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CONTENTS

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EASTERN STATES DIVISION

VOL. XXIII DECEMBER, 1945 No. 2

REV. RICHARD B. SCHMITT, S. J.

1888–1945

R. I. P.

EDITOR OF THE JESUIT SCIENCE BULLETIN 1929-1940

REV. RICHARD B. SCHMITT, S.J.

1888—1945

Rev. Jos. P. Kelly, S.J.

Success in life may not always be a striking thing. In some cases, it may seem rather commonplace and pass almost unnoticed. We have all seen men go along day by day, using their talents to the full extent, doing well the work at hand. They accomplish their tasks with a quiet ease that is sometimes deceiving. If they are members of an organization, their success is taken for granted; it is expected of them to fulfill the role assigned. They contribute much to the well-being and smooth running of the organization. It is only when illness or death places a halting hand on them that their lives stand out in a true light. Then we are impressed by the more-than-ordinary character of their accomplishments. Such was the life of the late Rev. Richard B. Schmitt, S.J.

Born in Brooklyn, N. Y., on July 14, 1888, Fr. Schmitt completed his high school course, at St. Francis Xavier High School, N. Y., in June, 1906, and on Aug. 14 of that year entered the Novitiate of the Society of Jesus, St. Andrew-on-Hudson, Poughkeepsie, N. Y. After two years of novitiate and two more of Classical studies, he began the three year course in Philosophical studies at Woodstock College, Wodstock, Md., 1910-1913. During these years he began his studies in Chemistry. His first appointment in teaching came in 1913, at Canisius College, Buffalo, N. Y., as assistant lecturer in Chemistry. After five years of successful teaching, he returned to Woodstock College for his theological studies, 1918-1922. He was ordained to the Sacred Priesthood in Dahlgren Chapel, Georgetown College, June, 1921. His last year of training as a Jesuit was spent at St. Andrew-on-Hudson, 1922-1923, and on its completion he was assigned to the Dept. of Chemistry, Ateneo de Manila, Philippine Islands. He pronounced the final vows of the Society of Jesus at Manila, Feb. 2, 1924.

As Professor of Chemistry at the Ateneo de Manila he readily recognied the importance of the Chemistry of Sugar in those regions. He devoted himself zealously to that work and by his writings and illustrated lectures attracted favorable attention both in the Philippines and in this country. But just as his research was well under way he fell an unfortunate victim to the painful leukoplakia and was compelled to return to the United States in 1926. He was appointed Head of the Dept .of Chemistry at Loyola College, Balto, Md., in the summer of 1926.

In this new position Fr. Schmitt at once manifested his excellent [illegible] teen years, 1926-1942, he carried on his work at Loyola with remarkable success. One of his contemporaries writes: "During his years as Head of the Dept. of Chemistry at Loyola, he kept the department up to a very high standard and maintained that fine reputation that had characterized the students of Chemistry in this college. By a masterly knowledge of his subject and clarity of exposition he proved himself a teacher of no mean calibre. He established the Chemists' Club of Loyola, whose meetings were given the added interest from the fact that he invited very prominent Chemists from a number of universities and from noted industrial firms to lecture to the students. Among these were Drs. Niederl, Taylor, Rice, Herzfeld, Albers and many others. These lecturers considered it an honor to speak before the Chemists' Club. Every four years the Chief Medical Examiner of New York came to lecture and his talks were eagerly anticipated because of the nature of the subject and of the humor which was invariably a part of them. It was after the visit of Dr. Niederl that Fr. Schmitt became interested in Micro-Chemistry and he spent many summers at New York University, where Dr. Niederl was on the staff. He also spent a few summers at Cornell University with Dr. Albers. A Micro-Chemical Laboratory designed and equipped by Fr. Schmitt made such a favorable impression in this vicinity that the F.B.I., from Washington sent some of their chemists to study the technique that would be useful to them in their work."

As a research scholar, Fr. Schmitt's outstanding achievement was in the field of Micro-Chemistry. As has been mentioned he spent many summers at other universities perfecting himself in this research. We are much in debt to Dr. Joseph B. Niederl, of the Chemistry Department of New York University for the following glowing tribute to Fr. Schmitt and his research investigations. "Fr. Schmitt was one of the first scientists of the United States to realize the importance of Micro-Chemistry, particularly quantitative organic micro-analysis. Since 1932 Fr. Schmitt spent practically every summer in my laboratory doing research on 'Micro-titrimetric combustion methods,' and later, on 'Isothermic micro-distillation.' These researches proved highly successful and were presented to the American Chemical Society at the following national meetings:

Sept. 1937. Rochester, N. Y. "A Volumetric Dry Combustion Method for Carbon."

Sept. 1940. Detroit, Mich. "Molecular Weight Determination by Isothermic Methods."

Sept. 1941. Atlantic City, N. J. "Molecular Weight Determination by Isothermic Micro-Distillation."

"I was honored to give the following lectures in his department of Chemistry at Loyola College, Balto., on Nov. 22, 1932; April 17, 1934, and April 16, 1935. The Science of Micro-Chemistry has lost in Fr. Schmitt a most enthusiastic sponsor, while I have lost an irreplaceable friend and a fatherly advisor, who among other things helped me to arrange my lectures on the Far East, particularly China."

After sixteen years at Loyola College, Fr. Schmitt was sent to St. Peter's College, Jersey City, in 1942. He taught Chemistry here for one year and in the summer of 1943 became Head of the Dept. of Chemistry at Fordham University, N. Y., succeeding the late Rev. Francis W. Power, S.J. Early in 1944, Fr. Schmitt was invalided by a stroke of paralysis which forced him to relinquish all active work. A few years previous to this he was obliged to undergo a very serious operation on his tongue and cheek. He was never free from the pain and distress that the treatment of this illness caused. After this operation his health began to decline. When invalided by the paralytic stroke, he was sent to St. Andrew-on-Hudson to recuperate but his health was too far impaired. On August 11, 1945, God called him to his eternal reward.

A fellow Jesuit who lived in community for many years with Fr. Schmitt wrote this beautiful, personal appreciation of him: "Fr. Schmitt never posed as a genius nor anything approaching it but he did have that excellent quality of carrying through whatever he undertook. He was extremely methodical and very orderly in all his work. Towards the members of his community he was always courteous, thoughtful and generous in his praise of work well done. Sensitive by nature, he would bloom with happiness at a word of commendation for his own success and by the same token was often keenly hurt when slighted. He was very proud of his calling as a Jesuit, grateful to God for his vocation and very happy in it. He had a high appreciation of the ideals of the Jesuit life and strove to fulfill these ideals. One never heard him complain of his sufferings; in fact, his patience and cheerfulness even at times when he was suffering intensely were most remarkable. He was a man of fine taste as was evident from his personal appearance and from the manner in which he conducted any function whether great or small.

For about fourteen years he was chaplain at Kirkleigh Villa, a home for the aged. In his quiet way he would do many favors for them and would be radiant with joy at the pleasure that they derived from his talks, lectures, movies and pictures that he made for them. These same kindnesses he extended to the orphan girls at the Institution adjoining the Kirkleigh Villa.

Fr. Schmitt was a member of the American Chemical Society, and of the International Association of Chemists and of the American Association for the Advancement of Scientists. He was one of the early members of the American Association of Jesuit Scientists and from 1929-1940 was editor of the Jesuit Science Bulletin. His frequent contributions were of scholarly merit. He devoted his powers to making the Bulletin representative of the high scholarship that was his ideal in all his studies. We offer this tribute to the memory of a Priest of Christlike charity, a Jesuit of Ignatian ideals and a teacher of scholarly character. R. I. P.

PUBLICATIONS BY REV. RICHARD B. SCHMITT, S.J.

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JESUIT SCIENCE BULLETIN.

	Vol.	No.
Dumas Micro Method for Nitrogen	V	2
Quantitative Determination of Potash in Cane Sugar Juice	V	3
Stability of Complex Elements	VI	1
Quantitative Analysis of Steel	VI	1
Quantitative Method for Determination of Silicon and Phosphate in Iron	VI	2
Tests for Methanol	VI	4
Relations of Science and Philosophy	VII	1
Decomposition of Sucrose	VII	1
Quantitative Determination of Chromium	VII	2
Determination of Carbon-Dioxide in Barium	VII	3
Separation by Sodium-hypochlorite of Cobalt and Nickel	VIII	1
Organic Micro-analysis	VIII	2
Micro-methoxyl Determination	VIII	3
Quantitative Gas Analysis	VIII	4
Evolution of Elements and Stability of Complex Atoms	IX	1
Micro Crystallization from Solution	IX	2

Use of Polarizing Microscope in Chemistry	IX	3
Micro-Chemistry	X	2
Micro-analysis of Carbon and Hydrogen	XI	2
Micro-chemical Analysis	XI	3
Deuterium	XI	4
Micro Determinations of Halogens in Organic Compounds	XII	1
Organic Chemicals for Micro-organic Analysis	XII	2
Fluorescent Materials in Ultra Violet Light	XII	4
Micro Determinations of Chlorine and Bromine in Organic Compounds	XIII	4
Micro-vaporimetric Determinations of Molecular Weights with Macro-analytical Balance	XIV	2
Micro Volumetric Dry Combustion Method for Carbon	XV	2
Radium, the Extraordinary Element	XV	4
Active Hydrogen in Organic Molecules	XVI	2
An Improved Method for Molecular Weight Determination for Organic Compounds	XVII	2
Three Micro Methods for Molecular Weight Determinations	XVIII	2
Molecular Weight Determinations by Isothermic Distillation. (In collaboration with Dr. Jos. Niederl)	XVIII	3
Application of the Isothermal Distillation Method for Higher Molecular Weights	XIX	3
Penicillin, the Welcome Murderer	XX	4

N. B. As Editor of the Jesuit Science Bulletin, Fr. Schmitt wrote numerous Editorials on current scientific subjects.

Also, an annual review of the developments in the field of Chemistry, entitled, "The Year in Chemistry."

ASTRONOMY

OCCULATIONS OF STARS BY THE MOON

by

REV. JAMES K. CONNOLLY, S.J.

(Continued from September Issue)

After finding the apparent place of the star at the time of occultation (Jesuit Science Bulletin, Vol. xxiii, number 1) the further work on fainter stars may be done in one of several ways. The way chosen will probably depend on the preference of the computer and, to some extent, on the method of computation, i.e., logarithmic or by calculating machine. It is to be noted that this section of these notes may be somewhat more compressed since it is to be expected that anyone who extends his observing schedule beyond the 7.5 magnitude limit of the NA will probably have done a fair amount of computation.

A logarithmic reduction can be carried out according to the form given in the Jesuit Science Bulletin, Vol. vi, number 2, page 17. The complete form of the reduction is given and explained by Father F. W. Sohon, S.J. One can reasonably suppose that a person using this issue of the Bulletin either possesses the previous issues or has access to them. Accordingly the matter referred to need not to be repeated here. It should be noted that the number 0.212 used in steps 22 and 25 of the form of reduction is subject to change and has been changed since Fr. Sohon's article. This number is the equivalent of the correction entered on space 4 of the reduction card described in the previous installment. The current value of the constant for steps 22 and 25 may be learned from the Astronomical Department of Yale University.

A person intending to reduce occultations with a calculating machine has a choice of methods. He may adapt the form given in Fr. Sohon's Bulletin article to convenient machine calculation. Or he may use the NASupp. method of reduction which is used on the brighter stars. For this latter method the computer will have to compute his own reduction elements for the fainter stars but this is not a very laborious task. The NA office computes for each hour of the year the quantities F and G found among the reduction elements. F and G are required for the hours before and after the occultation and will be supplied on request by the NA office.

This office computes also the quantities p and p_y (As before, underlined letters are those which are commonly represented by Greek letters. "p_x" is, accordingly read "pi sub x.") These quantities will be required for the two hours preceding the occultation and for the two hours following. The NA office will supply these, too, on request. With p_x and p_y thus known, with the apparent right ascension and declination (a_s and d_s as they are designated in the NASupp.) already determined, one can determine x and y for the two hours preceding and for the two hours following the occultation. The difference of successive values of x (or of y) gives D'. The difference of successive values of D' gives D''. The sum of the two D'' thus determined is the $D_1'' + D_2''$ of the reduction elements. All this is fully illustrated on page 35 of NASupp.

The remaining required quantities can be found by the simple formulas given on page 34 of the NASupp and illustrated on page 35. m^0 = sidereal time of Greenwich 0^h (given in eighth column of "SUN, FOR 0^h UNIVERSAL TIME" in the beginning of the AE.) minus a_s. $r = \cos d_s / k$ where $k = 0.2724953$. $s = -\sin d_s$ and $v = 150 \cos d_s$

m_0 should be listed in hours, minutes and thousandths of a minute. x, y, and r are to be listed in units of the fourth decimal place. p_y is in units of the fifth decimal place. s is given as a five place decimal. v is given as a three figure whole number. This completes the collection of the reduction elements and the reduction can be completed as directed previously for stars brighter than magnitude 7.5.

Results of these occultations will be on the reduction cards. For some time to come a copy of the card may be sent to Yale University. If the star is not from the NA list a note should be made of the source from which its position was taken. If it be decided to publish the results the first article of the projected series should state the type and aperture of instrument used, e.g., 3 in. refractor. The method of time recording should be stated, e.g., chronograph, stop watch and standard clock. A table should be made up of twelve columns. The first column carries one's own serial number of observed stars. The next ten carry the quantities on the bottom line of the reduction card: p, q, p^2, pq, q^2, Ds, pDs, qDs and the coefficients of Da and Dd from steps 22 and 23 on card. The last column gives the source of the data on the star, e.g., NA #850, or if a non-NA star Washington 7245. For non-NA stars a supplementary table should be made up of seven columns giving: 1) one's own serial number; 2) name or identification of star; 3) magnitude of star, 4) and 5) right ascension and declination of star; 6) and 7) date and Greenwich Civil Time of occultation.

APPENDIX

On page 107 of the Jesuit Science Bulletin, Vol. xxii, number 4, there is described the use of a pair of nomographs for finding the parallax of the moon in right ascension and in declination. As mentioned there, the construction of these diagrams is given in Popular Astronomy for May 1932. It may, however, be worth while repeating the construction details here for those who may not have easy access to sets of Popular Astronomy.

The diagrams may be conveniently drawn on paper of the common eight and a half by eleven inch size. The first diagram is for the determination of parallax in right ascension. Following letters refer to Figure 1, drawn for Holy Cross College. Dashed lines are for construction and need not be drawn in permanently.

a) Draw in permanently about the middle of the paper a ten inch line BC, parallel to the 11 in. side of the paper. On this line mark off from B distances equal to A sec $\underline{d}$ at 5° intervals from $\underline{d}$ = 0° to $\underline{d}$ = 30°. A convenient value of A is six inches.

b) From B draw BD at 45° upward from BC and draw BE at 30° down from BC. These angles are chosen as a matter of convenience.

c) Locate on BD a point F, 1.25 in. from B. From this point draw to the right a line FG about 5 in. long, parallel to BC. On this

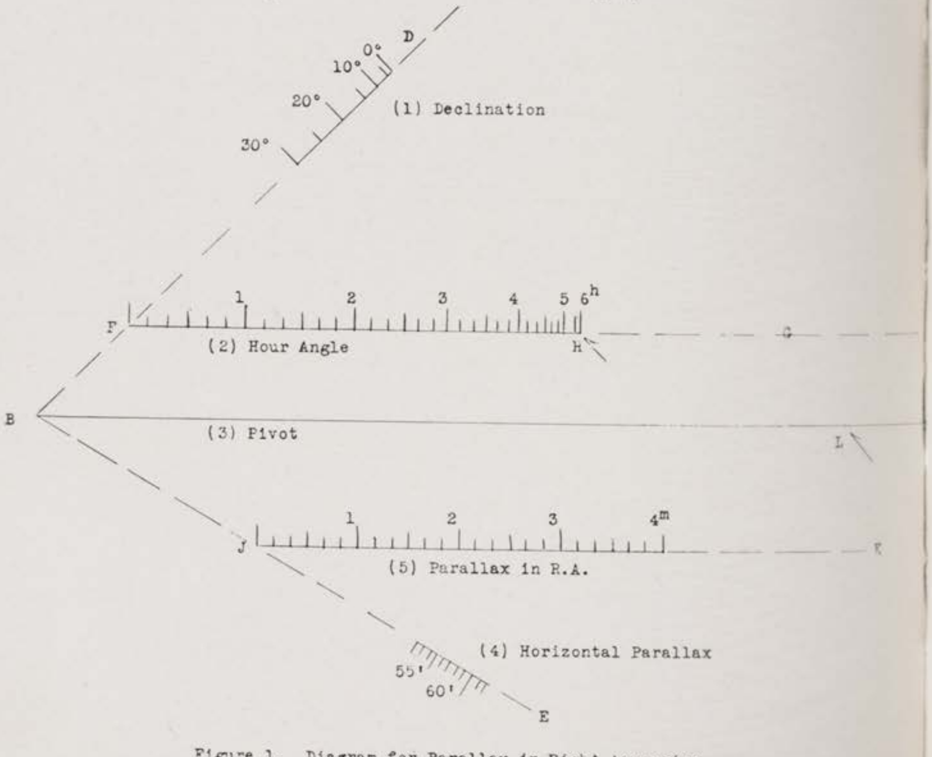

Figure 1. Diagram for Parallax in Right Ascension.

line mark off a point H distant from F by A r cos f′. (The method of finding r cos f′ and r sin f′ is given in AE, USE OF TABLES, ECLIPSES.") In Figure 1, the value of r cos f′ is taken as 0.742. Draw lines from the A sec d points on BC thru point H till they intersect BD. These intersections form a declination scale on BD and should be permanently drawn in.

d) Permanently mark FG by points distant from F by A r cos f′ sin h, where "h" is hour angle. It ranges from 0 hours at F to 6 hours at H. It is conveniently marked at 10^m intervals.

e) Locate on BE a point J 2.5 in. from B. From this point draw a line JK to the right, about 5 in. long, parallel to BC. This line carries the scale for parallaxes in right ascension. A convenient scale is 1^m = 1 in. Permanently mark off a uniformly divided scale from 0^m to 4^m. A convenient subdivision is to sixths of a minute.

f) On this same line a set of construction points will be needed. Consider the four inch parallax scale divided into 60 parts. Mark these fifteenth of an inch divisions from the 53rd to the 60th and extend the scale to mark the 61st and 62nd.

g) On BC locate a point L distant from B by A/(r cos f′).

h) From L draw thru the construction points on JK lines to intersect BE. Permanently mark these intersections as a scale of horizontal parallax.

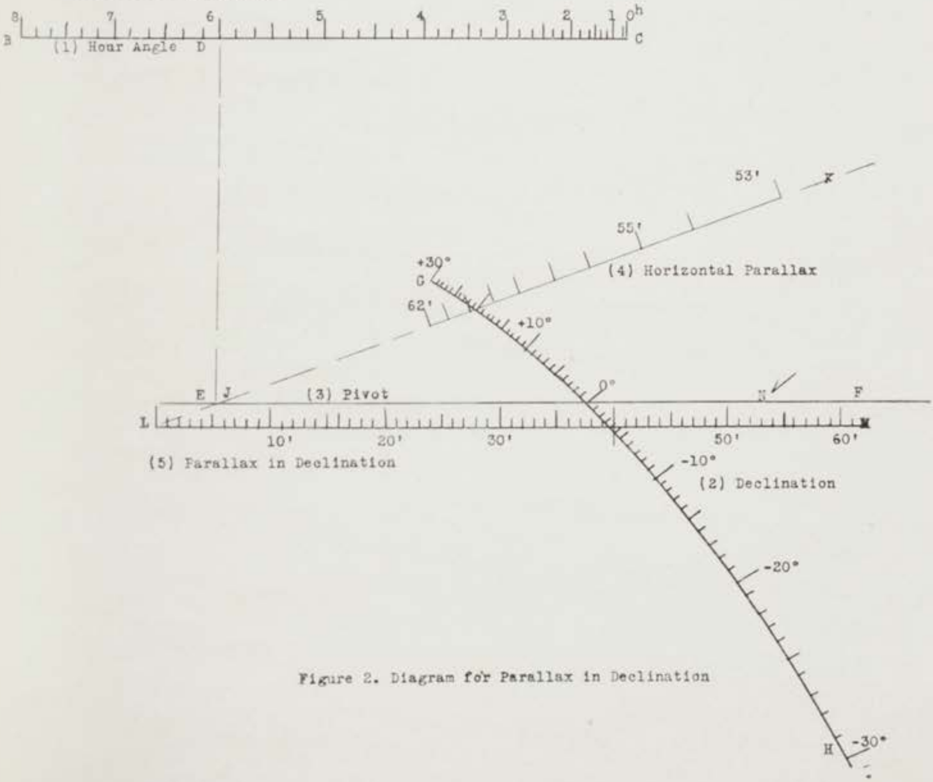

Figure 2. Diagram for Parallax in Declination

This completes the construction of the diagram for parallax in right ascension. The reference to its use has already been given. The letters that follow refer to Figure 2, which represents the diagram for declination.

a) At about 0.5 in. from left edge of paper (8.5x11) and 0.5 in from top of paper draw a line about 8 in. long parallel to the 11 in. side of the paper. Locate a point D about 2.5 in. from B. Mark off on BC to right of D values of A $\underline{r}$ cos $\underline{f'}$ cos h for each 10^m intervals of h from 6^h at D to 0^h. Similarly mark off to left of D values of the same A $\underline{r}$ cos $\underline{f'}$cos h from h = 6^h to h = 8^h. As before, A has been chosen, for convenience, as 6 in.

b) Drop a perpendicular from D, DE, of length A $\underline{r}$ sin $\underline{f'}$. In Figure 2 the value of $\underline{r}$ sin $\underline{f'}$ is 0.669 for Holy Cross. From E draw a line to the right to edge of paper, parallel to BC. Line is marked EF.

c) The line GH is next to be drawn. It is a section of a parabola. Seven points on the parabola are to be determined and a fair curve drawn thru these points. The point will be to the right of E by a distance x, equal to A $\underline{r}$ sin $\underline{f'}$ tan $(45°\text{-}\underline{d}/2)$. Use values of d at 10° intervals from +30° to —30°. The point will be above (or below) EF by a distance y = x tan $\underline{d}$. Point will be below if y is minus. When the smooth curve is drawn thru the seven points, thus determined, a protractor can be centered on E, zero angle on EF and radial lines drawn intersecting GH. These lines, drawn at each degree, serve to subdivide GH to single degrees. These radii should, of course, pass thru the previously plotted points at 0, 10, 20 and 30°.

d) Thru E draw a line JK at 20° (a convenient angle) to EF. Locate the point L on JK about 0.75 in. from E, and draw LM parallel to EF. Divide LM into 62 equal parts from L, each part equal to 1/8 in.

e) On EF locate the point E distant from E by A inches. From points 62 to 53 draw lines thru N intersecting JK. These intersections are the points on the horizontal parallax scale.

This completes the construction of the diagram for parallax in declination. The scales have been spread about as far as possible. If it seems desirable the intersection of the scales JK and GH can be avoided by choosing a value of A less than about five inches and making the angle KEF something over 30°.

CHEMISTRY

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Father Vitoria also published on the Bacon modification of the Piria method in ebulliometry; a 276 page, octavo, illustrated book on Chemical science and society; a 144 page, 12° book on Sweet wine for the Mass—a chemo-liturgical study and notes from many lectures given before the learned societies of Spain.

In the Razon y Fe, he wrote on the Chemical Laboratory at Ebro, on Electrolytic Interruptors, on the dissociation of matter and on radioactivity. A conference on "Chemical studies of some war gases," given at the Capitol in Barcelona appeared in a 12° pamphlet; on "Explosives of the organo-metallic type," given at the Artillery Academy at Segovia also appeared in a 12° pamphlet or book. He published notes on the "Distillation of oil, extracted by CS_2," and on the study of "Ethylenic and acetylenic compounds," read before the Real Academy of Arts and Science in Barcelona.

He also published notes on "Modern nomenclature in organic chemistry," on "Holleman's Method for the investigation of reduced and water soluble phosphates," on "Nevin and Lithopone," and on "Copper"—all from papers read before the Spanish Association for the Advancement of Science.

"The modern synthesis of gasoline" and the "Study and application of Raman spectra in the field of organic chemistry" occupied his attention in notes from papers read before the Real Academy of Sciences and Mathematics at Barcelona.

Bibliographical data on most of these unclassified items are incomplete. They are appended here so as not to consign them to oblivion.

GEOPHYSICS

OPPORTUNITIES FOR RESEARCH IN GEOPHYSICS

By Daniel Linehan, S.J.

The above title was suggested to the writer while examining some of the problems undertaken by various members of the Observatory Staff at Weston College during the past few years. If the reader were to add to the following list the numerous publications issued from the Institute of Geophysics of St. Louis University or Fordham University Seismic Station he would realize that the field of Geophysics offers many "opportunities" for research problems. Our list of titles includes some of the problems studied and published, or to be published, at Weston College. While not a complete list it comprises most of the more important and interesting subjects.

The titles in the first group represent studies made with the Weston College portable equipment. Some of these, as is noted, were published privately. These will be published for general use at a later date when permission is obtained from those furnishing part of the financial aid to make the study possible. At present the results are for their personal use. Likewise, the publications of the various States have not been released for general use. No doubt their later release may find them in a slightly different form.

The second group lists publications concerning results obtained from the fixed station equipment.

To the non-geophysicist the many applications of geophysics may come as a surprise. Indeed, it appears quite certain that many of the problems puzzling geologists can be solved only with the help of geophysicists. At Weston Observatory we have applied but one branch of geophysics—seismology. We hope to add other branches as conditions permit. Physicists, too, will find many interesting problems to be solved in the data collected at Weston Observatory. High velocity air waves: variation of directional velocity of sound in anisotropic media; generation of waves in various media; etc., are but some of the problems we have in mind.

Group I

(1) "Determination of Structure by Apparent Velocities of Sound in Gneisses, Schists, etc., of New Hampshire" by D. Linehan, S.J. Harvard Geological Conference 1939.

(2) "Depth of Sand Plains by the Seismic Method" by D. Linehan, S.J. Harvard Geological Conference 1939.

(3) "Bed Rock Surface Contours of the Town of Weston, Massachusetts" by D. Linehan, S.J. Private Publication to the Town of Weston 1939.

(4) "Preglacial Drainage of Eastern Massachusetts" by D. Linehan, S.J. The Boston Geological Society 1940.

(5) "Seismic Studies of Floored Intrusives in Western New Hampshire" by D. Linehan, S.J. and F. C. Kruger (Harvard) Bull. of Geol. Soc. of Am. vol 52 pp 633-648 1941.

(6) "Preglacial Surface of the Cambridge Argillite, Everett, Mass." by D. Linehan, S.J. and L. Don Leet (Harvard) Private Publication to the Boston Edison Co. 1941.

(7) "Preliminary Determination of Depth of Triassic Formations in the Connecticut River Valley" by D. Linehan, S.J. to be published in the Bull, of the Geol. Soc. of Am.

(8) "The Preglacial Merrimac River, Lowell, Mass." by L. Don Leet (Harvard) and D. Linehan, S.J. Harvard Geological Conference 1941.

(9) "Ground Roll in Surface Clays and Aqueous Sediments" by D. Linehan, S.J. Harvard Geological Conference 1941.

(10) "Submarine Seismic Survey of the Mystic River, Charlestown, Mass." by D. Linehan, S.J. and L. Don Leet (Harvard) Private Publication to the Boston Edison Co. 1942.

(11) "Shallow Refraction Surveys" by D. Linehan, S.J. Abstract in "Geophysics" 1942. More complete publication later.

(12) "Determination of Sink Holes in Dolomite at Elkton, Virginia" by L. Don Leet (Harvard) and D. Linehan, S.J. Private Publication to the Merck Chemical Co. 1944.

(13) "Glacial Deposits in Holden, Mass." by D. Linehan, S.J. Private Publication to the City of Worcester, Mass. 1944.

(14) "Determination of Till Age and Properties by Seismic Methods" by D. Linehan, S.J. and E. T. Apfel (Syracuse) Published by Commonwealth of Mass. and U. S. Geological Survey 1944.

(15) "Presence of Quartzitic Knobs in the Brimfield Schist Detected by Seismic Methods" by D. Linehan, S.J. to be published. Field work in 1944.

(16) "Depth of Varved Clays, Chicopee, Mass." by D. Linehan, S.J. and E. T. Apfel (Syracuse) Commonwealth of Mass. and the U. S. Geological Survey 1944.

(17) "Preglacial Drainage of the Mystic River Valley in Arlington, Medford and Cambridge, Mass." by D. Linehan, S.J. and E. T. Apfel (Syracuse) The U. S. Geological Survey 1944.

(18) "Ground Vibration At Various Distances Near Taunton, Mass." by D. Linehan, S.J. Private Publication to the U. S. Army 1944.

(19) "The Preglacial Connecticut River Bed at Springfield and Chicopee, Mass." by D. Linehan, S.J. and E. T. Apfel (Syracuse) U. S. Geological Survey 1944.

(20) "Bed Rock Contours in the Finger Lake Region of Western New York State" by D. Linehan, S.J. Private Publication to the City of Rochester, N. Y. 1945.

(21) "Marine Clays at Portland and South Portland, Maine" by D. Linehan, S.J. and L. Don Leet. To be published. Field Work in 1941 and 1945.

(22) "Difficulties in Sound Detection in Swamplands" by D. Linehan, S.J. to be published. Field work in 1945.

(23) "Seismic Survey of Talus Covered Slopes at Shelbourne Falls, Mass." by D. Linehan, S.J. and J. Maynard (Syracuse) Commonwealth of Mass. and the U. S. Geological Survey 1945.

(24) "Problems in Generation of Waves in Silts and Sands of Louisiana and Massachusetts" by D. Linehan, S.J. Partly published by Commonwealth of Mass. and U. S. Geological Survey 1945.

(25) "Low Velocity of Sound in the Carboniferous Schists of Rhode Island" by D. Linehan, S.J. State of Rhode Island 1945.

(26) "Buried Valleys of Providence, Rhode Island." by D. Linehan, S.J. to be published by the U. S. Geological Survey, Water Supply Division. Field work in 1945.

(27) "Depth of Cambridge Argillite at Somerville, Mass." to be published. Field work done by D. Linehan, S.J. 1945.

(28) "Ground Water Conditions in Walpole, Mass." by D. Linehan, S.J. Private publication to the Bird Roofing Co.

(29) "Bed Rock Contours on Cape Cod, Mass." by T. J. Smith, S.J. To be published in the Bull. of the Geol. Soc. of Am. Field work done 1944-1945.

Group II

(1) "The Electromechanical Transducer in the New Benioff Seismograph" by J. J. Devlin, S.J. Bull. Seis. Soc. of Am. vol 28 1938.

(2) "The Chelmsford, Mass. Earthquake of June 23, 1938" by D. Linehan, S.J. Bull. Seis. Soc. of Am. vol 30 1940.

(3) "Recent Earthquakes in the Eastern Area" by D. Linehan, S.J. Earthquake Notes 1939.

(4) "Earthquakes in the West Indian Region" by D. Linehan, S.J. Transactions of Am. Geophysical Union 1940.

(5) "Earthquakes of the Northeastern United States and Eastern Canada, 1938, 1939, 1940" by D. Linehan, S.J. and L. Don Leet (Harvard) Bull. Seis. Soc. Am. vol 32 1942.

(6) "Macroseismic Study of the New Hampshire Earthquakes of December 1940" by J. J. Devlin, S.J., L. C. Langguth, S.J., and R. L. Arringdale (Portland, Me.) Bull. Seis. Soc. of Am. vol 32 1942.

(7) "Instrumental Study of the New Hampshire Earthquakes of December 1940" by L. Don Leet (Harvard) and D. Linehan, S.J. Bull. Seis. Soc. Am. vol 32 1942.

(8) "Characteristics of Caribbean Earthquakes" by D. Linehan, S.J. Paper requested by U. S. State Department to be read at the Chilean National Science Congress of 1943. Later an abstract published by the Chilean Government.

Also two Bulletins are published each month giving the recordings of the Weston instruments. One is a Preliminary Bulletin and the other a more complete listing. Likewise, the Bulletin of the North Eastern Seismological Association is compiled and epicenters determined twice a month at Weston Observatory. This manuscript is then published and mailed from the Dominion Observatory, Canada.

During the War, and throughout the hurricane season, daily reports were sent to the Weather Bureau, Washington on microseisms. We have a letter at hand from the Head of the Bureau thanking us for inaugurating this study, which is now being used by the Government, at least in trial, for the study of hurricanes.

For a part of the War weekly reports were sent to the Navy Department, New York, listing and locating all submarine explosions recorded at Weston. This service was inaugurated at Weston and facilitated by readings from Fordham and Harvard. Extraordinary disturbances of submarine nature were reported by telephone. Due to the nature of these two latter studies, it is doubtful if the results will be published for general use.

We should take this occasion to thank the Humble Oil and Refining Company, Houston, Texas, for the use of the portable field equipment employed in making the studies under the first group of titles. Also to thank Mr. D. P. Carlton, Mr. D. H. Gardner and Dr. M. M. Slotnick of that Company for their assistance in this work. Prof. L. Don Leet and Prof. M. Billings of Harvard University have worked with us in quite a few of the above listed studies and we acknowledge their assistance. The names of members of the Society who have collaborated with us would make too long a listing here, but I am certain they realize our appreciation for their help in the field and in the office. Superiors, during the years of the Observatory's existence, have been most interested and appreciative of our research labours and we are grateful for their allowing us to continue this work.

MATHEMATICS

RADIAN MEASUREMENT

By Rev. Thomas D. Barry, S.J.

Students of mathematics in our colleges and houses of studies usually meet circular or radian measurement of angles for the first time in the Calculus course. But the textbooks treat the subject so sketchily and, I suspect, the teachers also cover the matter so briefly that the student is not much the wiser. He is accustomed from grammar school days, and especially in the trigonometry course, to measuring angles by degrees, and the mention of any other method does not rise above the level of an obiter dictum, and hence does not sink in.

The use of degrees for measuring angles (the sexagesimal system) comes down from ancient times. A quadrant was divided into 90 degrees, because 90 has a large number of factors. The degree was divided into 60 parts called minutes and the minutes into 60 parts called seconds, both numbers being chosen because of their factorability. This system was satisfactory in the beginning because measurements were rough and the formulae used in computation simple. But as measurements became more refined and formulae more complex, the use of degrees, minutes and seconds became more and more a nuisance. It still is. For instance in interpolating most tables of trigonometric functions, the divisions are by 60. And in so apparently simple a case as the subtraction of $23^\circ\ 47'\ 28''$ from $47^\circ\ 39'\ 19''$, the latter has to be changed to $46^\circ\ 98'\ 79''$ before the work can proceed. That is, one minute must be taken from the $39'$, converted into seconds, and *sixty* added to the $19''$ before $28''$ can be subtracted. Similarly for the subtraction of $47'$ from $38'$ (reduced from $39'$). The conversion of degrees, minutes and seconds to degrees and decimal fractions thereof and vice versa, even with the use of tables, is also a nuisance.

Parenthetically, it may be mentioned that when the French introduced the metric system they also tried unsuccessfully to introduce the centesimal system of angle measurement. In this system, the quadrant was divided into 100 degrees, with $1^\circ = 100'$ and $1' = 100''$. This system would do away largely with the difficulties mentioned above. In the use of tables, interpolation would be by hundredths instead of sixtieths. In the case of the subtraction problem, the minuend (where 38 and 19 are hundredths of the preceding units) would be changed to $46^\circ\ 138'\ 119''$. That is, the minutes and seconds would simply have a one *prefixed* instead of sixty *added*. For the third case, 47° 39′ 19″ could be readily converted to 47°.3919 and conversely 98°.1793 could be changed immediately to 98° 17′ 93″.

Both systems, however, fail completely in cases such as the following. Suppose a formula contains the following terms: v^2 + arc sin v. Here v is a *number* but arc sin v is an *angle*. If that angle is expressed in degrees, the addition is impossible, since the units involved are disparate. Again, suppose the equation x = cot x is to be solved. x is an angle and cot x is a number. A number cannot be equated to degrees because of the disparity of the units involved. The same difficulty is present in the case of a Maclaurin's expansion of a trigonometric function, as for instance, $\sin x = x - x^3/3! + \ldots$ This is true only when x is a number. If a way can be found to express an angle as a number, these difficulties vanish. In the radian system of measurement, angles are expressed as numbers.

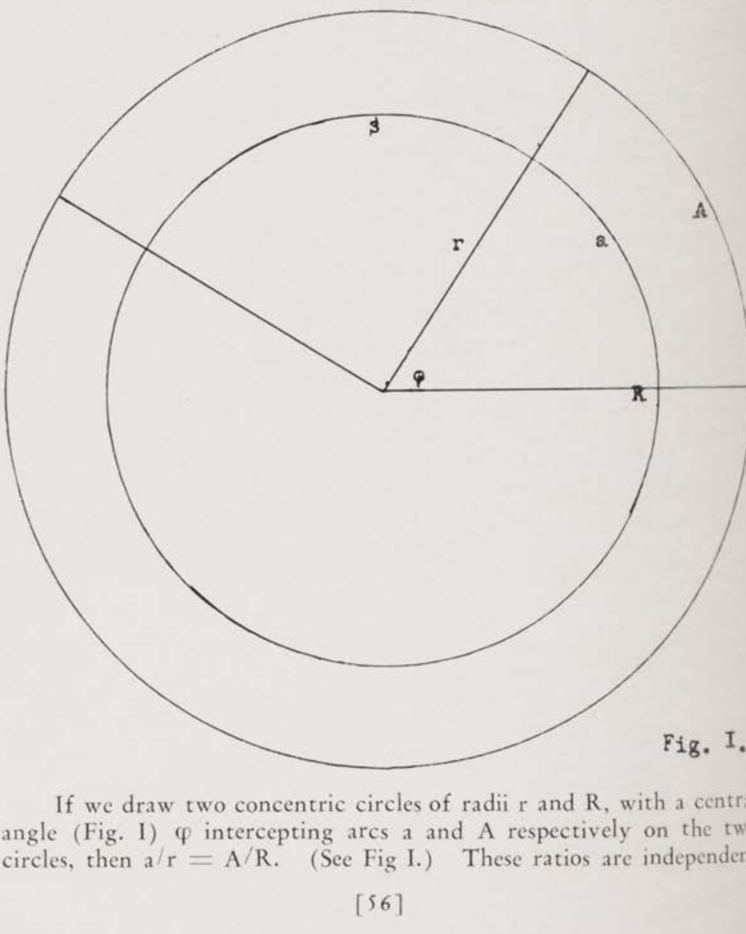

Fig. I.

If we draw two concentric circles of radii r and R, with a central angle (Fig. I) φ intercepting arcs a and A respectively on the two circles, then a/r = A/R. (See Fig I.) These ratios are independent of the size of the circles. That is to say that, for a central angle φ in a circle of any radius whatever, the ratio of the intercepted arc to the radius is the same as the ratio a/r. Therefore that ratio determines the angle φ uniquely and can be taken as a measure of that angle. Any other angle θ, different from φ, will intercept an arc s, different from a. The ratio s/r is then the measure of the angle θ. This concept is analogous to that of the trigonometric functions, where, for example, the ratio of the ordinate of a point on a circle to the radius vector to the point ($= \sin \theta$) determines the angle θ uniquely. For any other point the ratio of ordinate to radius will be different and the angle will be different.

If the arc a is equal to r, then the ratio a/r becomes $r/r = 1$. The central angle which intercepts the arc r thus becomes the natural unit of this system. This angle is called a radian, which is then defined as the central angle of a circle which intercepts an arc equal to the radius of the circle.

From the geometrical proposition that in the same circle or in equal circles central angles have the same ratio as their intercepted arcs, we see that $\theta/\varphi = s/a$, or $\theta = s\varphi/a$. If $\varphi = 1$ (the unit angle), then $a = r$ and $\theta = s/r$, as was seen two paragraphs back. That is, θ is equal to some number greater or less than 1, according as s is greater or less than r. Decimals are often necessary to express this number. For example, if $s/r = 12.357/10$, then $\theta = 1.2357$.

Certain common angles deserve special mention. If θ equals the whole circle (i. e. $360°$), s is the circumference (i. e. $2\pi r$). Therefore $\theta = 2\pi r/r = 2\pi$. That is, the whole circle is equal to 2π (radians). A semicircle is then equal to π. This makes a simple base from which to figure several angles, since any angle which is a simple fraction of $180°$ may be expressed as that same fraction of π. Thus $90° = \pi/2$, $45° = \pi/4$, $30° = \pi/6$, $120° = 2\pi/3$, $270° = 3\pi/2$, etc.

The relation $180° = \pi$ radians gives us a method of converting from one system to the other.Thus, $1° = \pi/180 = 0.01745$ radian. Any other angle expressed in degrees may be converted by multiplying 0.01745 by the number of degrees in the angle. Again 1 radian $= 180°/\pi = 57°\ 17'\ 44''.8 = 57°.29 \ldots$ The conversion is usually effected by means of tables, of which the following may be mentioned.

"Mathematical Tables from the Handbook of Chemistry and Physics," Chemical Rubber Publishing Company, Cleveland.

"Six-place Tables," McGraw-Hill, N. Y.

Some textbooks which are equipped with tables include those for such conversions. "Introduction to College Mathematics," by Hill and Linker (Holt) has very good ones. Mention may also be made here of the "Smithsonian Tables: Hyperbolic Functions," (Smithsonian Institution, Washington). This does not contain conversion tables, but there is an extensive table of natural sines and cosines and their logarithms of angles in radians from 0 to 1.600 (slightly more than 90°). The argument is given to four decimal places from 0 to 1 radian, to three places for the rest of the table.

Since the value of any angle is the ratio of the length of the intercepted arc to the radius, that is, $\theta = s/r$, it follows that $s = r\,\theta$, that is, the length of an arc of a circle is equal to the radius of the circle multiplied by the angle expressed in radians. In a unit circle, $r = 1$, making the length of the arc numerically equal to the angle. Furthermore, the areas of any two sectors of a circle are proportional to their central angles. Letting A be the area of a sector and remembering that the area of the whole circle is πr^2, we have $A/\pi r^2 = \theta/2\pi$, whence $A = r^2\theta/2$.

The sine of an angle is the ratio of the ordinate of a point on a circle to the radius, and the angle is the ratio of the intercepted arc to the radius. In the case of small angles the ordinate is almost identical with the arc, so that the two ratios are practically identical. For an angle of 1°, for instance, they agree to about the fifth decimal place. Consequently they are interchangeable that is, for small angles sin x may be replaced by x.

Two points should be emphasized. First, the measure of an angle expressed in radians does not depend on an arbitrary unit such as the degree, but on the ratio of intercepted arc to radius. This ratio is inherent in the circle, so that we have a *natural* measurement. Secondly, since the measure is a ratio of two like quantities (lengths), it is a *number*. In ordinary usage it is used simply as a number without adverting to its definition as a ratio, just as in using trigonometric functions we do not advert to their definitions as ratios, except in the case where a right triangle is being solved. Since the angles in this system are numbers they may be used where the degree measurement may not be used, as in the examples cited earlier in this article. Thus in solving the equation $x = \cot x$, if x is expressed in radians, both sides of the equation become simple numbers, which can be equated. Some difficulty may be found with regard to the use of the word "radian" in expressing an angle. Thus an angle may be written either as 2 radians or simply as 2. Since an angle is a number, 2 is a correct designation of the angle. The addition of "radians" serves as an indication of the system being used, that is, to distinguish the angle from 2°. It should be borne in mind that a radian is an angle in itself, whereas a degree is a measure of an angle.

At this late date it is scarcely possible that the people of the world could be persuaded to change from degree measurement to radian measurement, but the general use of radians would have a number of distinct advantages among which the following may be mentioned:

1) Addition and subtraction of angles would be greatly simplified. For example, the problem cited earlier in this article ($47^\circ 39' 19'' - 23^\circ 47' 28''$) would become 0.8317 — 0.4152, a simple exercise in ordinary subtraction.

2) If scientific instruments were equipped with circles graduated in radians, vernier readings would be much less complex.

3) The use of tables of trigonometric functions would be simplified, as interpolation would be by tenths instead of sixtieths, as at present. A separate table could give the functions of the common angles, 30°, 45°, etc. An apparent difficulty arises with regard to the angles of the second or higher quadrants. But if each page or pair of facing pages carried the radian values of the quadrantal angles ($90^\circ = 1.5708$, $180^\circ = 3.1416$, etc.), the ordinary rules for reduction to the first quadrant would still hold. Thus cos 2.6812 (second quadrant) may be found in either of the standard ways:

1) $\cos 2.6812 = -\cos(3.146 - 2.6812) = -\cos 0.4604$, or

2) $\cos 2.6812 = -\sin(2.6812 - 1.5708) = -\sin 1.1104$.

Brief mention may be made of an adaptation of the radian system of measurement which is used by the artillery. The unit angle is called the mil, which is defined as 1/6400 of a circle. Therefore 1 mil $= 2\pi/6400$ radian $= 1/982$ radian (about 3.5 minutes of arc). In practice, the mil is considered as 1/1000 radian. Since $s = r\,\theta$, 1 mil

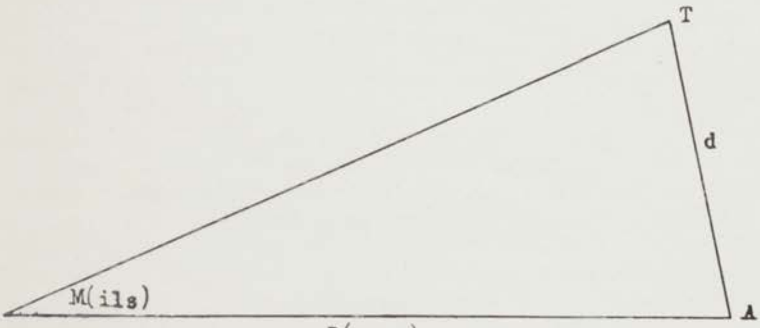

Fig. II.

intercepts an arc equal to 1/1000 of the radius or range. Therefore (see Fig. II.) $d = MR/1000$. Since the range is figured in yards, the unit can be taken as $R' = 1000$ yards. Then the formula becomes $d = MR'$. Some examples:

1) At range 2000 yards, a target T is seen to be 12 mils from a point A. What is the distance TA? Solution: $d = 12 \times 2 = 24$ yards.

2) At range 5000 yards, a shell is seen to burst at A, which is known to be 50 yards from the target T. What correction must be applied to the gun setting? Solution: $50 = 5$ M, therefore M = 10 mils.

THE EXPONENTIAL SOLUTION OF THE EQUATIONS OF THE OSCILLATOR

By Robert O. Brennan, S.J.

(Continued from the September issue)

THE FORCED OSCILLATOR:

The circuit contains inductance, capacitance and resistance. An alternating electromotive force (E cos ut volts) is impressed on the circuit. Kirchhoff's law then gives as the differential equation of the circuit:

$$LD^2q + RDq + Q/C = E \cos ut. \qquad (22)$$

In order to make use of the properties of exponentials, we transform the equation by adding to it the equation:

$$LjD^2q' + RjDq' + jq'/C = jE\sin ut.$$

Setting $q = q + jq'$, we have $LD^2z + RDz + z/C = E(\cos ut + j \sin ut)$. By the identity $\exp(jut) = \cos ut + j \sin ut$, (cf. the definitions at the beginning of the previous article), we obtain the convenient equation:

$$LD^2z + RDz + z/C = E \exp(jut) \qquad (23)$$

The real part of the solution of this equation will be the solution of equation (22).

In the previous cases, we assumed at this point a solution of the form exp(mt) where m was to be determined. Here our choice falls on $z = A \exp(jut)$ where A is to be determined to satisfy equation (23). What determines this choice is the fact that exp(jut) will now be a factor of every term of the equation. Physical considerations would also suggest this solution, for we should expect a driven oscillator to have the same frequency as the driver.

The derivatives of z are then given by:

$$Dz = juA \exp(jut) \; ; \; D^2z = -u^2A \exp(jut)$$

Substitution of these values into equation (23) yields:

$$(-Lu^2 + Rju + 1/C)A \exp(jut) = E \exp(jut)$$

Hence $$A = \frac{E}{-Lu^2 + 1/C + Rju}$$

and $$z = \frac{E}{L(\underline{w}^2 - u^2) + Rju} \exp(jut$$

where $\underline{w}^2 = 1/LC$ as defined for the free undamped oscillator (equation 4).

If we separate the real and imaginary parts of the coefficient, we have $z = (a - jb)\exp(jut)$, (25)

$$\text{where } a = \frac{EL(\underline{w}^2 - u^2)}{L^2(\underline{w}^2 - u^2)^2 + R^2u^2}\ ;\ b = \frac{ERu}{L^2(\underline{w}^2 - u^2)^2 + R^2u^2}$$

In the Argand diagram $a - jb = D(\cos d - j \sin d)$ where $D = \sqrt{(a^2 + b^2)}$, $d = \text{arc tan } b/a$. Application of the identity $\exp(-jd) = \cos d - j \sin d$ then gives $a - jb = D \exp(-jd)$. Substitution of this value for $(a - jb)$ in equation (25) yields $z = D \exp j(ut - d)$. Whence we obtain as the real part of z:

$q = D \cos (ut - d)$ (26)

$$\text{where } D = \frac{E}{\sqrt{[L^2(\underline{w}^2 - u^2)^2 + R^2u^2]}}\ ;\ d = \text{arc tan} \frac{Ru}{L(\underline{w}^2 - u^2)}$$

Another way of proceeding from equation (25) is worthwhile presenting because of its utility in dispersion theory. By setting $x = \pi/2$ in the equation $\exp(jx) = \cos x + j \sin x$, or by inspection of the Argand diagram, we find that $j = \exp j(\pi/2)$. Using this value for j in equation (25), we have

$z = a \exp(jut) - b \exp j(ut + \pi/2)$

The real part of z is:

$q = a \cos ut - b \cos(ut + \pi/2)$

or $q = a \cos ut + b \sin ut$ (27)

a is then seen to be the amplitude of a component in phase with the driving potential, while b is the amplitude of a component 90° out of phase. The amplitudes a and b are shown in Fig. 2, 1 as functions of the frequency.

If we multiply and divide equation (27) by D, it may be reduced to the same form as equation (26).

In the theory of differential equations it is shown that the complete solution of a second order differential equation such as we have in equation (22) contains two arbitrary constants. From the physical point of view we also expect them, for we have not yet taken into account the possibility of an initial charge or current in the circuit. Let us assume then as the complete solution

$q = D \cos(ut - d) + Q$

where Q is a function of t containing the two arbitrary constants we desire. Our complete solution must now satisfy the differential equation. Calculation of the derivatives and substitution into equation (22) gives as the condition on Q:

$LD^2Q + RDQ + Q/C = O.$ (28)

We have already solved equation (28) in the treatment of the damped free oscillator (Cf. A. A. J. S. Bulletin, September, 1945, p. 26). The complete solution of equation (22) may, then, take three forms depending on the amount of damping in the circuit. The solution for the underdamped case is

$$q — C'\exp(—Rt/2L)\cos(wt — c') + D\cos(ut — d) \quad (29)$$

The equation for the current is

$$i = —C'\,esp(—Rt/2L)\,[(R/2L)\cos(wt—c') + w\sin(wt—c')] —D\,u\sin(ut — d).$$

C' and c' are determined by the value of q and i at the time when the circuit is completed.

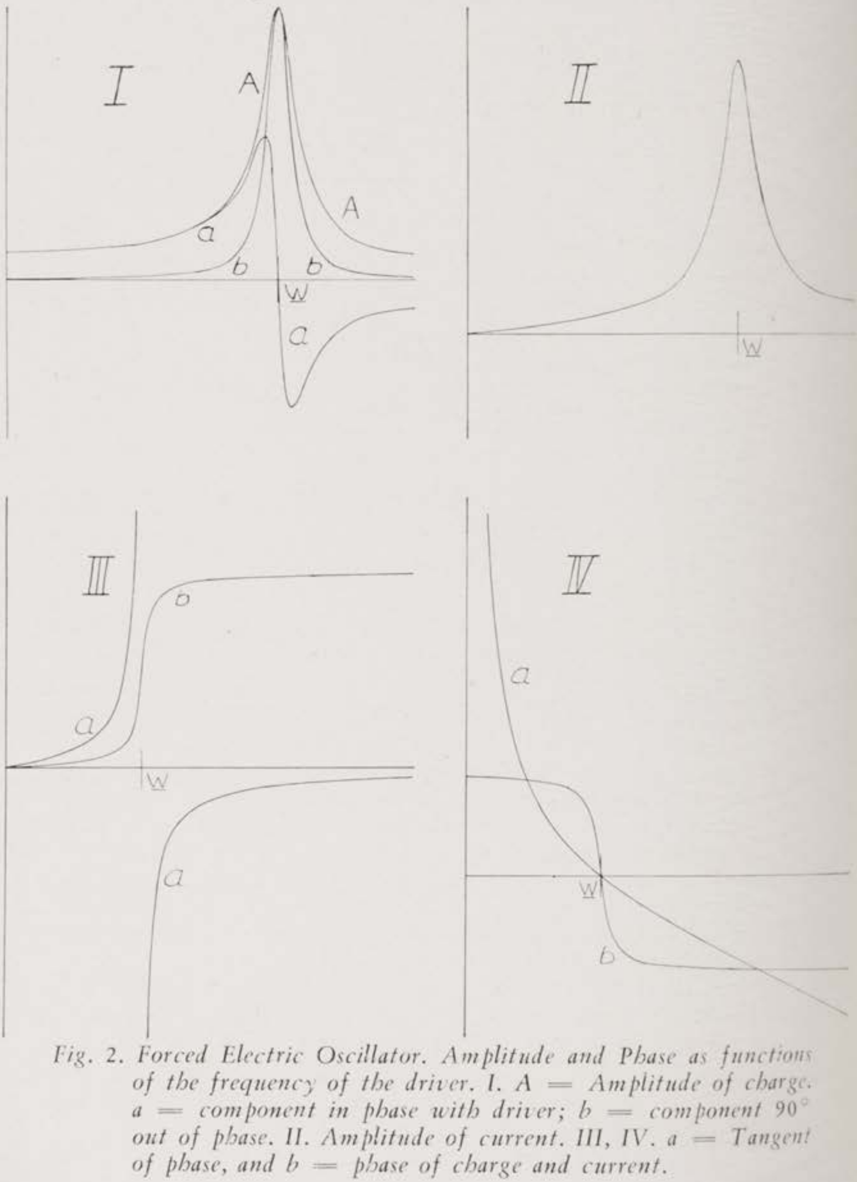

Fig. 2. Forced Electric Oscillator. Amplitude and Phase as functions of the frequency of the driver. I. A = Amplitude of charge. a = component in phase with driver; b = component 90° out of phase. II. Amplitude of current. III, IV. a = Tangent of phase, and b = phase of charge and current.

As may be seen from Fig. 1, the term with the exponential as a coefficient (the "transient") disappears after a short time, leaving only the sinusoidal "steady state" solution:

$$q = D \cos(ut - d)$$

$$i = -D u \sin(ut - d) = D u \cos(ut + e) \qquad (30)$$

where $e = \pi/2 - d$.

The form of the amplitude as defined for equation (26) suggests that we write the current equation as

$$i = E/Z \cos(ut + e) \qquad (31)$$

where Z corresponds to the ohmic resistance in the case of direct current. Then $Z = \sqrt{(R^2 + X^2)}$, where $X = Lu - 1/Cu$. The phase angle that appears in equation (31) is then $e = \arctan(-X/R)$.

The equation for the charge is similarly written:

$$q = (E/Zu)\cos(ut - d),$$

and d is defined as arc tan $(-R/X)$. Z is called the impedance and X the reactance of the circuit.

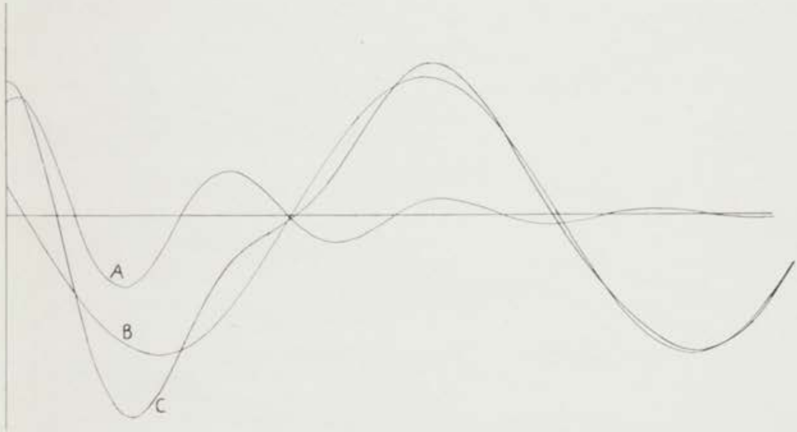

Fig. 1. Forced Electric Oscillator. Charge as a function of time. A = Transient. B = Steady state. C = Resultant.

In the steady state, the charge and current have the same frequency as the driving potential but differ in their phase. The variation of the amplitude and phase angles with the frequency are shown in the plots of Fig. 2.

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Jesuit educators are maintaining and directing nearly 300 Universities, Colleges and High Schools in the world.

Laus Deo Semper.