G. A. O'Donnell, S.J.

S.J.B.

A. M. D. G.

BULLETIN

of the

American Association of Jesuit Scientists

(Eastern Section)

For Private Circulation

LOYOLA COLLEGE

BALTIMORE, MARYLAND

VOL. XII MAY, 1935 NO. 4

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CUBAN GOVERNMENT HONORS JESUIT SCIENTIST

On February 2nd at Havana, Cuba, Father Mariano Gutierrez Lanza, S.J., for thirty-eight years attached to the Colegio de Belén and at present Director of the college's Meteorological Observatory, was decorated by the Spanish and Cuban governments in recognition of his labors for "science and humanity."

He was made a Knight Commander of the Order of the Spanish Republic and an Officer of the Order of Carlos Miguel de Cespedes (Cuban) at an impressive function attended by the President of Cuba, the Spanish Ambassador and many members of the diplomatic corps.

Father Gutierrez Lanza is an authority on hurricanes and on atmospheric conditions in the West Indies in relation to aviation. He has cooperated directly in many "first flights" or "non-stop flights" which have included Cuba in their itineraries.

SCIENCE AND PHILOSOPHY

THE RELATION OF SCIENCE AND PHILOSOPHY

Rev. Joseph P. Kelly, S.J

In spite of the fact that systems have been multiplied, philosophy has always retained this characteristic note: it is more universal and more comprehensive than other branches of natural learning. The natural sciences are limited; they are individual. I believe that this distinction will be admitted by all. The chemist, for example, chooses for his field, the composition and resolution of the elements. He deals with them in their quantitative aspects. He selects his materials, arranges his apparatus under such conditions as will lead him to success in determining the definite quantity of one element that will unite with a definite quantity of another. In terms of the Atomic Theory, the fomula H_2O tells us that two atoms of hydrogen will unite with one of oxygen. Perhaps the force of gravity enters into the operation but that does not concern him. Nor is he distracted from his purpose by the phenomena of radiation. These occupy the attention of the physicist. A scientist in his particular field assumes what he believes to be necessary for his science; he makes whatever hypothesis will help him and is satisfied if it can be verified. "It works", that is sufficient. So with the other natural sciences. Each is specialized, individualized and limited in its operations and purposes. Philosophy, on the other hand, is universal because it seeks first principles and more remote causes. The scientist takes observation for granted; the philosopher examines the meaning and the value of observation. Science assumes that it can know something about nature; the philosopher asks what is knowledge and how is it obtained. The scientist accepts as a starting point, the existence of the world; the philosopher looks to the origin of the universe and the purpose of its existence. These notions, while incomplete, will show a broad distinction between the outlook and procedure of the scientist and the philosopher. "Philosophy is not one among the sciences with its own scheme of abstractions which it works away at perfecting and improving. It is the survey of the sciences with the special objects of their harmony and their completion. It brings to this task not only the evidence of the separate sciences but also its own appeal to concrete evidence. It confronts the sciences with concrete facts."(1). Hence philosophy cannot

(1).Whitehead. "Science and the Modern World." p. 127.

be limited, as the special sciences are, either in its scope or its methods. For "it consists in examining what is supposedly ultimate, criticising this by means of first principles of reason, which are in their turn subjected to an analysis; and so establishing what must be and what follows from the admission of these ultimates. The subject matter of philosophy is therefore one which is of its nature constant, and it may be said to cover that body of experience which is at the same time the most profound and the most common." (2). These opinions are quite in keeping with the attitude of the Schoolmen towards science, although they did not have the same esteem for the natural science that we have today. I do not pretend for an instant that all our modern thinkers would ascribe to the view,—whether from a fear of returning to medievalism or from an honest conviction that this quasi-domination of philosophy over science would curtail its freedom, it is not our place to decide. At any rate, there has been a notable change in the relations between science and philosophy since the days of the Scholastic Philosophers. Specialization in the modern sense did not exist. The sciences were regarded as preliminary studies to philosophy. Since then the sciences have been multiplied. Material beings have been sifted, new points of view have been considered and these in turn have become the bases of new sciences. In scholastic terms we would say that new formal objects have been determined, and thus arose physics, chemistry, astronomy, geology, etc., in the modern sense. They cast off the ties that bound them to philosophy and became autonomous. The change was needed and new avenues of thought were opened to enterprising minds . The vast sum of scientific knowledge, both theoretical and practical, that is the fruit of science of the past three centuries, needs no exposition or comment. But the scientific movement was not without its dangers. The impulse was so rapid and the growth of knowledge so expansive that it could not be assimilated. Whereas in former times it was possible for one to become a master of science, to-day a lifetime hardly suffices to conquer a single branch. Nor was the absolute rejection of philosophy and metaphysical principles for the best interest of science. The proof of this statement lies in the fact that so many of our modern scientists and philosophers are calling for a philosophy of science. Since we are here discussing the relations of philosophy and science from the point of view of scholastic philosophy, we have neither time nor space to develop the relations of modern philosophy to science. (3).

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(2). Ed. by J. G. Crowther. "Science for a New World." p. 189.
Bosanquet. "Philosophy and Science." Ch. I.

(3). The relations of modern philosophy to science would form a fruitful topic for many instructive articles for the BULLETIN. I would like to indicate a few references for inquisitive spirits.

Whitehead. "Science and the Modern World."
Ed. by J. G. Crowther. "Science for a New World."
Bosanquet. "Science and Philosophy."
A. W. Carr. "A Scientific Approach to Philosophy."
Planck. "Where is Science Going."
"Philosophy." A quarterly pub. by the British Phil. Assn.
"Journal of Philosophy." Pub. by the Journal of Phil., Inc.

Many other references may be found in the BULLETIN. Dec. 1934.

A striking consequence of the scientific movement has been the change in the meaning of the word "science". Formerly science was synonymous with knowledge. It denoted knowledge (scientia) but an organized knowledge. Any organized system of knowledge was considered science in the general sense of the word. "Science is not merely a collection of theories about a special object a mere juxtaposition of facts and fragments of knowledge but a systematized body of knowledge, whose various parts hang together and harmonize and fit into each other like the cogs and wheels of a machine. It is only on this condition of such harmony that the manifold conclusions can be reduced to a unity and thus establish order in the mind." (4). Scientists recognize this fact, for when we speak of the Science of Physics, we mean an organized body of principles, theories and facts treating of material bodies in their physical aspects. Likewise, the Science of Chemistry, Biology, Government, etc. "A science is made out of facts just as a house is made out of stones. But a mere collection of facts is not a science any more than a pile of stones is a house. When we begin to relate one observation and fact with another and with established laws, then our former wonderings and observations become definite, organized and systematic science." (5). There is, then, a general acceptance of the notion that organization is an essential element of scientific knowledge. Nowadays, however, the term "science" seems to be limited almost exclusively to natural sciences. There is in this use the tacit assumption that real knowledge is found in these sciences alone.

The attitude of mind which sees in science the last word on all subjects is not confined to "the man of the street." Science is ever insisting on this: that it is concerned with facts and measurements. The word, "fact" is open to some ambiguity. If we were to ask a dozen scientists to define the word, I have no doubt that we would receive many definitions; books of science are not agreed on a definition. But as far as I can judge (salvo meliori judicio), a fact in the scientific sense means something like this: an event verifiable by experience (or experiment). The rejection of philosophy and the remarkable success that followed the introduction of the Inductive Method in the natural sciences, had the effect of concentrating the mind of the investigators on the phenomenal aspects of the world. Sense data and the external qualities alone were considered and whatever did not fall into this category was neglected: it was regarded as unscientific. In these conditions, knowledge and sense perception became equivalent. "Physics", says Planck, "is an exact science and depends on measurement, while all measurement itself requires sense-perception. Consequently all ideas employed in Physics are derived from the world of sense-per-

(4). DeWulf. "Scholasticism, Old and New." p. 94.
(5). Poincare. "The New Physics."

ception." (6). To limit one's field of investigation in the quest of human knowledge, to the data of the senses is, no doubt, very useful for specialization but it leads to a dangerous isolation. Science deals only with the phenomenal aspects of material bodies and insofar as these qualities are measurable. Thus science has cut itself off from all problems that are outside its proper field. As we have said many times, it is not our place to deny to the scientists the right to define the limits of their own sphere of investigation but we believe that a grave error has actually followed this mode of limitation: viz. the denial of the validity of knowledge outside their own branch. There are many who hold the opinion that questions which can find no answer in science have no meaning. For example, in the Theory of Relativity, absolute motion has no meaning because there is no ultimate, fixed norm by which it may be measured. One may place a distinction here and say that although they have no meaning in science, they may have importance in other branches of knowledge; but we contend that it is impossible in practice to isolate human knowledge in this way. Though in theory the distinction may be valid, yet in practice the scientists are applying the conclusions of science to almost every phase of human life. (7). Already a considerable volume of comment has appeared dealing with the philosophic consequences of the Heisenberg Principle of Uncertainty. It has opened once more the controversy of free will that was supposedly decided once and for all by the science of the last century. Naturally, in our position as scholastic philosophers, we hold that the scientific Principle of Uncertainty has nothing to do with the volitional faculty of man. There are many scientists who hold the same opinion. (8). But the point at issue is this: that although in theory they may distinguish between the scientific aspect and the human-value aspect of a problem, in the concrete, the separation seems to be impossible. On the other hand, I believe that this attempt to draw philosophical conclusions from the findings of science, is a recognition on the part of present day thinkers that there is a real need of a philosophy of science.

Let us look at the development of science from another point of view. Many of the principles and the formulae of Newtonian Physics consider things in an ideal state, or as a closed system. This afforded the scientist a better view of physical phenomena. By an act of the mind, called precision, they considered some aspects of material bodies and neglected

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(6). Planck. "The Universe in the Light of Modern Physics." p. 7.

(7). In the following works by some of our eminent scientists, one may note their philosophical opinions derived from science.
Planck. "Where is Science Going."
Planck. "The Universe in the Light of Modern Physics."
Millikan. "Science and the New Civilization."
Einstein. "The World as I See It."
Jeans. "The Universe Around Us."
Eddington. "The Nature of the Physical World."

(8). Planck. "Causality in Nature." c. f. "Science for a New World." p. 347 sq.

others, according to the purpose that they had in mind. They were conscious of the fact that in the concrete, certain extraneous factors would prevent the perfect realization of these principles. For example, a body in motion on the surface of the earth would be affected by frictional contact with the ground. By examining bodies in an isolated state, the scientists believed that they could approach nearer to reality. This notion was then applied to the different sciences and Physics became separted from Chemistry; Chemistry from Astronomy, etc. They became independent sciences, each with its principles and laws. Scientific knowledge was divided piecemeal among the specialists. There was a cardinal point whose truth and consequences seemed to have escaped unnoticed, i. e., that the same body (let us say, the atom or the molecule) was the object of investigation in all cases. Though they mentally divided and separated the various qualities and aspects of the same entity, in the concrete reality there was but one thing, one individual body possessing all these properties. The atom was at once physical, chemical, etc. Hence, just as in reality all these qualities were bound up in the same being, in a real unity, the knowledge of this body could not persist as distinct sciences. Men have come to recognize this fact with the growth of their knowledge. The clear distinction between Physics and Chemistry is dissolving into a branch, called Physical Chemistry. The natural sciences are breaking down their barriers. New sciences, sort of middle-sciences, have been formed. We have Bio-chemistry, Astro-physics. One might ask if it is possible that a sort of universal science may be created that could comprehend all the natural sciences. The mechanistic interpretation of nature was an attempt along these lines. One of its fundamental principles was that all natural phenomena should be interpreted in terms of matter and motion. It achieved some success in the inorganic world and it was applied to living beings. Lord Russell and Thos. Huxley were advocates of a mechanical theory of life in which all vital actions, including thought and volition, were determined in the same way as other actions of nature. In Psychology the Behavioristic Theory found favor in many quarters. To-day, the breakdown of Materialism, as a system, is discussed openly. Purpose, design, finality are again finding place in scientific literature. Strictly, these notions are unscientific because they are not measurable quantities "nor distinguishable by physical processes." Yet these concepts seem necessary for science. In a recently published book, Sir J. Arthur Thomson affirms that the scientist must include in his category some notion of a design or purpose in the world, and this will naturally demand the further step of the existence of a designer. (9). It is evident that in proposing these, the scientists are reaching out beyond the data of sense perception.

Sir J. Arthur Thomson's reason for professing a purpose in the

(9). "The Great Design." Edited by Frances Mason. Introduction.

universe is that without some such concept the world "does not make sense." The natural sciences are limited in their view and this limitation seems necessary for the minute accuracy demanded by the formulations of science. As Einstein says: "Even at the expense of completeness, we have to secure purity, clarity and accurate correspondence between the representation and the thing represented.......One realizes how small a part of nature can thus be comprehended and expressed in an exact formulation, while all that is subtle and complex has to be excluded. . . . . . ." Herein lies a key to the situation. Reality, I mean the real universe, is not a simple but a very complex affair. It has many angles, many avenues of approach. The very limitations of the natural sciences prevent any one science from interpreting nature in all its complexity. Neither Physics nor Chemistry nor Crystallography exhausts the possibilities of the atom. We need a compound of these to "make sense" of the totality of reality, or perhaps better, some more general principles that will comprehend all. In this the philosopher may play his role of completing the sciences. His study is a science of sciences. He does not start with all the facts of science but with those general principles which the scientist uses for discovery and correlation. His work will be "a systematized reflection upon the concepts and the methods of science and the less methodical thought of everyday practical life work, and an attempt to try them by the standard of ultimate reality and intelligibility." (10).

(10). O'Neill. "Cosmology." p. 36.

BIOLOGY

SNOW INSECTS

Gerard A. Harrington, S.J.

With the coming of winter, one would not think that an entomologist could practice his hobby out of doors. To us insects seem to be a part of summer; for those most familiar to us are simply pests and associate themselves with sultry days and mosquito-ridden nights. The frozen earth is no pleasant thoroughfare for most insects, nor is Boreas' biting blast an inducement to draw them from their hibernation haunts, so for a time at least they seem to leave us—until summer comes again.

Winter snows do not drive away all the insect species. Some of these, queerly constituted as they are, revel in the snow and ice and seem to thrive thereon. For instance, there is the glacier worm,—(not strictly an insect) living in high mountain glaciers; as well as a tiny insect seen only in winter and known to the scientist as the **Boreus**. But most prominent among the snow insects is a species familiarly called 'Spring Tails' or by their scientific name **Achorutes nivicola**, which we may see in the snows about us if we take pains and choose the right moment.

These 'Spring Tails' are soft wingless creatures which walk or run on six legs, or convey themselves by means of another appendage which gives them their peculiar name. This appendage, called a 'Furcula', consists of a long, forked flap hinged underneath the tail and folded close to the body, with its free, forked end towards the head. Two little fingers projecting from the abdomen hold the furcula in place; and when these fingers relax, the furcula pulls downward and backward, flinging the insect into the air. While the insect "flies through the air with the greatest of ease", the furcula is folded again under the body, so that it is ready for another leap once the insect has struck the ground. Thus it bounds across the snow.

Neither the size nor the mode of life of a Spring Tail would attract our attention. In size it ranges from one twenty-fifth of an inch to one twelfth of an inch, and so might seem to be a speck of dirt in the snow. Since it is in no way destructive to crops, it does not create any concern on the part of entomologists. When, however, swarms of these insects appear on the snow, they are easily distinguished because of their color (dark against the white background) and because of their peculiar movements.

Living in dead leaves, the bark of trees, and moss,—the Spring Tails emerge once mild weather has set in, with the thermometer registering twenty-five degrees F. and upwards. Dryness is death to the Spring Tail. Evaporation through their delicate skin is so rapid that they can live only in moist air. The more moist the air, the better they like it. That is why they appear as the humidity increases, and are nowhere to be seen when the atmosphere is cold and dry.

The movements of the Spring Tails are rather interesting as they emerge from their places of shelter. They do not come directly through the snow, for the crusts are at times too dense for them to penetrate; so they seek tree trunks, wood stems, stalks of grass and other objects penetrating the snow, since there is always a clear space about these objects for their pathway. When the Spring Tails are once above the snow, their movements are always towards light and open spaces, to the fields, frozen lakes and rivers. When the air has become too dry and cold, they make no attempt to return through the passages from which they came, but work their way into the snow again wherever they may be. Having struck a compact crust that obstructs their path, they travel along this crust to some object piercing the snow to the ground, where they again seek shelter.

That is the life of the Spring Tail, an insignificant little creature which bothers no one and which no one seems to bother; its only right to fame is that it is among the comparatively few insects of the snow.

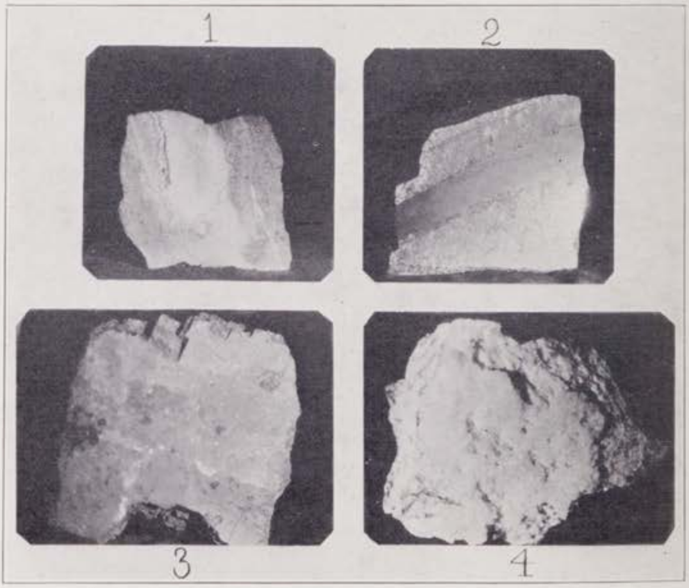
CHEMISTRY

FLUORESCENT MINERALS IN ULTRA-VIOLET LIGHT

Rev. Richard B. Schmitt, S J.

The ultra-violet region of the known range of electromagnetic vibrations is capable of properties useful for analytical methods. This region is between the shortest visible rays and the X-ray region of the longest wave-length. These rays may be considered as intermediate in properties, such as penetration, between X-rays and solar rays.

Ultra-violet rays have another useful property besides mere penetration and this depends on the power of certain substances to absorb them.



Photographs of minerals taken in a dark room
by the rays of ultra-violet light

All substances absorb electromagnetic vibrations, usually over a characteristic range of wave-lengths, and many emit or even re-emit such radiations. This phenomenon of emission, called luminescence, may be in the visible region or it may fall in some invisible region, and will therefore require special physical instruments for detection. This luminescence may be fluorescence or phosphorescence; fluorescence if it is visible during the period of excitation only, or phosphorescence if it persists when the exciting source is removed.

Where the luminescence produced is characteristic of the substance irradiated, it may be used as a means of analysis. For ordinary work it is sufficient in most cases to note the intensity and color, but the method is made more specific and is applicable to a greater range of materials, if the spectrum of the light emitted is examined spectroscopically.

Fluorescence is obtained only from a restricted number of substances, and such methods are further limited by the fact that it is usually produced only by light whose wave-length falls within a particular range of the ultra-violet region.

Many minerals show flucrescence in ultra-violet light, but the interesting fact is that several specimens of one and the same species may behave differently in respect to the intensity of the luminescence and the color of the emitted light. Furthermore, the behavior of these minerals in ultra-violet light depends to a great extent on their place of origin. Then too, small traces of some compounds often modify the fluorescence of a mineral, or cause fluorescence to appear where it would not otherwise be in evidence.

With these problems in mind, Dr. William M. Thornton, Associate Professor of Chemistry, at Johns Hopkins University, brought several specimens of fluorescent minerals to the Loyola Laboratory in order that we might photograph them and verifiy their behavior in ultra-violet light.

Minerals

No. 1. Calcio-larsenite $(Ca\ Pb)_2\ Si\ O_4$.
Franklin, Sussex Co., New Jersey.
Color of fluorescence: peach and pink.

No. 2. Basalt in Zinc Ore. (Ore: willemite and franklinite.)
Willemite: $Zn_2Si\ O_4$.
Franklinite: $(Fe\ Zn\ Mn)O.(Fe\ Mn)_2O_3$.
Franklin, Sussex Co., New Jersey.

No. 3. Zinc Ore: willemite, franklinite and gangue; brown garnet.
Willemite: $Zn_2Si\ O_4$.
Franklinite: $(Fe\ Zn\ Mn)O.(Fe\ Mn)_2O_3$.
Gangue: manganiferous calcite: $(CaMn)_2\ O_3$.
Brown Garnet: $R_3\ R_2\ (Si\ O_4)_3$.
Franklin, Sussex Co., New Jersey.
Color of fluorescence: uranium green, (garnet) red.

No. 4. Hyalite on pegmatite.
Hyalite: Si O_2. nH_2O.
Mitchell Co., North Carolina.
Color of fluorescence: white.

Technique

Place: dark room with black walls.

Source of Ultra-violet Rays: Hanovia Mercury Vapor Lamp.

Filter: Hanovia glass filter: Sc. 2682. (Transmitting a high percentage of the invisible radiations and excluding most of the visible light.)

Camera Lens: Bausch & Lomb Tessar B; 6½ x 8½.

Film: Defender; highly sensitive to green. 5 x 7.

Back-ground: maroon velvet.

Exposure: two to five minutes.

Aperture: eight.

From the photographs herewith reproduced, it is evident that our experiments were successful. It is hoped that a photographic record of these minerals while in active state of fluorescence might be analytically useful in certain cases, particularly when the substances of immediate interest exist in admixture with considerable matrix of non-fluorescent nature.

We are grateful to Dr. Thornton for his valuable suggestions and interest. Three of the specimens were loaned from the U. S. National Museum in Washington.

Our future endeavors will be to get a permanent record of the brilliant colors of these fluorescent minerals in color photography by the Finlay process.

Literature

J. A. Radley & J. Grant, "Fluorescent Analysis in Ultra-Violet Light." 1933.

H. Jackson, Proc. Roy. Inst. Gt. Brit., 1927.

F. Vignolo-Lutati, Industria chimica. 1931.

E. M. Gunnell, Am. Mineral. 1933.

W. L. Brown, Univ. Toronto Studies, Geo. Ser. 1933

THE NEGATIVE LOGARITHM AND THE pH-CONCENTRATION CONVERSION

Bernard A. Fiekers, S.J.

That the conversion from hydrogen and hydroxyl ion concentration to pH values and the reverse process cause the student considerable difficulty is recognized in the literature of chemical education. (Cf. Mathematical Requirements for Physical Chemistry, Farrington Daniels, J. Chem. Ed., 6, 254, 1929.) The reverse process will follow mathematically without too much difficulty, if the student has confidence in his own work in problems that require the use of the direct process.

This conversion involves the use of negative logarithms. The method that follows is adapted to other applications of this logarithm in the advanced courses of the sciences.

Probably the simplest solution of the difficulty is to have the student CHANGE ALL FACTORS THAT INVOLVE THE RAISING OF TEN TO A NEGATIVE POWER FROM THE NUMERATOR TO THE DENOMINATOR AND VICE-VERSA, CHANGING THE SIGN OF THE EXPONENT IN EACH CASE. After a pedagogical test of this procedure, it was found to have been successful; for the increased confidence of the student in the results of his own calculations indicated the success of the method to the writer. The examples that follow should clarify the procedure indicated above.

The pH value of a system is defined as the NEGATIVE LOGARITHM OF THE HYDROGEN ION CONCENTRATION. (The negative logarithm and the cologarithm are identical.)

$$_{p}H = \log_{10} \frac{1}{(H+)} = \text{colog}(H+)$$

When the hydrogen ion concentration is given directly, this conversion is made with relative ease. Thus:

$$(H+) = 1 \times 10^{-3} = \frac{1}{10^{+3}}$$

$$\begin{array}{lll}
\log\ 1 & & = 0.0000 \\
\text{colog}\ 10^{+3} & (\log = 3.) & = 7.0000\text{-}10 \\
\hline
+\log(H+) & & = 7.0000\text{-}10 \\
-\log(H+) & = {}_{p}H & = 3.0000
\end{array}$$

In the following case the suggestion is seen more clearly. Thus:

$$(H+) = 3.02 \times 10^{-5} = \frac{3.02}{10^{+5}}$$

$$\begin{array}{lr} +\log\ 3.02 & = 0.4786 \\ \text{colog } 10^{+5} \quad (+\log 10^{+5} = 5.0000) & = 5.0000\text{-}10 \\ \hline +\log(H+) & = 5.4786\text{-}10 \\ -\log(H+) = \text{colog } (H+) = {}_pH & = 4.5214 \end{array}$$

When the hydroxyl concentration is given and the pH value is required, use is made of the water equilibrium expression in either of the two forms given below:

$$K_{H_2O} = (H+) \times (OH-) = 1.2 \times 10^{-14} = 1 \times 10^{-13.92}$$

Then:

$$(H+) = \frac{1 \times 10^{-13.92}}{(OH-)}$$

FOR EXAMPLE:

The (OH-) ion concentration of a solution is 8×10^{-5}; what is the pH value of the solution? Substituting:

$$(H+) = \frac{1 \times 10^{-13.92}}{8 \times 10^{-5}} = \frac{1 \times 10^{+5}}{1 \times 10^{+13.92}}$$

Solving logarithmically:

$$\begin{array}{lr} +\log\ 1 & = 0.0000 \\ +\log 10^{+5} & = 5.0000 \\ \text{colog } 8 \quad (\log = 0.9031) & = 9.0969\text{-}10 \\ \text{colog } 10^{+13.92} \quad (\log = 13.9200) & = 7.0800\text{-}20 \\ \hline +\log (H+) & = 21.1769\text{-}30 \\ -\log (H+) = \text{colog } (H+) = {}_pH & = 9.8231 \end{array}$$

Notice that the change of factors with negative exponents was made before proceeding.

The REVERSE PROCESS from the pH value to the concentration may be studied from the mathematical definition above:

$${}_pH = \log 1/(H+)$$

$$10^{{}_pH} = \left(10^{\log 1/(H+)}\right) = 1/(H+)$$

Let us reverse the illustration given above: the pH value of a system is 9.82+; what is the (OH-) ion concentration?
Substituting:

$$10^{9.82} = 1/(H+)$$

$$(H+) = 1/10^{9.82} = 1 \times 10^{-9.82}$$

To find the (OH-) ion concentration, use the expression for the water equlibrium constant:

$$(H+) \times (OH-) = 1 \times 10^{-13 \cdot 92} = 1.2 \times 10^{-14}$$

$$(OH-) = \frac{1 \times 10^{-13 \cdot 92}}{(H+)} = \frac{10^{-13 \cdot 92}}{10^{-9 \cdot 82}} = \frac{10^{+9 \cdot 82}}{10^{+13 \cdot 92}}$$

$$= 10^{-4 \cdot 1} \text{ nearly equals } 10^{-4 \cdot 0986}$$

To change this value to an integral expression:

$$(OH-) = 1/10^{+4 \cdot 1}$$

Solve logarithmically:

+log 1		= 0.0000
colog $10^{4 \cdot 1}$	(+log = 4.1)	= 5.9000-10
+log(OH−)		= 5.9000-10

Antilog ("N") = 7.943×10^{-5}
which is nearly equal to 8×10^{-5}

This latter value was the hydroxyl ion concentration in the first part of this paper. The identity of the choice of values for the water equilibrium constant may be proved by this last method.

MATHEMATICS

THREE THEOREMS PRELIMINARY TO A PROOF OF CASE I OF FERMAT'S LAST THEOREM

REV. JOSEPH P. MERRICK, S.J.

Note: According to the Encyclopedia Brittanica, Fourteenth Edition, 1929, vol. 9, page 174, the proof for case 1 had not hitherto been worked out.

THEOREM 1. The sum of the numerical coefficients of the rth and (r+1) th terms of the expansion of $(x+y)^n$ equals the numerical coefficient of the (r+1)th term of the expansion of $(x+y)^{n+1}$. For:

$$\frac{n(n-1)(n-2)\dots(n-r)}{2.3.4\dots\dots(r+1)} + \frac{n(n-1)(n-2)\dots(n-r-1)}{2.3.4\dots\dots(r+2)} =$$

$$\frac{n(n-1)\dots(n-r)}{2.3.4\dots(r+2)}\left\{r+2+(n-r-1)\right\} = \frac{(n+1)(n)(n-1)(n-2)\dots(n-r)}{2.3.4\dots\dots(r+2)}$$

which is the (r+1)th term of the expansion of $(x+y)^{n+1}$.

HENCE when n is an integer, the numerical coefficients are all integers. For if they are integral when n is 2, then they are integral when n is 3, since the sum of two integers is an integer. But they are when n is 2; etc.

THEOREM 2. When n is a prime number, it is an integral factor of the numerical coefficient of every term of the expansion of $(x+y)^n$, except the first and last.

For (theorem 1) the numerical coefficient $\dfrac{n(n-1)(n-2)\dots(n-r)}{2.3.4\dots(r+1)}$

is an integer, and yet every factor of the denominator is less than n. Hence the denominator is cancelled by the other factors of the numerator and n remains as an integral factor of the numerical coefficient. (Since a prime is indivisible integrally by every smaller integer, except, of course, one.)

THEOREM 3. When n is prime $\dfrac{2(2^{n-1}-1)}{n} = \dfrac{2^n-2}{n} = \dfrac{(1+1)^n-2}{n} =$

$$\frac{1+n+n(n-1)/2+\dots\dots+n+1-2}{n}$$

A: $= \frac{n\,(\text{integer})}{n} = \text{integer}$ (See theorem 2).

Hence if $n \neq 2$, since $2/n \neq$ integer

$$\therefore \frac{2^{n-1}-1}{n} = \text{integer} \begin{cases} n \neq 2 \\ n = \text{prime} \end{cases}$$

Again, $\frac{3(3^{n-1}-1)}{n}$ (when n is prime but $\neq 3$) $= \frac{3^n-3}{n} = \frac{(2+1)^n-3}{n} =$

$$\frac{2^n+n(\quad)+1^n-3}{n} = \frac{2^n-2+n(\text{integer})}{n} = \frac{2^n-2}{n} + \text{integer}.$$

But $\frac{2^n-2}{n}$ = integer from A) above, for any prime value of n.

$\therefore \frac{3^n-3}{n}$ = integer for any value (prime) of n. Hence if $n \neq 3$

$\frac{3^{n-1}-1}{n}$ = integer.

B: Hence if $\frac{k(k^{n-1}-1)}{n}$ = integer, then $(k+1)\left\{\frac{(k+1)^{n-1}-1}{n}\right\}$ = integer

(n = prime; $k = 1, 2, 3, 4$ or 5, etc.)

But B) is true when $k=3$, therefore when $k=4$, etc.

Moreover if $k+1 \neq n$, then $\frac{(k+1)^{n-1}-1}{n}$ = integer for any prime value of n and any integral value of $k+1$.

FERMAT'S LAST THEOREM, CASE 1

The theorem states that x^n cannot equal $(x+a)^n-(x+b)^n$ where n is an odd prime and x, a and b are any integers whatever.

N. B. Since a common integral factor of a, b and x would cancel out, we suppose them to have no common integral factor.

Now $(x+b)$ can be written $(x+a-c)$ where obviously $a-c$ is b. Hence c is any integer.

If the theorm is false, then $(x+a)^n - x^n = \left\{(x-c)+a\right\}^n$

A: Expanding

$$x^n+nx^{n-1}a+n\frac{(n-1)}{2}x^{n-2}a^2\ldots\ldots+nxa^{n-1}+a^n-x^n$$
$$=(x-c)^n+n(x-c)^{n-1}a\ldots\ldots n(x-c)a^{n-1}+a^n \quad \textit{(Cancel d.)}$$

Hence $(x-c)^n = n\left[x^{n-1}a \ldots + xa^{n-1} - (x-c)^{n-1}a \ldots - (x-c)a^{n-1} \right]$

Therefore from preliminary theorem 2, $\frac{(x-c)^n}{n}$ is an integer and since n is prime, $\frac{x-c}{n}$ is an integer such as v. Thus $x-c=nv$ and $x=nv+c$.

From A: THEREFORE $(nv+c)^n=(nv+c+a)^n-(nv+a)^n$, or

$$(nv+a)^n+(nv+c)^n=(nv+a+c)^n=(pq)^n,$$ where $(pq\ldots)$ is the product of all the prime factors of $(nv+a+c)$

It is clear from this last equation that a and c are interchangeable.

Now a and c together cannot have n as an integral factor, for then n could be cancelled throughout the whole equation, which is contrary to our supposition that there is no common factor which can be cancelled. Let us suppose then that c equals dn^r where d has no integral factor n, and r is 0, 1, 2 or 3, etc. Hence a has no integral factor n. Then

B: $(nv+a+dn^r)^n-(nv+a)^n=(nv+dn^r)^n$. Expanding, we have

$$(nv+a)^n+ndn^r(nv+a)^{n-1}+n\frac{(n-1)}{2}d^2n^{2r}(nv+a)^{n-2}\ldots nd^{n-1}n^{r(n-1)}(nv+a)$$

$$+d^nn^{rn}-(nv+a)^n=(nv)^n+n(nv)^{n-1}dn^r+n\frac{(n-1)}{2}(nv)^{n-2}(dn^r)^2$$

$$\ldots+nnv(dn^r)^{n-1}+d^nn^{rn}$$

Let $v=en^k$ where e does not have n as an integral factor and k may be 0, 1, 2, etc. It will be noticed that the first term resulting from the expansion of the second term on the left, cancels the second term on the right; the first term of the expansion of the third term on the left, cancels the third term on the right, etc.

Hence n^nv^n, i. e. $n^{nk+n}e^n$ is the only term left on the right side and every term on the left side has $n^{r+1}d$ as an integral factor.

Therefore: if $r+1<kn+n$, then $\frac{da^{n-1}}{n}$ is an integer after dividing throughout by n^{r+2}. For all other terms have n^{r+2} expressly as an integral factor. But by hypothesis d and a do not have n as an integral factor. Hence this is impossible.

If $r+1>kn+n$, then $\frac{e^n}{n}$ is an integer, for similar reasons. This too is impossible. For by hypothesis c has not n as an integral factor.

THEREFORE $r+1=kn+n$ and r is not 0.

HENCE (proof of Case I) EITHER OF THE TWO SMALLER TERMS OF OUR ORIGINAL EQUATION MUST HAVE n AS AN INTEGRAL FACTOR, AND ONLY ONE OF ALL TERMS HAS n AS AN INTEGRAL FACTOR.

THE CANONICAL FORM OF INCOMPLETE DYADICS

J. A. DEVENNY, S.J.

In the general discussion of the Hamilton-Cayley equation we suppose A, B, C, p, and q (roots of the auxiliary cubic) are not zero. We thus obtain seven complete dyadics. If we suppose one or more of these constants vanish, we obtain nine incomplete dyadics. The following are their canonical forms and analytic properties.

1. $\Phi = 0$.

This is the null dyadic. It annihilates all vectors.

$$\Phi_s = \Phi_x = \Phi_2 = \Phi_{2s} = \Phi^{-1} = \Phi^n = 0.$$

The Hamilton-Cayley equation has the form

$$\Phi^3 = 0.$$

2. $\Phi = e_1 b'c$.

This is linear and self-perpendicular. As postfactor it annihilates vectors, or their components, collinear with its consequent line. It is a versor for vectors, or their components, collinear with its antecedent line, turning them 90°, so that they are collinear with the consequent. The magnitude after rotation is directly proportional to the magnitude of the component in the direction of the antecedents.

$$\Phi_s = \Phi_x = \Phi_2 = \Phi_{2s} = 0$$
$$\Phi^{-1} = e_1 c'b.$$

The Hamilton-Cayley equation has the form

$$\Phi^3 = 0.$$

3. $\Phi = e_1 c'c$.

This is linear, non-self-perpendicular. As postfactor it annihilates vectors, or their components, perpendicular to the antecedent line. It is a versor for vectors, or their components, collinear with the antecedent line, turning them through such an angle that they are collinear with the consequent. Their magnitude after rotation is directly proportional to the magnitude of the component in the direction of the antecedent.

If the dyadic be expressed in terms of i, j, k, it is unilinear. It then annihilates the j & k components of vectors and is an isotonic tensor for their i components.

$$\Phi_s = e_1, \qquad \Phi_x = e_1 \frac{c \times (a \times b)}{[a\,b\,c]}$$
$$\Phi_2 = \Phi_{2s} = 0,$$
$$\Phi^{-1} = e_1^{-1} c'c, \qquad \Phi^n = e_1^{\,n} c'c.$$

The Hamilton-Cayley equation has the form

$$\Phi^2 \cdot (\Phi - BI) = 0$$

where really $\qquad \Phi \cdot (\Phi - BI) = 0.$

4. $\Phi = e_1 (b'a + c'b)$.

This is planar and self-perpendicular. As postfactor it annihilates vectors, or their components, perpendicular to the antecedent plane. It rotates through 90° vectors, or their components, collinear with the antecedent plane. The magnitude after rotation is the sum of two terms directly proportional to the magnitudes of the components of the transformed vectors in the directions of b′ & c′ respectively.

$$\Phi_s = 0, \qquad \Phi_x = e_1(b' \times a + c' \times b)$$
$$\Phi_2 = e_1{}^2 ab', \qquad \Phi_{2s} = 0$$
$$\Phi^{-1} = e_1{}^{-1}(a'b + b'c),$$
$$\Phi^2 = e_1{}^2 c'a, \qquad \Phi^3 = \Phi^n = 0 \qquad (n \geq 3).$$

The Hamilton-Cayley equation has the form

$$\Phi^3 = 0.$$

5. $\Phi = e_1 b'b + e_2 c'a.$

This is planar and self-perpendicular. As postfactor it effects a transformation similar to that of 4.

$$\Phi_s = e_1, \qquad \Phi_x = e_1 b' \times b + e_2 c' \times a$$
$$\Phi_2 = -e_1 e_2 ac', \qquad \Phi_{2s} = 0.$$

The Hamilton Cayley equation has the form

$$\Phi^2 \cdot (\Phi - BI) = 0.$$

6. $\Phi = e_1(a'a + c'c + c'a).$

This is planar, non-self-perpendicular. It can be factored

$$\Phi = e_1(a'a + c'c) \cdot (I + c'a)$$

into the product of a (planar) isotonic tensor and a simple shear.

If the dyadic be expressed in terms of i, j, k, it is uniplanar. It annihilates the j component of vectors, and effects a simple shear in the i, k plane.

$$\Phi_s = 2e_1$$
$$\Phi_x = e_1(a' \times a + c' \times c + c' \times a)$$
$$\Phi_2 = -e_1{}^2 bb', \qquad \Phi_{2s} = -e_1{}^2$$
$$\Phi^n = e_1{}^n(a'a + nc'a + c'c).$$

The Hamilton-Cayley equation takes the form

$$(\Phi - AI)^2 \cdot \Phi = 0.$$

7. $\Phi = e_1 b'b + e_2 c'c.$

This is planar, non-self-perpendicular. As postfactor it annihilates vectors perpendicular to the plane of antecedents. It is the general tonic for the plane of consequents.

If the dyadic be expressed in terms of i, j, k, it is uniplanar. It annihilates the i component of vectors and is general tonic in j, k plane.

$$\Phi_s = e_1 + e_2$$
$$\Phi_x = \frac{(e_1 - e_2)ab \cdot c + e_2 bc \cdot a - e_1 cb \cdot a}{[a\ b\ c]}$$
$$\Phi_2 = e_1 e_2 aa', \qquad \Phi_{2s} = e_1 e_2$$
$$\Phi^{-1} = e_1{}^{-1} b'b + e_2{}^{-1} c'c, \qquad \Phi^n = e_1{}^n b'b + e_2{}^n c'c.$$

The Hamilton-Cayley equation takes the form

$$\Phi \cdot (\Phi - BI) \cdot (\Phi - CI) = 0.$$

8. $\Phi = e_1 (a'a + b'b)$.

This is planar, non-self-perpendicular. It is an isotonic tensor for the plane of consequents.

If the dyadic be expressed in terms of i, j, k, it is uniplanar. It annihilates the k component of vectors and is isotonice tensor for i, j plane.

$$\Phi_s = 2e_1, \qquad \Phi_x = e_1 c \times c'$$
$$\Phi_2 = e_1^2 cc', \qquad \Phi_{2s} = e_1^2$$
$$\Phi^{-1} = e_1^{-1} (a'a + b'b), \qquad \Phi^n = e_1^n (a'a + b'b).$$

The Hamilton-Cayley equation takes the form

$$(\Phi - AI)^2 \cdot \Phi = 0.$$

9. $\Phi = (I - a'a)\, p \cos q + (b'c - c'b)\, p \sin q$.

This is planar, non-self-perpendicular. It is the cyclotonic for the plane of consequents and may be factored

$$\Phi = (pb'b + pc'c) \cdot [\,(I - a'a) \cos q + (b'c - c'b) \sin q\,]$$

into the product of an isotonic tensor and a cyclic dyadic.

If the dyadic be expressed in terms of i, j, k, it is uniplanar. It annihilates the i component of vectors. It is versor for j, k plane.

$$\Phi_s = 2p \cos q$$
$$\Phi_x = \frac{b \times (a \times b) + c \times (a \times c)}{[a\,b\,c]}\, p \sin q + \frac{a \times (b \times c)}{[a\,b\,c]}\, p \cos q$$
$$\Phi_2 = p^2 aa', \qquad \Phi_{2s} = p^2.$$

The Hamilton-Cayley equation takes the form

$$\Phi \cdot (\Phi^2 - 2p \cos q\, \Phi + p^2 I) = 0.$$

DIFFERENTIATION OF THE DEFINITE INTEGRAL

Lincoln J. Walsh, S.J.

A rather common practice in the physical and mathematical literature is the determination of the derivative of a function which is defined in terms of the Definite Integral. The present paper will be devoted to two special cases. The first case deals with the differentiation of the Definite Integral with respect to its upper and lower limit. The second case treats of the differentiation of a function which is defined as a Definite Integral containing a parameter.

First Case:—[If the lower limit is a constant]

$$\Phi(b) = \int_a^b f(x)\,dx$$

$$\frac{\Delta\Phi(b)}{\Delta b} = \frac{\Phi(b+\Delta b) - \Phi(b)}{\Delta b}$$

$$\Phi(b+\Delta b) = \int_a^{b+\Delta b} f(x)\,dx$$

$$\therefore \frac{\Delta\Phi(b)}{\Delta b} = \int_a^b \frac{f(x)\,dx}{\Delta b} + \int_b^{b+\Delta b} \frac{f(x)\,dx}{\Delta b} - \int_a^b \frac{f(x)\,dx}{\Delta b}.$$

By the Theorem of the Mean for the Definite Integral

$$\frac{\Delta\Phi(b)}{\Delta b} = \frac{(b+\Delta b) - b}{\Delta b} \cdot f(\xi).$$

Where ξ is defined: $b < \xi < b + \Delta b$.

$$\text{As } \Delta b \doteq 0,\ \xi \doteq b \text{ and } f(\xi) \doteq f(b)$$

$$\therefore \frac{d\Phi(b)}{d(b)} = \frac{d}{db}\int_a^b f(x)\,dx = f(b).$$

[Note: A similar process of reasoning would give $\Phi'(a) = -f(a)$.]

One special application of this case, and one which will serve to illustrate the usefulness of the method, is the derivative of the Natural Logarithm.

$$\log_e x = \int_1^x \frac{1}{\xi}\,d\xi$$

$$\frac{d}{dx}\log_e x = \frac{d}{dx}\int_1^x \frac{1}{\xi}\,d\xi = \frac{d}{dx}\int_1^x f(\xi)\,d\xi = f(x).$$

Since $f(\xi) = \frac{1}{\xi}$, $f(x) = \frac{1}{x}$

$$\therefore \frac{d}{dx}\log_e x = \frac{1}{x}.$$

Second Case:

$$\Phi(\alpha) = \int_{g_0(\alpha)}^{g_1(\alpha)} f(x,\alpha)\,dx$$

$$\frac{\Delta\Phi(\alpha)}{\Delta\alpha} = \frac{\Phi(\alpha+\Delta\alpha)-\Phi(\alpha)}{\Delta\alpha} \qquad \text{[Eq. 1]}$$

$$\Phi(\alpha+\Delta\alpha) = \int_{g_0(\alpha+\Delta\alpha)}^{g_1(\alpha+\Delta\alpha)} f(x,\alpha+\Delta\alpha)\,dx. \qquad \text{[Eq. 2]}$$

Expanding Eq. 2 and substituting in Eq. 1

$$\frac{\Delta\Phi(\alpha)}{\Delta\alpha} = \int_{g_0(\alpha)+\Delta g_0(\alpha)}^{g_0(\alpha)} \frac{f(x,\alpha+\Delta\alpha)\,dx}{\Delta\alpha} + \int_{g_0(\alpha)}^{g_1(\alpha)} \frac{f(x,\alpha+\Delta\alpha)-f(x,\alpha)\,dx}{\Delta\alpha}$$

$$+ \int_{g_1(\alpha)}^{g_1(\alpha)+\Delta g_1(\alpha)} \frac{f(x,\alpha+\Delta\alpha)\,dx}{\Delta\alpha}. \qquad \text{[Eq. 3]}$$

Applying the Theorem of the Mean for Derivatives, and recalling that we are dealing with a function of two variables, x and the parameter α, the 2nd term in [Eq. 3] becomes:—

$$\frac{f(x,\alpha+\Delta\alpha)-f(x,\alpha)}{\Delta\alpha} = \frac{\partial}{\partial\alpha} f(x,a) = \frac{\partial}{\partial\alpha} f(x,\alpha+\theta\Delta\alpha),$$

evaluated for $a = \alpha + \theta\Delta\alpha$: where $(\alpha+\theta\Delta\alpha)$ is so defined that

$$\alpha < \alpha+\theta\Delta\alpha < \alpha+\Delta\alpha,$$

and where θ is any positive fraction.

Substituting this new value, and applying the Theorem of the Mean for the Definite Integral to the 1st and 3rd terms in [Eq. 3] we obtain

$$\frac{\Delta\Phi(\alpha)}{\Delta\alpha} = \int_{g_0(\alpha)}^{g_1(\alpha)} \frac{\partial}{\partial\alpha} f(x,\alpha+\theta\Delta\alpha)\,dx$$

$$-\frac{\Delta g_0(\alpha)}{\Delta\alpha} f(\xi_0,\alpha+\Delta\alpha) + \frac{\Delta g_1(\alpha)}{\Delta\alpha} f(\xi_1,\alpha+\Delta\alpha). \qquad \text{[Eq. 4]}$$

$$\therefore \frac{d\Phi(\alpha)}{d\alpha} = \int_{g_0(\alpha)}^{g_1(\alpha)} \frac{\partial}{\partial\alpha} f(x,\alpha)\,dx$$

$$-\frac{dg_0(\alpha)}{d\alpha} f[g_0(\alpha),\alpha] + \frac{dg_1(\alpha)}{d\alpha} f[g_1(\alpha),\alpha]. \qquad \text{[Eq. 5]}$$

[*Note*: In [Eq. 4] ξ_0 and ξ_1 are so defined that $g_0(\alpha)+\Delta g_0(\alpha) < \xi_0 < g_0(\alpha)$, and $g_1(\alpha) < \xi_1 < g_1(\alpha)+\Delta g_1(\alpha)$. Hence as $\Delta\alpha$, and therefore also as $\Delta g_0(\alpha)$ and $\Delta g_1(\alpha) \doteq 0$ as their limit, $\xi_0 \doteq g_0(\alpha)$ and $\xi_1 \doteq g_1(a)$.]

Equation 5 is, then, the formula for determining the derivative in problems coming under Case 2. In the following application it will be observed that besides obtaining the derivative of a specific type of function, we have in hand a rather ingenious device for evaluating an integral not easily handled by other methods.

Problem: Evaluate $\Phi(\alpha)$ in the expression $\Phi(\alpha) = \int_0^1 \frac{x^\alpha - 1}{\log x}$

$$g_1(\alpha) = 1; \qquad g_0(\alpha) = 0; \qquad f(x,\alpha) = \frac{x^\alpha - 1}{\log x}.$$

Substituting in [Eq. 5] and obtaining $\Phi'(\alpha)$:

$$\frac{d\Phi(\alpha)}{d\alpha} = \int_0^1 x^\alpha dx = \frac{x^{\alpha+1}}{\alpha+1}\Bigg|_0^1 = \frac{1}{\alpha+1}$$

$$d\Phi(\alpha) = \frac{1}{\alpha+1}\, d\alpha$$

$$\therefore \Phi(\alpha) = \int \frac{1}{\alpha+1}\, d\alpha = \log(\alpha+1).$$

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PHYSICS

A CATHODE RAY OSCILLOSCOPE FOR THE PHYSICS LABORATORY

Rev. John S. O'Conor, S.J.

Little more than a year ago the Cathode Ray Oscilloscope could be found only in the better equipped electrical research laboratories, but within the last few months at least five manufacturing concerns have brought out oscilloscope and auxiliary equipment which are well within the reach of colleges even with quite limited budgets.

In view of these recent developments and also because the oscilloscope is perhaps one of the most versatile instruments in the field of modern physics, we are submitting this description of two units recently acquired at Woodstock. The first is the oscilloscope proper, which was purchased from the National Company of Malden, Mass. The second is a Bedell sweep circuit which was constructed at Woodstock from standard radio parts, according to RCA data.

The Cathode Ray Tube is of course the essential element around which the above mentioned scope is built. The tube is the RCA No. 906. It is a highly perfected development of the old Braun tube (a familiar item in most of our laboratories), and it improves on its ancestor by having a much higher vacuum, a hot cathode with indirect heating for electron source, possessing also a three inch fluorescent screen, and requiring only 1000 volts for its accelerating potential. With a control grid and focusing electrode it constitutes an electron gun used to project a beam upon the fluorescent screen, which produces a luminous spot easily visible in a brightly lighted room.

The deflection of the beam is produced by the use of two interconnected sets of plates serving to control the electron stream by two electrostatic fields at right angles to each other. In operation one set of plates reproduces the variations of voltage under observation, while the other pair provides a suitable timing axis.

The purposes to which such a properly installed cathode ray tube may be put are practically unlimited. With the modest equipment herein described it is possible to use the scope as a high frequency A.C.

volt meter; to adapt it for use as a frequency meter; to show permanent images of the wave form of various sources of alternating current; to show characteristic curves of vacuum tubes; to produce Lissajous figures; to reproduce hysteresis loops; to show the continuously varying modulating voltage produced by voice or music, from radio, phonograph or local microphone and amplifier, and to show the difference between such complex waves and the pure note of a tuning fork or other source of constant frequency vibrations. In addition to these demonstrations and practical uses, the tube and its associated equipment constitute the main items required for the performance of the fundamental experiment of J. J. Thomson on the determination of the ratio of charge to mass of the electron. And finally the tube serves as the basis, for the explanation at least, of the most promising method of television transmission and reception.

The Oscilloscope put out by the National Company is contained in a metal housing 18″ x 8″ x 6″. In addition to the mounting for the 906 tube, it includes power supply for filament and high voltage, potentiometers for focusing and brilliance control, as well as a means of applying the 60 cycle A.C. from the power transformer directly to the horizontal deflection plates, thus giving a self-contained horizontal sweep.

This A. C. sweep is quite satisfactory for certain purposes, such for example as the determination of percentage modulation of a broadcast transmitter, and the unit is so used without further auxiliary equipment by several of the Washington Stations. The complete schematic wiring diagram of the National Oscilloscope is given in Figure 1.

For many of the other uses mentioned above it is necessary to have a time axis that is truly linear, and since the output voltage of the commercial generators is not such, another type of sweep circuit is needed, especially when permanent images of wave forms are desired.

Such a linear sweep circuit is shown in Figure 2. In some oscilloscopes this circuit is built in as an integral part of the entire instrument. Since it is the more expensive part of the scope, and is not essential for modulation measurements, the National Co. does not include it in their instrument. We have found the locally assembled unit most satisfactory for the purposes for which it is designed, and far more reasonable to construct than to purchase.

Its operation depends on the remarkable properties of another recently developed thermionic tube, the Thyratron. Built as a separate unit, this sweep circuit is connected to the scope of Fig. 1 by a pair of leads from BB to AA, thus replacing the A.C. sweep when S_2, the changeover switch, is turned to the right.

Following (in Fig. 2) from the terminals BB (syeep voltage), we see that one of the bank of condensers (C_3 to C_7) may be connected (by means of a selector switch) between the points BB in such a way that

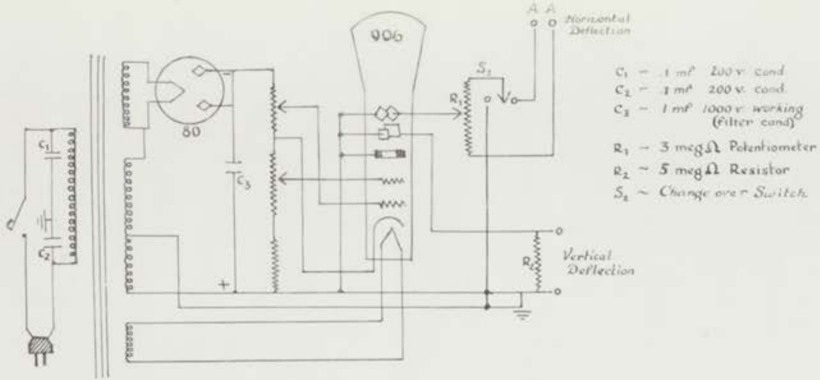

Fig. 1: National Cathode Ray Oscilloscope

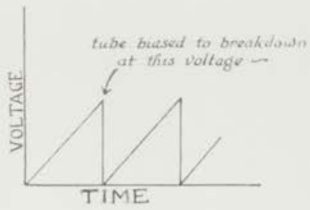

Fig. 3: Output Wave Form of Sweep Circuit

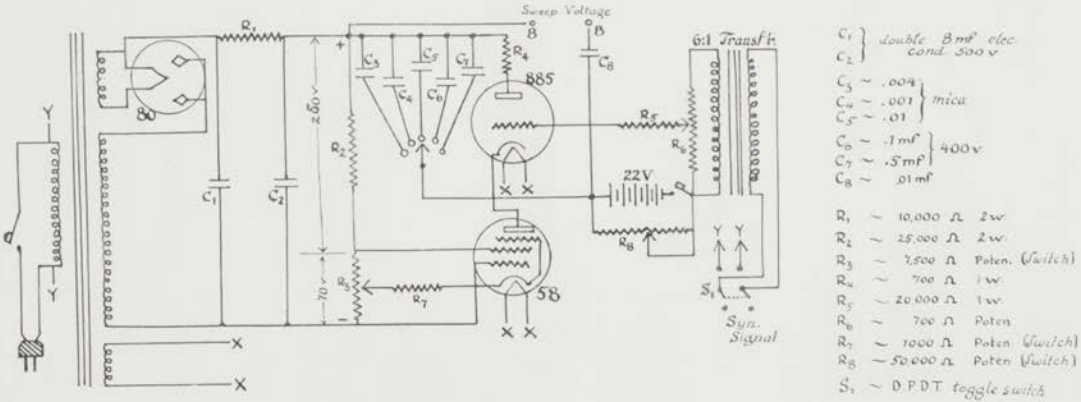

Fig. 2: Linear Time Sweep Circuit (constructed from R.C.A. data).

the voltage of the particular condenser selected is applied (through the leads) to the horizontal deflection plates of the tube of Fig. 1. This condenser is then charged by a constant current delivered through the plate circuit of the 58 pentode. The voltage, due to the charging current, is therefore proportional to time, and the deflection of the cathode ray beam increases in one direction accordingly. When this voltage reaches a certain limit, the thyratron (885) ionizes and discharges the condenser almost instantly, and the electron beam of the cathode ray tube snaps back to its original undeflected position. The charging cycle is then repeated and the spot of light moves over the screen with practically constant velocity in one direction, returning in the other direction so rapidly that no image can be seen on the screen during this slight fraction of the cycle.

Frequency control of this cycle is had by regulating the value of the charging current, or by varying the size of the condenser or both.

The thyratron used is the RCA 885, and is a grid-controlled, gaseous-discharge tube of the heater cathode type. Its operation as described above is made possible by the feature that a negative voltage on the grid either maintains plate current cut-off or promptly loses control, depending on the value of the plate voltage.

As seen above, the plate voltage is determined by the charge on the condenser; and when breakdown potential is reached, the condenser discharges through the tube, the plate voltage drops, the grid regains control, and the new cycle starts.

For frequencies in the audio range the 58 can be used very satisfactorily as the tube feeding constant current to the condenser. For higher frequencies the type 34 is preferable. Figure 3 shows the wave form output of the linear sweep circuit.

The exact synchronizing of the sweep circuit oscillator with the pattern of a wave under observation can be conveniently done, as seen in fig. 2, by supplying the grid of the 885 with a small portion of the wave voltage under test. A very low voltage is adequate to cause the pattern to lock and hold stationary with several complete cycles of the wave visible on the screen. This voltage is appiied by means of the 6:1 transformer at the right of Figure 2. It should have an air core if radio frequencies are to be used.

It will also be noted that the power supply for scope and linear sweep are entirely separate. This of course is not necessary, but was found more convenient than tapping the power pack of the National unit. Values of resistors, potentiometers, etc., used in the construction of the sweep circuit are to be found on the diagram. The power transformer is a Philco general purpose one (replacement part 7421), and was used because it happened to be on hand. Both filament and plate voltages had to be adjusted by the use of the resistors indicated. Actually what is needed is filament voltage for 80, 885 and 58, and a high voltage of approximately 300 after rectification and filtering.

Credit for a great part of the work of assembly and adjustment of this unit is due Mr. Edward S. Hauber, and the finished product compares favorably with commercial oscillators of this type, due to his efforts. Its cost, exclusive of time and including tubes, was about $12.00

Demonstration of pure-tone wave forms was mentioned as on of the uses of this oscilloscope. In this connection we have found the *RCA Technical Purpose Records most suitable.* These records are made with frequencies from 25 to 8000 v.p.s. and when played on an electric victrola with the output coupled to the oscilloscope instead of the loud speaker, give an almost perfect wave form on the screen, corresponding to the frequency used. Catalogue and prices may be had by writing to RCA Victor, Camden, N. J.

Incidentally, these records also serve three other purposes; the formation of Lissajous' figures when used in combination with the A.C. sweep; the calibration of the sweep frequencies themselves; and lastly the constant frequency note can be readily amplified and used as the oscillation source in A.C. bridge measurements of inductance and capacitance.

A list of some of the manufacturers of Oscilloscopes, and the intrument prices, is followed by a bibliography.

National Company, Malden, Mass.

Type No. CRO (without linear sweep or tubes)................$17.70
RCA Cathode Ray Tube No. 906..........................$18.00
" Thyratron No. 885 ....$ 2.00

RCA Oscillograph Type TMV-122B (just put on the market)
(Wholesale Radio, 100 6th Ave., N.Y.C. This includes self-contained linear sweep circuit, amplifier and all tubes.........$84.50

General Radio Co., Cambridge, Mass. Type 687-A with sweep and tubes (5 inch screen) $184.00

Milvay Clough Brengle (Chicago Apparatus Co.)
Oscilloscope with tube $50.00
Sweep circuit $50.00

Standard Instruments Co. (Wholesale Radio) Oscilloscope with sweep (no tubes) $120.00

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A Steady Mercury Lamp for Use in Research...........A. L. Johnsrud
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Note on Life Tests of Commercial Type Standard Cells......T. T. Smith
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The Waterbury Telecell (about 0.66 volts) ($1.00)
The Waterbury Battery Co., Waterbury, Conn.

For Making a Good Pair of Beam Compasses:
No. 59A Trammel Heads (with one pair of points) ($2.40)
L. S. Starrett, Athol, Mass.

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Recueil de Conférences et Mémoires de Calcul des Probabilités et Physique Theorique. (Volume I, fascicule 1 appeared in 1931.)
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49, Boulevard Saint-Michel.

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FOURTEENTH ANNUAL MEETING

of the

AMERICAN ASSOCIATION

of

JESUIT SCIENTISTS

August, 1935

SEISMOLOGY

FATHER MACELWANE, S.J. GIVES LOWELL INSTITUTE LECTURES

A course of eight illustrated lectures on "Some Old Seismological Problems and Recent Solutions" was given this year by Father James B. Macelwane, S.J., of St. Louis University. The lectures were given under the Lowell Institute in Huntington Hall, Rogers Building, Boston, Mass., on Fridays and Tuesdays at eight o'clock in the evening, beginning Friday, February 1, and omitting Friday, February 22.

The lectures were as follows:

1. **Earthquakes.** Their nature and distribution. Intensity. Destructiveness. Earthquake resistant construction.

2. **Shallow Earthquakes.** Probable causes and mechanism. Relation to the structure of the earth's crust.

3. **Deep Earthquakes.** Characteristics. Distribution. Problem of origin and mechanism.

4. **The Seismograph.** Principles. Types in general use. Characteristics and limitations.

5. **Seismographic Records.** Seismograms from a near origin; from a distant origin. The problem of the epicenter. The problem of depth of focus.

6. **Earthquake Waves.** Types of waves inside the earth. Stress and strain. Waves on the surface of the earth.

7. **Artificial Earthquakes.** Refraction and reflection of elastic waves. Applications to seismic prospecting.

8. **Speeds and Paths of Earthquake Waves Inside the Earth.** The rock mantle. The Dahm layer. The Gutenberg discontinuity and the core of the earth.

SEISMOGRAPHIC OBSERVATION OF TILTING

Rev. John P. Delaney, S.J.

Several years ago one of the seismographs of the Canisius College Observatory, Buffalo, disclosed a queer preference for leaning toward the southwest, a constant drifting away from the northeast. The persistence of the instrument in its tendency toward the southwest, even after several quite accurate relevellings, finally suggested a serious study of the phenomenon. Could it be possible that the southwest tilting of the Great Lakes region, so long studied by geologists, was revealing itself on the seismograph?

The Lakes Region appears to be the most stable and also the most mobile section of the North American Continent. Earthquake catalogs give the region scant attention, for the excellent reason that for many generations the región has been immune to earthquake catastrophe. No other section of the continent has presented such freedom from seismic disturbance.

Nevertheless the Lakes Region is the most mobile area on the continent. This seeming contradiction, exceptional stability associated with exceptional mobility, disappears with the realization that immunity from serious earthquakes may be expected in a region that offers constant and easy elastic readjustment under the various stresses brought to bear upon it.

The delightfully broad beaches and upraised beach terraces that feature the northern shores of the lakes have been interpreted by authoritative geologists as unmistakable evidence of a continued and general northeast to southwest tilting of the entire Great Lakes Region. This interpretation is confirmed by the water level records of the Lakes Survey, further confirmed also by direct observation of older residents and farmers along the northern and southern shores. These observers have noted a constant recession of the lakes from their northern shores and an aggressive erosion destructively at work along the southern shores.

This immense crustal readjustment has been observed for many years. Its rate also has been measured with precision, and its causes have been explained satisfactorily. Just yesterday, geologically speaking, untold thousands of tons of glacial ice pressed down upon the Lakes Region. The neatly balanced forces of this segment of the earth's crust were greatly disturbed. With the recession of the glacial ice, these disturbed forces went to work toward the restoration of their former equilibrium, a work that continues in present geological time.

Geologists until recently pictured such crustal readjustments as abrupt and spasmodic, earthquake catastrophes of devastating proportions. The younger science of geophysics favors rather an elastic and generally gentle easement of uncompensated stresses on the earth's surface. Normal readjustments are elastic and constant rather than violent and spasmodic.

Infinitesimal as is the rate of tilting affecting the Lakes Region, yet this minute rate has been measured and it comes well within the sensitivity limits of modern seismographs. It is of an order that would tip a structure as high as the Empire State Building only a few thousandths of an inch each year. Much larger tilts than this are daily affecting seismographs. The most sensitive spirit level is a crude instrument compared to the modern seismograph. Even the infinitesimal shifting of ground level under the gentle influence of atmospheric pressure and temperature changes, the flow and ebb of the tides, is matter of daily seismographic observation, source of annoyance to most seismologists the world over.

For this reason the seismographic observation and study of slow processes of land tilting becomes involved and statistical. The study should extend over considerable periods of time, and with the cooperation of several properly distributed observatories. However, the data on land tilt taken from a single observatory should prove a worthwhile contribution, and with this objective the Canisius College Observatory is following up with interest the deflection of the seismographs.

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