A. M. D. G.

BULLETIN

of the

American Association of Jesuit Scientists

Eastern States Division
(Founded 1922)

(for private circulation)

Published at
COLLEGE OF THE HOLY CROSS
Worcester 3, Massachusetts

Vol. XXVII   DECEMBER, 1949   No. 1

Contents

Biology:

Protoplasmic Movement. Part II. William D. Sullivan, S.J., Weston College 4

Chemistry:

Bibliography of Chemistry Textbooks in Spanish and Portuguese . . 10

Teaching Isomerism in Organic Chemistry 12
Rev. Bernard A. Fiekers, S.J., College of the Holy Cross

Chemical Laboratory Hints: Use of Bromine Ampoules. Metal Foil Insulation for Wood Table Tops. Rev. Albert F. McGuinn, S.J., Boston College. Flask Heaters. The Oxybomb. Gas Trap for HBr. HBr Fumes. Inexpensive Polarizing Microscope. Hot Parts of Flasks. Rev. Bernard A. Fiekers, S.J., College of the Holy Cross 12

Mathematics:

The Catenary. Rev. Thomas D. Barry, S.J., Weston College . . . 15

A System of Dimensional Analysis. Rev. Stanley J. Bezuszka, S.J., Doctorate Candidate at Brown University, Providence, R. I. . . . 18

A Brief Review of Slide Rules Currently Available. James J. Ruddick, S.J., St. Louis University 32

Physics:

Current Nuclear Physics. Part III. William G. Guindon, S.J., Weston College 23

Important Notice:

Ateneo de Manila Library Requests Backruns of Chemical Journals . 31

News Items:

Saint Peter's College, Chemistry Department, Jersey City . . . 34

College of the Holy Cross, Chemistry Department 35

Reviews and Abstracts:

The Effect of Cholesterol etc. William D. Sullivan, S.J. 36

Mathematics, the Language of Science. Rev. John A. Tobin, S.J. . . 33

Bulletin of the American Association of Jesuit Scientists

EASTERN STATES DIVISION

VOL. XXVII | DECEMBER, 1949 | NO. 1

Biology

PROTOPLASMIC MOVEMENT. II.*

William D. Sullivan, S.J.

Ciliary Movement

In contrast to amoeboid movement, which takes place upon a solid substrate and involves a change in the contour of the cell, ciliary movement takes place in a liquid medium, in which the organisms move freely by minute whip-like structures located on the surface of the cells. These whip-like structures appear in two forms, *flagella*, few in number and long in relation to the cell, and *cilia*, numerous and very short in relation to the cell. Ciliary movement is found in every phyla of animals, except in the nemathelminthes and arthropoda, as well as in some plants. In the protozoa, especially, thousands of these cilia propel the organisms forward, rotating them through the liquid medium in helical paths. Among the protozoa, one class in particular, the infusoria, possess a modification of ciliary appendages, i.e. *cirri,* or, as they are sometimes called, *undulating membranes,* which are a fusion of many cilia forming a large conical structure. Should an undulating membrane be cut in one section, there will appear immediately many cilia where formerly one cirri existed.

The following is a brief list of some of those cells manifesting ciliary movement.

1. Protozoa.
2. Cells of the epidermis of the larva of invertebrates, e.g. ptenophores and tubularia.
3. Cells of the alimentary tract, e.g. in the frog. They act as superficial currents allowing the alimentary canal to remain clean.
4. Cells of the intestine and liver of the molluscs.
5. Cells of the excretory system, driving fluid through the narrow tubes, e.g. the nephrostomes and the nephridia of the annelida.
6. Cells of the reproductive system, i.e. the vasa defferentia.
7. Cells of the Fallopian tubes.

Generally the movement of these cilia in the metazoa is in one direction only, removing solid particles from the different organs which might be injurious to the organism. Cilia are also found as external appendages of the metazoa, e.g. the rotifers, which have discs of cilia on their outer surfaces. In some of the platythelminthes and nemertinea, as well as the larvae of annelidae, cilia are found on

---

* Part I. This Bulletin, *26,* 121-131 (1949).

the surface in large areas, and these cilia determine the movement of these animals.

In the higher animals, the cilia beat for life, nor can these animals control ciliary beat. In some cases the cilia are dependent on the nervous system; in others they are not. In the lower animals, the ciliary beat is under the control of a control-center. As to just what the nature of this control center is, no one is certain.

The typical ciliated cell is in the form of a prism, with the cilia along the free surface. The cilium passes through the membrane into the cell cytoplasm and ends in a minute granule, called the *basal granule*. A complete morphological study of the cilium has been impossible because it has not been possible to correlate structure with observed function. Saguchii (1917) has given us, perhaps, the best picture of the ciliated cell. From these basal granules, fine threads, called *fibrillae*, pass further into the cytoplasm. These fibrillae converge into a cone-shaped bundle, the apex of which terminates at the side of the nucleus (fig. 4).

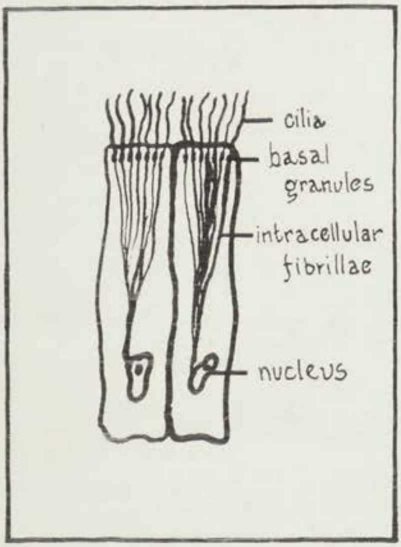


Fig. 4. Diagrammatic sketch of a ciliated cell.

The exact nature of the basal granules has been the basis for much discussion. According to the Hennegy-Lenhossek theory, the basal granules are derivatives of the centrioles. Though such does seem to be the case in some of the cells studied, it is almost certain that such is not the case in other cells, e.g. in the epithelial cells of the invertebrates. These ciliated cells lack basal granules completely. The theory finds support in the fact that the flagella of spermatozoa are attached to derivatives of the centrosomes. Also the cells which line the kidney tubules of the salamander and the seminal vesicles of man shows a long cilium attached to a true centriole. In the spermatozoa of plants there is also evidence that the flagella are attached to the blepharoplasts, which seem to take their origin from the centrosome.

As for the internal structure of the cilium and the flagellum, very little is known. They are so minute and so delicate that even under the highest powers of the microscope it is almost impossible to observe anything more than a filament. Recently, however, due to the electron and the polarizing microscopes, an advance has been made into the submicroscopic structure of these filaments. According to Schmidt (1939) the cilia and flagella manifest a *positive intrinsic* and *form birefringence*. This new finding leads one to believe that they are composed of fibrillae lying in the long axis of the filament. Since the use of birefringence has also entered into the study of the submicroscopic structure of the muscle fibers, of which we shall speak presently, references to works, that describe the phenomenon and technique, are given.**

Schmidt worked on the tails of the spermatozoa, on the flagella and vibratile cilia. He showed that the cilia and the flagella are positively birefringent and that the anistropy is due to intrinsic and form birefringence. He also discovered that they were composed of fibrillae which were fairly uniform in number and bound together in bundles.

When the cilia are examined under the microscope, they seem to move very rapidly. However, it is known that the fastest ciliated organism does not move twenty feet in one hour. Gray (1928) has shown that an average cilium has an angular velocity of a flywheel making 360 revolutions per minute. While the angular velocity may be very high, the linear velocity is slow. Both the cilia and their linear velocity are magnified under the microscope. From this it is clear that in determining the rate of ciliary movement, two factors must be taken into consideration: the velocity of the ciliated cells and the velocity of the individual cilia. Through the use of the stroboscope and stroboscopic synchronization, Martius (1884) found that the frequency of ciliary beat in the frog's pharynx was 10 to 17 beats per second. When the frequency of the illumination and the cilium beat become exactly the same, the cilium appears motionless. Knowing the frequency of the illumination, the beat of the cilium can then be calculated. Edgerton and Germeshausen (1934) constructed a high speed motion picture camera capable of taking 6000 pictures per second. Combining the stroboscopic principal and this high speed camera, Jennison and Bunker (1934) took pictures of the different stages in the beat of a cilium from the gill of the clam, mya. Obviously, such a method of timing the cilium is far above the means of the ordinary scientist, and until a more tangible method is discovered, very little more can be said about it.

The movement of the cilia may be *isochromal* or *metachromal*. When the cilia are found to be in the same phase of contraction, they are said to beat in isochromal rhythm. This seems to imply some kind of a mechanism of regulation. And due to the fact that cells bearing cilia have been separated from the rest of the organism, this mechanism can be truly said to be independent of the nervous system. When the cilia beat in metachromal rhythm there is a sequence of beat throughout the cell so that there appears a series of wave-like formations passing over the entire cell (fig. 5).

The different types of ciliary movement and the details of these types have been known now for some time. The first type is called the *pendular movement* or *motus vacillans*. The cilia bend back and forth, bending only at the base. There is a forward movement, or effective beat, and a slow recovery, or return beat. There is no noticeable change in the cilia as they bend. This is the common type of the protozoan movement. The *hook-shape movement*, or *motus unicinatus*, is a second type of movement and more common in the higher animals. In this type of movement there is a noticeable change in the shape of the cilium in the effective and return beat. Like the first type, it too takes place in a single plane. The cilium begins its beat at the tip and works its way down to the base. In the return beat the reverse is true, i.e. the cilium begins to straighten from the base and works its way to the tip. A third type of ciliary movement is the *undulatory movement* or *motus undulatus*. In this beat the action of the cilium resembles a series of waves from the base to the distal end or vice versa, depending on the organism. The fourth type of ciliary movement is called the *funnel-shape movement* or *motus infundibuliformis*. In this type of movement the cilia do not beat in a single plane but in three dimensions. Combinations of these four fundamental types of ciliary movement may also be found in some tissues.

According to Weiss (1909) the amplitude of the beat varies anywhere from 25 degrees to 50 degrees normally. In some cases it has been noticed that the amplitude of the beat has reached as high as 90 degrees. Also, though the cilium usually begins its beat when it is perpendicular to the surface of the cell, it has been observed that the beat begins when the cilium is flat against the surface of the cell (Verworn, 1915). The effective stroke is much faster and much more forceful than the return beat.

The capacity for the beating cilia to do work has been the study of much investigation. Maxwell (1905) spread the epithelial from the frog's gullet on an inclined plane. By placing loads of various weights and sizes on the tissue, he found that the rate of ciliary movement increased with the weight of the load until a maximum was reached. Fatigue finally set in and the cilia ceased moving. Gray, reviewing the work of Maxwell, found that the oxygen consumption will vary directly with the speed of ciliary action. In other words, he found that there is an ordinary relation between oxygen consumption and the amount of work done by the cilia and also the rate at which the cilia can do the work. Jensen (1893) had already studied this problem in the paramecia. He centrifuged the organisms and used just enough centrifugal force to oppose the beat of the cilia. He found that the cilia can produce a force of 0.00017 mg. on the surface, which is 9 times the weight of the organism itself. Each individual cilium exerts a force of 4×10^{-7} mg. Each square centimeter of surface exerts a force of 21 mg. Eighty-seven percent of the energy is expended to overcome the viscosity of the water, leaving very little for effective use. In general, it can be said that the efficiency of cilia and flagella movement is extremely low. It is, however, suitable for small animals which have a small specific gravity, which move at slow speed and in a liquid medium. Weiss (1909) proposed that the work done by a single cilium in a given unit of time varies with the cube of the speed of the ciliary movement, or ciliary beat.

Though the mechanism of ciliary movement is not known in detail, there have been many theories to explain it. Since the size of the cilia are far below the resolving power of the microscope, an exact investigation of the internal structure is impossible. However, as far back as 1835, Grant proposed the theory that ciliary movement was due to the existence of currents of fluid passing from the cell to the cilia and back to the cell. Cilia and flagella, therefore, were thought to be hollow tubes, much like the tube feet of the echinoderms. Bending was considered to be due to the return flow of the liquid into the cell. Schaeffer (1891) also proposed the theory of the hollow tube. The bending of the cilia, according to Schaeffer, was due to the variant pressure of the fluid coming from the cell and entering the cilia. As yet it has been impossible to demonstrate the hollow core within the cilium. A still more advanced theory in ciliary movement is that proposed by Gray (1928). According to him the differential absorption of water will explain not only the beat, but also the bending of the cilia. The sides of the cilium differ in their capacity to absorb water. One side will absorb more water than the other side; much like a piece of paper which has been moistened on one side only, it will curl up, bending inwards towards the side which has been moistened. However, the latest studies on the structure of the cilium by the electron and the polarizing microscopes gives a very good foundation for the theory that the cilium is composed of fibrillae, and the difference in degree of contraction of these fibrillae determine ciliary movement. Such an explanation will place the study of ciliary beat and ciliary bending in the submicroscopic field. As we shall see in the next section, such also seems to be the explanation of muscular movement and contraction in the higher animals.

The following are some experiments performed by the author on ciliary movement. Studying the ciliary beat of paramecia under the microscope, it was observed that the organisms generally move with the narrow rounded end forward, although, at times, a backward movement was noted. In the backward movement the blunt end was forward. This type of movement was noticed especially when the organism struck an obstacle in its path such as plant material, and is called the "avoiding reaction". The paramecium rotates in its long axis in a motion that is counter-clockwise, when viewed from behind. Occasionally, and particularly in its so-called "avoiding reaction", it rotates in a clockwise fashion. When carmine particles are introduced into the culture, it is difficult to observe the currents produced by the organism in motion due to its speed. However, in a resting specimen it is possible to observe the currents of water close to the oral groove. This current pushes the food particles, as well as non-food particles, towards the open gullet and thereby assists in the process of ingestion. In moving paramecia it is not possible to observe any currents in this region of the oral groove and hence it would seem that the animals do not feed while in motion.

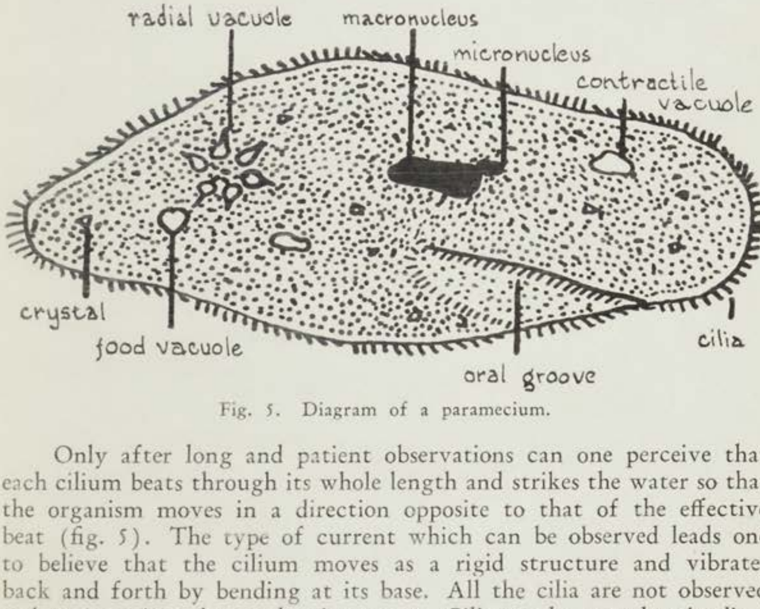


Fig. 5. Diagram of a paramecium.

Only after long and patient observations can one perceive that each cilium beats through its whole length and strikes the water so that the organism moves in a direction opposite to that of the effective beat (fig. 5). The type of current which can be observed leads one to believe that the cilium moves as a rigid structure and vibrates back and forth by bending at its base. All the cilia are not observed to beat in unison, but rather in groups. Cilia on the same longitudinal row can be seen to beat metachronously, whereas the cilia within each group may be seen to beat synchronously or in isochromal rhythm.

Carmine particles and pieces of cork were placed on the exposed palate of the frog and the time in seconds it took these objects to travel up an inclined plane for a distance of two millimeters can be seen in Table II. Still heavier weights than those recorded were used, but the bulkiness of the cork was believed to have injured the cilia to such an extent that the cilia were unable to move. If a heavier piece of cork covering a smaller area of the palate had been available, it is believed that this would be carried along by the cilia, since the pieces used, 7 mg. and 10 mg., were moved along with such ease and speed.

Bathing the ciliated tissue from the frog's gullet with various salt solutions changes the rate at which a particle of cork may be moved. The 7 mg. piece of cork used to demonstrate this fact showed the following measurements. The distance was 6 mm. Molar sodium chloride solution stopped the motion of the cilia. Tenth molar sodium chloride solution allowed the transportation of the cork particle to take place at an average speed of 56.4 seconds. When bathed with

TABLE II.

	Carmine	Cork (7 mg.)	Cork (10 mg.)
	3.0 seconds	8.0 seconds	8.0 seconds
	3.0 "	7.5 "	7.5 "
	4.0 "	8.1 "	6.0 "
	3.5 "	7.6 "	7.8 "
Mean	3.4 "	7.8 "	7.3 "

tenth molar potassium chloride solution, different speeds were observed. At first the reading showed that the particle was moved the distance at 46.5 seconds. In the next reading, 37 seconds were noted; then 24.8 seconds; and finally, 23 seconds. When an additional dose of potassium chloride was added, the particle moved the distance in 31 seconds. When bathed in molar calcium chloride solution, the cilia moved the particle the whole distance in 34.3 seconds.

One of the general laws of ciliary movement states that the processes always beat in the same direction. This is also true in the case of the frog palate cilia. There the beat is always towards the esophagus and the stomach. The experiments with the frog's ciliated tissue confirms the fact that some cilia are independent of the nervous system. There are no ganglia present in the mucosa of the palate or of the upper esophagus. The removal of the tissue, therefore, cuts off any source of nervous stimulation. Still the cilia continue to beat. On the other hand, a paramecium definitely has some control center for its cilia, since it slows down, briefly halts or reverses, the locomotor cilia. These appear to be in constant motion.

(To be continued)

**Bibliography

1. Pamphlet. "The use of polarizing microscopes," 21 pp., Spencer Lens Co., Buffalo, N. Y., **1943**. A bibliography on the use of the polarizing microscope in biology appears on page 21 of this item.
2. Pamphlet. "Determination of refractive index of transparent and translucent solids by means of the microscope," Bull. RF-1, 2nd Printing, Jan. **1943**, R. P. Cargille, 118 Liberty St., N. Y. 6.
3. Pamphlet. West, P. W., "Polarized light microscopy," reprinted in pamphlet form from the *Chemist Analyst, 34*, 76-81 (1945); *35*, 4-8, 28-35 (1946). Gratis: J. T. Baker Chemical Co., Phillipsburg, N. J.

Editor's Note. The section of manuscript on polarization microscopy was submitted by the author but not published here in order to save space. The original manuscript might be borrowed from the author.

Chemistry

BIBLIOGRAPHY OF CHEMISTRY TEXTBOOKS IN SPANISH AND PORTUGUESE

(A notice)

REV. BERNARD A. FIEKERS, S.J.

The title of this notice is an abbreviation of the title to an article by Wallace R. Brode which appears in the current *Journal of Chemical Education* for October (26 (1949) pp. 553-565). We call attention to it here because many items of Jesuit Bibliography in the field of chemistry are listed. It contains five items of Father I. Puig, S.J., on general chemistry; and one of his on organic chemistry; one item on general chemistry by Father E. Saz, S.J.; and three by him on physical chemistry; by Father E. Vitoria, S.J., one item on general chemistry; two texts and two laboratory manuals in organic chemistry; and one text on catalysis; and by Father Theodor Wulf, S.J., one item on atomic physics. It is possible that other Jesuit authors were also listed, but they could not be recognized by the writer.

If a study of the number of editions of these books is permissible, according to Spanish bibliographical practice and the care and intention of the original bibliographer, then the following data might be of interest. In many cases the number of the edition is not given. This could be interpreted as a listing of the first edition. Of those indicated few items are beyond their fourth edition. Hawk, Ober and Summerson's *Practical Physiological Chemistry* is in its thirteenth edition in Portuguese and in Spanish; the Jesuit Vitoria's *Manual de Quimica Moderna* is also in its thirteenth Spanish edition. There is an item on *2000 industrial procedures* by a non-Jesuit author in its ninth edition. Then come two items by Father Puig: his *Curso General de Quimica* in its seventh edition, and his *Vade Mecum del Quimico* in its sixth edition. This seems to provide eloquent data for the academic apostolate of our Spanish and Portuguese Fathers, especially when these texts seem to be at a level that is heavily populated with students.

Other interesting products of the study include the following. A number of standard German, British and American textbooks have been translated into these languages. References then to these in our works would then have greater appeal because of wider availability. The majority of items in the History of Chemistry section are by non-Spanish or Portuguese authors. Presumably the same difficulty in the choice of the history text exists with them as with us. Further it is evident from the bibliography that the outstanding American publishers of chemistry texts plan to publish heavily for the Spanish and Portuguese market. One is gratified to find that translations into the Spanish and Portuguese are in process for the Plastics Laboratory Manual by Dr. G. F. D'Alelio, an alumnus of Boston College.

TEACHING ISOMERISM IN ORGANIC CHEMISTRY

REV. BERNARD A. FIEKERS, S.J.

The problem of listing all of the alcoholic isomers of amyl alcohol, for example, can be tackled by student and professor in a variety of ways. It is largely one of varying alkyl and —OH groups on a given structure and then checking back in order to cancel repetitions. The most efficient way of solving the problem, it seems to the writer, is first to determine the carbon skeletons that are involved by varying alkyl groups and thus deriving structures for the corresponding pentanes, and then varying the —OH group on each of these until all possibilities are exhausted. For, (1) the number of isomeric pentanes is far less than that of the corresponding alcohols, and (2) the introduction of an —OH group into any position could never occasion the writing of a new carbon skeleton.

To vary both alkyl and —OH groups indiscriminately is repetitious, time-consuming and inefficient. To vary alkyl groups on alcoholic structures is equally ill-advised since the alcoholic isomers generally outnumber those of the parent hydrocarbon structure.

In solving this problem then, the pentane structures are pentane, 2-methyl butane and 2,2-dimethyl propane or neopentane.

The alcoholic derivatives of pentane are: pentanol-1, pentanol-2 and pentanol-3. Those corresponding to 2-methyl butane are: 2-methyl butanol-1, 2-methyl butanol-2, 3-methyl butanol-1 and 3-methyl butanol-2. Neopentane has one alcoholic derivative, namely, 2,2-dimethyl propanol-1.

CHEMICAL LABORATORY HINTS

USE OF BROMINE AMPOULES. The ordinary container for one pound of bromine is a glass ampoule. The empty ampoule can be used to make a useful tool for transferring solid or liquid into a narrow mouth flask or bottle. My method is to make a file scratch around the middle of the ampoule. Moist filter paper, cut with straight edge, is then wound about the ampoule on both sides of the scratch. A hot flame is applied to the scratch with rotation, and usually a clean break is obtained. The neck of the ampoule is broken cleanly in the same way. The resulting product should be fire-polished, and, since it is soft glass, it must be done cautiously with a bushy reducing flame, preferably with the piece fixed, and the flame directed by hand, —slowly. *A. F. McG., S.J.*

USE OF METAL FOIL AS INSULATION FOR WOOD TABLE TOPS. Long continued heating with gas or electric hot plate on a wooden table is apt to injure the surface of the table. My own desk is a sturdy maple top with a coating of chlorinated rubber paint. On this table I have operated a muffle furnace at 1000° C. for several hours, and a gas burner at full blast without any injury to the painted surface. The protection was afforded by a piece of thin metal foil, similar to that used in packaging cigarets. The following data can be presented to show the effectiveness of this method of insulation.

A piece of metal foil, one foot square, was placed on the table under an ordinary gas burner at full gas pressure, the heat being reflected from an asbestos pad. After one hour the following temperatures were recorded: (1) Under the metal foil 36° C. (2) Above the metal foil and close to burner 55° C. (3) On desk at edge of metal foil 69° C. (4) On desk, 3 inches from edge of metal foil 53° C.

It is obvious from the above data that a piece of metal foil can assure continued use of intense heat on a wood table without danger of injury to the surface. By use of this principle of heat reflection, I have operated a muffle furnace at about 1000° C. for 12 hours with no injury to the table surface.

I highly recommend a 12 inch square of thin metal foil for safety, when long continued heating is required on wood tables, and continued attention is not possible. *A. F. McG., S.J.*

FLASK HEATERS. Plaster filled heaters for standard round-bottom and other flasks can be made economically and in quantity for general laboratory and research use. The greatest difficulty is usually encountered when one tries to form the electrical heating element into shape for the flask desired. The length of coil nichrome wire to be used can be calculated from the desired wattage and from data on the spool. It is elongated somewhat and its extremities are stretched out sufficiently for making external connections. It is then attached to a flask, which is used as a form, by spots of sealing wax. Almost any scheme of spiralling the wire around the lower half of the flask can be used. A spiral design from the bottom of the flask up to about short of the great circle at the halfway mark is suggested. The wires should not cross or touch at all. A fireclay mixture of about putty consistency, mixed with a little shredded asbestos for strength, is then layed over the wired part about one-quarter or one-half inch thick. It is best to leave little knobs or lumps on the outer surface of this, for the purpose of locking it into the plaster of Paris later on. Before this material has set solid, shredded asbestos should be worked into its surface by hand. A suitable container is selected, probably a gallon preserve can, cut to about half height with tinning shears. Binding posts are attached to the side of this. The insulation of the posts from the can is checked. Connections are made with the heating element. The can is filled to sufficient height with plaster of Paris. The flask and element are placed into this; the plaster between flask and rim of the unit smoothed out so as to drain outward; and the plaster is allowed to set. Five or six flask heaters may be connected in series under 115 volts in order to hasten the drying. Once dry they are heated under a hood using 115 volts in parallel in order to melt and burn out the wax that attaches element to flask. The flask is withdrawn and cleaned with acetone. The cavity it leaves is lined with wet asbestos paper or with fire clay in order to prevent the heating element from coming into direct contact with the flask during use. We wish to acknowledge that this suggestion came originally from Albert Chouinard, Holy Cross, '38. *B. A. F., S.J.*

THE "OXYBOMB" is a small vest pocket tank of oxygen, not dissimilar to the small cartridges of carbon dioxide used in connection with siphon bottles. The cartridge of oxygen is provided with a threaded collar near the sealed gas outlet, to which a simple needle valve can be attached for dispensing the gas. The construction of the valve allows for easy control by means of a ratchet indicator that contacts with a knurled thumbscrew control. The tank itself contains the equivalent of 164 cu. in. of oxygen gas. The bombs sell at $3 per dozen, and the valve, which need not be discarded once used, costs $1.25. A. Daigger & Co., 159 W. Kinzie St., Chicago 11, Ill., supplies the Oxybomb. Nitrous oxide and carbon dioxide are the only other gases, the contributor knows of, which are available in similar form. The former is used for whipping cream in a siphon bottle; the latter has many uses. But, as best we know, these are not provided with the threaded collar for controlling the gas flow with a valve. It would be a good thing if someone would adapt the valve of the oxybomb to the tool of the cartridge dispensers, so that this source of gases would be available for laboratory work and lecture demonstrations. *B. A. F., S.J.*

A GAS TRAP FOR HYDROGEN BROMIDE in the synthesis of butyl bromide is commonly described in the laboratory manuals of organic chemistry. Generally it consists of an inverted funnel over a beaker of water whose stem is connected to the top of the reflux condenser by means of glass or rubber tubing. The new edition of Adams and Johnson (Laboratory experiments in organic chemistry, 4th ed., MacM., N.Y., 1949, p. 199 footnote) suggests that a suction filtering flask be used in which the gas to be absorbed comes through a glass tube supported above the surface of the water.

B. A. F., S.J.

HBr FUMES. In connection with the solubility of hydrogen bromide in the above system, we have noticed that hydrogen bromide does not dissolve in pure water as readily at the beginning of the experiment as it does later on dissolve in a solution of hydrogen bromide itself. This of course explains why the HBr fume nuisance is encountered in so many student laboratories while this experiment is in progress. Once the trap is saturated with HBr, it should not be refilled with pure water. Some of the saturated HBr solution should be discarded; and some of it should be left in the trap to be diluted with water. Some students who start the experiment later than others can use some of the HBr solution already prepared by others. It is remarkable what a difference this consideration can effect in a large student laboratory. *B. A. F., S.J.*

AN INEXPENSIVE POLARIZING MICROSCOPE that is an adaptation of the Bausch and Lomb School Microscope and sells for $190 without accessories has recently come onto the market from Kenneth A. Dawson Co., 2000 Massachusetts Avenue, near Porter Square, Cambridge 40, Mass. Polarization is effected with Polaroids. The revolving protractor stage is built in. *B. A. F., S.J.*

HOT PARTS OF FLASKS are protected from staining by the rubber on clamp jaws, as probably every chemist knows, by wrapping the glass with a small piece of filter paper at point of contact with the rubber. Some prefer to wrap the clamp jaws with asbestos, usually in cord form. Generally the asbestos is painted with water glass solution. *B. A. F., S.J.*

Mathematics

THE CATENARY

REV. THOMAS D. BARRY, S.J.

The curve whose form is that of a flexible cord or chain, hanging freely from two points of suspension, is called a catenary. Its equation is usually given as $y = a/2\ (e^{x/a} + e^{-x/a})$. For our purposes, it will be more convenient to change from exponential to hyperbolic functions, giving $y = a \cosh (x/a)$. Since, for $x = 0$, $\cosh x/a = 1$ and $y = a$, and for x not equal to zero, $\cosh x/a$ is greater than one, the lowest point (vertex) of the curve is on the y-axis, and *a* is the intercept on that axis. Substituting —x for x in the equation(seen, perhaps, more clearly in the exponential form) makes no change in the equation, so the curve is symmetrical with respect to the y-axis.

LIMITING FORMS OF THE CATENARY

1) When *a* becomes infinite: by Lhopital's rule

$$\lim_{a \to \infty} a \cosh x/a = \infty.$$

Therefore, as *a* becomes infinite the catenary approaches $y = \infty$.

2) When *a* approaches zero: first, solve for x.

$$x = a \cosh^{-1} y/a.$$

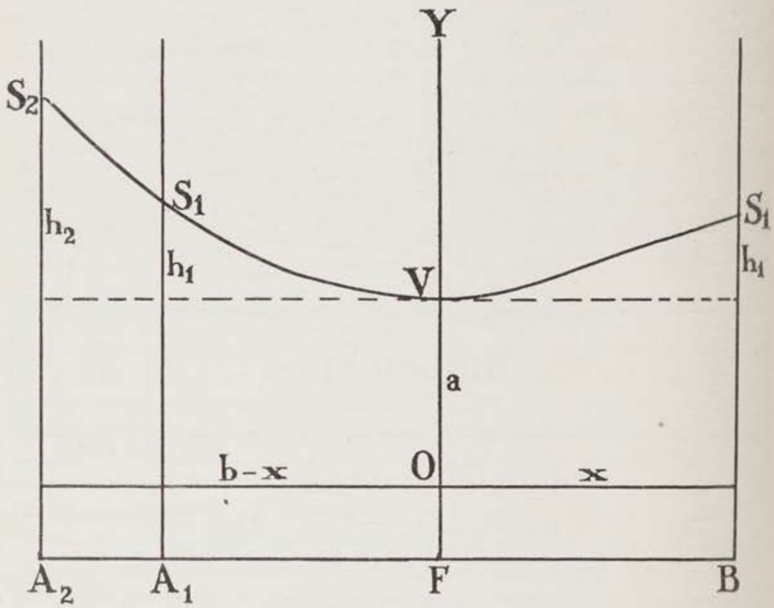
Then $\lim_{a \to 0} a \cosh^{-1} y/a = 0$.

Therefore, since y is always positive, the limiting form of the curve as *a* approaches zero is the positive side of the y-axis.

Slope of the Catenary

$$y' = \tan\ t = \sinh\ x/a,$$

and the inclination $t = \tan^{-1} \sinh x/a = \text{gd}\ x/a$ (i.e. gudermannian x/a).



Length of Arc of the Catenary

$$1 = \int_a^b [1 + \sinh^2 x/a]^{1/2}\, dx = \int_a^b \cosh x/a\, dx = a[\sinh x/a]_a^b.$$

In the examples below, these values are:

Case I. $t = \text{gd}\ 5/1.67 = \pm 84^\circ\ 15'$. (Smithsonian Tables, cited below, pp. 276 ff.)

1 (between supports) $= 2 \times 1.67\ [\sinh x/1.67]_0^5 =$
$3.34\ (\sinh 2.993 - \sinh 0) = 3.34\ (9.948) = 33.23.$

Case II. $t_1 = \text{gd}\ 16.95/15.82 = 52^\circ\ 12'$,
$t_2 = \text{gd}\ (-23.05/15.82) = 116^\circ\ 14'$.

$1 = 15.82\ [\sinh x/15.82]_{-23.05}^{16.95} =$
$15.82[\sinh 1.072 - \sinh(-1.457)] =$
$15.82\ (1.289 + 2.030) = 52.51.$

The following method of obtaining the value of *a* in the equation of the catenary is a by-product of a problem presented to me in connection with the Weston College chicken ranch. Suppose a rope is attached to two opposite walls of a room, with the following measurements known: (a) the heights of the supports above the floor, (b) the height of the lowest point of the rope above the floor, (c) the horizontal distance between the supports. Required to find the equation of the rope. The unknowns are, in general, the location of the y-axis with respect to the points of support (as seen above, it passes through the vertex), and the distance a of the vertex above the x-axis. The x-axis does *not*, unless by sheerest accident, lie in the plane of the floor. We may distinguish two cases.

CASE I. WHEN THE SUPPORTS ARE AT THE SAME HEIGHT. (See figure). In this case, because of the symmetry of the figure, the y-axis is known to be half-way between the supports, i.e. $b - x = x$. The coordinates of S_1 are $(x, a+h)$, where x is one-half the distance between the supports, and h is the difference between the heights of S and the vertex. Substitute in the equation (solved for x) of the catenary, giving

$$a \cosh^{-1} (1 + h/a) = x.$$

This can be solved for a by successive approximations, using a slide rule and the Smithsonian Mathematical Tables (Hyperbolic Functions), pp. 88 ff. To get the second column in the example below, find h/a on the slide rule, add one, look up that value in the cosh column of the tables; the argument then gives the inverse cosh. The third column is the product of the first two, giving the left-hand side of the above equation. For the correct value of *a*, the difference (col. 4) between this and the known value of x should be zero.

EXAMPLE. Let $A_1B = 10$, $VF = 10$, $SB = 25$. Then $x = 5$ and $h = 15$. Therefore the equation to be solved is

$$a \cosh^{-1} (1+15/a) = 5.$$

(1)=a	(2)	(3)=L	(4)
5	2.064	10.32	+5.32
2	2.830	5.66	+0.66
1.7	2.975	5.06	+0.06
1.69	2.981	5.04	+0.04
1.67	2.991	5.00	0

Therefore the equation is $y = 1.67 \cosh x/1.67$. The origin is 1.67 below the vertex or 8.33 above the floor AB.

CASE II. WHEN THE SUPPORTS ARE AT DIFFERENT HEIGHTS. In this case the location of the y-axis is also unknown. If *b* is the horizontal distance between supports, and h_1 and h_2 the differences between the height of V and those of S_1 and S_2 respectively, the coordinates of S_1 are $(x, a+h_1)$ and those of S_2 are $(-(b-x), a+h_2)$.

Whence $$x = a \cosh^{-1} (1+h_1/a)$$

and $$-(b-x) = -a \cosh^{-1} (1+h_2/a).$$

($\cosh^{-1}$ is minus to left of y-axis.)

Equate values of x to get the equation to be solved.

$$a \cosh^{-1} (1+h_1/a) = b - a \cosh^{-1} (1+h_2/a).$$

The left-hand side is equal to x, which locates the y-axis with respect to S_1B. In the example below the first three columns are the same as in Case I, giving the left-hand side of the equation. Columns (4) and (5) correspond to (2) and (3) for the right-hand side. Column (6) is *b* minus column (5), giving the right-hand side, and column (7) is (3) minus (6), which should be zero for the correct value of *a*.

EXAMPLE. Let $A_2B = b = 40$, $VF = 10$, $S_1B = 20$, $S_2A_2 = 30$. Then $h_1 = 10$, $h_2 = 20$, and we have $a \cosh^{-1} (1+10/a) = 40 - a \cosh^{-1} (1+20/a)$.

(1)=a	(2)	(3)=L	(4)	(5)	(6)=R	(7)
20	0.963	19.26	1.317	26.34	13.66	+5.60
18	1.011	18.20	1.379	24.80	15.20	+3.00
16	1.067	17.07	1.451	23.21	16.79	+0.28
15.9	1.070	17.01	1.455	23.12	16.88	+0.13
15.8	1.073	16.95	1.458	23.02	16.98	—0.03

Therefore $y = 15.82 \cosh x/15.82$. The origin is 16.95 to the left of S_1B and 15.82 below V or 5.82 below A_2B.

A SYSTEM OF DIMENSIONAL ANALYSIS

REV. STANLEY J. BEZUSZKA, S.J.

The subject of Dimensional Analysis is treated in so simplified and limited a form in the first few years of Physics that, the student is frequently misled in appraising its true value and applicability. A major difficulty for a more extensive treatment of the subject matter seems to come from the lack of adequate treatments of Dimensional Analysis at about Sophomore and Junior level. Recently, in an examination of sources and methods on the subject, besides the classical treatments, it was found that a simple and yet thorough discussion of Dimensional Analysis has been developed and is available. It is hoped, that the brief outline here of the method and the extensive bibliography will prove helpful to those who plan to make further use of Dimensional Analysis.[1]

The success of classical mechanics in the 19th century fostered the belief that since heat (by the kinetic theory) was already a part of mechanics, only the addition of electromagnetism was necessary to complete the whole subject of physics. Under these circumstances, the concepts of length, mass, and time, which were fundamental in mechanics, were transferred naturally to the other branches. Unfortunately, this procedure led, in the case of electromagnetism, to ambiguous dimensional formulas. It was only after the advent of

[1] This article is essentially a synopsis of the modern approach to Dimensional Analysis as developed and systematized by Parry Moon and Domina Eberle Spencer. The original articles are given in the Bibliography.

Quantum Mechanics and Relativity, that physicists extended their "dimensions" beyond the fundamental l, m, τ, and with Bridgeman felt that since dimensional analysis was arbitrary, it could be manipulated as occasion demanded. This then requires a decision as to what choice of fundamental concepts are suitable and what rules are best for their use.

Geometry

The geometric approach to "dimension" theory has many advantages. A physical quantity is specified by designating the magnitude and kind of quantity. The supplementary text which explains the meaning of the symbols is essential since the usual equations of physics deal only with magnitudes. In the present system, part of this text is included in the equation by using symbols that not only indicate the magnitude but also designate the kind of physical quantity. Thus we represent a complete physical quantity by $\dashv A \vdash$. This quantity is called an *idon* and is formally written as

$$\dashv A \vdash = A\,[a^1, a^2, \ldots\ldots, a^k]$$
$$= A\,a^i$$

where $i = 1, 2, 3, \ldots\ldots k$

A the magnitude of the physical quantity and the bracket specifies the kind of physical quantity.

For example, in the l, m, t system, energy is designated as $l^2 m\, t^{-2}$ and in our notation would be written as

$$\dashv E \vdash = E\,[2, 1, -2]$$

where $[2, 1, -2]$ is called the base vector

and $2, 1, -2$ are the coordinates of the base vector.

Geometrically, the complete physical quantity is represented by a vector drawn from the origin in a k-dimensional affine space.[2]

Algebra

The meaningful operations for idons include:

I. *Addition.* Give two idons $\dashv A \vdash$ and $\dashv B \vdash$

$$\dashv A \vdash = A\,a^i \qquad \dashv B \vdash = B\,b^i$$

Addition is defined only if these two vectors are collinear, $a^i = b^i$. In this case, $\dashv A \vdash + \dashv B \vdash = (A + B)\,a^i$.

Addition is commutative and associative. Subtraction is an obvious special case of addition.

II. *Multiplication.* The multiplication of two idons requires that their magnitudes be multiplied and the coordinates of their base vectors added. Thus,

$$\dashv A \vdash \dashv B \vdash = AB\,[a^i + b^i].$$

The product is commutative, associative and distributive with

---

[2] Since idon space is an affine space, it need not be 3-dimensional, its angles have no absolute significance, and base vectors along different base axes need not have the same lengths.

respect to addition as defined in I. Powers are included here as an extension of the theory giving:

$$\prec A \succ^n = A^n\,[na^1]$$

III. *Division.* In division, we take the quotient of the two magnitudes and the difference of the base vectors:

$$\prec A \succ / \prec B \succ = (A/B)\;[a^1 - b^1].$$

Differentiation and integration can be included as simple extensions of the above operations which are the only operations permissible in idon theory.

Perhaps a few examples will clarify the rules above. Newton's second law (using l, m, t) becomes:

$$\prec F \succ = \prec m \succ \prec a \succ = ma\;[0, 1, 0]\;[1, 0, -2]$$

$$\prec F \succ = ma\;[1, 1, -2]$$

Addition of two forces: $\prec F \succ + \prec F' \succ = (F + F')\;[1, 1, -2]$.

Division of two forces: $\prec F \succ / \prec F' \succ = F\,[1, 1, -2] / F'[1, 1, -2] = (F/F')\;[0, 0, 0]$.

This last requires a word to be said about zero. In any idon representation $\prec A \succ = A\,a^1$ either A or a^1 may vanish. If the magnitude A is zero we have $0[a^1]$ which represents zero amount of a particular physical quantity. The vanishing of a^1 means that its coordinates are all zero and it can thus be considered as a ratio of two similar idons which have a definite magnitude but no direction. Such a quantity is a scalar in idon space.

Uses of Idon Theory

The theory has five interesting and practical applications:

(a) It provides a method of designating concepts and exhibiting relations among the concepts.

(b) It allows the derivation of equations without detailed analysis.

(c) It gives a basis for experiments on models.

(d) It provides a systematic way of changing from one set of units to another.

(e) It allows transformation from one set of fundamental concepts to another set.

(a) If we consider these applications in order, we find that in the first application, the use of base vectors is a convenient method of designating concepts. A set of fundamental concepts (such as l, m, t) is chosen, and all other concepts are expressed in terms of these fundamental quantities. Other quantities can be added as occasion demands, and it is customary to include T (temperature) for heat problems and Q (charge) for electricity and magnetism. One very important point must be mentioned here. Evidently, if this method of designating concepts is to be of maximum usefulness, there must be a one-to-one correspondence between base vectors and physical concepts. The l, m, t system has many familiar ambiguities and we mention in particular *torque* with base vector [2, 1, —2] and *energy* with the same base vector. This difficulty can be eliminated by distinguishing between radial l_r and tangential length l_t. Thus the fundamental concepts would be l_r, l_t, m, t and we have for some familiar variables,[3]

Force [1, 0, 1, —2]
Torque [1, 1, 1, —2]
Energy [2, 0, 1, —2]
Moment of inertia [2, 0, 1, 0]

(b) Brevity prevents a treatment here of the use of idon theory for the derivation of equations of physics. The subject can be found in the references given. However, we do wish to give an example of the method and application to a problem.

A term of a physical equation can be written as

$$K \{A\}^u \{B\}^v \{C\}^w \ldots\ldots \{N\}^z$$

where A, B, C, ... are n physical quantities;
u, v, w, ... arbitrary powers;
K is a scalar, which may contain trigonometric, exponential, or other functions of dimensionless (scalar) quantities.

The most general form of a physical equation will be a sum of terms such as those above. By a famous theorem (called the Pi theorem and derived by Vaschy, Riabouchinsky, and Buckingham), it can also be written as a product of scalars in idon space. Whence

$$(Pi)_n = \{A\}^{\frac{u}{n}} \{B\}^{\frac{v}{n}} \ldots\ldots\ldots \{N\}^{\frac{z}{n}}$$

Finally then, the most general form of an equation for physical quantities may be written as

$$F(P_1, P_2, \ldots\ldots\ldots P_n) = 0$$

The Pi theorem can be neatly utilized in the derivation of equations in physics and engineering. In any particular problem, we decide upon the *n* essential variables $\{A\}, \{B\}$, ... that affect the problem. Then a choice is made of *k* fundamental concepts, namely, *l*, m, t etc. The rest of the theory provides the mechanics of manipulation. From this method we can get at once such results as the pressure dependence in a perfect gas on temperature, the flow of fluids in smooth pipes of uniform cross section, the classical example of Einstein in the study of specific heats of solids and their connection with quantum phenomena and the electrodynamic theory of gravitation.

(c) Since direct analysis in many engineering problems is difficult, the best procedure is often to build a scale model and make tests on it. The obvious success of this method for ship models tested in towing tanks is evident proof of its usefulness. Here again the details

---

[3] The rules for distinguishing between radial and tangential lengths:

a If there is a direction of motion, l_t is tangential to the direction of motion.

b. If there is a radial direction, l_r is in this direction.

c. In any case these two lengths are perpendicular to each other.

are omitted and may be found in the literature. After a choice of pertinent quantities (namely: force, viscosity, density, velocity, length, etc.), we can derive the famous Reynolds and Froude numbers.

(d) This part deals with the use of idon theory for change of units employed in the measurement of physical quantities. Geometrically, the transformation of units corresponds to change of scales along the coordinate axes. By a proper representation of the physical quantities, we can get the transformation equations for a change, say, from the *c g s* to the *m k s* system. Though these results may be derived without idon analysis, the special feature of the idon method is its systematic approach.

(e) The transformation theory for a change in coordinate axes is a trifle more elaborate, but the procedure is quite straight-forward. It gives a physical significance to coordinate transformations in affine space.

Conclusion

Application (a) is without doubt the most valuable, since it gives a better understanding of the way in which physical concepts are related. The introduction of the two distinct lengths, the radial and tangential, does away with some of the common ambiguities of the standard system. The most satisfying applications of idon theory are found in (b) and (c) with the use of the Pi theorem. Despite the fact that the common use of (d) in dimension theory has elevated this part of the theory to the status of an essential application, it turns out to be a rather trivial use, much less important than the others.

A copy of the essential steps in the methods of idon analysis and prepared tables of variables expressed in fundamental concepts may be had on request by writing to the Author.

Bibliography

1. Parry Moon and Domina Eberle Spencer, "Internationality in the names of scientific concepts", Am. J. Phys., *14*, 1946, p. 431; *14*, 1946, p. 285; *15*, 1947, p. 84. "Modern Terminology for Physics", Am. J. Phys., *16*, 1948, p. 100. "Utilizing the mks system", Am. J. Phys., *16*, 1948, p. 25. "The *dimensions* of physical concepts", Am. J. Phys., **1949**. "A modern approach to dimensions", Franklin Institute. "A geometric treatment of dimensions", to be published in *Physics*.
2. Bridgman, P. W., "Dimensional analysis", Yale University Press, New Haven, **1931**.
3. Lanchester, F. W., "The theory of dimensions and its application for engineers", Crosby, Lockwood, and Son, London, **1936**, p. 263.
4. Williams, W., "On the relation of the dimensions of physical quantities to directions in space", Phil. Mag., *34*, 1892, p. 234.
5. Brinsmade, J. B., "Plane and solid angles" (Am. J. Phys., *4*, 1936, p. 175) attempts to eliminate ambiguities in designation symbols by introducing plane angles and solid angles as fundamental concepts.
6. Fourier, J. B. J., "Théorie analytique de la chaleur" (Paris, **1822**, Section 160). English translation by A. Freeman, Cambridge Univ. Press, **1878**, p. 128.
7. Buckingham, E., "On physically similar systems; illustrations of the use of dimensional equations", Physics Rev., *4*, 1914, p. 345; "Model experiments and the forms of empirical equations", A.S.M.E. Trans., *37*, 1916, p. 263.

Physics

CURRENT NUCLEAR PHYSICS. PART III.

William G. Guindon, S.J.

I. Nuclear Reactions

3. Nuclear Bombardment

a. Apparatus

The past few years have seen a great variety of high energy accelerators developed and put into use. The most powerful of the early machines was the University of California's frequency-modulated cyclotron, accelerating helium ions to energies near 400 million electron-volts (1). Other types of accelerators include betatrons and synchrotrons: both differ essentially from cyclotrons in that the accelerated particles travel in a circle instead of an outward spiral. This leads to a problem that received a good deal of study: how to inject the particles into this circular orbit and keep them in it, despite the many influences tending to make them wobble off the orbit and get lost (2). Of course one of the most important sources for bombardments is the nuclear reactor, or "pile", which produces neutrons. Some data have been recently released on the design of the new reactor soon to be in operation at the Brookhaven National Laboratory (3); it will produce usable slow neutron currents of about 10^{12} per second per square centimeter.

b. Experiments

The use of electrons as projectiles in nuclear reactions is somewhat rare, but one study notes that 17 million volt electrons can cause the ejection of neutrons from the target (4), and others show that while the elastic scattering of 2 million volt electrons does not give information on the distribution of charge within the nucleus, that of higher energy electrons should (5).

More attention has been given to the ejection of neutrons from nuclei by gamma radiation: the bombardment of many elements at energies up to 100 million electron-volts shows that the production of photoneutrons is caused by gamma rays of energy below 50 million electron-volts and increases by large jumps as the mass of the target isotope is increased (6). In some of these studies photoprotons are also observed; their production is similar to that of neutrons. An interesting search looked in vain for mesons produced by 100 million volt gamma-rays (7). Other investigations studied the neutrons and protons ejected from nuclei by gamma radiation of lower energy (8).

Part I. This Bulletin, *25*, 95 (1947); Part II. ibid., *26*, 58 (1948).

Neutron bombardments, partly because of the availability of strong sources in nuclear piles, have been very numerous. Large currents of very slow ("thermal") neutrons have made practical the construction of crystal spectrometers, in which the diffraction of the neutron beam from a single crystal provides a variable source of monoenergetic neutrons (9). Observations of the scattering of slow neutrons by other materials have been made using the monochromatic neutrons from such spectrometers (10). Another type of instrument for providing neutrons of a single energy is the rotating-shutter variety: a beam of neutrons of mixed energies is periodically interrupted by a shutter and the detecting apparatus is set to record neutrons only at the time required by neutrons of the desired energy to pass from shutter to detector (11). The Columbia time-of-flight spectrometer works on a similar principle: the neutrons are produced in brief pulses by a cyclotron, and the registering apparatus is timed to respond to neutrons only at a fixed interval after the cyclotron pulse, thus recording the passage of neutrons of one energy only. Surveys of the collisions of slow neutrons with many different nuclei have been carried out with this apparatus (12). Measurements with all these types of neutron sources give the value and energy-dependence of the scattering cross-section (apparent size) of the target isotope and the amount of absorption of neutrons by the target (9-13).

The similarity between neutron and optical crystal spectroscopy appears again in the transmission of neutron beams through crystalline materials. A relatively large group of papers is devoted to the theory of this effect and experiments with single crystals and microcrystalline powders study the phase of scattering and the effect of the relative orientation of neutron and scatterer (14).

Problems studied with higher energy neutrons include bombardment with fast neutrons: scattering cross-sections, both elastic and inelastic (in the latter some of the neutron energy produces internal excitation of the target nucleus), have been measured for a large number of materials (15). The production of compound nuclei by fast neutron capture in the target, which then undergoes radioactive decay, was investigated (16). Various new types of reactions initiated by high energy neutrons from the California cyclotron were also reported (17).

Special studies have been made of the absorption by nuclei of slow neutrons: the particular isotopes responsible for the capture, and the relative capture probabilities, have been observed (18). Traditional methods for studying these effects consist in measuring both the current of incident neutrons and the rate of production of the compound nuclei, but the development of chain-reacting piles has led to two new methods. The absorption cross-section of a particular isotope is determined by noting the effect on the pile fission rate either of the insertion into the pile of a known amount of the absorber or of the periodic insertion and withdrawal of a sample of the absorber (19). Another topic of interest is the polarization of neutrons: the transmission of neutrons through magnetized iron differs according as the neutron axes are parallel or antiparallel to the magnetic field, and hence filters of ferromagnetic materials can be used to produce polarized beams of neutrons (20).

Accelerators in which protons are the projectiles are quite common. In connection with the proton bombardment of light nuclei the production of gamma radiation in the target has been measured (21), and, for bombardment by protons of energies up to 140 million volts, the formation of C^{11} from C^{12} has been studied (22). A case of individual importance is the proton bombardment of Li^7 in which the compound nucleus formed splits into two alpha particles: this relatively uncomplicated case has been the object of investigation both theoretical and experimental (23). The production of neutrons by proton bombardment of A, Ne, Cu and Mo is also reported (24).

Deuteron-induced reactions are relatively frequent for the same reason that proton bombardments are. A problem receiving special consideration is the collision of deuterons with deuterons: the incident particles may be scattered or a compound nucleus formed, leading to the production of He^3 or H^3 with, respectively, a neutron or a proton (25). Bombardment of B, C, Al, Cu, Mo and Au, some of these with 200 million volt deuterons, has also been the subject of research (26). A special reaction has been noted in the case of 200 million volt deuteron bombardments: the presence of a forward spray of 100 million volt neutrons shows that a "stripping" process is occurring, the proton in the deuteron having been captured by the target while the neutron proceeds almost unaffected. Similar forward beams of 100 million volt protons show that the neutron may be captured in the same fashion and the proton escape (27).

The use of tritons (nuclei of H^3) as projectiles is not so common, since tritium has not been produced in quantities sufficient for use in accelerators, but tritons from other reactions have been used to bombard Ag, Rh and Co (28). Alpha particles produce multiple neutron emission in many nuclei (29), and bombardments have been made with alphas from naturally radioactive substances (30).

c. Theory

The theory of scattering and absorption cross-sections as functions of bombardment energy, especially near energy thresholds (minimum energies at which a process can take place) or resonances (energies at which absorption or scattering is much larger than at neighboring energies), leads to formulae similar to the familiar "Breit-Wigner" ones (31). The angular distribution of the disintegration products of various nuclear reactions has also been studied (32) and perturbation methods have been applied to general scattering theory (33). A new starting point has been advanced by Heisenberg: the relation of scattered to incident particles, as expressed in terms of the S ("scattering") matrix, is suggested as being more important for scattering problems than the more familiar Hamiltonian (total energy) function; several studies in this theory have been published (34).

The general features of nuclear collisions with very high energies have been explored. Experiments suggest that here incident particles collide with individual nucleons (protons and/or neutrons), not with the nucleus as a whole, and that photoneutron emission by high-energy gamma quanta can be described in terms of a dipole vibration of the target nucleus (35). Prominent in the theory of fission reactors is the Milne problem, concerning the distribution-in-energy of neutrons in simple geometrical scatterers (plane slabs, spheres, etc.) under idealized assumptions as to the scattering properties of the medium and the position and energy of the neutron sources (36).

II. Isotopes

1. Energy Levels and Resonances

a. General Remarks

The fact that most nuclear processes occur with greater yield at certain resonance energies than at neighboring ones indicates an important isotopic property: an internal structure with discrete energy levels. In general there are two main classifications of resonance phenomena in nuclear physics: resonances in scattering processes and resonances in absorption-emission phenomena.

The theory of resonances in scattering processes has already been discussed in connection with the theory of scattering itself (31, 33), and a good deal of experimental material, especially in connection with slow neutron scattering experiments (9-13), has been presented. Absorption-emission phenomena, two-stage processes in which the absorption of a nuclear projectile and the formation of a highly excited compound nucleus lead to the emission of some type of radiation, are really radioactive processes. The energy and relative probability of these instantaneous radioactive emissions (4-30) as well as of the slower types mentioned earlier under Radioactivity (37) provide information on the energy levels of the active isotopes.

b. Scattering Resonance Levels

Not many experimental determinations of resonances in scattering have been made, apart from the thermal neutron experiments. One paper attempts to fit data on the resonance scattering of neutrons by Fe^{57} and Ni^{59} with theoretical assumptions that the resonances are due to nuclear rotation-vibration levels (38). Other studies concern the levels observed in the inelastic scattering of protons by Be, B, C, N, O, Mg, Al and Ni (39).

c. Absorption-Emission Resonance Levels

The resonance emission of protons and alpha particles from nitrogen bombarded with fast neutrons of various energies was studied (40). Bombardments using protons as projectiles were more numerous: special interest centered about the very sharp resonance levels observed when aluminum is bombarded with protons of energies near a million electron-volts (41). The gamma-ray spectra of F and Li under proton bombardment was also subjected to scrutiny, and each was found to emit two distinct lines (42). Similar studies concentrated on the properties of the proton-neutron reaction in Li^7 for proton energies up to 3.20 million electron-volts, three neutron emission levels were observed (43).

Deuteron-induced reactions were rather varied. Both the deuteron-proton reaction in Li^6 and the deuteron-alpha reaction in Be^9, which produce the residual nucleus Li^7, indicate the presence of a level at 482 kilovolts (44). Li^7 itself, on deuteron bombardment, gives evidence of three neutron-emitting resonance levels in the excited compound nucleus, Be^9 (45). The bombardment of Be^9 with deuterons followed by neutron emission shows the energy levels of B^{10} (46). The neutron and gamma-ray yields from the collision of deuterons of energies up to 3.25 million volts with carbon have been studied (47). The resonance levels for the emission of protons subsequent to deuteron bombardment have been investigated for O^{16}, Ne^{20}, Ne^{22} and Mn^{55} (48).

The investigation of resonance phenomena consequent on alpha particle bombardment dealt with targets of N, F, Ne, Na, Mg, Al, Si, P and S. In all of these the correlation of protons and gamma-rays was studied to determine the level system; in Al the alpha-neutron process was also investigated (49).

2. Moments, New Isotopes, Etc.

a. Spins, Magnetic Moments and Quadrupole Moments

Among the important static properties of a nucleus are its moments: mechanical angular momentum ("spin"), magnetic dipole moment (strength of the magnetic field caused by the spin) and electric quadrupole moment (a measure of the asymmetry of the charge distribution in the nucleus, positive if the nucleus is prolate, negative if oblate). These moments are observed by means of their interaction with electromagnetic fields impressed from the outside or caused by nearby nuclei and electrons. The spin and magnetic moment produce a splitting of the energy levels known as fine structure, and the quadrupole moment superimposes a hyperfine splitting on the fine structure. Theoretical studies principally concerned the quadrupole moment: detailed applications were made for the interpretation of the hyperfine spectra of different types of molecules (50). Pseudo-quadrupole effects, due to the interaction between the magnetic moment of the nucleus and the electrons of the molecule, must not be misinterpreted as genuine (51). Calculations have also been made of the Zeeman effect (52) and the Stark effect (53) in microwave molecular spectra.

There are two general types of experimental procedure employed in the investigation of these effects: microwave methods and molecular or atomic beam experiments. In microwave investigations the spectrum of energy levels is observed by noting the energy absorbed at various frequencies by a sample of the element placed in the radiative field of a microwave oscillator. These absorption lines, which indicate transitions between energy levels, can be determined with very great accuracy. Highly important information from this source includes the values of the magnetic moments of the neutron (54), the deuteron (55), the triton (56) and the nucleus of He^3 (57). Other isotopes whose magnetic moments have been measured by microwave methods include B^{11}, C^{14}, P^{31}, Cu^{63}, Cu^{65}, Ga^{69}, Ga^{71}, I^{127} and Tl^{205} (58).

The determination of the quadrupole moment of a nucleus from its microwave hyperfine structure is not as easy as the measurement of its magnetic moment, because in the theoretical expression for the spectrum the quadrupole moment always occurs multiplied by a factor depending on the electric field intensity inside the molecule. Since this factor is hard to determine accurately, the deduction of the quadrupole moment is difficult and uncertain. Experimental papers give the quadrupole coupling (product of moment and electric field factor), together with tentative deduced values of the moment itself. The quadrupole coupling of N^{14}, a very frequently studied isotope, was measured in many molecules (59). A class of nuclei which have been investigated carefully is that of the halogens: Cl^{35}, Cl^{37}, Br^{79}, Br^{81} and I^{127} (60); in most cases the value of the nuclear spin is also observed. Spin and quadrupole moment values for B^{10}, B^{11}, C^{13}, S^{33} and S^{34} are given in other papers (61). A general survey gives the quadrupole moments for all the above-mentioned isotopes and in addition reports on the observation of O^{18} (62).

Other studies of nuclear moments by means of microwave absorption deal with the interpretation of the widths and shapes of the resonances. The effect of "relaxation", the exchange of energy between the atoms of a crystal due to the interaction between the dipole moments of the nuclei, has been worked out in theory and experiment (63). The shapes of resonances in non-crystals has also been probed (64). Line shapes have been used to study the properties of matter especially at low temperatures because of the effect of state of aggregation on line widths (65).

In molecular or atomic beam experiments a beam of ions is passed through a polarizing and analyzing system similar to the Nical prisms of optical demonstrations but formed by magnetic or electric fields. Between the polarizing and analyzing fields a third field, consisting of a small radiofrequency field superimposed on a constant one, is arranged. At appropriate frequencies this third field causes reorientation of ions in the beam, lowering the intensity passing through the analyzer to the detection apparatus. Resonance dips in the detected beam intensity indicate energy levels of the ions in the beam. With beams of molecular ions studies have been made of the spins, magnetic moments and quadrupole moments of Br^{79}, Br^{81} and

Na^{23} by magnetic resonances (all fields magnetic) (66), and of Cs and F by electric resonances (67). More accurate information on nuclear properties is obtained from the study of magnetic field resonances for beams of atoms: the spins and nuclear moments of Na^{22}, Al^{27}, Cl^{35}, Cl^{37}, Ga^{69} and Ga^{71} (68). The accuracy of some of these determinations of the quadrupole moment indicates that the quadrupole couplings from microwave resonance experiments may be used to yield information on the electric field intensity inside the molecule.

Spectroscopic methods can also give the spins and moments of nuclei: the band spectra of diatomic carbon give the spins of C^{13} and C^{14} (69), while measurements of the hyperfine separations and intensities at optical wavelengths yield spin values for Cb^{93}, U^{235} and Np^{237}, as well as the magnetic moment of the first named (70).

b. Isotopic Abundances and Masses

It is generally true that the isotopic constitution (percentage composition by isotopes) of a naturally-occurring stable element is constant, independent of the origin of the sample. The relative isotopic abundances of some three dozen stable elements have been determined (71). These measurements were all made on ordinary electromagnetic mass-spectrometers, in which isotopes of different mass follow circular paths of different curvature in a constant magnetic field. A new design has been tentatively suggested, employing as its basic principle the fact that the most general path of a charged particle in a magnetic field is a helix in which the angular velocity is constant, determined by its mass (72). Evidence has also been gathered from optical spectroscopy on the isotopic constitution of a few elements, but the accuracy of this method is not high (73).

Any mass-spectrometer separates the various isotopes of an element, but usually not in weighable quantities. In connection with work on uranium fission special research was devoted to the development of electromagnetic separators of quantitative output (74). This type of apparatus has achieved the separation of the isotopes of Br and Cl, using NaBr and CuCl sources, and of those of Sm (75). Much attention has been devoted to the separation of the stable isotopes of helium: He^3 and He^4. These are of special interest on two scores: the anomalous behavior of helium at very low temperatures and the value of such light isotopes in testing theories of nuclear forces. Most of these studies concern the difference in the relative concentration of these isotopes in the liquid and vapor phases at temperatures close to absolute zero; apparently He^3 does not take part in superfluid flow. Several methods for utilizing these low-temperature effects as well as the ordinary method of thermal diffusion have been applied to the separation of the He isotopes (76).

Problems connected with the isotopic constitution of meteors were studied: the relative abundances of isotopes of different elements, the differences in isotopic composition of meteoritic and terrestrial Cu and Ga, and the He content of meteors (77).

Not many exact determinations of isotopic masses have been reported, and most of these are related in connection with the bombardment and radioactivity energy measurements from which the masses were inferred. One statistical study attempts to get the values for the exact masses of the lightest nuclei from a least squares fit of all the fundamental mass measurements (78).

(*To be continued*)

REFERENCES

(Note. Since all the papers referred to appeared in the *Physical Review* for the years 1947 and 1948, reference will be made by indicating only the volume and page.)

(1) *71*, 449; *72*, 649; *73*, 424.
(2) *72*, 247(L), 978(L); *73*, 1413; *74*, 140, 503(L).
(3) *74*, 1883(L).
(4) *73*, 420(L).
(5) *72*, 678; *74*, 1759.
(6) *72*, 1272(L); *73*, 1156, 1311; *74*, 442, 1190(L), 1538(L).
(7) *71*, 511, 649.
(8) *71*, 378(L); *74*, 1533(L), 1536(L), 1707.
(9) *71*, 294, 752; *72*, 109.
(10) *71*, 556(L), 757; *72*, 986(L).
(11) *72*, 193, 585.
(12) *71*, 65, 165, 174; *73*, 733, 963, 1399(L).
(13) *72*, 729(L), 866, 888.
(14) *71*, 589, 666, 915(L); *72*, 260(L), 408, 907; *73*, 527-(L), 830, 842, 1385; *74*, 103-(L), 222(L), 335.
(15) *71*, 508; *72*, 196, 439, 875, 881; *73*, 1307.
(16) *73*, 85(L), 106, 659; *74*, 1, 495(L).
(17) *72*, 1254(L), 1264(L); *73*, 262(L), 265(L); *74*, 1269.
(18) *71*, 272(L), 454(L), 561(L), 745, 826(L), 829(L); *72*, 362; *73*, 925(L), 956; *74*, 505(L).
(19) *72*, 16; *74*, 851, 864.
(20) *73*, 1277; *74*, 111(L), 1285, 1604.
(21) *73*, 181(L), 1130(L); *74*, 1725(L).
(22) *72*, 873(L); *73*, 80(L), 264-(L); *74*, 1732(L).
(23) *71*, 212(L); *73*, 241; *74*, 21, 405.
(24) *73*, 421; *74*, 1574, 1870(L).
(25) *73*, 815, 822, 1474(L); *74*, 1293, 1594, 1599.
(26) *71*, 187, 565; *72*, 76(L), 872-(L); *74*, 1574, 1722(L).
(27) *71*, 159; *72*, 1003, 1008; *73*, 742; *74*, 1001.
(28) *72*, 101; *73*, 22.
(29) *72*, 1117(L), 1117(L); *73*, 417(L).
(30) *73*, 271; *74*, 1063.
(31) *71*, 145, 563(L); *72*, 29; *73*, 1002, 1463.
(32) *71*, 402; *72*, 680; *73*, 528(L), *74*, 764.
(33) *74*, 206, 664, 835(L), 1548-(L).
(34) *74*, 131, 982(L).
(35) *72*, 1114; *74*, 1046.
(36) *71*, 443, 688, 694, 852; *72*, 47, 550, 556, 558, 564; *73*, 437.
(37) Cf. THIS BULLETIN, *26*, 60-62.
(38) *74*, 351(L).
(39) *73*, 1323, 1473(L); *74*, 1773.
(40) *73*, 89(L).
(41) *71*, 661, 905(L); *74*, 352(L), 648, 1782.
(42) *73*, 666; *74*, 315.
(43) *73*, 931; *74*, 373, 397.
(44) *74*, 1569.
(45) *71*, 11.
(46) *73*, 636(L).
(47) *73*, 274.
(48) *71*, 127(L), 917(L); *72*, 378, 736(L); *73*, 230.
(49) *72*, 736(L), 1196; *73*, 7, 947, 1014; *74*, 5.
(50) *71*, 747; *72*, 1116(L); *73*, 97, 627, 1204(L); *74*, 286, 533.
(51) *72*, 504; *74*, 106(L).
(52) *74*, 1396.
(53) *71*, 126(L); *72*, 715; *73*, 1430.
(54) *71*, 878; *74*, 1025.
(55) *71*, 878; *72*, 979(L), 1125-(L), 1271(L).
(56) *71*, 372(L), 373(L), 551(L).
(57) *73*, 919(L).
(58) *72*, 637(L); *73*, 523(L), 1112-(L), 1405(L); *74*, 228(L), 1885(L).
(59) *71*, 639(L), 640(L), 644(L), 829(L), 909(L); *72*, 263,

973(L), 974(L), 1262(L); *73*, 633(L), 713; *74*, 107(L), 626(L), 1113.
(60) *71*, 644(L), 829(L), 909(L), 917(L); *72*, 249(L), 259(L), 344(L), 1273(L); *73*, 254(L), 645(L), 1334; *74*, 243, 370, 1870(L).
(61) *72*, 513(L); *74*, 626(L), 1191-(L).
(62) *74*, 1113.
(63) *73*, 679; *74*, 979(L), 1168, 1184.
(64) *73*, 942.
(65) *71*, 738(L); *72*, 637(L); *74*, 346(L).
(66) *72*, 258(L), 1075.
(67) *74*, 718.
(68) *73*, 525(L), 584; *74*, 1193(L), 1550(L).
(69) *73*, 639(L); *74*, 355.
(70) *71*, 911(L); *72*, 451; *73*, 1215(L).
(71) *71*, 212(L); *72*, 349(L), 517-(L), 967; *73*, 180(L), 1206-(L), 1206(L); *74*, 98(L), 773, 991, 1531(L), 1724(L).
(72) *74*, 622(L).
(73) *74*, 74, 838(L), 1535(L), 1881(L).
(74) *72*, 989.
(75) *73*, 813(L); *74*, 980(L).
(76) *71*, 911(L); *72*, 502, 510(L); *73*, 256(L), 638(L), 729, 1188; *74*, 345(L), 495(L), 496(L), 508(L), 605, 946, 1590.
(77) *72*, 347(L), 456; *74*, 343(L), 501(L).
(78) *72*, 127(L).

ATENEO DE MANILA CHEMISTRY LIBRARY REQUESTS BACKRUNS OF JOURNALS

AN IMPORTANT NOTICE

Current subscriptions to chemical periodicals by the Ateneo de Manila include the following items: Journal of Chemical Education, Industrial and Engineering Chemistry, Chemical and Metallurgical Engineering, Journal of the American Chemical Society, Chemical Abstracts and Chemical Reviews. As we all know the libraries of the Ateneo were lost during the war. Accordingly a plea is here made for help in rebuilding the library by the contribution of extra holdings of back issues of chemical periodicals that you may care to donate to the Ateneo. This year finds the Ateneo specializing on collections in chemistry, physics and the social sciences. Older runs of THIS BULLETIN have also been requested. The faculty of the Ateneo have always been staunch contributors to the BULLETIN. Those who care to reciprocate by contributions in this way should write to the *Reverend Martin J. Casey, S.J., Ateneo de Manila, 406 Padre Faura, Manila, P. I.*, for details for shipping, etc.

Editor's Note. Other departments or colleges, interested in having notes of this sort published in the BULLETIN, should not hesitate to submit them in manuscript to the editor and everything possible will be done to forward this phase of our work.

A BRIEF REVIEW OF SLIDE RULES CURRENTLY AVAILABLE

JAMES J. RUDDICK, S.J.

Slide rules can save many hours of labor for students, instructors, and research men in science, especially in physics. Most engineering courses and undergraduate physics courses involve so much computation that students would be "penny wise and pound foolish" in not having a good *rule*. That *Ours* teaching such courses may have information on the better types of rule available, the author has made a survey of the various rules on the market.

The well-known and reliable Keufel and Esser rules range from the Beginner's Rule to the Log Log Duplex Vector. A recent innovation is the all plastic rule. In addition to several pocket rules, there is a Log Log Decitrig model in plastic. This has the same scales as its boxwood counterpart, but sells for $12.00.

The Eugen Dietzgen Co. puts out rules similar to the K & E models, at approximately the same price. They too are of long-standing reliability and need no further comment.

A less widely known line of rules is that of the Pickett and Eckel Co. These rules, all of the bi-faced type, have a light metal core with a washable plastic surface. The range in complexity from the Simplex with A,B,C,D,K, and either CI or S,T,L scales to the three Deci Log Log rules with their 30-in cube root, 20-in square root, and eight log log scales, as well as a directly reading colog scale and folded scales for reading natural logs. An intermediate, and comparatively inexpensive, rule is the Ortho-Phase Log Log with the usual log log decimal trig scales. This latter rule is, by the way, recommended as fulfilling the slide rule requirements of engineering students at St. Louis University.

As with most new products, the P & E rules may have their reliability questioned. The author has used a Deci Log Log Vector Hyperbolic rule almost daily for over a year and considers it very satisfactory. For mechanical stability and ease of operation, the rule leaves little to be desired. Furthermore, the extended square and cube root scales have been found especially valuable.

Some users of slide rules, especially those just beginning, are likely to find helpful some legend diagrams on the back of the Deci Log Log and the Deci Log Log Multiphase. The diagrams indicate decimal point location for trig scales, for exponentials, and for cubes, squares, and their roots.

There are several other slide rules on the market. Worthy of mention among them are the Bruning plastic Mannheim model, with log and trig scales, at $4.50, and the Post log log model, at $18.00, imported from Japan. In addition, some supply houses carry occasional rules put out without any manufacturer's name. These appear to be hold-overs from the post war jam, and are not very reliable.

The following table gives detailed information about the chief models of the three main slide rule manufacturers:

Model	Scales	Price	Comment
K & E			
Beginner's	A, B, C, D, L, S, T, K, CI	2.25	
Mannheim	A, B, C, D, K, L, S, T, CI	11.00	boxwood, with inch and cm scales
Polyphase	A, B, C, D, L, S, T, ST, K, CI, DI, CF, DF, CIF	18.50	boxwood
Log Log Duplex Decitrig	A, B, C, D, CI, DI, L, CF, DF, CIF, S, T, ST, K, LLO1, LLO2, LLO3, LL1, LL2, LL3	20.50	plain case, 3.00 more for leather
Log Log Duplex Decitrig	(as above)	12.00	plastic model
Log Log Duplex Vector	Th, Sh 1, Sh 2 for K, DI	22.50	hyperbolic scales
Dietzgen			
Maniphase Mannheim	A, B, C, D, CI, K, S, T, L	11.00	with inch and cm scales; plain case
Maniphase Multiplex	A, B, C, D, K, L, S, T, CI, CF, DF	13.75	leather case 1.75 extra; ditto for other models
Maniphase Multiplex Trig	(as above, plus ST, DI)	15.75	also in decimal trig style
Maniphase Multiplex Log Log Trig	A, B, C, D, CI, DI, L, K, S, T, ST, CF, DF, CIF, LLO, LLOO, LL1, LL2, LL3	20.50	also in decimal trig style
Mani. Multiplex Log Log Vector	Th, Sh 1, Sh 2 for K, DI	22.50	
P & E			
Simplex, #901	A, B, C, D, K, CI	3.50	boxed; no case
Simplex, #902	A, B, C, D, K, S, T, L	3.50	boxed; no case
Ortho-Phase Duplex, #1000	A, B, C, D, K, L, S, T, ST, CI, CF, DF, CIF	6.00	felt case
Ortho-Phase Log Log, #500	(All scales of the Maniphase Mult. Log Log exc. DI)	10.50	felt case
Deci Log Log, ##2, 3, 4	(Cf. text above; #3 is typical with 27 scales; #4 is hyperbolic)	16.75	felt case; plastic case, 1.00 more

MATHEMATICS, THE LANGUAGE OF SCIENCE, by Rev. J. A. Tobin, S.J. (Boston College), *Address before the Ricci Mathematics Academy*, *Ricci Mathematical Journal*, 5, 3-9 (January 1949). Here an apostolic plea is made to Catholic students. In the atomic age Catholic scientists are needed. One has to know the language in order to be a scientist. In this age too mathematics is the language. Details of general curricula are included. Text is interspersed with quotations of higher ecclesiastics and others on, for example, our ethical infancy among nuclear giants. *B. A. Fiekers, S.J.*

(*See also page* 36)

News Items

"Magnopere juverit crebo alios de aliis certeriores fieri, ac audire quae ex variis locis ad aedificationem et eorum quae geruntur cognitionem afferuntur."—Const., VIII., I.

ST. PETER'S COLLEGE

Jersey City

For the year 1948-1949 we had some four hundred students taking chemistry. All of these were either pre-medical or B.S. students from the day school. We have no extension or graduate courses, and not even a survey course this year. The faculty consists of two doctors, two masters and four instructors: three with the B.S. and one, an undergraduate. In addition we have a competent supply clerk-technician.

A Chapter of Student Affiliates of the American Chemical Society was started here in October 1948 with the formal presentation of the charter. As far as possible, the organization is run by the students. The burden of handling the film program is completely their responsibility. About thirty members attended the recent meeting of the student affiliates in North Jersey, held at Upsala College. One of their number presented a paper on the surface tension of milk. Dr. Perry Jackson amused the same gathering with his after-dinner talk, *Quackery in Chemistry*.

Under the direction of Dr. Dodd, a new elective was introduced this semester to supplement the rather meagre four-credit quantitative course. In addition to some of the usual gravimetric experiments, the laboratory work includes such experiments as: proof spirit, food analysis, fat in milk, Kjeldahl nitrogen in blood, sugar in syrups, electrodeposition, indicators, polarography and potentiometric and conductometric titrations.

We hope to acquire a semi-micro balance and a polarizing microscope this year. Enough parts have finally been rounded up to enable us to operate our war-assets, Dietert, 1.5 meter grating spectrograph. It should be in operation next year. Also on our program for the coming year is the completion of our organic laboratory. This will involve three more laboratory tables and a change from macro to semi-micro qualitative organic analysis. If any readers would like to send us the fruit of their experience with a similar change in the form of a few suggestions, they will be gratefully received.

One of the articles on the series on Marketing Research in the Chemical Industry, which appeared in *Chemical and Engineering News*, was written by Mr. Warren C. Heyer, a member of the Business School Faculty.

The Alumni Chemists' Club is cooperating with the department in collecting information about the activities of our graduates.

Department of Chemistry. Enrollment figures show that we have 73 candidates for the B.S. in Chemistry coming into the department each week for instruction; correct this statement by 11 who duplicate courses and the total is 62. Overall enrollment in the department each week totals 423. About 325 or so of these men are in the premedical courses. Some of the sophomores in both curricula are taking quantitative analysis for the first semester and qualitative for the second. This experiment, originally necessitated by large enrollments, is working out well. After all, there is so much overlap in qualitative and quantitative theory in modern academic practice, that successful results are expected. Junior B.S. chemistry men now start their physical chemistry course at the second semester of junior, thus leaving the colloid course, that they would have taken here, for the second half of senior where it can rest on a foundation in physical chemistry. In the course of events, the last term of senior in chemistry might evolve into an advanced physical chemistry course with emphasis on colloidal chemistry or possibly into a course on instrumentation.

Graduate students this year include Mr. Edward J. Kilmartin, S.J. from Weston College, who did postgraduate qualifying work last year and Father Michael A. Leonard, S.J. of the Canadian Jesuit Province, who comes to us from Pomfret, Conn., and who is doing part postgraduate, and part graduate work here this year.

Drs. Baril and VanHook (staff) attended the Fall Meeting of the American Chemical Society at Atlantic City, the week of September 19th through the 24th. Dr. VanHook read a paper before the Sugar section of the convention, entitled: "Interfacial Energies in the Sucrose-solutions system. Father Fiekers attended the Eleventh Summer Conference of the New England Association of Chemistry Teachers held at the University of New Hampshire during the second last week of August. He was appointed to the program committee for the twelfth Summer Conference to be held at Storrs (University of) Connecticut, next year. During the second half of the summer, he audited a summer course in advanced inorganic chemistry given by Prof. W. C. Schumb at M.I.T. (5.062). Mr. Kilmartin, S.J. took a course in advanced organic chemistry there during the same period.

Recent departmental publications include: VanHook, A., Whelan, Jr., W. P. and Galkowski, T. T., "Kinetics of sucrose crystallization, VII., Real Massecuites," Proc. Am. Sugar Technicians, 5, 552-6 (1948); the book, "Sugar, its production, technology and uses," (Humanizing series), Ronald Printing Co., N. Y., 1949, by A. VanHook; and, VanHook, A. and Bruno, A. J., "Nucleation and growth in sugar solutions," Discussions of the Faraday Soc., 5, 112-7 (1949). In press for Dr. VanHook are contributions: to *Science* with C. F. Turner, M.S. '48; and a monograph on the rate of crystallization of sugar to be published by the Sugar Research Foundation in New

York next year, as an item of their technological series, and now being circulated privately among the members of the foundation. T. W. Sarge, M.S. '42 and Dr. VanHook (staff) are listed as *Chemical Abstractors*.

During the summer of 1949 a new fireproof stockroom annex was substantially completed—a one story affair, under the research laboratory windows at the corner of the back O'Kane tower. The structure measures approximately 18 by 33 feet. It is entered from the department and is otherwise provided with an overhead delivery door and an emergency exit. A thermostatically controlled steam fan blower at the inner corner provides the heating. Steel shelving in double aisles and along the walls, of twelve and eighteen inch depth, has been erected from floor to ceiling. The aisles are twenty-four inches wide and illuminated from end to end with fluorescent lights. About 460, 42 inch long, steel shelves, spaced generally one foot apart, will provide reasonable storage for our ordinary and standard needs. Air and hot and cold water services are provided. The structure is done in weather-proofed cement blocks, with steel roof supports, insulated corrigated steel ceiling, a gravel-asphalt roof with copper trimming for gutters and drains. Four translucent, industrial-type windows are provided, two of which are so built that two more garage doors can be used to replace them if the structure should eventually be used for garaging purposes.

It has been found that shelf spacing in the dimensions given is approximately suitable for receiving the contents of one, modern-type case of Pyrex glassware. Aisle dimensions along the walls are such that unopened cases can be stacked there with easy access for replacement of stock onto the shelves. A new partition across the large lecture hall within the O'Kane building provides ready access to the main stockroom from the laboratories and local supply rooms. Of course some errors and miscalculations occurred during the construction and the department will be glad to discuss these privately with those who have similar plans and interests.

Reviews and Abstracts

THE EFFECT OF CHOLESTEROL ON THE GROWTH OF COLPYDIUM CAMPYLUM by W. D. Sullivan (of THIS ASSOCIATION). Trans. Am. Microscopical Soc., 67, 262-5 (1948).

(*See also page* 33)