. WESTGATE, ROLAND MCKEE, and M. W. EVANS. Farmers' Bulletin 495. Pp. 36, figs. 14.

Cotton improvement under weevil conditions. O. F. COOK, Farmers' Bulletin 501, Pp. 22.

Seeds and plants imported during the period from January 1 to March 31, 1911: Inventory No. 26; Nos. 29328 to 30461. Bulletin 233. Pp. 98.

Seeds and plants imported during the period from April 1 to June 30, 1911: Inventory No. 27; Nos. 30462 to 31370. Bulletin 242. Pp. 99.

Farm management: Organization of research and teaching. W. M. Hays, Andrew Boss, A. D. Wilson, and Thomas P. Cooper. Bulletin 236. Pp. 96, pls. 5, figs. 57.

Cost and methods of clearing land in western Washington. Harry Thompson. Bulletin 239. Pp. 60, figs. 25.

The diseases of ginseng and their control. H. H. Whetzel and J. Rosenbaum. Bulletin 250. Pp. 44, pls. 12, figs. 5.

The use of artificial heat in curing cigar-leaf tobacco. W. W. Garner. Bulletin 241. Pp. 25, figs. 4.

Results of boys' demonstration work in corn clubs in 1911. Bradford Knapp and O. B. Martin. Document 741. Pp. 7, figs. 2.

Selection of cotton and corn seed on southern farms. Bradford Knapp. Document 747. Pp. 8, figs. 4.

Emergency crops for overflowed lands in the Mississippi Valley. Bradford Knapp. Document 756. Pp. 8.

The corn crop in the Southern States. Bradford Knapp. Document 730. Pp. 12, figs. 2.

The agricultural possibilities of the Canal Zone. Part I, Reconnoissance soil survey. Hugh H. Bennett. Part II, The outlook for agriculture. William A. Taylor. Report 95, Office of the Secretary. Pp. 49, pls. 12, fig. 1.

The adulteration and misbranding of the seeds of red clover, Kentucky bluegrass, orchard grass, and hairy vetch. B. T. Galloway. Circular 39, Office of the Secretary. Pp. 7.

The control of cotton wilt and root-knot. W. A. Orton and W. W. Gilbert. Circular 92. Pp. 19, figs. 12.

The danger of using foreign potatoes for seed. William Stuart and W. A. Orton. Circular 93. Pp. 5.

The seed-corn situation. C. P. Hartley. Circular 95. Pp. 13, figs. 2.

Title Page and Contents, Bulletins of the Bureau of Plant Industry Nos. 218 to 226, Inclusive, 1911–1912, Volume XXIX. Pp. 16.

Title Page and Contents, Bulletins of the Bureau of Plant Industry Nos. 227 to 230, Inclusive, 1911–1912, Volume XXX. Pp. 9.

Title Page and Contents, Bulletins of the Bureau of Plant Industry Nos. 231 to 240, Inclusive, 1912, Volume XXXI. Pp. 15.

The history and cause of the coconut bud-rot. John R. Johnston. Bulletin 228. Pp. 175, pls. 14, figs. 10.

The structure and development of crown gall: A plant cancer. Erwin F. Smith, Nellie A. Brown and Lucia McCulloch. Bulletin 255. Pp. 60, pls. 109, figs. 2.

The nematode gallworm on potatoes and other crop plants in Nevada. C. S. Scofield. Circular 91. Pp. 15, figs. 21.

The measurement of the oxidase content of plant juices. Herbert H. Bunzel. Bulletin 238. Pp. 40, pls. 2, figs. 9.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE BOTANICAL SOCIETY OF WASHINGTON

The 82d meeting was held at the Cosmos Club October 17, 1912. Mr. W. E. Lamb of the Forest Service was elected to membership. The following papers were read:

The cotton of the Hopi Indians: F. L. Lewton. This paper will be published in full in the Smithsonian Miscellaneous Collections.

A botanical trip to the Sevier Forest, southern Utah: W. W. Eggleston.

Damping-off of coniferous seedlings: C. P. Hartley. With the exception of the cedars, damping-off of seedlings is a serious hindrance to the raising of conifer seedlings. Surfacing beds with gravel tends to decrease the trouble. The disease is generally worst under moist conditions, but a well drained nursery in dry climate in southwestern Kansas has suffered especially heavy loss from damping-off parasites. No positive control method has ever been developed for general use.

In western porous soils damping-off is simply a root-rot of very young seedlings, which may attack at any point from the ground surface to several inches below. Seedlings several weeks old may have the younger parts of their roots rotted and yet survive.

Pythium debaryanum appears to be the most dangerous parasite in western nurseries. *Rhizoctonia sp.*, *Fusarium sp.*, and probably *Trichoderma lignorum*, also cause damping-off. Pythium and Rhizoctonia have been successfully inoculated on autoclaved soil, but inoculations do not succeed uniformly on unsterilized soil, due probably to competition of bacteria and other fungi. Rhinzoctonia loses parasitism in culture and different strains vary greatly in virulence.

All active Pythium in nursery soil can be killed very cheaply by means of fungicides. Heat, and fungicides which break down soon after application, such as mercuric chloride, or acids and copper salts followed by lime, are not effective in the west, because Pythium often reinfects such disinfected soil, running thru it rapidly before seedlings raised on it develop resistance. This reinfection at least sometimes takes place thru the air, and is difficult to prevent under nursery conditions. Excellent results have been obtained by treating beds before seeding with sulfuric acid and formalin, and on alkaline soils with zinc chloride and copper sulfate. These fungicides seem to leave a slight residue in the soil which protects against reinfection. This

protection sometimes fails. Rather complicated watering methods are necessary in the west to prevent chemical injury to the germinating seed by fungicides which leave residues. Further work is required to place any of the treatments on a firm economic basis.

W. W. Stockberger, *Corresponding Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

The 462th regular meeting of the Anthropological Society of Washington, D. C., was held in the New Museum Building, Washington, on October 15, 1912.

Major Richard Sylvester, Superintendent of Police for the District of Columbia, read a paper on *Criminal characteristics.* He reviewed the history of crime and pointed out that as civilization progresses the cruder crimes, such as homicide, tend to give place to subtler forms, such as forgery or embezzlement. The general government, he continued, has been urged to establish a national bureau of criminal identification, but such cooperative work has been left to the heads of American police departments.

There are practical difficulties in establishing a standard for the normal human being and in the distinction of criminals therefrom; for the police tests are applied only to those who have broken the law and many are non-criminal simply from lack of occasion. Moreover, many cases of apparent criminality are due to mental defect or disease.

The popular impression of the criminal as hungry and furtive is erroneous. The average man who makes crime a business in large cities is fairly prosperous and has no fear of arrest. Some of the anatomical characteristics which Lombroso thought decisive of criminality are common in the lower races of man, whether criminal or not. Measurements in general give racial rather than criminal characteristics.

Descriptions of a number of criminals charged with murder were compared in detail with the result of showing many varieties of human appearance bracketed together.

Some special kinds of crime are associated with peculiarities of appearance and develop these, but the criminal does not usually differ in appearance from other people. Stress was laid on the importance of circumstances beyond the control of the individual as largely determining the category to which a man belongs.

The paper was discussed by Drs. Hrdlička, Frank Baker, Hough, Glueck and others. The first two emphasized the unreliability of external peculiarities, relied on by Lombroso and others, and of every sort of test which has been devised for general distinction. Dr. Hrdlicka insisted that crime is a matter of the nerves and brain, or that the mentality and criminal characteristics may be more due to organs and parts which are hidden than to the obvious and chiefly irrelevant external ones which Lombroso depended upon for his diagnosis. Dr. Hough explained tattooing as devoid of significance in primitive conditions, but in civilization as a survival indicative of some weakness that might

predispose to crime. Dr. Glueck referred to his experience in charge of the criminal branch of the Government Hospital for the Insane and to the necessity of learning all about a man's past and about his circumstances and behavior at every stage of his life rather than trusting to his behavior or condition at the time of any one act as a proof of criminality.

A special meeting of the Anthropological Society was held at 4.30 p.m., October 29, 1912, in the National Museum, the President, Mr. Stetson, in the chair.

Dr. I. M. Casanowicz read a very interesting paper on the Mithra cult, explaining it as a religion of redemption, which for several centuries was the most important competitor of Christianity. It was Aryan in origin, antedating the separation of the Aryan people of India from the Iranians, and was transferred westward by stages, accumulating elements in the Mesopotamian valley and the Mediterranean basin, but preserving an Iranian nucleus. It entered Rome as the religion of the poor and lowly, but was taken up by society when found helpful to imperial policy and made its first convert of an emperor in Commodus. Mithra was essentially the god of light, hence of truth and benevolence; and from the antithesis of light and darkness grew the conception of his war against the powers of evil. Zoroaster built his system on this duality and conflict, though relegating Mithra to a lower place. Later he came to be regarded as occupying a middle place (on earth) between the powers of heaven and the evil powers of the underworld, serving also as a mediator between man and the unapproachable supreme deity. The cult of Mithra, he said, had influenced Christianity, especially in the conceptions of the powers of evil, the efficacy of sacraments and the procedures of the church.

Wm. H. Babcock, *Secretary.*

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

Vol. II, DECEMBER 4, 1912 No. 20

GEOCHEMISTRY.—*The various forms of silica and their mutual relations.* Clarence N. Fenner, Geophysical Laboratory. Communicated by Arthur L. Day.

Character of the investigation

Problems presented by the various forms of silica occurring in nature, in the relations which they bear to each other, have been the subject of investigation by a number of experimenters. The results obtained have not been altogether concordant and the present investigation was undertaken in order to reconcile or explain these discrepancies if possible and to obtain such additional information as would definitely establish the equilibrium relations of the various forms. The investigation is not yet concluded, but the general relations have been established and can be stated with confidence. Later, the whole will be presented at length and with full details of apparatus and methods of work.

The first subject of investigation was the determination of the exact relations between quartz, tridymite, and cristobalite. Two principal difficulties were encountered. First, the velocity of transformation of one form into another is extremely small at most temperatures; and second, it was found that silica possesses pre-eminently the property which Ostwald has expressed in his principle of successive reactions, namely, that a given form when subjected to conditions under which it is unstable,

frequently does not pass directly into the form which is most stable under those conditions, but first into some less unstable condition, and only after a lapse of time into the stable form.

Because of the sluggishness of transformation the writer has not found it possible, without employing a catalytic agent, to convert quartz into tridymite at any temperature, but at temperatures in the neighborhood of 1400°C. quartz gradually changes into cristobalite. 1400° is still well below the temperature at which cristobalite is stable, but in the passage from quartz to tridymite cristobalite is reached and there the process halts. It is only by the addition of a small quantity of some catalytic agent, such as tungstate of soda, that the reaction proceeds to completion. A parallel case is afforded in the transformation of silica glass into quartz at a temperature of 850°. In the course of a few hours it becomes converted into tridymite, but this is only an intermediate stage, for after a much longer time at the same temperature crystals of quartz make their appearance, and this is in reality the stable form at that temperature. It was only after much experimenting that such facts were fully brought out and their significance appreciated.

Inversion of quartz to tridymite

When finely ground quartz is heated with tungstate of soda it remains unchanged until a temperature of about 870° is reached. At temperatures above 870° it is gradually converted into tridymite. Near the inversion temperature the reaction proceeds very sluggishly so that it is only after the lapse of several days that identifiable tridymite appears.

At higher temperatures the change proceeds more rapidly. In several experiments conducted at about 1300° for 24 hours the surface of the cake in the crucible showed comparatively large crystals, easily visible to the naked eye.

As tridymite, in passing from the temperature of formation to ordinary temperatures, goes through a second inversion point the crystals lose hexagonal symmetry as regards optical properties but retain the outward form. The hexagonal plates therefore are not isotropic but are divided into faintly birefringent fields.

These show a biaxial, positive figure, with the acute bisectrix normal to the plate. Three determinations of the value of the optic axial angle gave for 2V an average of $35\frac{1}{2}°$. The index of refraction, as determined by the immersion method, is 1.475.

When tridymite, prepared at a high temperature as described, is in turn heated with a little tungstate of soda at temperatures below 870°, the transformation is reversed and quartz is formed. The relation of the two is therefore enantiotropic.

Inversion of tridymite to cristobalite

Tridymite is stable at all temperatures from 870° ± 10° up to 1470° ± 10°, where the inversion to cristobalite takes place. Like the inversion of quartz into tridymite that of tridymite into cristobalite, even in the presence of tungstate of soda, is very slow near the inversion point, but proceeds more rapidly at higher temperatures. At 1570° the reaction is complete in a few hours. At temperatures below 1470° cristobalite is reconverted into tridymite. The relations between tridymite and cristobalite are therefore analogous to those between quartz and tridymite.

As cristobalite also passes thru a low-temperature inversion-point in cooling to room temperatures the grains are not isotropic, but posses a faint birefringence.

The grains have been too small to determine the optical character with certainty, but some of maximum birefringence were found to give a fairly satisfactory interference figure, apparently perpendicular to the optic normal. The acute bisectrix was then found to be α and the mineral may provisionally be considered negative. The index of refraction as determined by the immersion method is close to 1.485.

From 1470° no further change was found to take place up to the melting point. The latter was considered by Day and Shepherd to be about 1600°.[1] No further information has been obtained with regard to this.

Silica glass, when devitrified without a flux, passes into cristo-

[1]The Lime-Silica Series of Minerals, Am. Jour. Sci., 4th ser., **22**: 265–302. October, 1906.

balite, even at temperatures below 1470°. From this intermediate stage the transformation to tridymite can be completed only with the assistance of a flux. Below 870°, even with tungstate of soda present, the glass is transformed first to tridymite and only very slowly to quartz. Precipitated silica behaves in the same manner as silica glass and is probably to be considered as strictly amorphous and analogous to the fused material.

The mutual relations of the three crystalline minerals and the amorphous forms have been repeatedly confirmed. Quartz has been converted into tridymite and into cristobalite; tridymite into quartz and into cristobalite; and cristobalite into quartz and into tridymite. Moreover in numerous cases where, in conformity with Ostwald's principle, intermediate stages have been reached, it has been found without exception that by longer heating or by the use of a catalytic agent the appropriate stable form can be attained.

Preparation of quartz in aqueous solutions

Quartz may be prepared with facility by heating either silica glass or amorphous, precipitated silica in a steel bomb with water and sodic carbonate at 400° to 500° for two or three days.

In a slightly varying form of experiment artificial tridymite was employed and quartz crystals were obtained as usual. Artificial cristobalite likewise recrystallized as quartz. In no case has the presence of tridymite or cristobalite in preparations made in aqueous solution been detected, but, on the contrary, when the higher forms of silica have been used they have recrystallized as quartz.

Other inversions

The inversions of silica thus far described are characterized by a complete change in the outer form of the mineral, and can only be produced slowly and with difficulty. There is, however, a second class of inversions which take place almost instantaneously. The outer form of the mineral is retained, but the internal structure must necessarily be modified. These are the transformations of α- into β-quartz, of α- into β-tridymite, and of

α- into β-cristobalite. The method chiefly employed in investigation was that of heating-curves.

Inversion of α-quartz into β-quartz. By optical methods this inversion had previously been placed at 575°. The writer confirmed this, finding a well-defined break in the heating-curve at 576°. The change has been regarded as one from tetartohedral to hemihedral symmetry of the crystals.

Inversion of α-tridymite into β-tridymite. The hexagonal plates of tridymite are birefringent at ordinary temperatures, even on basal sections, but when heated they suddenly become isotropic. The inversion point has been placed by F. E. Wright at about 120°.

By the use of heating-curves the writer has found what appear to be two inversions, one at 117° and another, less pronounced but quite sharp, at 162°. The significance of this is not readily apparent and more investigation is required.

Inversion of α-cristobalite into β-cristobalite. The temperature at which the birefringent, low-temperature form changes to the isotropic state appropriate to the external symmetry of the crystals was placed by Mallard at 180°. F. E. Wright, working on spherulites formed by the devitrification of silica glass, found that Mallard's point was too low and determined it as approximately 225°. The writer, making use of cristobalite formed in various ways, and employing both optical methods and heating-curves, obtained rather remarkable results. On different preparations the point at which the break occurs on the heating curve has been found as high as 274°.0 and as low as 240°.1. On the cooling curve the break occurs as high as 236°.6 and as low as 209°.3. The first results obtained were much higher than the figures of Mallard and of Wright, and the explanation which suggested itself was that the abnormally high temperatures were due to hysteresis or to the presence of impurities in solid solution, but these possibilities were eliminated. It was found, however, that the temperature to which the silica was heated in con-

verting it into cristobalite, was certainly a factor affecting the inversion point of the resultant product, but it could not be considered that the whole effect was due to this cause. Such wide variations in the inversion point of a mineral appear very remarkable. A certain analogy is suggested to the behavior of antimony upon freezing.[2]

Relation of chalcedony to other forms of silica

The relation of chalcedony to quartz has been the subject of considerable discussion. As optical methods appear to have been pursued as far as possible without obtaining conclusive evidence, the writer has endeavored to attain a solution by working along other lines, and certain results of significance have been obtained. As quartz shows a sharp break at 575°, chalcedony should, if it is identical with quartz, show the same break. The region on both sides of 575° has been carefully explored by means of heating-curves, but so far chalcedony has failed to give any trace of a break.

A second class of experiments has had for their object the determination of the form into which chalcedony would invert when heated with sodic tungstate to temperatures near to but lower than 870°. A number of experiments have resulted in the formation of tridymite and of new quartz crystals.

On the supposition that chalcedony is the same mineralogically as quartz it is difficult to interpret these results, but on the supposition that it represents a different phase the results are perfectly consistent. The evidence therefore points to the existence of still another form of silica in chalcedony.

Recapitulation of inversions

The various inversions of silica may be briefly recapitulated.

At some unknown, but probably rather low temperature chalcedony passes into α-quartz (tetartohedral hexagonal), (the relation between the two may be monotropic),

575° α-quartz $\rightleftarrows$ β-quartz (hemihedral hexagonal),

[2] A. L. Day and R. B. Sosman, Am. Jour. Sci., 4th ser., **29**: 126. February, 1910.

870° ± 10° β-quartz $\rightleftarrows$ β-tridymite (holohedral hexagonal),

1470° ± 10° β-tridymite $\rightleftarrows$ β-cristobalite (isometric).

The above are all stable forms, each with a certain range of temperature, but on cooling β-tridymite or β-cristobalite, metastable forms result, as follows:

115°–120° β-tridymite $\rightleftarrows$ α-tridymite (biaxial, perhaps orthorhombic)

180°–270° (inversion point easily displaced and not definitely determinable) β-cristobalite $\rightleftarrows$ α-cristobalite (crystal character unknown, mineral may belong to any system but isometric).

There are thus apparently at least seven separate and distinct crystalline forms of silica.

It may be pointed out as a curious fact, whose significance is not known, that with rising temperature each form passes successively into one possessing a higher grade of crystallographic symmetry. Chalcedony, about which our knowledge is deficient, must, of course, be excluded from this general statement.

Geological Application

A brief examination may be made into the geological significance of the results which have been attained. Since the existence of tridymite and cristobalite became known the problem of the conditions under which they have been formed has been rather a baffling one. It is believed that from the results of this investigation answers may be given to some of the questions involved.

Ordinarily cristobalite forms crystalline deposits in small cavities in igneous rocks. These rocks bear evidence of having been subjected to corrosive agencies. The process of deposition may have involved a reaction between some volatile compound of silicon, such as the chloride or fluoride, with the vapor of water, or the decomposition of silicates or alumino-silicates by halogen acids, with the removal of the volatile halide and recrystallization of the silica. The difficulty which arises is to explain the deposition of cristobalite, whose field of stability lies above 1470°, in cavities in rocks which would certainly be in a

fluid condition at such a temperature, but in view of the repeated instances of the formation of cristobalite at temperatures well below the inversion point, which the writer has met in these investigations, the difficulty appears to vanish. It is quite probable that under such conditions as have been suggested cristobalite would be deposited at temperatures below 1470°.

With tridymite the case appears essentially the same. With either mineral it is only when in contact with a flux for a considerable length of time that the stable form is necessarily reached.

Effect of pressure upon the quartz-tridymite inversion point

All the inversion points which have been given have necessarily been determined under atmospheric pressure. It may be of interest to inquire into the effect which great pressure would have in increasing the range over which quartz is stable.

In the calculations which follow the numerical values which have been employed are only roughly approximate and at the best we can obtain merely the probable order of magnitude of pressure-effects.

For the purposes of the calculation we shall take the temperature of inversion under one atmosphere pressure as 870°, for the volume change a value derived from the differences in volume between quartz and tridymite at ordinary temperatures, or 0.057 cc. per gm., for the energy-change 15 calories, or approximately two-fifths of the energy involved in all the inversions from α-quartz to fused silica, according to the investigations of O. Mulert.[3] We may then employ the fundamental Clausius-Clapeyron formula, arranged as follows

$$\frac{dT}{dp} = \frac{T}{L}(v_2 - v_1)$$

in which $\frac{dT}{dp}$ is the increase in temperature for an increase of pressure of 1 gm. per cm^2.

[3] Zs. für Anor. Chem., Bd. 75, Heft 2, p. 206. May, 1912.

T = absolute temperature
L = latent heat, expressed in work units,
= $15 \times 4.1833 \times 1.02 \times 10^4$ gm. cm.*
= 15×42670 gm. cm.
$v_2 - v_1$ = increase in volume in cc. per gm.

By substitution

$$\frac{dT}{dp} = \frac{1143 \times 0.057}{15 \times 42670}$$

$= 0.000102°$ for 1 gm. pressure per cm².
$= 0.10537°$ per atmosphere.

Therefore 9.5 atmospheres will raise the inversion point 1°, and a column of rock 10,000 feet deep will raise the temperature 88°.

This is probably as close an approximation as we can attain with our present knowledge. In order to make a more precise calculation the specific volume of tridymite at high temperatures (up to and beyond 870°), and the energy-change involved in the transformation of quartz into tridymite must be determined. With this information available it should be possible to arrive at conclusions of great value regarding the conditions of temperature and pressure under which quartziferous rocks have crystallized.

Summary

The results of the investigation may be concisely stated as follows: Either tridymite or cristobalite may, under certain conditions, form at temperatures below their inversion-points. The favorable conditions, we believe, are those which induce rapid crystallization, such as the reactions of vapors or the sudden cooling of a melt. Either mineral, when formed under such circumstances, will probably persist to ordinary temperatures unchanged as regards the outer form. Quartz, on the other hand, will probably never be deposited at a temperature greater than 870° (i.e., neglecting the rather slight effect of pressure)

* 1 gm. cal. = 4.1833×10^7 ergs. (Landolt-Börnstein tables, p. 810.)
1 erg. = 1.02×10^{-8} kg. metres = 1.02×10^{-2} gm. centimetres.
∴ 1 gm. cal. = $4.1833 \times 1.02 \times 10^4$ gm. cm.

and if either tridymite or cristobalite, formed under any conditions, be kept in contact with a melt in which it is slightly soluble, for a comparatively short time at a temperature below 870°, it will pass over into quartz, and no record will be left of the previous existence of the higher form.

The α-β inversions of each of the three minerals are of a different class. They take place immediately when the appropriate temperature is passed in either direction, and the value of the α-β inversion-point of quartz at 575° as establishing a point on the geological thermometer, is left unchanged by the present investigation.

HELMINTHOLOGY.—*Further notes on Tricoma.* N. A. Cobb. Communicated by F. V. Coville.

In the years 1888 and 1889, while carrying on some investigations at the zoological station at Naples, where thru the liberality of the British Association for the Advancement of Science, I had the use of one of its tables, I discovered a remarkable nematode—so remarkable indeed, that competent helminthologists have repeatedly expressed doubt as to whether it is really a nematode.

Later a short note on this species was published in the *Proceedings of the Linnean Society*[1] (N. S. W.) under the title, *Tricoma* and other New Nematode Genera, concluding with the words "These few notes comprise all that is known concerning the structure of a worm, which, were it less remarkable, I should not notice at this writing."

The note in the *Proceedings* was accompanied by two carefully drawn figures, one of the head and the other of the tail. Unfortunately the only preserved specimen in existence at that time was lost immediately after the drawings were made, so that no further details were available. However, before the specimen was lost I had become thoroly satisfied that it was a nematode of typical internal organization, but with an unusual development of the cuticle. This development is so exceptional as

[1] Vol. viii (Series 2). October 25, 1893.

to obscure the natural relationships of the species. These first came to light thru a careful microscopic investigation of the internal anatomy.

Tho the published figures mentioned above are accurate so far as they go, they are unfortunately incomplete, and this incompleteness of observation led to the adoption of a generic name, *Tricoma*, which is misleading. Instead of three cephalic setae, there are four. Later researches have shown that the setae on these worms are very fragile, and even now, in spite of the examination of a larger number of specimens, a full knowledge of the setae has not been obtained. It is certain, however, that all the known species possess four cephalic setae.

During visits to the Island of Jamaica I have latterly come across a second species of *Tricoma*, inhabiting marine algae and adjacent sand. As very few specimens were found, the inference is that the individuals are not common. All those found came from near low tide mark on open, rocky sea-shores subject to the unosbstructed action of ocean waves. Soon after discovering the Jamaican species I received, thru the kindness of my friend, Mr. F. Muir of Honolulu, a collection of free-living nematodes from Larat, an island off the east end of New Guinea, and in this collection also there were a few specimens of *Tricoma*.

Prof. E. Bresslau, writing from Strassburg, informs me that he observed a specimen of *Tricoma cincta* on the coast of Heligoland in the North Sea.

It thus appears that *Tricoma* is a genus having a very wide distribution.

The accompanying figures are largely self explanatory. It is only necessary to add a few words concerning the missing features.

The single cephalic seta, *c*, was drawn from another specimen on which it grew. The setae, *bb*, drawn with dotted lines, are reconstructions on the basis of the seta, *c*. Here and there on the figures irregular scattered setae are shown. These are the ones that actually existed on the specimen drawn. The dots indicate the annules of the cuticle on which the stumps of broken off setae were observed. It will be seen, therefore, that

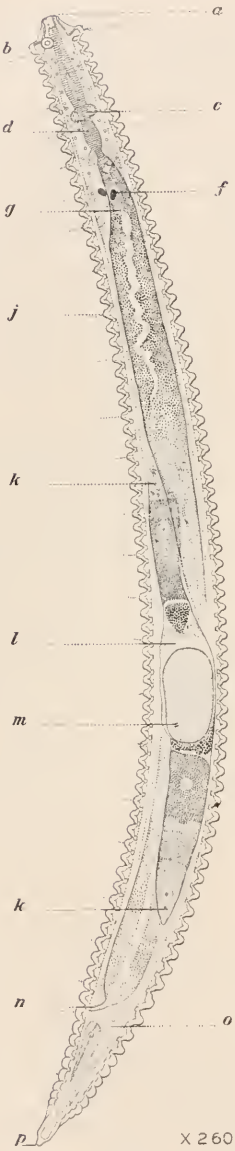

Fig. 1. Female of *Tricoma similis*, n. sp.

a, mouth opening and pharynx;
b, reconstructed cephalic seta;
c, nerve ring;
d, esophagus;
f, eye-spot;
g, intestine;
j, annule of the cuticle;
k, blind end of ovary;
l, location of the vulva;
m, nucleus of egg;
n, anus;
o, one of the three caudal glands;
p, spinneret.

the worms are hairy thruout. The mouth cavity is very small, prismoid and unarmed. Three obscure lips occur. Neither the Jamaican species, *T. major*, nor the Larat species, *T. similis*, appear to possess the cephalic alae observed in *T. cincta*. Otherwise the head on all three species has practically the same form, namely, approximately that of a quadrangular, blunt, truncated pyramid, with two edges of the pyramid ventrally submedian and the other two dorsally submedian. The four corners of the base of the pyramid project slightly and to them are attached the four cephalic setae. No labial papillae have been seen. There is some uncertainty about the function of the two pigmented submedian bodies behind the base of the neck. Their form, number and position somewhat favor the supposition that they are eye-spots, but if so they are farther back than in any species of nematode known to me. No lateral organs have been seen. There occurs uniformly in three specimens of *T. similis* an organ of considerable size in the body cavity on the ventral side just behind the oesophagus. It seems probable that this is the ventral gland and that it has a smaller companion cell in its rear, after the manner of the ventral gland in *Spilophora*, *Chromadora* and related genera.

In this species the ventral excretory pore appears to be in the seventh annule. The caudal glands are confined to the tail and empty thru the relatively massive, nipple-shaped spinneret. The female sexual organs are double, symmetrical and outstretched. The eggs appear to be deposited before segmentation begins. The male possesses a single outstretched testicle. The spicula are two in number and equal, and are accompanied by a well developed accessory piece.

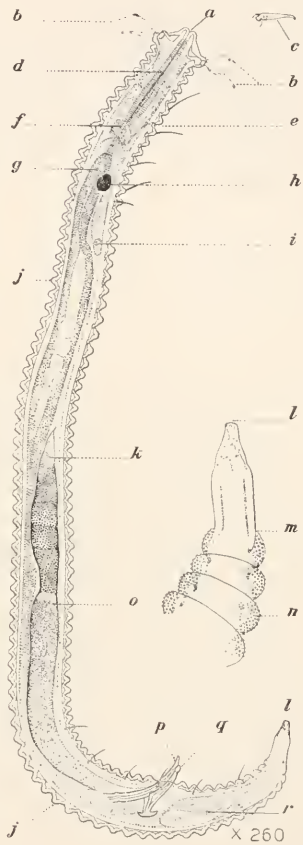

Fig. 2. Male of *Tricoma similis*, n. sp.

a, mouth and pharynx; *b*, reconstructed cephalic setae; *c*, drawing of single seta of another specimen; *d*, esophagus; *e*, excretory pore; *f*, nerve ring; *g*, intestine; *h*, eye-spot (?); *i*, ventral gland (?); *j*, annule of the cuticle; *k*, blind end of testicle; *l*, apex of the spinneret; *m*, base of the spinneret; *n*, tuberculate surface of annule; *o*, uterus; *p*, one of the 2 spicula; *q*, accessory piece; *r*, one of the 3 caudal glands.

The following are the known species of *Tricoma:*

1. *T. cincta*, Cobb. Marine sand, Bay of Naples.

Dimensions unknown.

2. *T. similis*, n. sp. Larat, East Indies. Eye-spots at the twelfth annule. Male tail of eleven annules.

38							40						
2·	8·	13·	–57–	90·	0·6 mm.		0·7	11·	15·	–M	83·	0·5 mm.
5·	7·	7·	8·	5·			2·1	5·7	5·8	6·5	6·3	

3. *T. major*, n. sp. Jamaica, West Indies. Eye-spots at the ninth annule. Male tail of seven annules.

Female unknown.

			40		
1·3	5·9	9·5	–M	92·	0·9 mm.
3·4	4·5	5·4	5·6	4·2	

It is proposed at a later date to publish detailed descriptions of the latter two species.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOGRAPHY.—*Kostarika: Beitraege zur Orographie und Hydrographie.* H. PITTIER in Dr. A. Petermann's Geographische Mitteilungen, Ergaenzungsheft no. 175, July 20, 1912; with a map and six profiles.

This paper gives a part of the scientific results of the author's surveys in Costa Rica, from 1887 to 1903. For the introduction, a short historical sketch of the cartography of the country is given, together with a description of the methods followed in the topographical survey and the subsequent construction of the map. This is followed by a detailed study of the mountain and river systems, with frequent discussions of the geological factors which have affected the general relief of the country.

The memoir contains also a list of nearly 500 altitudes arranged alphabetically. From this it is seen that the highest summit in the country is 3832 m., or about 12,572 feet, above sea level, an altitude much higher than has been admitted heretofore. For a concluding chapter, the author expresses his views on the much disputed boundary question between Costa Rica and Panama, and tries to show the injustice of the Loubet award.

The map is on the scale of 1: 500,000 and measures 83 x 71.5 cm. It gives in distinct colors the altitudinal zones and is executed with the usual care of all the publications of the justly celebrated German firm of Justus Perthes. The profiles are reproductions of the tours d'horizon used in connection with the astronomical triangulation of the country. H. P.

METEOROLOGY.—*Daily changes in temperature up to 4000 meters.* ALFRED J. HENRY. Bulletin Mount Weather Observatory **5**: 1–18. 1912.

This paper is a discussion of the 24-hour accidental changes in temperature of the free air from the ground to 4000 meters above sea level as determined by means of kite flights made at Mount Weather, Va. Inasmuch as only flights made on consecutive days and to approximately the same altitude could be used the total number of flights available was less than 100 and for that reason the results reached are perhaps a trifle uncertain.

The accidental changes in temperature in the free air to warmer and colder, respectively, is a subject about which comparatively little is known. On the earth's surface, however, it is known that in a general way changes to lower temperature are greater in magnitude and occur with greater frequency than those of an opposite character. In a measure this is also true of the free air up to the altitude mentioned. There appears to be a point in the free air above Mount Weather where the accidental changes are at a maximum value. In rising temperature in winter the accidental changes are greatest between the 1 and $1\frac{1}{2}$ kilometer levels above sea where they are several degrees greater than at the ground on the mountain top. This is also true of falling temperature, the greatest change, however, extends thru a deeper stratum, viz., from the first to the second kilometer above sea or from 1553 to 4833 feet above the mountain top. This characteristic is much less pronounced in summer than in winter.

A comparison between the temperature of the free air in the ascent and the descent of the kites, respectively, shows that the temperature of the air is changing by small amounts practically all the time. Naturally the greatest changes are recorded under the influence of a nearby storm-center, as when a warm southerly wind is replaced by a cold northerly one. A typical case was investigated; it showed an hourly fall of 0.9°C. which if continued for 24 hours would amount to 21.6°C. or 39.6° F. This amount is believed to closely approximate the true daily fall under extreme weather conditions.

It was found that changes in the free air temperatures above Mount Weather in the layers below 4000 meters occurred under very definite pressure distribution, that is to say, changes to higher temperatures almost invariably occur when the region to the east and northeast is occupied by an area of high pressure and the Mississippi valley or the upper Lake region is occupied by low pressure. Mount Weather is

then in the transition region between a high which is retreating to the eastward and a low which is advancing from the west. In cases of falling temperature in the free air the pressure distribution just described is reversed.

The pressure distribution in the two cases above mentioned are practically those which control accidental temperature changes in the air which rests upon the earth's surface whence it appears that the entire mass of the lower air up to at least 4000 meters, 2.5 miles is similarly conditioned with respect to accidental temperature changes. That accidental temperature changes such as those discussed in this paper do not cease at the 4000 meter level is evidenced by the sounding balloon ascensions made under the direction of the Mount Weather Observatory.

A. J. H.

PHYSICS.—*Instruments and methods used in radiometry. II.* W. W. Coblentz. Bulletin Bureau of Standards **9**: 7–63. 1912.

In this paper is given an account (see Bulletin, Bur. of Stds., Reprint No. 85) of the recent development and improvement of spectral radiation instruments. This includes air- and vacuum bolometers, thermopiles, and radiomicrometers: new combinations of instruments; linear and surface thermopiles of bismuth-silver of high sensitivity; and (Note I) the Callendar radio-balance.

The aim of the research was the production of instruments of precision rather than the attainment of high sensitivity. The vacuum bolometer was found to excel all the other types of radiometers in accuracy, in speed, and in range of sensitivity. The instrument is difficult to handle and for most work the bismuth-silver thermopile is recommended. The latter is as sensitive as a bolometer. The novelty of this type of thermopile is the solid surface which is exposed to radiation, thus utilizing all the energy from a spectral line, which is not possible with the type of iron-constantan thermopile in present use. The various modifications of these thermopiles are applicable to radiation pyrometers, sunshine recorders, and thermogalvanometers for measuring weak alternating currents.

W. W. C.

CHEMISTRY.—*On a modified form of stability test for smokeless powder and similar materials.* H. C. P. Weber, Bureau of Standards. Bulletin Bureau of Standards **9**: 119–129. 1912.

The stability test is a form of the so-called explosion test. In the German test the sample is heated to 135°C. and the length of time is

noted until the sample explodes. In the other form of high temperature test the temperature of the sample is gradually raised until a point is reached at which the sample explodes or at least decomposes with explosive violence.

The decomposition of products of this class is exothermic and autocatalytic and the temperature of the decomposing material may be few or many degrees removed from the temperature of the heating bath. The amount of this difference will depend on a number of variables, such as the mass of the material, its heat conductivity and the heat conductivity of the systems used for test. These factors enter into the German 135° test as well as into the ordinary high temperature explosion test. In the former, the time will vary with the heat insulation, in the latter the explosion temperature will vary with the rate of heating.

The proposed test consists in the determination of a time temperature explosion curve. The samples are chosen small enough to practically eliminate the factor of heat conductivity of the sample. The apparatus consists of a heating bath which may be kept at various constant temperatures. For this work the temperatures chosen were 200°C.; 180°C.; 170°C.; 160°C. The length of time necessary for a sample to explode is determined with the aid of a stop watch at one constant temperature and then at the next and so on. The results are plotted in a curve with time and temperature as ordinates and abscissae.

That the results are reproducible to within a few per cent is shown by numerous repetitions. After the curve has been plotted by means of three or four points, determinations made at intermediate temperatures fall on the curve. The curve is therefore characteristic of the sample. It represents in effect the rate of change of decomposition velocity with change of temperature and as such is an index of the stability of the powder.

Inspection of the curves show that for stable powders there is a pronounced bend, while the ratio of explosion periods at 200°C. and 160°C. is at least 2 : 9. In the unstable powders this ratio falls as low as 2 : 3 and the irregularities become greater. It also becomes evident that one explosion temperature, even if time is considered, does not give much information.

It is possible that with sufficient accumulated data the test may throw some light on the actual effect of a stabilizer on the natural decomposition velocity of powders.

A short résumé of the literature on stability tests is given.

H. C. P. W.

CHEMISTRY.—*Application of the dimethyl sulfate test for determining small amounts of petroleum or asphalt products in tars.* CHARLES S. REEVE and RICHARD H. LEWIS, Office of Public Roads. Eighth International Congress of Applied Chemistry, 1912.

This paper, after briefly reviewing the literature on the dimethyl sulfate test, notes that the best method to date fails to detect the presence of open-chain hydrocarbons in tar-asphalt mixtures when the asphalt or petroleum is 10 per cent or less of the mixture. Commercial specifications are now being drawn which require less than 10 per cent of asphalt in mixtures with tar. The authors proceed to show that as low as 3 per cent of asphalt or petroleum can be detected in these mixtures by making the dimethyl sulfate test on higher boiling fractions (315°C.-350°C. and 350°C.-370°C.). Tables of experimental data are given.

The results do not give any absolute idea of either the amount or exact nature of the material which has been fluxed with the tar. It is thought possible, however, that the improvement which has been made in the test will enable the chemist to ascertain whether his specifications are being fulfilled, by checking up the material supplied against laboratory mixtures of the same amount and grades of materials required. C. S. R.

ANALYTICAL CHEMISTRY.—*Determination of manganese as sulfate and by the sodium bismuthate method.* WILLIAM BLUM. Bulletin of the Bureau of Standards **8**: Reprint 186.

Manganous sulfate is the only compound adapted to accurate weighing of manganese, either in gravimetric analysis, or in obtaining a definite amount of manganese as a primary standard. Of the various volumetric methods considered, the bismuthate method appeared to be most nearly free from the influence of the precise conditions of operation, and therefore most suitable for use as a standard method.

This method depends upon the oxidation of manganese to permanganic acid by sodium bismuthate in nitric acid solution. After filtration thru asbestos to remove the excess of bismuthate, ferrous sulfate is added in slight excess, which is then titrated with permanganate of known manganese value and of known ratio to the ferrous sulfate. The method of standardizing the permanganate is of course fundamental, and forms the principal subject of this paper. The manganese value may be determined by two general methods: (a) titration of a known amount of manganese, e.g., as $MnSO_4$, under the conditions of opera-

tion; and (b) calculation from the oxidizing value of the permanganate, derived from some accurate oxidimetric standard, such as sodium oxalate. The former would be more satisfactory, provided a simple and accurate means of obtaining a known amount of manganese is available. Otherwise the latter is preferable, tho it involves the use of a conversion factor, which may be either theoretical or empirical. Since Brinton and others claimed that the sodium oxalate values were 1 per cent lower than those derived from manganous sulfate, the subject was studied in detail.

A study of the standardization of permanganate with sodium oxalate showed that the conditions recommended by McBride must be slightly modified for use with 0.03 N permanganate, the strength usually employed for the bismuthate method; since the relative errors caused by variation in conditions with 0.03 N permanganate may be much larger than with 0.1 N. By the use of a small volume in the titration the errors from this source are reduced to a minimum.

After it was found that heating for a considerable period at temperatures of 450–500° is necessary to obtain anhydrous normal manganous sulfate, and that the salt does not begin to decompose unless heated above 550°, solutions of known manganese content were prepared by dissolving a definite weight of manganous sulfate which had been heated to constant weight at 450°–500°.

A study of the effect of conditions upon the bismuthate oxidation, showed that for amounts of manganese up to 0.05 gram, accurate results may be obtained over a wide range of conditions, viz., at from 5° to 25° in a volume of 50 to 150 cc., containing 20 to 40 per cent nitric acid by volume, filtration after standing one-half minute or one-half hour with bismuthate; addition of ferrous sulfate immediately or after one-half hour. The results were accurate in the presence of as much as 3 grams of iron. Addition of phosphoric acid to the ferrous sulfate solution rendered the end points more distinct. The only conditions found which yielded inaccurate results were (a) deficiency of nitric acid, (b) failure to agitate after addition of bismuthate, and (c) allowing the solution to stand after addition of the excess of ferrous sulfate. For analyses of rich ores and similar high grade materials, the use of 0.1 N permanganate is recommended, permitting the use of about 0.1 gram sample.

Experiments upon seven permanganate solutions, of different strength (0.03 N and 0.1 N), prepared from different sources, showed that the values derived from sodium oxalate and manganous sulfate agreed in

every case to within 1 part in 500. The accuracy of these values was confirmed by analysis of specially purified potassium permanganate crystals and by additional experiments upon the reduction and reoxidation of permanganate solutions. Comparative analyses of the Bureau of Standards manganese ore, as well as other ores, showed that the tendency of many of the commercial methods is to yield high results for manganese.

The bismuthate method is recommended as equal or superior to any other known methods for the determination of manganese, whether present in large or small amounts. W. B.

BOTANY.—*The branching habits of Egyptian cotton.* ARGYLE MCLACHLAN. Bulletin Bureau of Plant Industry No. 249. 1912.

The relationships of the two kinds of branches of Egyptian cotton are discussed. Vegetative branches are borne either in or outside the leaf axils at the lowest ten nodes or so of the main axis and are frequently nearly as large as the axis in actual length and in number of nodes. They do not bear flower buds, but, like the main axis, bear fruiting branches.

Fruiting branches are borne outside the axil at each node of the main axis, beginning at about node 12 from the base; they are shorter than vegetative branches, being only 6 to 8 nodes long; bear a flower bud at each node opposite a leaf, and are further distinguishable by the long basal internode. Fruiting branches borne by vegetative branches are termed secondary fruiting branches. Seemingly axillary fruiting branches occur on the main axis and on fruiting branches. It has been suggested that the first mentioned are secondary fruiting branches of axillary vegetative branches themselves suppressed.

A large vegetative branch and a fruiting branch never occur together at a node in Egyptian cotton. The further facts, that a vegetative branch sometimes replaces a fruiting branch; that branches of intermediate form with long basal internode, robust growth and no flower buds occur infrequently in the places of fruiting branches; and that cases of fruiting branches as low as node 5 or 6 of the main axis have been observed indicate that homology may exist between large basal vegetative branches and fruiting branches, rather than between the large basal vegetative branches and axillary vegetative branches of smaller size which sometimes occur with fruiting branches. A few nodes on the main axis above the basal vegetative branches but below the fruiting branches usually bear no branches, but sometimes produce abortive branches or branches of an intermediate nature.

Some fluctuation in number and size of vegetative branches and in location of the earliest fruiting branch is observed in different locations, on different soils, and under various modes of culture, the habits of branching of Egyptian cotton being governable to large extent thru cultural means. A. M.

BOTANY.—*On the identity of Cyathea multiflora, type of the genus Hemitelia R. Br.* William R. Maxon. Bulletin Torrey Club **38**: 545–550. Pl. 35. 1911 (published January 6, 1912).

In the original description of *Cyathea multiflora* the source of the specimen was given as Jamaica. It is here shown, after examination of a photograph and fragments of the type that it agrees with none of the many elements commonly included in *Hemitelia multiflora* but represents, instead, a rather common species of Central America usually known as *Hemitelia nigricans* Presl. Further data at hand indicate that the citation of Jamaica as the original locality is erroneous. The paper is illustrated by a photograph of the type in the Banksian Herbarium.

P. C. Standley.

BOTANY.—*Studies of tropical American ferns. No. 3.* William R. Maxon. Contr. U. S. National Herbarium **16**: 25–62. Pls. 18–34. 1912.

The paper consists of seven parts, the first being a revision of the North American species of Hemitelia, subgenus Cnemidaria. Twenty-one species are recognized in this group, 8 of which are new, while one new combination is formed. A key is given for the determination of the species and most of them are fully described. In Further Notes on the West Indian Species of Polystichum, a new species is described from Jamaica, one new combination is formed, and brief notes are given upon other members of the genus. In the third part of the paper the name Pteropsis is adopted in place of Drymoglossum, and a key is given to the three North American species, one of which, from Costa Rica, is described as new. Under the heading of Two Unusual Forms of Dicranopteris mention is made of two aberrant specimens which seem to represent a reversion to some generalized ancestral type of the genus. In the fifth article, The American Species of Cibotium, four species are recognized, all from Mexico and Central America. The sixth, Two New Species of Notholaena, consists of descriptions of *Notholaena leonina* and *N. rosei*, both from Mexico. The concluding article, Miscellaneous Notes and Changes of Name, contains brief notes on miscellaneous species of various genera. P. C. Standley.

BOTANY.—*A remarkable new fern from Panama.* WILLIAM R. MAXON. Smithsonian Miscellaneous Collection **56**: no. 24. Pp. 1–5, with 3 plates. November 22, 1911.

A description of *Polypodium podocarpum*, a new species from the Cordillera of Chiriqui. This plant is unusual for the genus in having fronds of indeterminate growth and the sori borne at the apices of lobes of the pinnae. Its morphology is otherwise peculiar.

P. C. STANDLEY.

BOTANY.—*Maturation artificielle lente de la datte Deglet-nour.* WALTER T. SWINGLE. Comptes Rendus **155**: 549–552, no. 12. September 16, 1912.

Deglet Noor date palms from Algeria, introduced into Arizona and California in 1900, have never properly ripened their fruit on the tree although the total heat in some parts of these states exceeded that necessary for the ripening of this date in the Algerian Sahara.

A satisfactory method of artificial ripening is therefore necessary. Slow artificial ripening at a low temperature gives much better results than any chemical means hitherto employed, and is perhaps still more important than the incubation system used by Prof. George F. Freeman of the University of Arizona.

Attention was first called to this new method by the transformation of unripe, yellowish, bitter fruits into delicious, amber-colored, translucent dates within ten days. These dates were in a valise and remained at a temperature of 20° to 30° C. in hotels or sleeping cars during a trip from Mecca, California, to Washington, D. C.

As it seemed probable that the slow ripening which had taken place in the valise is similar to that which takes place in the boxes of dates shipped from the Algerian or Tunisian Sahara to Biskra and Marseilles for packing and exportation, opportunity to investigate this question was taken on a trip to Africa in December, 1911. As a matter of fact, most of the dates in the boxes shipped from the Sahara are ripened by this slow process to which, however, no attention has ever been given.

Date ripening is composed of two distinct phases—the botanical ripening in which the fruit attains its size and has a ripe seed, and the true ripening during which the cane sugar becomes inverted sugar and the diffused tannin is deposited in insoluble form in the giant cells.

While the important factor in botanical ripening is heat, humidity is essential for true ripening. The air surrounding the fruit must be saturated by the moisture given off by the dates as they dry and become

wrinkled. This is the case in the boxes used for shipping the dates from the Sahara to Marseilles.

The Deglet Noor may ripen on the tree in many of the Saharan cases but this cannot take place in the southwestern United States because of the extreme dryness in the deserts.

A good system of slow artificial ripening for Deglet Noor dates may become important in Algerian and Tunisian commerce. Further experiments are necessary, however, for securing conditions of humidity and temperature best suited to this method.

MAUDE KELLERMAN.

BACTERIOLOGY.—*The virulence of Bacillus pestis of ground-squirrel origin.* GEORGE W. MCCOY and CHARLES W. CHAPIN. Public Health Bulletin No. 53, U. S. Public Health Service, 1912.

At the Federal Laboratory at San Francisco, there have been isolated during a period of three years, a large number of cultures of the plague bacillus from naturally infected ground-squirrel (*Citellus beecheyi*, Richardson). The virulence of 68 cultures was tested, wild rats being used as the test animals. One of the cultures indistinguishable from any of the others was found to be avirulent. The others were fatal to the test animals. The avirulent culture immunized against a virulent culture of the plague bacillus. G. W. M.

BACTERIOLOGY.—*A note on the susceptibility of ground-squirrels (Citellus beecheyi, Richardson) to tuberculosis.* GEORGE W. MCCOY and CHARLES W. CHAPIN. Public Health Bulletin No. 53, U. S. Public Health Service, 1912.

This paper supplements a previous one in which the presence in nature of tuberculosis among ground-squirrels was reported. The organism was shown to agree with the bovine type of *B. tuberculosis.*

The present paper reports the results of artificial infection of ground-squirrels. The results indicate that they are uniformly susceptible to the disease, death occurring in from 46 to 98 days. G. W. M.

BACTERIOLOGY.—*Immunity of wild rats (Mus norvegicus) to plague infection.* GEORGE W. MCCOY and CHARLES W. CHAPIN. Public Health Bulletin No. 53, U. S. Public Health Service, 1912.

Observations made in San Francisco three years prior to the present experiments showed that there was a considerable degree of immunity to plague infection among the wild rats. Another series of experiments

was carried out to determine the extent of immunity three years after the subsidence of the epizootic in the city. An attempt was also made to determine the relative susceptibility of rats of different sizes, and the susceptibility to varying doses of culture. It was found that three years after the epizootic many of the rats found in San Francisco were immune to plague. The size of the rats was found to be of comparatively little importance in determining the success of the inoculation but the dose of the culture had a very marked influence. G. W. M.

BACTERIOLOGY.—*Susceptibility of a ground squirrel (Ammospermophilus leucurus, Merriam) to plague.* George W. McCoy and Charles W. Chapin. Public Health Bulletin No. 53 U. S. Public Health Service, 1912.

Ammospermophilus leucurus is a small ground-squirrel found in California. Nine of the rodents were used for the purpose of determining their susceptibility to plague. The experiments proved fatal in every case and in the majority a high degree of plague septicaemia developed.

G. W. M.

TECHNOLOGY.—*Physical testing of mechanical rubber goods.* Circular No. 38, Bureau of Standards. 1912.

This circular outlines the methods used at the Bureau of Standards for determining the physical properties of rubber and gives a brief description of the processes of manufacture, beginning with the collection of crude rubber, and including processes for reclaiming rubber. The tension test is the most widely applicable, being used to determine the more important physical properties such as elasticity, strength, and ultimate elongation. Machines and apparatus for conducting these tests have been designed and constructed at the Bureau of Standards.

In preparing samples for test a die is used which insures uniformity of size. Gage marks are placed on the test piece from which the permanent set and ultimate elongation are measured. Results of tests are shown graphically, illustrating the characteristics of various rubber compounds. The effect of continued heat at 160°F. on different rubbers is shown and these tests are being extended with a view to establishing an accelerated aging test. An analysis of the distribution of stress in a ring test piece is given showing that as a result of the uneven distribution of stress the ring method does not develop the full tensile strength of rubber. This result has been verified by tests.

P. L. Wormeley.

REFERENCES

ECONOMIC BOTANY.—Publications of the Bureau of Plant Industry, Department of Agriculture, from January 1 to June 30, 1912, as follows: *An improved method of artificial pollination in corn.* G. N. Collins and J. H. Kempton. Circular No. 89. Pp. 7, figs. 2.

A plant-disease survey in the vicinity of San Antonio, Texas. Frederick D. Heald and Frederick A. Wolf. Bulletin 226. Pp. 129, pls. 19 and figs. 2.

Absorption and excretion of salts by roots, as influenced by concentration and composition of culture solutions. Rodney H. True and Harley Harris Bartlett. Bulletin 231, Pp. 36, pl. 1, figs. 21.

Wild volatile-oil plants and their economic importance: I. Black Sage; II. Wild Sage; III. Swamp Bay. Frank Rabak. Bulletin 235. Pp. 37, figs. 6.

The wilting coefficient for different plants and its indirect determination. Lyman J. Briggs and H. L. Shantz. Bulletin 230. Pp. 83, pls. 2, and figs. 9.

Agricultural varieties of the cowpea and immediately related species. C. V. Piper. Bulletin 229. Pp. 160, pls. 12.

Heterozygosis in evolution and in plant breeding. E. M. East, assisted by H. K. Hayes. Bulletin 243. Pp. 58, pls. 8.

ENGINEERING.—*Publications of the Office of Public Roads, Department of Agriculture,* in 1912, as follows: *Inorganic road Materials.* E. C. E. Lord. To be published in the Year Book, 1912.

Highway bridges and culverts. Charles H. Hoyt and William H. Burr. Bulletin No. 43.

The physical testing of rock for road building. Albert T. Goldbeck and Frank H. Jackson, Jr. Bulletin 44.

The physical testing of broken stone railroad ballast. A. T. Goldbeck and F. H. Jackson Jr. Paper before the International Association for Testing Materials. VIth Congress. 1912.

Oil-mixed portland cement concrete. Logan Waller Page. Bulletin 46.

Effect of diameter of bitumen holder on the penetration test. C. S. Reeve, Office of Public Roads. Sixth Congress of the International Association for Testing Materials. 1912.

PROGRAMS AND ANNOUNCEMENTS

THE XIX INTERNATIONAL CONGRESS OF AMERICANISTS, 1914

In the fall of 1911 a number of delegates to the past Congresses of the Americanists met in Washington, under the auspices of the Smithsonian Institution and the Anthropological Society of Washington, for the purpose of taking preliminary steps toward extending an invitation to the Congress at its London meeting, to hold its nineteenth session, in 1914, at Washington. A temporary organizing committee was selected, consisting of Prof. W. H. Holmes, chairman; Mr. F. W. Hodge, and Dr. A. Hrdlička, secretary. This committee entered into communication with the principal local institutions and organizations which are interested in the work of the Americanists, and by May 1, 1912, a formal invitation to the Congress was agreed upon by the Smithsonian Institution, the Anthropological Society of Washington, the George Washington, Georgetown, and Catholic universities, and the Washington Society of the Archeological Institute of America. A list of names of persons to form the permanent organizing committee was agreed upon and Dr. Hrdlička was instructed to present the joint invitation with the list just mentioned to the council of the London meeting of the Americanists, which was done, and both were accepted without objection. In addition an official invitation from the Bolivian government was accepted for a second session, to be held at La Paz following that in Washington.

On October 11, 1912, the permanent committee for the Washington session met in the U. S. National Museum for organization. Its membership is as follows: Messrs. Franklin Adams, Frank Baker, Chas. H. Butler, Mitchell Carroll, Charles W. Currier, A. J. Donlon, J. Walter Fewkes, Alice C. Fletcher, Gilbert H. Grosvenor, F. W. Hodge, H. L. Hodgkins, William H. Holmes, Walter Hough, Aleš Hrdlička, Gillard Hunt, J. F. Jameson, George M. Kober, D. S. Lamb, Chas. H. McCarthy, James Mooney, J. Dudley Morgan, Clarence F. Norment, Thomas J. Shahan, H. J. Shandelle, George R. Stetson, Chas. H. Stockton, J. R. Swanton, Harry Van Dyke, Charles D. Walcott, and M. I. Weller.

The elections of officers resulted, in the main, as follows: *Patron of the Congress*, The President of the United States; *President of Organizing Committee*, Mr. W. H. Holmes, Head Curator, Department of Anthropology, U. S. National Museum; *Secretary*, Dr. A. Hrdlička, Curator, Division Physical Anthropology, U. S. National Museum; *Auxiliary Secretaries*, Dr. Chas. W. Currier and Mr. F. Neumann; *Treasurer*, Mr. C. F. Norment; *Head of General (honorary) Committee*, Dr. Charles D.

Walcott, Secretary of the Smithsonian Institution; *Committee on Finance,* Dr. George M. Kober; *Committee on Arrangements and Entertainment,* Prof. Mitchell Carroll, General Secretary Archeological Institute of America; and *Committee on Printing and Publication,* Mr. F. W. Hodge, Ethnologist in Charge of the Bureau of American Ethnology.

The sessions of the Congress will be held, thru the courtesy of the authorities of the Smithsonian Institution in the new building of the National Museum. The exact date for the meeting will be decided upon later, in accordance with the wishes of the majority of the delegates to the Congress, but the month will, in all probability, be September. Active preparations for the session, which promises to be one of the most important ever held by the Americanists, will be begun without delay.

A. Hrdlička,
Secretary of the Committee on Organization.

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January 4, 1912.

JOURNAL

OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED SEMI-MONTHLY

EXCEPT IN JULY, AUGUST AND SEPTEMBER, WHEN MONTHLY,

BY THE

WASHINGTON ACADEMY OF SCIENCES

OFFICE OF PUBLICATION
THE WAVERLY PRESS
BALTIMORE, MD.

Journal of the Washington Academy of Sciences

THE JOURNAL OF THE WASHINGTON ACADEMY OF SCIENCES is a semi-monthly publication and will be sent to subscribers on the fourth and nineteenth of each month, except during the summer, when it will appear on the nineteenth only. Altho the first volume began with the July issue it will end with 1911 and subsequent volumes will correspond to calendar years.

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January 19, 1912.

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OFFICE OF PUBLICATION
THE WAVERLY PRESS
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PROGRAMS AND ANNOUNCEMENTS

PHILOSOPHICAL SOCIETY OF WASHINGTON

The 706th meeting will be held at the Cosmos Club March 9, 1912 at 8:15 P.M. Dr. C. G. Abbot: *Experiments on the light of the sky.* Dr. T. A. Bauer: *On the formation of the solar corona and the total solar eclipse of October 9–10, 1911.*

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ANNOUNCEMENTS

The Washington Academy of Sciences will hold an exhibit on the evening of Thursday, March 28, 1912, at the New National Museum, to which the members of the Affiliated Societies and their friends are invited.

It is intended to exhibit at this meeting new apparatus, methods, and results from various government bureaus and other scientific institutions of Washington. Arrangements will be made to have some of the apparatus in operation. Much of this apparatus is of special interest and is but little known outside of the institutions where it is in use, and will be here exhibited for the first time.

The Chemical Society of Washington will hold a special meeting at the Cosmos Club, Friday Evening March 22, when Dr. A. M. Comey will lecture on *The testing of explosives.*

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May 4, 1912.

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Vol. II. No. 10.

May 19, 1912.

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Vol. II. No. 11.

June 4, 1912.

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June 19, 1912.

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Vol. II. No. 14.

August 19, 1912.

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September 19, 1912.

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Vol. II. No. 16.

October 4, 1912.

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Vol. II. No. 18.

November 4, 1912.

JOURNAL

OF THE

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PUBLISHED SEMI-MONTHLY
EXCEPT IN JULY, AUGUST AND SEPTEMBER, WHEN MONTHLY,

BY THE

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November 19, 1912.

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Vol. II. No. 20.

December 4, 1912.

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