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Eastern States Division

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EASTERN STATES DIVISION

VOL. XXX OCTOBER, 1952 NO. 1

OFFICERS OF THE ASSOCIATION

NOTICE TO AUTHORS

Manuscripts are to be submitted to associate editors of the appropriate section and *may* be submitted directly to the editor in chief. Clear manuscript, preferably typed, with wide margin to the left, with double spacing between lines, is desirable. Please try to follow the typographical style of the most recent issue of the Bulletin. Line drawings should be submitted on Bristol board, or similar material, and done in India ink. Figure number should be written on this in pencil. Titles for drawings, with figure numbers, should be typed on a separate sheet. Please try to minimize footnotes. Appended references and bibliographies, clearly so marked, should be done in the style of the A.A.A.S. publication, *Science*.

Program

Twenty-seventh Annual Meeting
of the
AMERICAN ASSOCIATION OF JESUIT SCIENTISTS
EASTERN STATES DIVISION
Fordham University
AUGUST 25, 26 AND 27, 1952

FIRST GENERAL MEETING

Monday, August 25, 1952 at 7:00 P.M. in Freeman Hall

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FINAL GENERAL SESSION

Wednesday, August 27, 1952 at 10:30 A.M. in Freeman Hall.

Report of the Secretaries of the Sections
Report of the Resolutions Committee
Report of the Nominating Committee
Election of Officers
Meeting of the Executive Council

SECRETARY'S REPORT

FIRST GENERAL SESSION

The twenty-seventh Annual Meeting of the AMERICAN ASSOCIATION OF JESUIT SCIENTISTS, Eastern States Division, was called to order at 7:07 P.M., August 25, 1952, in Freeman Hall, Room 105, Fordham University. Reverend President Edward B. Berry, S.J., introduced the Rector President of Fordham—Rev. Laurence J. McGinley, S.J., who welcomed the members of the Association and pointed out as a main contribution of Jesuit Scientists "the spirit of asceticism" and "Christian inference" in scientific work.

Father Berry read resolutions from the BULLETIN concerning sorrow of Association upon the death of Father Michael Ahern and read thank you letters from Mr. Maurice Ahern, brother of Father Michael Ahern, and Father Rector of Weston. General announcements by the President followed. A resolution was made that the minutes of the 1951 meeting be accepted as they appeared in the BULLETIN. The motion was seconded and carried.

Father Berry announced the committees as follows:

Committee on Nominations	*Committee on Resolutions*
Rev. Bernard A. Fiekers	Rev. John A. Tobin
Rev. Francis Heyden	Rev. Joseph S. Didusch
Rev. Thomas Cullen	Rev. James J. Pallace

Father Buck Ewing, at 7:22 P.M., spoke for a few moments on the "finds" at Auriesville—in 1952 some parts of an Indian village were found; however, at least ten further summers will be needed to complete the work. At 7:40 P.M., Father Berry gave the Presidential address on "Microseisms." At 8:00 P.M., Fr. John McCarthy, the BULLETIN Editor, asked for abstracts of papers to be presented at

this meeting. Father Joseph P. Kelly of Weston made known Father Rooney's (of J. E. A.) request for a 7000 word history of the AAJS for publication. Suggestions were offered by Fr. Ewing, Fr. Joseph Lynch and Mr. Joseph Mulligan. A motion was made and seconded for adjournment. The motion was carried at 8:05 P.M.

Final General Session

Father Berry opened the meeting in Freeman Hall—Room 105, at 10:33 A.M., with a prayer. New sectional officers were announced by secretaries of Chemistry and Biology sections.

Chemistry—*Chairman*—Rev. Vincent F. Beatty
Secretary—Mr. Paul J. McCarthy

Biology —*Chairman*—Rev. George Lawlor
Secretary—Mr. John B. Berte

A few general announcements were made. Fr. Ewing offered copies of articles. Fr. Tobin read the report of the Committee on Resolutions as follows:

1. Be it resolved that the AAJS (E.S.D.) express its sincere gratitude to the Reverend Father Rector, Father Minister, and the Community of Fordham University for their cordial reception and gracious hospitality shown the Association during its meeting.
2. Be it resolved that the Association express its heartfelt thanks to Rev. Edward Berry, President, and to the officers of the Association for their thoughtful generosity that made the meeting a success.
3. Be it resolved that this Association express its continuing appreciation of the work of Fr. John J. McCarthy, Editor-in-Chief of the Bulletin.
4. Whereas this Association has, on the death of Father Edward C. Phillips, lost the inspiration of one of its Founding Fathers, be it resolved that this Association express its profound regret at this loss. Also the Association has, on the death of Father George O'Donnell and Father T. Joseph Brown lost most loyal members and be it resolved that the Association express its profound regret at this loss.
5. Be it resolved that the Association extend its heartfelt congratulations to our member, Father Joseph M. Kelley, on his golden anniversary as a Jesuit.
6. Be it resolved that the Secretary of this Association be instructed to send a copy of these resolutions to Rev. Fr. Rector and Father Minister of Fordham University, and a copy of the resolution on Fr. Phillips to Rev. Fr. Provincial of the

New York Province and a copy of the resolutions on Fr. Brown and Father O'Donnell to their nearest relatives.

Signed: JOHN A. TOBIN, *Chairman*
JOSEPH S. DIDUSCH
JAMES J. PALLACE

Father Fiekers read the report of the Nominating Committee as follows: for President: Rev. John S. O'Conor
for Secretary: Mr. Joseph Mulligan
Both were elected by unanimous vote. Father Secretary cast the vote.

Father Fred Canavan reminded the members of the Association that the tour to the Farand Optical Company would begin at 1:00 P.M. Father Joseph M. Kelley thanked the Association for its jubilee congratulations offered him.

At 10:42 A.M. Father O'Conor closed the meeting with a prayer.

Respectfully submitted,

(REV.) VINCENT F. BEATTY, S.J.
Secretary

Presidential Address

MICROSEISMS

EDWARD B. BERRY, S.J.

It is not surprising that earthquakes have attracted universal attention from the earliest times. Their destructive power, the physical changes made by them in some localities and the tremendous waves set up by them in others, rank them with the greatest catastrophies, and have spurred men on to study them in an effort to learn their cause, be able to predict the time and place of their occurrence, and as they cannot be prevented, to minimize their effects by designing buildings capable of withstanding their force.

It was early realized that to carry on this study with any hope of success instruments would have to be devised. Since the scientist was rarely at the scene of an earthquake when it occurred, study without instruments was—and still is—made by visiting the stricken area, inspecting the damage and the changes in the earth's surface, and interrogating those who felt the quake. This last, particularly, has not been too satisfactory. Those who survive an earthquake are generally confused and give conflicting accounts of the time of the event, the direction of the ground motion, and so on; and it is difficult to collect information from a sufficiently large number of observers before time has faded their impressions.

The problem then was to devise an instrument which would record the motion of the earth when everything was moving. Seemingly, a hopeless task. But the scene of the quake itself gave the clue. It was noted that, due to the inertia of objects, there was a relative motion between certain things which could be put to use in recording the motion of the earth. For instance, during the Long Beach earthquake of March 10, 1933, a house moved with the earth while, overlooking some motion due to friction, a gas range remained at rest with the result that the approximate motion of the earth was traced by the stove on the floor. Some of Ours have observed this phenomenon in the Philippines when billiard balls seemed to be rolling around the table without any propulsive force having been applied to them.

This knowledge was put in practice by using a pendulum to detect lateral motions, and a steady mass supported by a spring for vertical motions, both equipped with a stylus which would make a trace on paper which moved with the earth. Omitting many mechanical, electrical, and optical details, constant study and improvement for centuries have given us an instrument having a coil of wire between the poles of a permanent magnet which is attached to the ground. The ground motion sets up relative motion between coil and magnet generating an electrical current which is fed to a galvanometer. Light reflected from a mirror on the galvanometer is focused on photographic paper which is on a revolving drum thus recording any motion of the galvanometer. Time signals are put on the recording paper at regular intervals. A well equipped seismic station will have one horizontal instrument to record the north-south component of the vibration, another for the east-west component, and a vertical instrument to care for the vertical component. These instruments will magnify the relative motion of the coil and the magnet thousands of times.

As seismographs became more sensitive, observers noted that, over and above actual earthquakes, there was a great deal of motion going on in the crust of the earth. These movements were named microseisms by Bertelli in 1878. I shall designate as artificial those microseisms in which the hand of man can be detected, and others as natural. Artificial microseisms which have been recorded at the observatory here at Fordham include disturbances caused by a loaded milk train going by our grounds toward the city, the explosion of an ammunition barge at South Amboy, N. J., the R. O. T. C. regiment marching in parade near the observatory, quarry blasts in various places, and traffic generally. Exploration geologists in their search for oil produce artificial microseisms with dynamite and Fr. Linehan and Fr. Lynch in recent explorations in Rome dropped a heavy piece of iron from a height of three feet onto the pavement of St. Peter's.

The natural microseisms follow a rather regular pattern and persist for hours. They vary in period but fall into four main groups; those with very short periods around one tenth of a second, those with periods around two seconds, those with periods around six seconds, and those with periods above ten seconds.

Some study has been made of long period microseisms. Authors in India, Europe, Africa and America all attribute them to local causes such as temperature changes in the ground, the effect of strong winds on buildings or the ground, air circulation around the instrument.

The six second microseism has engaged the attention of a far greater number of seismologists than either the very long or very short ones. Over two hundred and fifty papers were published on the subject during the first half of this century. Of the several theories proposed regarding the source of these microseisms two had the greatest support, namely the breaking of surf on rocky coasts and storms on the open sea. Now the cause of the microseisms might also be the cause of the heavy surf. Also, seismologists in widely distant countries observed that these disturbances died off as storm centers passed from the sea to the land, while the surf often continued heavy for hours. No doubt with this in mind Fr. Macelwane in 1937 suggested to Fr. Ramirez, then a student at St. Louis University, that he undertake an investigation which has turned out to be a classic of research in its field. He set up four instruments, two at St. Louis University, one at Washington University four miles west, and one at Maryville College about the same distance south. With such a triangular installation, called a tripartite station, it is possible to determine the direction of the origin of the microseisms. Over a period of two years Ramirez found that in all cases the waves came from the direction of a storm center at sea and followed the direction of this low pressure area and not the location of the surf. A fourteen month study by Father Westland at Spring Hill College confirmed these findings.

In 1943 the Navy set up a tripartite station at Guantanamo Bay, Cuba, under the direction of Marion H. Gilmore. This station was very successful in using six second microseisms to determine the direction of centers of hurricanes, sometimes two days before the storm was violent enough to attract the attention of meteorologists. In 1945 similar stations were established by the Navy at San Juan, Puerto Rico, and Richmond, Florida. Knowing the direction of the storm center from at least two of these three stations, it is no great task to locate the actual position of the storm. From the last report I read, these stations have been operating satisfactorily in keeping track of hurricanes and have also provided information of interest to seismologists concerning faults in the bed of the sea. The mechanism by means of which the storm over the sea sets up vibrations in the ocean floor has not yet been determined.

Passing over the one tenth second microseisms, as investigation of them is in its infancy, we come to those with a period of two seconds. About the only extensive study of them has been done by Fr. Lynch. Tripartite stations were established here on the campus and at the Maritime Academy close to the Whitestone Bridge, with an instrument at Iona College in New Rochelle to form the third vertex of a larger triangle. Because the two smaller triangles proved too small, and the

larger one too large; and because local traffic caused too much interference, a station was set up at St. Andrew's, Poughkeepsie. This showed microseisms coming from almost all directions, but in every case from the direction of a cold front in the atmosphere. Since all the authorities agree at present that the presence of a large body of water for the atmosphere to act on is necessary for the formation of microseisms, the possibility of the Hudson River being the source of waves coming from the west had to be investigated. A station located at Mother Cabrini's School for Orphans, west of the Hudson River, also recorded disturbances from the west. This suggested the Great Lakes as a possible source. To get about as far south of the Great Lakes as we are east of them, Hot Springs, N. C., was selected as the site of a station last Christmas week and, sure enough, waves were received coming from the north. More experimentation is needed, and more stations widely separated and recording simultaneously, before final conclusions can be drawn regarding the exact source of these two second microseisms and the mechanism of their production.

Microseisms provide a wide field for research. It is hoped that some members of our association will become interested in this branch of geophysics. In many of our colleges and universities the equipment is standing ready to be employed. Any time and labor devoted to its use would be well rewarded by the interest and satisfaction afforded by such a fascinating study.

ARCHAEOLOGY AT THE MARTYRS' SHRINE, AURIESVILLE, N. Y.

J. Franklyn Ewing, S.J.

This past summer, a Fordham expedition excavated a number of trenches in the Shrine grounds at Auriesville, N. Y., and discovered the remains of part of the Mohawk Indian town of Ossernenon. This brief note will recount the type of evidence found. For those specially interested, a fuller account has been mimeographed, and copies may be obtained by sending a postcard to the writer. The expedition was made possible through a donation from a source which wishes to remain unnamed, and with the cooperation of the Very Rev. Raymond Goggin, S.J., Rector, and the Rev. Louis Devaney, S.J., Director of the Shrine, at Auriesville.

The largest amount of Colonial and later materials were found near the Old Chapel. Mixed in with these finds were Indian artifacts. This is caused by the erosion of the topsoil, and by disturbances due to ploughing, when the land was farmed. The remains of the town were uncovered a few meters south of a line drawn between the Old Chapel and the Pietà, and about midway between these two structures.

After removing the sod, we come upon a dark, sandy loam for topsoil; the depth of this topsoil varies, but it averages about twenty-five centimeters. In this topsoil most of the artifacts are found, but

the ash pits of Colonial times, and an occasional object or two, go deeper. After the topsoil has been stripped away (and sieved, for small objects), we come on a layer of yellow sand.

Fortunately for us, this sand shows up the darkened spots which may indicate erstwhile posts, thrust into the ground by the Mohawk Indians. These posts may have supported a house, or may have been part of the palisades. We have not yet discovered the palisades, but there should be no trouble in doing so next year.

The round spot one comes on may have been caused by a large tree root. In order to prove that it was caused by a post, we bisect it vertically. If the outline is pointed, then we know it was a post; no root, six inches in diameter, comes to a symmetrical pointed end within two feet. In very rare cases, too, some of the wood remains.

The post hole molds we have found so far all belong to houses. We did not excavate enough territory to outline any houses, and, indeed, this is very difficult. Across the river, at Fonda, Father Thomas Grassmann, O.F.M.Conv., has uncovered the outline (palisades) and most of the interior of the village of Caughnawaga (where Kateri Tekakwitha was baptized; she was born at Ossernenon). Father Grassmann finds such a welter of post hole molds, that he has been able to outline only three long houses, and these are only probable. The Mohawks built flimsy houses of bark, and built them over and over again. They thus have assured us of a minimum of archaeological evidence, with a maximum amount of question marks.

There have been numerous surface finds picked up at Auriesville in the past, and a number of nearby graves have been unsystematically dug up. Not many of the finds remain for the Tekakwitha Museum on the grounds, because of the cavalier treatment they received. The actual artifacts we uncovered this past summer do not add any startling novelty to the list of objects known to derive from the site, but I shall summarize them for the record.

The list includes objects clearly Mohawk Indian, objects capable of having been used by both the Indians and the Dutch (and more likely used by the Indians who received them as trade goods), and objects predominantly Colonial. It will be remembered that the Mohawks were in continuous and enthusiastic trading contact with the Dutch at what is now Albany, at this time.

The first class contains: firestone beads and pendants; shell wampum beads; a perforated phalanx of a young deer (used in making a necklace); a discoidal grinding stone; a conical metal arrow point; flint projectile points. In the second class were: many fragments of metal pots; metal trade knives; many fragments of clay pipes; gun flints; a musket ball. In the third class we have: hand made nails; fragments of early glass; a leaden ladle; Colonial pottery; several ash pits, including among other things fragments of bricks. The remains of food animals, with the exception of those of the cow, the

horse and the pig, belong in the second class: bear, beaver, deer, dog, freshwater clams, turtle bones.

These finds add their contribution of certitude to the knowledge that we have here an Indian site, belonging to the time when the Indians were in trading contact with the Whites. Previous surface finds indicated the same thing, but not with such accuracy of location. All the Mohawk towns, at the time of the death of Our Saints, were on the south bank of the Mohawk River. The topographical evidence is very strong (it was first really cleared up by General John S. Clark in 1877). The post hole molds, finally, prove that this was not simply a place visited by the Indians, but the site of an actual town.

Next year, we hope to go far towards uncovering the major portion of the town. The location and orientation of the town, the position of its gates, and such like evidence, will be the key to our search not only for the scene of the martyrdom of the Saints, but, if God allows, the finding of the relics of the Martyrs. However, discovering the palisades, on the points of whose stakes were placed the heads of St. Isaac Jogues and St. Jean de LaLande, and of the gate, within a few feet from which St. René Goupil was martyred, would be reward enough.

Biology

PROBLEMS OF RACE AND FORM

(*Abstract*)

J. Franklin Ewing, S.J.

Many special difficulties confront the student of human races. Racial differences within any species are small; in the case of humans, we have long-continued mixture within a polytypic species, and we are unable to perform breeding experiments. This is also the only species in which we have an historical interest, and a small percentage of racial characteristics are displayed by skeletal material.

Various approaches to the problem have been made. (1) The *anthropometric* approach, characterized by the use of many measurements and subsequent statistics, has succeeded only in refining the crude observations of the "man on the street," without producing a single classification agreed upon by the majority of workers. A number of morphological concepts and conclusions derived by such students are valuable; but this approach does not even begin to posit satisfactory principles of causation. (2) The *genetic* approach is young. It insists that we should start with the characteristics which we know to be genetically analysable (controlled by one or only a

few genes). Thus, Boyd and others use blood groups; Spuhler focusses on taste-bud patterns and the like; Birdsell uses genetic models. This is a dynamic approach, but so far has had very little with which to work, and seems to ignore the environmental factor. (3) The *environmental* approach is usually submerged in the anthropometric, but Coon *et al.* have dragged it out into the open. This approach, too, has little to work with, and, without experiment, will continue in that sad state. (4) The *experimental* approach has been greatly neglected, but is now spear-headed by Washburn. Proceeding from experiments on single bones. Washburn has lately insisted on the study of natural, mechanical units (*e.g.*, the masticatory) and sub-units (*e.g.*, the parts of the mandible and maxilla, the teeth, etc.).

Particularly because it should be the most interesting to general biologists, this approach was used as the background for the discussion of several envisioned animal experiments. These were designed to amplify our knowledge of the specific applications of Wolf's Law, and another set drew inspiration from the hitherto unnoticed hypothesis of Marett concerning the role of mineral deficiency in race formation. This latter set might well be definitive from the point of view of environmentalists.

AUTOGENY AND ANAUTOGENY IN *CULEX PIPIENS*

(Abstract)

JOSEPH E. SCHUH, S.J.

Roubaud (1929) reported that two types of *Culex pipiens* could be distinguished on the basis of whether or not they required a blood meal for egg development. Those that were capable of egg development without a blood meal he called autogenous and those that required a blood meal anautogenous. Since then, many, sometimes conflicting, reports have made their way into the literature. These will be reviewed and some data, obtained on a colony of mosquitoes that had been kept for almost three years and was derived from a single egg-raft will be presented. It is suggested on the basis of this data that autogeny may be a gene-controlled character and that the female from which this colony was descended may have been heterozygous for this character.

THE EFFECT OF CHOLESTEROL ON GROWTH IN *COLPIDIUM CAMPYLUM*

(Abstract)

WILLIAM D. SULLIVAN, S.J.

Colpidia cultivated in cholesterol cultures (0.05%, 0.005% and 0.0005%) do not reach their maximum growth until one or two days later than those cultivated in the pure proteose-peptone solution.

Growth curve for first three days is approximately the same for the cholesterol and control cultures. This indicates that during this time the organisms are living on the food reserved within the organisms. When the food reserve becomes depleted an inhibition phase of three days results, during which time the colpidia are becoming acclimatized to the cholesterol medium. The fact that they again assume the normal growth curve indicates that they have become acclimatized and the fact that they reach a higher growth curve may indicate that there is a slight growth stimulating effect of cholesterol on the growth of *Colpidium campylum.*

Chemistry

LABORATORY PRACTICE IN X-RAY DIFFRACTION

(Abstract)

CLARENCE C. SCHUBERT, S.J.

If suitable equipment is at hand it is quite practical to perform the analysis of a simple cubic crystal in the time allotted for an experiment in the physical chemistry course. This experiment can prove to be a stimulus to the investigation of crystallography, factors leading to emission and absorption of X-rays, and to the study of mathematics. It leads to an appreciation of the work of Moseley, Bragg, Laue and others. Moreover it serves as an introduction to radiation laboratory technique.

SOME NOTES ON THE ELEMENTARY ANALYSIS COURSE

(Abstract)

GERALD F. HUTCHINSON, S.J.

The place of Qualitative Analysis in the Chemistry Major course is a question of some discussion among chemists. The system used at Fairfield University was outlined. The regular course in Quantitative analysis is given, consisting of two lecture and two laboratory periods a week. An additional laboratory period is available throughout the year which is used chiefly for qualitative laboratory work with occasional lectures interspersed as needed. Thus both courses are run simultaneously and integrated in both lectures and laboratory. Results from last year's class were given in terms of A.C.S. examinations to substantiate the validity of the method.

SPECTROPHOTOMETRIC DETERMINATION OF EQUILIBRIUM CONSTANTS

(Abstract)

ARTHUR G. KEHOE, S.J.

Information on equilibrium constants of complex-ions both in aqueous and non-aqueous solution is often needed by a chemist; but, due to the difficulty of measuring them and to the large number of such complexes, literature on the subject is rather sparse. Many of the constants that are recorded are of little value because of poor control of variable experimental factors.

An outline of the procedure for control of the variable factors, namely, pH, concentration, temperature, "salt-effect", and the inhibiting influence of "foreign" ions, was presented together with the method of collecting data on a complex, based on Job's "Method of Continuous Variations" (*Ann. chim.:* (10), 9, 113, (1928)). The material was exemplified by using the first complex of ferric and thiocyanate ions, and two methods of quantitative treatment of the data were summarily outlined, one of which was graphical, the other, algebraic.

SOME FACTORS AFECTING CHELATE STABILITY

(Abstract)

PAUL J. MCCARTHY, S.J.

This paper distinguished chelates from ordinary coordination complexes, and stated some of the particular features of the former. It outlined the major factors upon which depend the stability of such complexes. Among these are the nature of the metal, the nature of the complexing agent or ligand, the size of the ring formed, resonance in the molecule, and the solvent conditions, that is, the nature and ionic strength of the solution.

A DISCUSSION OF COVALENCE

(Abstract)

ROBERT E. VARNERIN, S.J.

The mathematics of quantum mechanics has prevented many chemists from seeking information in that field. There are many physical pictures which will enhance the chemist's understanding of many topics in a qualitative and almost intuitive manner. In order to illustrate this covalence is discussed.

Atomic theory serves as the foundation for molecular theory. Electrons in an atom exist in atomic orbitals. An atomic orbital is an electronic energy sublevel and can accommodate two electrons with opposite spins. The atomic orbital characterizes the properties of the electrons. These properties can be calculated quantitatively by

the methods of quantum mechanics and can be qualitatively understood by the physical picture employed. These properties classify the bonds which may be formed subsequently from the electron.

The formation of a bond is an example of the tendency for atoms to form a more stable electronic configuration, a configuration which approaches as much as possible that of the rare gas elements. In a covalent bond valence electrons which occupy unfilled orbitals in two atoms couple in the formation of a filled bonding molecular orbital. A molecular orbital is a molecular electronic state which can hold only two electrons at any one time. The characteristics of the molecular orbital can be calculated and understood much in the same manner as atomic orbitals. The molecular orbital defines the characteristics of the bond.

Examples of simple bond types are as follows. Unhybridized bonds are seen in: H_2 which has an s to s bond, H_2O which has two s to p bonds, Cl_2 which has a sigma p to p bond, N_2 which has one sigma and two pi p to p bonds. Hybridized bonds are seen in a wide variety of compounds. In the chemistry of carbon the sp^3 tetrahedral hybrid is observed in methane, the sp^2 planar trigonal hybrid is seen in ethylene, and the sp linear hybrid is seen in acetylene.

This simplified treatment makes it possible to classify bonds and to predict bond types in various compounds.

CHEMICAL STRUCTURE AND TUMOR DEVELOPMENT

(Abstract)

MIGUEL M. VARELA, S.J.

The relationship between the chemical structure of a compound and its activity in living organisms has of late years been increasingly valuable particularly in its applications to Medicine, Pharmacy and even Industrial Chemistry. "Metabolic antagonists" or "antimetabolites" have been found to inhibit certain normal activities of the protoplasm because of their chemical structural similarities with certain compounds found in the living cells. At the Fordham University Biochemistry laboratories work has been going on along this line in the studies of the action of oxythiamine, on thiamine. Thiamine is also known as Vitamin B_1. Aside from devising methods for the synthesis of oxythiamine, our laboratories are conducting research on the antagonistic effect of oxythiamine on thiamine diphosphate (also known as Cocarboxylase). Cocarboxylase is a valuable coenzyme in pyruvic acid decarboxylation and in some phases of carbohydrate breakdown.

Although oxythiamine is non-toxic to isolated yeast enzyme systems when experiments are conducted in vitro, nevertheless oxythiamine diphosphate is toxic. This discrepancy is presumably due to the inhibiting effect which oxythiamine diphosphate exerts on the thiamine diphosphate. This toxicity decreases with increasing amounts of thiamine in the system containing both oxythiamine and thyamine.

Nucleic acids which are present in the living cells have been found to be closely related to the development of cancerous growths. Work in our laboratories have corroborated the results of other researchers on the rise of nucleic acid content of cancerous tissue as well as embryonic tissues. Moreover, nucleic acid values increase too, even when the tumor is not spontaneous, but transplanted or induced into the animal. The organs showing this increase are the liver, lung, kidney and spleen.

When these observations were extended to human tissues, the same results were obtained, in spite of certain limitations encountered in the use of human tissues. Then, too, studies on the amino acid content of the tissues of rats and mice during normal as well as neoplastic growth revealed significant increases in the content of several of the essential amino acids. Since all these nucleic acids form a part of the protein and enzymic systems of living organisms it may be possible to find an antimetabolite that would arrest the production of these acids and thus check the development of cancerous cells.

Mathematics

THE NOTION OF A LOGISTIC SYSTEM

(Abstract)

WALTER J. FEENEY, S.J.

A mathematical statement is true if it has a mathematical proof. What precisely is a mathematical proof? Mathematicians strive to express their mathematics in the exact language of a formal logical (or logistic) system because in such a system the notion of what constitutes a proof is very precise.

A logistic system consists of primitive symbols, formulas, rules for well-formed fomulas, axioms, rules of inference, proofs, theorems. *Primitive symbols* are effectively listed. A *formula* is a finite sequence of instances of primitive symbols. Certain formulas are designated as *well-formed formulas* (wff's) by an effective set of rules for recognizing them. *Axioms* are certain wff's picked and listed effectively. Effective *rules of inference* indicate when a certain wff can be immediately inferred from certain other wff's. A *proof* is a finite sequence of wff's each of which is an axiom or is immediately inferred from certain wff's preceding it in the sequence in accordance with the rules of inference. A *theorem* is a wff which can be the last wff in a proof.

An example of a logistic system is the propositional calculus. Questions of interest concerning logistic systems deal with their con-

sistency, their completeness, their decision problems, their adequacy for expressing mathematics. A theorem of Gödel dashes any hope of satisfactorily defining truth in mathematics as probability in some formal system, for any formal system adequate for intuitive mathematics will contain undecidable propositions.

GAUSZ AND PLUS OR MINUS

(Abstract)

DOMHNALL A. STEELE, S.J.

In concrete puzzles, the sign is sometimes "obvious from the problem", but in mathematics proper, it is not so. Here is a case where (i) the difference between plus and minus is the difference between one of the deepest and most fertile theorems in all mathematics, and a colossal triviality; (ii) the ascertainment of the sign cost even a Gausz four years of unremitting toil; (iii) on which we possess biographical material of especial interest to our Association of Jesuit Scientists.

We take complex numbers only from Kronecker, and their geometrical images only from Wessel. After sketching other problems on the n-th roots of 1, we turn to the Gausz Sums $G(n)$. Using a as dummy and leading it through the remainder classes modulo n, this $G(n)$ adds the n numbers: $\exp(2i\pi a^2/n)$. For example, $G(8) = (1+i)\sqrt{8}$.

To determine the ABSOLUTE value $|G(n)|$ is comparatively easy. The outcome is a fourfold alternative: $|G(n)|/\sqrt{n} = \sqrt{2,1,0,1}$ according as n congruent 0, 1, 2, 3 modulo 4.

To determine the NATURAL value $G(n)$ is comparatively difficult. The outcome is: $G(n)/\sqrt{n} = 1+i, 1, 0, i$ according as n congruent 0, 1, 2, 3 modulo 4. Proofs by Gausz, Dirichlet, Cauchy, Kronecker, Landsberg, Mertens, Weber, Mordell, Schur and Landau employ a wide choice of higher techniques.

Towards the ABSOLUTE value, the stages are in order: (i) the Legendre Symbol (a/p) is introduced organically rather than arbitrarily, as follows: (ii) let p be an odd prime; the $(p-1)$ nonzero classes modulo p constitute a multiplicative group; the chief step uses Fermat in the shape $a.a^{p-2} \equiv 1$ to establish reciprocals; (iii) the structure of this group is cyclic, in that successive powers of at least one member G reconstitute the group; (iv) what once was a mere symbol is defined anew by $(a/p) = (-1)^m$ when $a \equiv G^m$, the choice of G proving immaterial; (v) naturally now, not artificially, $(a/p) = 1$ or -1 according as a is or is not square modulo p; (vi) in modern terms, the group is mapped homomorphically onto the multiplicative group formed by just the two numbers 1 and -1, so that (vii) the Legendre symbol emerges as a group character.

The Gausz sum is transformed by its means, and written out

twice with different ways of ranging the remainder classes. When these two versions are multiplied out, we obtain

$$G(p)^2 = (-1)^{\frac{1}{2}(p-1)}p,$$

which delivers over and beyond the desired $|G(p)| = \sqrt{p}$ the more explicit alternative: $G(p) = \pm\sqrt{p}$ when $p \equiv 1$ modulo 4, but $G(p) = \pm i\sqrt{p}$ when $p \equiv 3$ modulo 4. When all else is prepared, we add the numbers $\exp(2i\pi bs^2/a)$ by leading dummy s through the remainder classes modulo a. Calling this fresh sum $\varphi(b, a)$, we link it with the Gausz sums by the theorems

$$\varphi(q,p) = (q/p)G(p) \text{ and } \varphi(q,p)\varphi(p,q) = G(pq),$$

which together yield, as the key to our final result:

$$G(pq) = (p/q)(q/p)G(p)G(q).$$

At this juncture, two degrees of knowledge come into play. The knowledge of ABSOLUTE values, and even the slightly more explicit alternatives, just won, yield only

$$(p/q)(q/p) = \pm 1,$$

and each factor being already ± 1, this is a COLOSSAL TRIVIALITY. The knowledge of NATURAL values, so much more difficult to obtain, yields in its stead

$$(p/q)(q/p) = (1 + i^{3pq})(1 + i^3)/(1 + i^{3p})(1 + i^{3q}).$$

Now so soon as either $p \equiv 1$ or else $q \equiv 1$ modulo 4, this cancels down to 1, whereas $p \equiv q \equiv 3$ makes it the quotient of the square of $(1 - i)$ by the square of $(1 + i)$ namely -1. In words:

> When p and q are distinct odd primes, the quadratic characters of p modulo q and of q modulo p are identical, unless $p \equiv q \equiv 3$ modulo 4, in which case they are opposite.

This is the original, since highly refined form of the celebrated theorem of *Quadratic Reciprocity*. Concerning it, we add: (i) it is together with unique factorization one of the twin pillars of number theory from the lowest level to the highest; (ii) no wonder that the sign was difficult to ascertain; (iii) Gausz discovered seven proofs, and the number of proofs has since risen above sixty-four; (iv) each proof opened up a more or less wide tract of mathematical science, helping to scotch the myth that physical science be its principal stimulus; (v) Gausz' experiences with his first proof have an especial interest to the AAJS, discernible from the letter he wrote four days after the discovery to his friend Olbers.

Gausz' letter contains the passage in translation: "What then follows, namely the determination of the sign of the square root, has continually racked me. The lack of it has spoilt my pleasure in all other discoveries. For four years past, hardly a week went by without my making one or several vain efforts to unravel this knot, and in recent times with ever growing agitation. But all my brooding and

all my seeking ended in failure. Every single time, I was compelled to lay down my pen with a sad heart. At long last, a few days ago, success came to me—not so much to my unwearied search, as rather, I would like to confess, through the *Grace of God.* As the lightning strikes, so did the riddle dissolve away. I myself am quite unable to trace the thread between what I knew before, and what led to the final success. Strangely enough, the answer to the riddle now seems easier than many problems which cost me only as many days as that one cost me years. Nobody to whom I shall ever lecture on this subject will ever have an inkling of the prolonged straits to which it put me."

WANTZEL'S METHOD FOR DETERMINATION OF THE POSSIBILITY OF GEOMETRIC CONSTRUCTION USING COMPASS AND STRAIGHTEDGE ONLY

(Abstract)

WALLACE CAMPBELL, S.J.

The Wantzel Method is an algebraic method for determining the possibility of geometric construction when we are restricted to the compass and straightedge alone. We prove that a compass and straightedge construction is impossible because a simple necessary condition is unfulfilled.

EXAMPLES OF WANTZEL'S METHOD FOR DETERMINING POSSIBILITY OF CONSTRUCTION WITH STRAIGHTEDGE AND COMPASS ALONE

(Abstract)

JAMES FISCHER, S.J.

An historical note broadly traced the development in this field from Descartes' work in the theory of equations to Wantzel's method. Wantzel's use of not only Descartes' equation theorems but also his discovery of similar structures in algebra and geometry which makes possible the transfer of problems to establish existence proofs was pointed out. The constructions of various polygons were demonstrated to be impossible as were also the duplication of a cube and the trisection of any angle in general.

THE MARGIN OF KNOWLEDGE IN MATHEMATICAL HISTORY

(Abstract)

DOMHNALL A. STEELE, S.J.

Mathematics is ill taught by the teacher a page or two ahead. Its growth is ill told by the historian a page or two ahead. He listens

even to Greek mathematicians with too little resonance in his own mind. Schoolroom mathematics is not an initial segment of scientific mathematics, and not the best graphpaper for plotting the mathematics of the past. Sharper comparisons between earlier and later states of a subject help to understand both better. The boundaries of Greek mathematics will be justly drawn only if we pace them from both sides. Even as historians, we not only explore the consciousness of our author, but also ask what secret stimuli he gave to mathematical posterity.

The Address selected a number of themes and weighed up their treatment in standard English works from the special point of view of whether a sufficient margin of knowledge is present for the ancient knowledge to be correctly described, correctly interpreted and correctly traced in its consequences.

Such matters scarcely admit an intelligible abstract. In lieu of one, some of the themes shall be mentioned.

The Eudoxian Logos Theory is at least an instance of classification by an equivalence relation. Its transitivity is formally demonstrated. Eudoxian order ($nA > B$) is rightly made a condition of admission to the theory. Dedekind avows its stimulus to him. The full force of Eudoxian order is felt when we attempt to Dedekindize, instead of the rationals, any densely ordered ring.

Concerning Theaetetus' theory of quadratic irrationality classes, with its non-vacuity theorems and unique additive composition and fragmentary class calculus, let none say that a simple formula would have embraced it all. Algebraic structure is the very object of investigation. Do not start by wiping it out.

Our recognition that the lemma $p/ab \rightarrow p/a$ or p/b is a nodal point in primality theory came through a wide experience of rings other than the integer ring. By sheer logical acumen did Euclid, as author or expositor, make the selfsame lemma be the selfsame nodal point. Algebraists are exalted, Heath is unruffled.

To take a free point in the plane, and bind another to it by a fixed relation, is to provide an instance of functionality. To let the free point trace a curve, and to ask what curve the bound point traces, is to provide an instance of transformation. To ascertain that a category of curves is merely permuted under a set of transformations, is to provide an instance of invariance. Apollonius did all three. His set of transformations is now the Möbius group in plane metric geometry. The account in Pappus is not a mere medley of elementary trifles.

Several problems in Greek mathematical history can only be solved by the use of Galois Theory. If we cannot distinguish between quadratic quadrability and quadratic constructibility, we are blind to finer points in Hippocrates' tractate on lunules. Its date is approximately 440 before Christ. Mathematical knowledge essential to its interpretation was won only in 1935.

Ruler and compass in Plato is a problem of many vicissitudes. The *Meno* 87 A sets a quartic problem. Plato refers to a condition for real solutions. The modern theory of equations guarantees that no quadratic solution exists. For Plato, a solution does exist. Therefore, one more reason for abandoning the old myth. The requisite hyperbola was invented, and similarly applied, by a member of the Academy named Menaechmus.

Modern integration starts with sets of undersums and sets of oversums. Eudoxus and Archimedes showed repeatedly that a certain number was both upper bound to the lower sums and lower bound to the upper sums. They and Riemann reject infinitesimals. Archimedes had geometrical stimuli, treated self-offering functions, needed to know which number to test, partitioned into aliquot intervals and lacked theorems on the integral as such. Riemann had arithmetical stimuli, treated any univalent real function, was the beneficiary of real number construction, partitioned into complementary intervals and provided theorems on the integral as such. Lebesgue passed to sets of covering intervals. One straight line joins Eudoxus and Archimedes to Riemann and Lebesgue, leaving both Leibniz and Newton on one side. The fivefold comparison is more specific than to say that Archimedes "practically" integrated, and more just than to commiserate Archimedes on missing integration for want of our glorious infinitesimals or differentials!

Chiefly but not exclusively examined were: (1) Thomas Little Heath's *History of Greek Mathematics*, and (2) an article by Thomas Greenwood in the July 1952 issue of the *Thomist*.

NOTES ON THE DIFFERENTIAL

(Abstract)

CHARLES J. LEWIS, S.J.

In 1903 Russell banished the differential, at least when it was interpreted as infinitesimal in the explanation of continuity as "unnecessary, erroneous, and self-contradictory." In 1904 Poincaré declared that it was time to think in terms of derivatives and not differentials. Yet a perusal of discussions of the differential in the *Mathematical Gazette* (1935) and in the *Mathematical Monthly* (1952) reveal a most unhappy disagreement and confusion regarding both the role and the respectability of the differential. Two questions were mooted in the present paper: 1) Should the differential be introduced in a calculus course? 2) How should it be introduced?

In answer to the second question, a definition of the differential of a function on a real number domain was introduced. The differential of such a function is itself a function of two variables; despite sad historical associations, there is no suggestion of the non-mathematical notion of "smallness," much less a suggestion of the "infinitely small" or "infinitesimal." Moreover, the differential as a func-

tion of two variables is to be most carefully distinguished from the incomplete symbol, say dx, written in association with the integral sign to indicate the variable of integration.

In answer to the first question it was remarked that the pure mathematician could well dispense with differentials. The mathematical physicist, however, needs them in his task of approximation; so the differential might as well be introduced with caution and precision in the calculus course as the adventitious and utilitarian thing that it is. When recognized in its proper setting, it is less likely to mislead or create confusion.

Physics

THE BROOKHAVEN NATIONAL LABORATORY

WILLIAM G. GUINDON, S.J.

To most of us, following the news announcements, the name Brookhaven probably is connected with the instrument which accelerates protons to the fantastic energy of two or three billion volts, the Cosmotron. This really is but one of the many things of interest to Jesuit physicists that are going on at this Laboratory, and the purpose of this paper is to give at least a sketchy account of the scientific activities connected with the physics department.

The Brookhaven National Laboratory is one of the half-dozen similar laboratories founded by the United States Atomic Energy Commission shortly after World War II. On the site of an army camp famous in both World Wars, Camp Upton, the laboratory is owned by the Atomic Energy Commission, but operated by a corporation formed by thirteen eastern seaboard universities, Associated Universities, Incorporated.

The aims of the Laboratory are quite coincident with the purposes of the civilian atomic energy program of the AEC. Directly, by making available uranium fission reactors, research projects connected with the peaceful uses of atomic energy are made feasible, while indirect stimulus is given to the nation's scientific manpower through the training afforded on an expanded scale. Brookhaven, like the other National Laboratories, serves as a center for dissemination of the applications of atomic energy to the physical sciences, to medicine and to agriculture.

One of the announced aims of the Associated Universities in undertaking to operate this Laboratory for the AEC was to make collectively available apparatus which no individual university could afford. As a result there are several striking "pieces" of apparatus

available at Brookhaven, notable among which are the fission reactor, or pile, and the Cosmotron. The reactor is a fairly well-known device today, a chain-reacting "pile" of uranium imbedded in a graphite moderator, producing tremendous fluxes of neutrons (and other radiations) which may be adapted to a manifold of experimental investigations. The Cosmotron, so named because it has been designed to produce two to three billion volt particles, energies hitherto available only in uncontrollable cosmic radiation, accelerates protons in a tremendous "race-track" for high energy bombardment of other nuclei. Of course, even within the physics department there are many other types of apparatus in use, a cyclotron, a Van de Graff generator, mass-spectrometers, continuous-flow cloudchambers, and so on. And this is but one of many departments, for there are departments of chemistry, biology, biochemistry, and electronic instrumentation. There is a meteorological research station, a health-physics group, a forty-bed research hospital, an agricultural laboratory, and, last but not least, an excellent research library.

Only a very small percentage of the research going on at Brookhaven is of a classified (secret) nature. Even at the pile, most of the projects are not secret: there are medical studies directly connected with cancer research, and many investigations of interest to the physicist. Chiefly these may be grouped under the headings of solid-state physics, including crystal structure, neutron diffraction, and radiation damage studies, and of nuclear physics proper, including studies of nuclear energy levels, of gamma radiation emitted following the capture of neutrons by nuclei, of short-lived radioactivities. At facilities other than the pile experiments are under way, or recently completed, on neutron-proton bombardments, on very-high energy bombardments, meson physics, mass-spectrometry, etc.

The theoretical research in progress at Brookhaven roughly parallels the experimental studies, and is mainly divided into nuclear physics and solid-state studies. The latter, investigating crystal structure, semiconductors and the like, have a special relation to the experiments with the neutron beams available at the uranium reactor, for details of the structure of matter not amenable to x-ray investigation can be probed with neutron spectrometry. These theoreticians are efficiently located close to the experimental facilities. The nuclear physicists, properly so-called, also are closely associated with their experimentalist counterparts and divide their interests according to the same broad categories. Most of the work is really aimed about the central problem: the nature of the nuclear force that binds proton and neutron together. Superficially it may be broken up into meson physics and high energy phenomena (interpreting the results of cosmic ray studies, preparing to do the same for whatever may come from the eagerly awaited Cosmotron experiments), lower energy nuclear force studies, and nuclear energy level investigations.

Equity, and the desire to give a balanced picture to the activities

at Brookhaven, make it imperative to point out that this is merely a sketch of some of the projects of the physics department alone, and that the various other departments have many striking and important investigations, experimental and theoretical, under way.

Up to this point the Brookhaven National Laboratory has been looked at "quoad se"; it deserves further scrutiny "quoad nos" ("quoad Nostros"?).

First of all, Brookhaven (and the same applies to the other National Laboratories in other regions, Oak Ridge, Argonne, etc.) is a source of training and employment for our students. For those not going on for further studies there are some technical positions open, mostly as assistants in experimental research. If the proper arrangements are made, graduate theses may be carried out at the facilities of the laboratory, thus opening to our schools a range of apparatus completely impossible to our limited budgets. Finally, the summer program, which this year saw one hundred fifty summer guests in its various subdivisions, offers the opportunity to work under expert direction on first line projects. Open to both graduate students and undergraduates (especially those going into Senior year in a scientific course), the summer program employs them as assistants in all departments. In addition to the direct training connected with their actual work, there is an excellent series of orientation lectures on the work of the Laboratory, several sets of colloquia on special topics, and special training films. It is not a way to make much money, as the salary paid pays for little except ordinary expenses, but the value of the experience should not be discounted.

Another valuable opportunity afforded by the National Laboratories concerns ourselves and our lay colleagues. The summer program includes many guests who come to the laboratory to pursue some research project in which they have a personal interest and which can fit into the investigations under way there. Some of these opportunities, especially those for longer terms, as for people on sabbatical leave for research, carry a salary corresponding to equivalent university rank. It is a golden opportunity to work with the top men of science, a chance to pick up again the enthusiasm and awareness of current problems that will better our teaching and help us in directing our own students. Coming from small, limited-budget schools as we do, it is to our advantage to make whatever use we can of this opportunity; this was also the aim of the AEC in establishing the National Laboratories.

Of course, a more fundamental motive for our entering into active participation in the work of these laboratories is the apostolic one. In an age of emphasis and dependence upon the sciences, the obligation rests on us, as Catholic scientists, to move among the men whose opinions are becoming more and more controlling, to prove to them in our own persons the compatibility of theology and science, of philosophy and empirical knowledge, and to create the opportunity of

bringing Christ to them. The total percentage of students and faculty members coming from Catholic colleges to Brookhaven this summer was only about two percent! Surely this is not indicative of our numbers, even in our limited science programs. If this is interpreted by those who know nothing of us or our colleges as evidence of the conflict between religion and science, or of the poor quality of our students and faculty, whom can we blame but ourselves? Here is an apostolic field that would thrill Ignatius or Xavier, a difficult one to till, but a most important one for the Church. Let us bend our backs to the task of forming our students and ourselves so as to win this branch of learning for Christ.

THE LOGICAL STRUCTURE OF PHYSICAL SCIENCE

(Abstract)

JOSEPH T. CLARK, S.J.

Classical analysis (Aristotle, Alexander, Boethius, Avicenna, Albertus Magnus, Aquinas, John of St. Thomas, Maritain, and the neo-scholastics) determines the logical structure of physical science by simultaneous reference to the content and implications of four presumed fundamental characteristics of its enterprise: (1) concept formation by processes of automatic abstraction; (2) subordinate location in a hierarchical classification of the theoretical sciences; (3) syllogistic demonstration as the unique logical implement of its inferences, and (4) subalternation as the logical link between pure and applied sciences, such as mathematics and physics in the hybrid science of mathematical physics. Sober examination discloses: (1) abstraction fails to render an adequate and acceptable account of the process of concept formation in mathematics and of the operative conceptual schemes in current physics; (2) the hierarchical classification scheme misrepresents as subordination the intellectual cooperation of independent and autonomous sciences; (3) restriction uniquely to syllogistic demonstrative techniques is a caricature of the hypothetico-deductive methodology characteristic of mathematics and contemporary physical science; (4) subalternation theory is a mistake which cannot survive the successful appearance in physics of (a) n sets of physical phenomena correlated with one piece of mathematics or (b) one set of physical phenomena correlated with n pieces of distinct mathematical apparatus. Hence the paramount and urgent task of reconstruction can successfully be achieved in contemporary times if and only if it proves feasible to insert within the Scholastic system of interpretation the assured results of modern analysis: (1) creative construction of deductively fertile conceptual schemes in place of the photographically filtered reproduction of ideas by automatic abstraction; (2) hypothetico-deductive methodology for the sterile technique of demonstrative syllogisms; (3) coordinate parallelism at strategic points of autonomous sciences for the hierarchical classifica-

tion scheme of classical analysis; (4) isomorphism or an identity of relational structure amidst a diversity of relations and relata, for subalternation with its presumed but unwarrented identity of relations and relata. The paper closes with a vindication of modern analysis against the charges of (a) subjectivism, (b) scepticism, (c) relativism, and (d) general disarray.

SEMICONDUCTORS

(Abstract)

JAMES J. RUDDICK, S.J.

The basic explanation of semiconductors is given in terms of a model having a forbidden band of energies between a filled band and an empty conduction band. If the gap is narrow, conduction can result from the raising of electrons to the conduction band by heat energy. More commonly, conduction depends on the raising of electrons either to the conduction band from donor impurity levels in the gap or from the filled band to acceptor levels in the gap. These processes give rise, respectively to electron and hole conduction. Although a comprehensive theory is not yet available, this model is the basis for the considerable theoretical and experimental work currently being done on semiconductors. Studies on conductivity, mobilities, luminescent properties, and the like are of importance because they give the background of present and future theories explaining the complex nature of semiconductors.

THE INTERLAYER BINDING IN GRAPHITE

(Abstract)

ROBERT BRENNAN, S.J.

Graphite occupies a peculiar place in the theory of the solid state. For if we make the usual division of solids into ionic crystals, metals, valence crystals and molecular crystals, we find that graphite has some title to three of these four categories.

The way in which graphite is able to find its way into so many different categories becomes clear when we consider the structure of the graphite crystal. Graphite is a layered structure. The layers are relatively far apart (3.37 A as opposed to 1.42 A for atoms within the layers) and quite loosely bound together. It is this loose binding of the layers which accounts for the lubricating properties of graphite.

The atoms within the layers are bound tightly together by the usual chemical valence forces and arranged in hexagons. This is the arrangement we expect to find if the carbon atoms are held to each other by "resonating double bonds." Each of these layers is a two-dimensional metal. Calculations have been made which show that the conduction electrons are made available by thermal excitation.

Within each layer, then, graphite is at the same time a valence crystal and a metal. The layers themselves, on the other hand, are like very large molecules, and in this sense graphite is a molecular crystal.

We have two reasons for expecting that the forces holding these layer-molecules together are of the same nature as other inter-molecular forces we meet in physics: first, the magnitude of the forces and, second, the saturation of the valence forces within the layers. It is these inter-molecular forces we want to discuss here.

Inter-molecular forces are usually called van der Waals forces since they were first considered in the theory of imperfect gases by van der Waals. Until the advent of quantum theory they were a thorny problem for the physicist. There seemed to be no way to account for forces which were attractive at large distances and repulsive at small distances so that the combined effect determined a distance at which the net force vanished. As a matter of fact, there were very general theorems to show that such forces could not be wholly electrical.

The quantum theoretical treatment showed that the inter-action of two neutral atoms or molecules was governed by an inverse sixth power attractive potential and the coefficient of this R^{-6} term was evaluated in terms of the optical properties of the molecule or atom. Unfortunately for us, the necessary optical data for graphite are not known. Further, certain simplifying approximations which are usually made would not seem justified for graphite.

In the case of the repulsive potential we were more fortunate. The repulsion is caused by the Pauli Exclusion Principle. When we try to press two molecules together, we are trying to get electrons in the same quantum state to occupy the same region of space, and according to Pauli's Principle, this cannot be done. The calculations of the repulsive potential were very tedious but straightforward.

We were now in the position of knowing the form of the attractive potential: namely C/R^6, and the numerical values of the repulsive potential. Since we knew the equilibrium separation, we were able to determine the coefficient of R^{-6}.

The binding energy was then found to be 3.99 kcal/mol. Since no experimental determinations of this quantity have been made, we are not able to make a critical evaluation of the accuracy of the approximations used. The calculated value is somewhat higher than previous estimates, somewhat lower than some subsequent ones.

The compressibility of graphite has been measured by Bridgman. We made the assumption that the volume change of graphite under hydrostatic pressure would be almost entirely caused by the change in interlayer spacing. When we calculated the bulk modulus in this approximation we obtained .39 as compared to the $.336 \times 10^{12}$ d/cm^2 of Bridgman's measurements.

This work has been reported in detail in *The Journal of Chemical*

Physics 20, 40 (January 1952) where also bibliographical material will be found.

SOME RECENT DETERMINATIONS OF THE VELOCITY OF LIGHT

(Abstract)

JOSEPH F. MULLIGAN, S.J.

A number of important measurements of the velocity of light have been made in recent years. Four of these measurements were reviewed in a recent article (J. F. Mulligan, S.J., *American Journal of Physics*, 20, 165-172 [1952]). These measurements all yield a value very close to 299,790 km/sec for the velocity of light in vacuum, a value which is considerably higher than the 299,776 $\pm$ 4 km/sec generally accepted in the years 1934-1949 by physicists. After the publication of the above article some interesting correspondence was had with C. Aslakson and R. Birge on the cause of this discrepancy. Some physicists think that there may be a slight frequency dependence of the velocity of electromagnetic waves in free space. Since the older value for c was obtained by Kerr-cell and rotating-mirror measurements at optical frequencies, while the newer value is based mostly on measurements at microwave frequencies, this could account for the discrepancy.

There are, however, serious experimental and theoretical difficulties with such an explanation. Shapley has shown that the velocity of red and blue light coming to us from the Cepheid Variables is the same to at least one part in 10^{10}. If no dispersion is observed here, it would seem unlikely that it would be observed over the rest of the electromagnetic spectrum. Theoretically Maxwell's electromagnetic theory predicts that c is equal to the ratio of the electrostatic to the electromagnetic units of charge, and this has been confirmed to a very high degree of accuracy by the experiments of Rosa and Dorsey. If c varies with frequency, just what value of c did Rosa and Dorsey measure? Again, the constancy of c is a fundamental postulate of the theory of relativity, and the theory leads to the important mass-energy relationship $E = mc^2$, in which there is no indication of any frequency dependence. Hence both Maxwell's electromagnetic theory and Einstein's theory of relativity give strong evidence against the possibility of a frequency dependence of the velocity of electromagnetic waves in free space.

GEODETIC MEASUREMENTS BY MEANS OF A SOLAR ECLIPSE[1]

(Abstract)

FRANCIS J. HEYDEN, S.J.

This paper gave the details of an expedition to Africa for the purpose of observing the eclipse of February 25, 1952 by Georgetown Observatory in conjunction with the United States Air Force. The purpose of the expedition was to measure a first order geodetic line between two observers. This requires the determination of the exact instants when two observers along the path of the eclipse are on the axis of the shadow. Difficulties in hearing time signals were caused by the jamming tactics of Russian anti-propaganda transmitters. The mistakes of inexperienced personnel operating scientific equipment under pressure were troublesome. The mathematical work of computing results promises to be involved and the services of an electronic computor will be necessary.

PHOTOGRAPHY — INDISPENSABLE TOOL IN PHYSICS

(Abstract)

JOHN P. DELANEY, S.J.

A century and a half ago Young demonstrated the wave nature of ultraviolet by Newton's rings produced on paper impregnated with silver chloride. In 1860 Father Angelo Secchi established beyond doubt the reality of solar prominences by his photographs of the total solar eclipse. Roentgen's discovery of x-rays, Becquerel's discovery of the radioactivity of uranium, Villard's discovery of gamma rays, Laue's spot patterns, these and other photographic achievements advanced Physics by leaps and bounds directly into the development of Nuclear Science.

Current research relies extensively on photography, whether spectrography, seismography, mass spectrography for isotype separation, ballistics and projectile flight analysis, ultrasonic research and shock waves, isotopic radioactivity so widely applied in advanced biological and medical research. Modern astrophysics has practically abandoned visual observation in favor of photographic, and the glass giants on Mount Palomar and Mount Wilson are functioning as cameras for nightly photography of distant universes.

The alert Physics teacher prepares lantern slides for his classes and shows his own work in spectrography, Laue spot patterns, oscillograph analyses, and also encourages his photographically interested students toward undertaking their own recordings along these simple and fascinating lines.

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[1]This paper will be published in the January issue of the BULLETIN. *Ed.*

THE USE OF PHOTOGRAPHIC EMULSIONS IN THE STUDY OF NUCLEAR REACTIONS

(Abstract)

FREDERICK L. CANAVAN, S.J.

A brief survey is given of the use of the various types of photographic emulsions in the detection and identification of the products of nuclear reactions. The significant differences between nuclear track plates and ordinary emulsions are discussed and typical experimental arrangements for the use of the plates shown. A simple experiment using nuclear track plates to determine the range in air of particles from naturally radioactive substances is illustrated.

PHOTOMETRY IN SPECTROSCOPY

(Abstract)

JAMES J. DEVLIN, S.J.

The instrument used by the spectrographer to measure the density of a spectrum line is a microphotometer. Several properties are incorporated in this instrument to provide the spectrographer with the instrument needed to relate photographic density to the intensity of the radiation that fell on the photographic plate. By observing the proper precautions the spectrographer can avoid several effects which would give him a false characteristic curve for a given emulsion. There are three principal methods of imprinting calibration marks on a photo emulsion. Each has its own limitation but properly used can produce reliable data for a calibration curve. This curve will allow the spectrographer to convert density readings of spectral lines to intensity ratios of the incident radiation.

PHOTOGRAPHY WITH THE SOLAR SPECTROGRAPH AT GEORGETOWN

(Abstract)

FRANCIS J. HEYDEN, S.J.

For the past two years work has been progressing on the construction of a spectrograph for photographing the solar spectrum at Georgetown. This paper reported the progress made up to this time. Much time has been spent in trying to get the best focus at all fifteen positions along the pier of the spectrograph for the Rowland grating. Another problem has been "ghost" lines due to flaws in the grating. A half dozen varieties of emulsions are needed to cover the entire spectrum; the speed of the instrument varies all along the spectrum and is very critical for the slightest hazy condition of the

sky. As a result standardization of exposure has been difficult. At the present time work is being done on completing one set of plates of the entire solar spectrum. Also a search is being made for some Tantulum lines in the far infra-red and the ultra-violet.

DISTANCE, COLOR AND EXTINCTION CORRECTION IN PHOTOGRAPHIC PHOTOMETRY

(Abstract)

MARTIN F. MCCARTHY, S.J.

This paper treats of one of the fundamental problems encountered by astronomers in photographic photometry: the correction of the observed stellar magnitudes for the errors which arise from the combination of lenses, filters and emulsions and also from the peculiar conditions of the atmosphere in the vicinity of the observing station. After a brief resume of what is meant by a stellar magnitude, an analysis of the various factors which modify the stars' brightness is presented. The three chief corrections, for the distance of the images from the optical axis of the camera, for the effects of color errors, and for the absorbing properties of the earth's atmosphere, are discussed with reference to a practical problem in photographic photometry: the determination of accurate photographic and photored magnitudes of Cepheid variable stars in the Crux-Carina region of the Southern Milky Way.

Author and Title Index

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LEGEND
ABS Abstract of paper
AUTH Author
BRev Book Review
OBIT Obituary