A. M. D. G.

BULLETIN

of the

American Association of Jesuit Scientists

(Eastern Section)

For Private Circulation

HOLY CROSS COLLEGE
WORCESTER, MASS.

Vol. VII

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EASTERN STATES DIVISION

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Catholic Scientific Research Movement

C. A. BERGER, S.J.

The recent New York meeting of the A. A. A. S. was the occasion taken by certain prominent Catholic scientists for a private meeting for the promotion of Catholic Research. The meeting took place on December 23, 1928 at Hotel Endicott, New York City. Those present were: Dr. Karl F. Herzfeld, professor of Physics, J. H. U., Rev. Dr. Anselm M. Keefe, O. Praem. President, St. Norbert's College, West de Pere, Wis., Rev. Dr. Arthur J. Scanlan, Vice President, St. Joseph's Seminary, Yonkers, and the three following members of the staff of the Catholic University of America: Dr. Hardee Chambliss, head of Dept. of Chemistry, Rev. Dr. C. J. Connelly, Psychology, and Rev. Dr. John M. Cooper, professor of Anthropology. Others of the movement unable to attend were: Dr. Hugh Taylor, Chemistry, Princeton U., Rev. Dr. J. B. Macelwane, S.J., Dr. Julius Nieuwland, C.S.C., Chemistry, Notre Dame, Rev. Henry Retzek, Chicago, Dr. Stephen Richarz, S.V.D., Geology, Techny, Ill., Rev. Dr. Alphonse M. Schwitalla, S.J., St. Louis U.

The objective of the group is the encouragement of productive scholarship as distinct from absorptive scholarship, by Catholics, especially in the field of natural science, since the Catholic status in the scientific field is dependent not on past performances but on present and prospective work of a productive nature.

The program for 1929 will consist of: 1. Articles on the importance and value of productive research and the need of accuracy in Catholic literature that touches on the natural sciences. The articles will appear in The Ecclesiastical Review, The Commonweal, The Catholic Educational Review, The Catholic World, Primitive Man, Thought, America, and The Fortnightly Review. 2. Efforts will be made to encourage the publication of Catholic research. A yearly list of such original contributions will be published in Thought, America, or the Catholic Yearbook. 3. The matter of Catholic research will be brought before the National Catholic Educational Association. 4. Attempts will be made to have more attention given to scientific news items in the N. C. W. C. News Service.

The originators of the movement decided not to form any formal organization beyond the yearly meeting at the time and place of the A. A. A. S. meeting, and the yearly appointment of someone to take charge of the next meeting. Invitations and reports of minutes will be sent to all who attended or expressed sympathy in previous meetings.

Dr. Karl F. Herzfeld's article "Scientific Research and Religion" in the Commonweal for March 20, 1929, throws an interesting light on the proportion of Catholic research workers.

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Notes for Authors

THOMAS D. BARRY, S.J.

In case any members of the Association are thinking of writing a book, they may find very helpful in preparing the manuscript, a small book entitled "The Manuscript—A Guide for its Preparation." It is published by John Wiley & Sons, and may be had free of charge by writing to the publisher.

The following note was inserted in a recent number of the Bulletin of the American Mathematical Society.

SUGGESTIONS TO AUTHORS.

Much needless expense and many errors can be avoided. The editors of several mathematical journals have agreed upon the following suggestions:

1. Typewrite words and the very simplest formulas only.
2. *Do not* try to typewrite any complex formulas. Write them.
3. Keep a copy and send the editors two copies if you can.
4. *Do not* underline any symbols or formulas.
5. Underline theorems with blue pencil (avoid ink).
6. Follow our recent styles in abbreviations, footnotes, etc.
7. Write carefully the (often misunderstood) capitals C K P S V W X Z.

8. Write ϵ, not e. Write very carefully gamma, eta, kappa, lambda, nu, tau, upsilon, chi, omega).
9. Among Greek capitals, use only gamma, delta, theta, lambda, xi, pi, sigma, phi, psi, omega.
10. Punctuate carefully, especially in formulas.
11. Use the solidus (/) to avoid fractions in solid lines.
12. Use fractional exponents to avoid root signs elsewhere.
13. Use extra symbols to avoid complicated exponents.
14. In typewritten formulas, 1 means "one"; to indicate "ell" in formulas, backspace and overprint /: thus ł.
    Similarly, 0 means "zero." To indicate "Cap O," backspace and overprint period: thus ʘ.

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A Summary of Our Knowledge of Chromosomes

C. A. Berger, S.J.

Chromosomes were first known about 1870 when with the initiation of improved fixing and staining methods they were discovered in cell division after the apparent dissolution of the nucleus. Waldeyer gave them the name chromosomes because of their intense staining capacity. The first accurate count of chromosomes was made in 1882 by Flemming in the salamander and by Strasburger in several species of plants. Following these other counts were made and soon showed that the chromosome number is constant for any one species. The next important step was the epoch-making discoveries of Van Beneden 1883-84 when working on Ascaris he demonstrated that in fertilization the male and female pronuclei not only do not fuse but give rise to two separate groups of chromosomes, each one half the species number, that enter the equatorial plate and independently divide, the daughter chromosomes going separately into the daughter nuclei. He thus showed for the first time that the number of chromosomes in the ripe germ cell is haploid or one half the species or diploid number, and that the chromosomes of the offspring are derived equally from the two conjugating germ cells and hence from the two parents.

Flemming and Strasburger had noticed that chromosomes in the same species were of different size and shape but they thought that these differences were mere quantitative variations or fluctuations and they did not suspect that they were constant features. Montgomery 1901 working on the germ cells of insects found that these differences were constant for the species. Following this demonstration of the morphological difference between the chromosomes came Boveri's celebrated experimental demonstration, 1902-07 that there is also a qualitative and physiological difference between them. These researches of Boveri were made on the multipolar mitoses of dispermic eggs of the sea-urchin and the monstrous resultant larvae. His conclusions may be stated as follows—the developmental disturbance in these abnormal larvae from dispermic eggs results from an irremedial derangement in the distribution of the chromosomes produced by the initial multipolar mitosis. His final conclusion drawn after showing that this abnormal development was not due to variations in the mere number of chromosomes, or quantity of chromatin, nor to a derangement of the cytoplasm of the egg, was that normal development is dependent on the normal combination of chromosomes and this can only mean that the individual chromosomes must possess different qualities.

In all cases where a clear size and shape difference between the chromosomes has been noted a paired condition also exists and there are two chromosomes of each different size and shape. Montgomery first indicated this fact in 1901 and Sutton 1902 studied it more fully and clearly showed eleven recognizable pairs of choromosomes and one unpaired X chromosome in a male grasshopper.

Van Beneden as already noted had discovered in 1883-84 that the fertilized egg contains two haploid chromosome groups or in other words that a reduction had taken place. How this reduction came about was first mentioned seven years later in 1901 by Henking who suggested that reduction is initiated by a conjugation of chromosomes two by two and a subsequent disjunction of the two conjugants. In 1901-02 Montgomery and Sutton reached the further conclusion that the synaptic mates or conjugating chromosomes of each pair are respectively of paternal and maternal origin. Sutton 1901 expressed the opinion that during the reduction division a random assortment of chromosomes took place but cytological proof of this was first brought forward in 1913 by Miss Carothers in the mitotic division of certain insects in which the synaptic mates differed in size and shape so that their position and distribution could be followed.

One great question remains regarding the chromosomes namely their individuality or genetic continuity. Of course chromosomes exist as definite bodies only during cell division and disappear with the reformation of the resting nucleus. It is obviously impossible for the chromosomes appearing in successive cell divisions to preserve their individuality in the strict sense of the word since they divide and grow by assimilation of new material just as all living cell structures do, hence the question is not one of "individuality" but of genetic continuity, i. e. that every chromosome coming from a nucleus has some direct genetic connection with a corresponding chromosome that entered the nucleus. Genetic continuity was first suggested in Van Beneden's famous work on Ascaris 1883-84. One observer Rabl in 1885 concluded that chromosomes lose neither their identity nor their grouping at the end of cell division but thin out into a branching network which persists and which he believed could be distinguished in the resting nucleus. Other investigators make like claims that the chromosomes can be traced through the resting stage of the nucleus but the evidence brought forward is far too scanty to constitute a demonstration of this view. The development of the genetic continuity theory was largely due to Boveri who began in 1887 a series of researches extending through nearly thirty years. He established the fact that no matter how the number of chromosomes is abnormally or artificially increased or decreased the altered number appears at every division thereafter. He found this to be so in cases of double fertilization, enucleated egg fragments fertilized by a sperm, parthenogenetic development, hybrids between varieties or species with different chromosome numbers and many other interesting and ingenious experiments. He states his conclusion as follows: "For every chromosome that enters a nucleus there persists in the resting stage some kind of unit, which determines that from this nucleus come forth again exactly the same number of chromosomes that entered it, showing the same size relations as before and often the same grouping." This discovery together with the fact that the chromosomes reappearing at each division have the same size and shape differences characteristic of the germ cells constitutes the main evidence for genetic continuity. Negative confirmation is had from the high improbability of the only alternative theory which holds that the chromosomes are completely dissolved at the end of each division and new ones are crystallized out again at the next division. The weakness of this theory is that it does not take into account the many characteristic differences of the chromosomes in size, shape and behavior which are known to be constant, whether the chromosome group be haploid, diploid, triploid or broken up into other numbers by multipolar mitosis. The matter of sex chromosomes and sex-linked characters will be summarized in a future paper.

When Prometheus Kindled a Flame

REV. JOHN A. FRISCH, S.J.

I was living in the country at the time. Not that I was a farmer. I was studying in that venerable Jesuit College, set on a hill and named after the huddle of houses it looks down upon, Woodstock College. The Patapsco river, only a creek at this distance from Baltimore, winds around the foot of the college hill and segregates it from the township. An old cantilever bridge forms a friendly link between the two. With its bridge and its narrow stream this scene has always reminded me of some fabled, moated castle on a hill. I had often expected to find the bridge drawn up for the night.

Second growth woods crowd the school grounds on all sides. Step off the "mile path" that circles the building halfway down the hill and you can wander through the woods for hours without ever meeting a soul. Because of its isolation and its undisturbed nature, its woods and its waters, Woodstock is an ideal home for the naturalist. Small wonder then that some of us students filched many an hour from our studies to investigate more closely the wild life that obtruded itself wherever we turned.

Thus a blind crow, a sparrow hawk, a screech owl, two chipmunks, swifts and skinks, ant-lions, several colonies of ants, muddaubers, caterpillars of many varieties and especially snakes had at various times shared board and lodging with me in the same room. In season, wild flowers are always standing about patiently in jars and cans waiting to be identified. All the year round a screen-covered box containing cocoons and chrysalids of moths and butterflies and even of hunting wasps adorned the inner ledge of the only window my room boasted.

Into this peaceful naturalist's haven there wandered one evening three Mr. Prometheus moths and for a time they wrecked its serenity. The evening before, June 24th, one of my cocoons had hatched into a female Prometheus. Since she showed no inclination to leave I did not release her. A day of rest, after the labors of emergence, would make her more fit to take up the duties of motherhood. She was still resting the next day, but I judged that, when the shadows would begin to lengthen, she would feel the call of duty.

We were alone at 4.50 P. M., she with her thoughts, I with my books. The lower sash of the window was up. A flutter and a flapping on the upper part of the window roused me. I looked up and then the commotion began. I blinked several times for I could not believe my eyes. Three Prometheus males were trying to get through the window panes. Then I remembered my roommate on the window ledge and instantly I understood. At the same moment the three swains dropping lower on the window panes found the open part of the window and straightway made for the cocoon-box. They fluttered and bounced all over the screen cover. I was beside myself with excitement. Fabre's experience with the peacock moth, when his house was literally invaded by a horde of males flashed into my mind. Here was I living through a similar scene, only on a smaller scale. Even as he, I speculated on what had called these visitors from their sylvan homes at this early hour when they should still be dreaming of the shadows and the moonlight, their natural habitat. Was it some subtle odor that emanated from the female and permeated the air for miles around? Or was it some eerie call too faint for our ears, yet all-compelling in its lure to these three males? I cared not. Here they were and these three swains knew why they had come and what they wanted.

Delighted as I was with witnessing for myself this power of the female to attract her mates I saw here also an opportunity for determining the details of mating, egg-laying and the incubation period and so I decided to capture the three males. They were so absorbed in trying to get into the cage that I netted them without any difficulty. They ignored me completely.

I then put one of the males into the cage with the female. The other two I confined in another cage. Mating took place immediately and continued for almost two and a half hours. The two disappointed males raised a fearful racket fluttering about wildly in their cage. But after about twenty minutes they calmed down and remained quiet all night and until I liberated them the next morning. Did they realize that they had been cheated and that further fuss was useless? Most likely, for they did not have any further interest in the lady after being liberated.

The mating continued nearly two and one-half hours as I said, or more exactly until 7.30 P. M. By eight o'clock the behavior of the lady indicated that she might be laying her eggs. Close inspection revealed 10 eggs adhering to the screen top. By 10 P. M. there were 38 more on the screen. By the next morning, June 26th, 78 eggs had been laid. During the day the female rested. But that night she started laying again so that by the morning of June 27th there were 177 eggs scattered on the walls of the cage. The lady had died during the night. Dissection of the ovaries revealed another 29 eggs, a few of which were undersized. This is not an unusual number of eggs. A female Cecropia, a much larger moth, once presented me with 338 eggs, and 24 more were found in her ovaries.

I kept the eggs in three separate batches and waited for the hatching. Those laid during the night of June 25th showed their patriotic spirit by hatching on July 4th an incubation period of about 8 days. The eggs laid during the night of June 26th emerged a day later, on July 5th. The eggs removed from the ovaries failed to hatch. The egg-shell was not devoured as happens in some species. The babies merely cut a neat little hole in the shell large enough to allow them to crawl out. Here was I with 177 babies on my hands. I knew it would be a large task to be nurse-maid to so many youngsters, with voracious appetites. My studies would more than suffer. So firmly, though wistfully, I turned them out to shift for themselves. I was happy, despite the parting, for had I not relived a scene the great Fabre had once lived and with same joyous feeling of awe and wonder?

Yet often that fall as I gathered Prometheus cocoons I wondered whether any of them perchance harbored one of those 177 youngsters that had been born in my study room. And I wished I could tell. But the parting had been forever.

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The Preparation of Protozoa for Class Use

The rapidity of movement of protozoa makes their study a matter of great difficulty for the beginner, particularly if he is getting acquainted with the use of the microscope at the same time. Identification and careful study likewise are rendered equally trying for the more experienced student. The time-honored method of partially immobilizing the organisms in a viscous medium such as a gum solution or by means of cotton fibers is of great assistance and has the advantage of permitting a study of the living organism. The use of the surface tension, as developed by the microdissectionists, is not feasible for class use unless perhaps as a means of demonstration.

Attention is called to the following method because of the rapidity with which the common protozoa and algae may be prepared for class use. The method is not by any means new, but does not appear to have received the attention it deserves. The material is collected from the aquaria or other source of protozoans by means of a pipette and placed in a centrifuge tube. A hand centrifuge will throw down the organisms within a minute at most, and immediately after the removal of the tube from the centrifuge the greater portion of the supernatant water is pipetted off. A few drops of 1 per cent. osmic acid solution are added so that the resulting solution of osmic acid is about one half per cent. Two cubic centimeters of such a strength of osmic acid will fix a cubic centimeter of precipitated organisms, so that the expense of the reagent is negligible. A few drops of distilled water are added and the material is ready for class use. For continued study a glycerine solution is better. The common fresh water protozoa—amoebae, ciliates and flagellates—when so prepared can scarcely be distinguished from living material except for the absence of movement. Chloroplasts such as those found in Euglena and the algae retain their green color, and with a nearly closed condenser the finer details, particularly of the cilia or flagella, are shown very clearly.

If permanent mounts are desired the usual staining methods may be applied, the various reagents being added to the material in the centrifuge tube. Iron haematoxylin gives splendid results after fixation with osmic acid, and with the exception of the destaining process with iron alum, the material need not be removed from the tube until it is in xylol. Chloroplasts do not seem to be affected by the various reagents, and material in balsam will remain green for weeks, after which the chloroplasts slowly fade. For finer details in such organisms it is better to bleach the chloroplasts with potassium permanganate, 1 per cent., and oxalic acid, 5 per cent., for about five minutes each before staining. Fixation in the osmic acid should be for from thirty minutes to an hour if permanent preparations are desired. This fixation, being cytoplasmic, offers an enlightening contrast to the more customary Schaudinn's fluid.—From *Science*, July 31, 1925.

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A Culture Medium and Indicator for Paramecium

REV. JOHN A. FRISCH, S.J.

Make an infusion of 30 grams of red cabbage leaves to a liter of water. The fresh medium is light reddish purple in color. Twenty-four hours after seeding with Paramecium it is red in color due to the formation of acids. In four to five days the color changes to a green indicating an alkaline condition of the medium. The quantity of Paramecium present is greatest when the medium is brilliant green. In one to two months the cultures becomes the color of an old hay infusion and the paramecia have all died off.

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A Culture Medium Selective for Euglena

REV. JOHN A. FRISCH, S.J.

Boil quince seed (can be bought in drug stores) in distilled water and pass the thick gelatinous mass through a sieve to remove particles of the seed. Dilute with water to the desired consistency.

This jelly seems specific for Euglena, some other chlorophyll-bearing Protozoans and for bacteria. Tubes of this jelly were inoculated with cultures of mixed Protozoans and after a period, two months only, the Euglena and a minute green flagellate survived, the other Protozoans living only as long as the supply of bacteria lasted.

Two hundred successful transplants have been made from a single culture.—From "Science."

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Staining Paramecium in the Class Room

REV. JOHN A. FRISCH, S.J.

One or two drops of the culture are studied in the usual way. When trichocysts are to be studied the cover slip is removed and a dab or two of Sanford's red ink is carefully stirred into the culture by means of a toothpick or a pin head. The cover slip is then replaced.

The red ink will not harm the paramecia. In about four minutes a fountain pen containing Waterman's blue ink is applied to an edge of the cover glass while the preparation is watched in the microscope. When a paramecium swims into the encroaching wave of blue the expulsion of the trichocysts can be clearly seen. In a flash the cytoplasm turns a deep red with purplish tinge, the cilia a flame color, and the trichocysts a deep blue, all without disruption of the specimen.

Various shades may be produced by varying the amounts of ink used and the length of time allowed before applying the blue. The nucleus takes on a more concentrated hue than the surrounding cytoplasm.—From "Science," Jan. 23, 1925.

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Bacterial Strategy

REV. VINCENT A. GOOKIN, S.J.

A recent study of the book of Daniel in scripture class demonstrated the strategy of Cyrus in the capture of Babylon. An apparently impregnable city was taken with scarcely a struggle despite its two massive walls of almost incredible height and width. The invaders were able to divert the course of the river which ran through the city and wade along the shallow bed into the heart of the capital.

It has long been a mystery to the neurologist and bacteriologist how bacterial infections manage to reach the central nervous system, the capital city of the body, and destroy it. Some results of investigations point to the use of tactics similar to those of the Persian.

The central nervous system is enclosed within three successive membranes. The dura mater, the outermost, is tough and fibrous, and the arachnoid and pia mater come next in order. All is surrounded by a rigid, bony box and the complicated structure of brain and cord seems as well protected from external invasion as anything could be. The connection between the spinal fluid and the blood system is blocked by the choroid plexus of the pia mater acting usually as a barrier to infection. When we include in the defense the lymphatics acting as filters the success of the attack seems impossible, except by way of sinus infection. The fact of the central nervous system becoming involved with toxemia apart from sinus trouble remained unexplained.

Rather certain evidence has shown that the nerve cells are reached by means of the perineural lymphatics. These lymph channels are concomitant with and accompany the spinal roots and cranial nerves and seem to be the path by which the infection enters. A number of cases of infection of the medulla with progressive degeneration of the cells have been recorded, after an apparently remote attack of mumps. The diphtheria toxin furnishes another example, when it produces a paralysis of the palate. The toxins travel up the lymphatic vessels of the nerves and assail the cells from which these fibres proceed. The fibre itself is usually found intact but due to the destruction of the cells, they and the muscles which they motivate are rendered useless.

In this way, by moving up the paths of the lymphatic stream, the bacterial toxins reach the cells of the chord and brain and accomplish their degeneration.

Scientific Curiosity Satisfied

REV. JOSEPH J. SULLIVAN, S.J.

The readers of the Bulletin may have tried to answer for themselves the questions proposed in my brief paper entitled "Scientific Curiosity." I wonder if they would agree with the following solutions offered by the professor who asked them?

Problem 1. The thermometer will record a lower temperature on the clear night than on the cloudy night. The reason is that all bodies are continually radiating heat to one another, and finally each attains its equilibrium temperature under the given conditions. Clouds have a finite temperature. The clear sky has the temperature, as far as we know, of Absolute Zero. Therefore, the thermometer receiving radiations from clouds should record a higher temperature than that receiving no radiations from celestial space.

Problem 2. The logs will dry quicker in the moist air than in the dry air. The reason given is that two processes are at work in the drying of the logs. First, surface evaporation. This is a cooling-down process, as we know. Second, capillary attraction, by which moisture is brought from the interior of the log to the surface. This process is slowed down by cooling devices. Now dry air will cause more rapid evaporation at the surface than moist air. But it will also cause more rapid cooling at the surface, and therefore slow down capillarity. It will be apparent that the latter process is the more important of the two, as most of the moisture is in the interior of the log. Therefore the moist air will dry the log faster than the dry air. This principle is applied in modern kiln drying.

Visualization of Chemical Facts

REV. JOSEPH J. SULLIVAN, S.J.

There is no need of emphasizing the importance of Visual Methods in general education. I should like to make a plea for their application in one form, namely the familiar "graph," in our Chemistry Courses. Not so much in the A. B. course, as this is more of a cultural introduction to chemistry. But in the B. S. course, where the students are supposed to acquire something of scientific habits, the study and analysis of graphs, presented to the class, and particularly the preparation of such graphs by the members of the class, should to my way of thinking, be part of the regular routine.

For instance, in the very first chapters of most Chemistry texts, are found data on the distribution of the elements. How many students, even after years of Chemistry, have really grasped the significance of these data, have learned to visualize them? According to the above suggestion, each member of the class would be required to plot this information, that is, plot the elements in their serial order

(Atomic Number), against percentage distribution, and draw a curve connecting the points. From this curve, at least one fact will be clear, namely that only elements up to copper occur in any abundance. And this is in the form of a picture which is fairly easy to recall.

In the chapter on Gas Laws, few students, except those who have had a good course in Physics, fully realize the effect of pressure on the volume of a gas, or the effect of temperature. I should suggest that after a study of Boyle's Law, and Charles' Law, the class be given two additional problems. First, calculate the volume of some gas (ideal) at several pressures. Plot the results—volume against pressure. Second, calculate the volume of a gas at several temperatures. Plot the results—volumes against temperature. The resulting curves will show the trend of these Laws, and will help the student to visualize these relationships.

Again, the concept of vapor pressure is one which can be introduced in discussing the chapter on Water. Most books give the figures for the vapor pressure of water from 0° C. to 100° C. If the student plots these data, vapor pressure against temperature, he will get an idea of the meaning and magnitude of vapor pressure, its steady increase with temperature, and also the real reason for the Boiling Point.

These are a few instances which come to mind now. It would be an easy matter for the members of the Chemistry Section of our Society to prepare a set of such "visual" problems covering the field of B. S. Chemistry. Such problems would initiate the student into the use of a common form of Chemical expression, namely the Graph, and facility in the manipulation of a common scientific tool, namely co-ordinate paper. And if he later leaves our College to take up Medicine or Higher Chemistry—and there he is daily confronted with such visualized data—he certainly will be grateful to us for the pains we made him take in plotting graphs.

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Quantitative Determination of Chromium

REV. RICHARD B. SCHMITT, S.J.

The extensive use of chromium or stainless steel in the automobile industry (radiators, head-lights, bumpers, etc.,) and in the manufacture of cutlery, has made it necessary to modify the methods of quantitative analysis. Chromium in alloy steels, until recently, was used only in small amounts; but at present the content of chromium in stainless steel ranges between 11% and 15%; and some manufacturers have used more than 20% of chromium in these new alloy steels. Consequently, the methods given in the various text-books for the quantitative analysis of chromium must be modified.

1. Determination of Chromium in Stainless Steel.

Dissolve 0.5 g of the sample in 100 cc of sulphuric acid (sp. gr., 1.2) and carefully evaporate the solution until salts separate in order to break up carbides. Cool, dilute to 50 cc, heat to boiling and cautiously introduce 10 cc of nitric acid (sp. gr., 1.2) and continue boiling until all oxides of nitrogen have been expelled.

From this point on proceed according to Standards Am. Soc. Testing Materials, 1927, 1, 310—p. 10 of reprint, with the important exception that the ferrous ammonium sulphate solution and potassium permanganate must be stronger than specified. Accordingly, dissolve 70 g of the Mohr's salt in 950 cc of water and acidify with 100 cc of concentrated sulphuric acid, and also prepare a 1/10 normal solution of permanganate.

N. B. a) Some specimens of ammonium persulphate do not contain anything like their full amount of actual persulphate.

b) If the permanganate color does not develop, add more persulphate.

c) If the permanganate color is not destroyed by the sodium chloride aften ten minutes boiling, or if a precipitate of manganese oxide separates, add from 1 to 5 cc of dilute hydrochloric acid (1:3) and continue to boil.

2. Determination of Nickel in Nickel Steel,

Proceed according to Treadwell-Hall, Vol. 11, p. 168 (1928).

3. Determination of Nickel and Chromium in Chrome-Nickel Steel.

a) Determine the nickel according to Treadwell-Hall, Vol. II, p. 168. (1928).

b) Determine the chromium according to Standards Am. Soc. Testing Materials, 1927, 1, 309—p. 10 of reprint.

4. Determination of Chromium and Vanadium in Chrome-Vanadium Steel.

a) Determine the chromium according to Standard Am. Soc. Testing Materials, 1927, 1, 309—p. 10 of reprint.

b) Determine the vanadium according to Standards Am. Soc. Testing Materials, 1927, 1, 317—p. 18 of reprint.

5. Determination of Chromium and Molybdenum in Chrome-Molybdenum Steel.

a) Determine the chromium—as mentioned above.

b) Determine the molybdenum according to Standards Am. Soc. Testing.

Materials, 1927, 1, 335—p. 36 of reprint.

N. B. Before gassing with hydrogen sulphide, make the solution exactly neutral with ammonium hydroxide (litmus paper) and then add 2.5 cc of sulphuric acid (1:1) for every 100 cc of the liquid.

6. Determination of Chromium, Vanadium and Tungsten in Chrome-Vanadium-Tungsten Steel.

   a) Determine both chromium and vanadium according to Standards Am. Soc., Testing Materials, 1927, 1, 327—p. 28 of reprint, assuming cobalt to be absent.

      N. B. After the removal of the tungsten, the chromium is determined as in Chrome-Nickel Steel; and the vanadium as in Chrome-Vanadium Steel.

   b) Determine the tungsten according to Standards Am. Soc. Testing Materials, 1927, 1, 324—p. 25 of reprint.

      N. B. In volatilizing the small amount of silicon dioxide that may be present in the tungstic anhydride, add 2 drops of concentrated sulphuric acid, 5 drops of concentrated nitric acid and 5 cc. of hydrofluoric acid (48%) and evaporate very carefully in the nickel crucible radiator. (Concerning the radiator cf. J. Ind. Eng. Chem., Vol. III, p. 419—1911.)

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The Angle of Minimum Deviation

T. H. QUIGLEY, S.J.

The deviation of a ray of light in passing through a prism may be expressed as a function of the angle of refraction at the first surface of the prism by the following equation:

$D = \arcsin(\text{in} \sin r) + \arcsin(n \sin(A - r)) - A$ (eq. 1)*

where D represents the angle through which the ray is deviated due to the refraction at the first and second faces of the prism,

A is the angle between the faces,

r represents the angle of refraction at the first face,

n represents the index of refraction of the prism.

Then $dD/dr = n\,[\,(1 - n^2 \sin^2 r)^{-\frac{1}{2}} \cos r - (1 - n^2 \sin^2 (A - r))^{-\frac{1}{2}} \cos (A - r)\,]$ (eq. 2).

Equating the right hand member of equation (2) to zero, we find that dD/dr is zero when r is equal to A/2. (It is also seen by inspection that when $r = A - r$, i.e. when $r = A/2$, $dD/dr = n\,(O) = 0$.)

Equation (2) may be written as follows:

$$dD/dr = n\left[\left(n^2 - \frac{n^2 - 1}{\cos^2 r}\right)^{-\frac{1}{2}} - \left(n^2 - \frac{n^2 - 1}{\cos^2 (A - r)}\right)^{-\frac{1}{2}}\right] \quad \text{(eq. 3)}$$

Since n is greater than 1, $(n^2 - 1)$ is positive.

When $r \geqq A/2$ (i.e. when $r \geqq A - r$),

$$n^2 - (n^2 - 1) / \cos^2 r \geqq n^2 - (n^2 - 1) \cos^2 (A - r)$$

$$\left(n^2 - \frac{n^2 - 1}{\cos^2 r}\right)^{-\frac{1}{2}} \leqq \left(n^2 - \frac{n^2 - 1}{\cos^2 (A - r)}\right)^{-\frac{1}{2}}$$

Then dD/dr is negative.

When $r \leqq A/2$, (i.e. when $r \leqq A - r$),

$$\left(n^2 - \frac{n^2 - 1}{\cos^2 r}\right)^{-\frac{1}{2}} \geqq \left(n^2 - \frac{n^2 - 1}{\cos^2 (A - r)}\right)^{-\frac{1}{2}}$$

Then dD/dr is positive.

Therefore, when $r = A/2$, D has a minimum value.

*Wood—Physical Optics (1923) p. 75.

N.B. cf corrections vol VII no. 3 p. 39

Francis X. Kugler, S.J., Astronomer

Rev. H. M. Brock, S.J.

An article on the late Father Francis X. Kugler, of Valkenburg, by Dr. F. A. Herzog, professor of Old Testament Exegesis at Lucerne appeared in "Aus der Provinz" for March, 1929, and in "Nachrichten" for April, 1929—two publications of our German Provinces. It is a sketch of his life and an appreciation of the important researches he carried on for many years and which won for him a high place in the world of learning. Father Kugler had the rather unique distinction of being an able Assyriologist and also an astronomer and mathematician and for this reason some account of his work as given in the article may be of interest to readers of the Bulletin. He was born at Königsbach in the Rheinpfaltz on November 27th, 1862, and studied science at the Universities of Heidelberg and Munich. He took his doctor's degree in 1885 and in the following year he entered the Society. He made his philosophy at Exaten in Holland and his theology at Ditton Hall in England, the predecessor of Valkenburg. While in philosophy he received the first inspiration for his life work from Father Joseph Epping, professor of mathematics and astronomy. The latter had previously taught at Maria-Laach and with some of his brethren had responded in 1872 to the call of Garcia Moreno, president of Ecuador, to become a member of the faculty of the Polytechnicum in Quito. Some years after his return to Europe, with Father Strassmaier he entered the almost unknown field of Babylonian astronomy. Fr. Strassmaier was an able Assyriologist and had already become acquainted with the vast collection of "bricks" with cuneiform inscriptions which had been brought to light by excavations of the ruins of ancient Babylon. Thousands were preserved at the British Museum in London awaiting interpretation. They covered almost every phase of ancient oriental life. Some contained astronomical observations and tables and he therefore induced Father Epping to take up their study. The task was a difficult one. The key was found after much labor. Lunar observations and references to the planets Mars, Saturn and Jupiter were identified. The fruit of their labors appeared in 1889 in the volume "Astronomisches aus Babylon." It was looked on as an epoch making work and made a deep impression among scholars. Luckily the inscriptions studied belong to the late Babylonian period and consequently many of the results obtained could be verified by comparison with Greek data of the same time.

Father Epping died in 1894 and Father Strassmaier in his later years was operarius at Farm Street Church in London. Father Kugler realized the importance and interest of the field they had opened up and he had already formed the plan of carrying on their work. To this end he took up the study of Assyriology. As he said himself he sought to combine in one head the necessary linguistic as well as mathematical and astronomical knowledge since the astral religion, astronomy and chronology of the Babylonians form one whole.

Fr. Kugler was ordained in 1893 and in 1897 he became professor of higher mathematics at Valkenburg. Here he devoted himself to research in his chosen field making use of the rich collections of cuneiform inscriptions in the British Museum. His first work appeared in 1900, "Die Babylonische Mondrechnung." It was very favorably received by scholars. In 1905 he published "Die Götter Babyloniens und das Neue Testament." In the meantime his training and his growing reputation enabled him to take a prominent part in two controversies concerning the Old Testament. The first was a reply to an attack by the Berlin Assyriologist Friedrich Delitzsch whom he met and vanquished on his own ground. The second was a refutation of the Pan-Babylonian theories of Hugo Winckler and his school. The fruit of his studies in this connection was the first volume of his "Sternkunde und Sterndienst in Babel." In 1909 the first part of the second book appeared in which he took up the question particularly of precession. Many of the Pan-Babylonians had claimed that it was known to the Babylonians some thirty centuries before Christ. In 1912 the second part appeared. His reckoning of the second Babylonian dynasty based on records of the planet Venus was a noteworthy achievement. This exhaustive work was only completed in 1924. In 1914, while studying a fragment of an astronomical tablet dating back to 141 B. C., Father Kugler discovered an account in the form of a chronicle of the unsuccessful invasion of Medea by Demetrius. This was of great interest to Biblical scholars as it confirmed and supplemented the account of the same event given in the first book of the Machabees c. 14, v. 1-3. This led him to give considerable attention to questions of Biblical chronology. His studies in this connection appeared 1922 in a scholarly work entitled "Von Moses bis Paulus." Besides his books he also published numerous articles in the "Zeitschrift für Assyriologie" and similar journals and in the "Stimmen aus Maria-Laach" and in the "Stimmen der Zeit."

Though a member of the faculty at Valkenburg until his death, Father Kugler apparently did not do much teaching, at least in his later years, but gave his time to special study and writing. I had the pleasure of meeting him there in the spring of 1913. He showed me some of the inscriptions he was working on. They were photographic copies of cuneiform bricks in the British Museum. He doubtless found it necessary to consult the originals from time to time. Dr. Herzog in his article pays high tribute to his religious spirit, deep scholarship and his geniality and he makes mention of the high esteem in which he was held both in and outside the Society. Father Kugler died at Lucerne on January 25th, 1929.

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The Day of the Week Corresponding to a Given Calendar Date

THOMAS D. BARRY, S.J.

It is frequently desired to know on what day of the week some future calendar date is to fall. Frequently too, in historical research it is a valuable check on the value of the chronology of an author to ascertain whether his calendar dates really did fall on the days of the week mentioned by him. The following are a few simple methods of solving the problem of finding the day of the week on which any given calendar date has fallen or will fall.

In case the given date falls within a few years before or after the present year, the problem may be simply solved by looking up in the current calendar the day and month required and adding or subtracting, according as the required year is later or earlier than the present, one day for each year, with an extra day for each leap year that may occur in the interval. For example, suppose it is required to know on what day of the week July 31, 1935 will fall. In 1929, by consulting this year's calendar, we find that July 31, fell on Wednesday. From 1929 to 1935 the interval is six years. Adding one day for the leap year 1932, we add to Wednesday seven days, showing that the required date falls also on Wednesday.

If the required date falls within the next forty years, there are two tables in the introduction to the Missal and also to the Breviary, which are of great help in this matter. One of these, entitled "Kalendarium," contains the Feasts celebrated by the Church on each day of the year. For each day is given a letter in the column headed L.D. (Littera Dominicalis). These are arranged in rotation from A to g, beginning with A for January 1. The other table, entitled "Tabella Temporaria Festorum Mobilium," contains in the first column the years during the period covered by the table, and in the second column the Dominical Letter corresponding to each of the years given. The Dominical Letter gives the days on which Sundays may be found in the Kalendarium. The procedure for using these tables is as follows: first find in the Tabella Temporaria, the Dominical Letter for the year required, then look in the Kalendarium for the day nearest to the required month and day which is designated by that letter. That day is Sunday, and from that day the day required may be easily found. For example, let us use the date given in the first method, namely, July 31, 1935. In the Tabella Temporaria we find after the year 1935 that the Dominical Letter is f. Turning now to the Kalendarium, we find that the nearest day to July 31 so designated is July 28. In 1935, then, July 28 will be a Sunday. Working forward from that date, we find that July 31 will fall on Wednesday. It should be noted that in the Tabella Temporaria two letters are given for leap years. The first should be used for dates which occur in the first two months of such years, the second should be used for the remainder of the year.

If the investigator has at hand tables of Julian Days, he may find them helpful in solving this problem, especially for dates which do not fall within the limits set for the use of the first two methods given in this article. Such tables are given annually in the "American Ephemeris and Nautical Almanac," published by the United States Naval Observatory at Washington, D. C. The table is Table XII near the end of the volume. The Julian Day numbers afford a method of counting the days continuously, according to the Julian calendar, the beginning of the era being around 4657 B. C. It is much used by astronomers in work such as the computing of periods of variable stars. The procedure in using this method is as follows: Find the Julian Day number of the given date from the table. Find also the Julian Day number of the month and day in the current year (for which the corresponding day of the week is found by consulting the calendar). Subtract the first from the second, divide by seven and subtract the remainder from the day of the week on which falls the given month and day of the current year. For example, let us find out on what day of the week October 12, 1492 fell. On consulting Table XII. of the Ephemeris, we find that October 12, 1492 was Julian Day 2266296. October 12, 1929 was Julian Day 2425897, and furthermore it fell on Saturday. The difference between the two numbers is 159601, which, divided by 7, gives a residual of one. Therefore, by going back one day from Saturday, we find that Columbus discovered America on a Friday.

A method which combines the advantages of speed of application and freedom from the use of any tables whatever is given in a recent number of the *Astronomische Nachrichten* (235.161). The article, by Joachim Mayr, and entitled "Neue Wochentagbestimmungen," gives methods for the conversion into the day of the week of any date according to Julian, Gregorian, Mohammedan, or Abyssinian Calendars. As the last two are not of general interest to the readers of the BULLETIN, I shall leave their discussion to the private investigation of anyone that may be interested. The method consists in forming two numbers, one by introducing two changes into the given year, the other formed by a combination of the month and day. The process is as follows:

1. Drop the century numbers in the given year and replace them by twice the difference between them and the next smaller number divisible by 4; e.g. 19-28 becomes 6-28, since 19-16=3, and 2x3 = 6. (The hyphens introduced here are merely for the sake of aiding in the understanding of the application of the principles, and are not to be used in actual practice.) That rule holds for all dates given according to the Gregorian calendar. In case the year is given according to the Julian calendar, the century numbers should be merely increased by 2. E.g. 10-66 becomes 12-66.
2. The last two figures of the given year should be reduced to the next smaller number divisible by 4, and the difference added on as an extra place. E.g. 19-29 becomes 6-28-1 (applying the first rule at the same time, since the two rules are independent of each other). 9-79 becomes 11-76-3.

   N.B. If the given year is already divisible by four (though not necessarily a leap year, e.g. 1900), the rule holds if the month is either January or February. Thus 19-28 becomes 6-24-4. If the month is after February, simply add a 0 as the extra place: 1928 becomes 16-28-0.
3. The second number in the general process is formed as follows. The day of the month is used in the tens and units places. The number of the month (3 for March, 4 for April, etc.) is placed in the thousands place. *For January and February, this part of the number is omitted.* For the hundreds place, 5 is used for the even-numbered months, 3 for the odd-numbered months *before* August (except January, where this number also is omitted), and 7 for the odd-numbered months after August. A few examples may make this clearer. April 27 becomes 4-5-27; July 2 becomes 7-3-02; November 11 becomes 11-7-11; February 22 becomes 5-22 (since, according to the rule, the thousand place is omitted for January and February); January 27 becomes simply 27.

4. The two numbers thus obtained are now added, the sum divided by seven, and the remainder gives the day of the week directly, 1 denoting Sunday, 2 Monday, etc.; 0 (equivalent to a remainder 7) denoting Saturday.

A few examples are given to illustrate the method:—

July 1, 677.	8761	Oct. 12, 1492.	16920
	7301		10512
	7)16062		7)27432
	2294,		3918,
	rem. 4, ∴ Wed.		rem. 6, ∴ Fri.
			(Cf. third method)
Jan. 1, 1930	6282	Feb. 22, 1732.	2284
	1		522
	7)6283		7)2806
	897,		400,
	rem. 4, ∴ Wed.		rem. 6, ∴ Fri.

Since the remainder after the division is the only thing that is used in determining the day of the week, the quotient need not actually be expressed.

5. This method holds also for dates before the Christian era, with the following modification: years less than 2801 should be subtracted from that number and the remainder treated as a Julian year according to the method given above. If the year is less than 5601 but more than 2801, the former should be used as the minuend. In general the minuend for B.C. dates is 1 + (the next higher multiple of 2800 above the given year). Examples:

Mar. 1, 479 B.C.	2801	Dec. 17, 4783 B.C.	5601
	− 479		−4783
	2322		818
	25202		10162
	3301		12517
	28503		22679
	Rem. 6, ∴ Fri.		Rem. 6, ∴ Fri.

The method works also in those centennial years which are not leap years as well as in those that are leap years. Care should be taken in the application of rule 2, since in going back four years, the century numbers of the date are diminished by one. The following are two examples of the use of the method for two consecutive days, first for the year 1600, which was a leap year, and for 1800, which was not a leap year.

1600: Feb. 29.	6964 529 ——— 7493 Rem. 3, ∴ Tues.	Mar. 1. 0000 3301 ——— 3301 Rem. 4, ∴ Wed.
1800: Feb. 28.	2964 528 ——— 3492 Rem. 6, ∴ Fri.	Mar. 1. 4000 3301 ——— 7301 Rem. 0, ∴ Sat.

It is interesting also to see how the change in method from the Julian calendar to the Gregorian applies to October 4, 1582 and October 15, 1582, which were consecutive days, due to the dropping of ten days from the calendar at that time.

Oct. 4 17802 10504 ——— 28306 Rem. 5, ∴ Thur.	Oct. 15 6802 10515 ——— 17317 Rem. 6, ∴ Fri.

This method may be summarized as follows for reference:

1. Year:
   - a) Century figures:
     - 1) Julian, add 2.
     - 2) Gregorian, back to century divisible by 4; use twice the difference.
   - b) Last two figures:
     - 1) back to last number divisible by 4; add difference as extra figure.
     - 2) if already so divisible, add 0 for months after Feb.
2. Day:
   - a) thousands place = number of month (exc. Jan. and Feb.)
   - b) hundreds place =
     - 1) 5 for even months.
     - 2) 3 for odd before Aug. (exc. Jan.)
     - 3) 7 for odd after Aug.
   - c) tens and units place = day of month.

November 8, 1929.

6281
11708
———
17989

Rem. 6, ∴ Friday.

The Manila Observatory Expedition for the Total Eclipse of the Sun, May 9, 1929

REV. CHARLES E. DEPPERMANN, S.J.

Originally, it had been intended that the Observatory expedition be concentrated entirely at Iloilo, P. I., but when it was learned that the Hamburg Observatory was willing to lend us a four meter camera with coelostat, and was actually sending them with the other instruments of their expedition, it was decided that confusion would be avoided if the writer would "pitch his tent" close to the Germans. Serious consideration was later given to the idea of separating from the Germans by about ten miles, in order to give a better chance for at least one of the expeditions to get something in the event of a small cloud obscuring the sun, but when Dr. Baade, of the German expedition, found that the clouds generally traveled in banks, it was concluded that this was hardly worth while, in view of the manifest advantages of companionship (and it may be added of expert advice for myself) accruing from joining forces. Hence we both encamped in the backyard of the public elementary school of Sogod, Cebu, about sixty kilometers north of the city of Cebu. As it was vacation time, we had the whole school to ourselves for our instruments, etc. The Germans also slept at the school, but my companion, Mr. Mariano Herrera, a faithful mechanic of the Observatory, and I, stayed at the parish house at Sogod, some two kilometers distant.

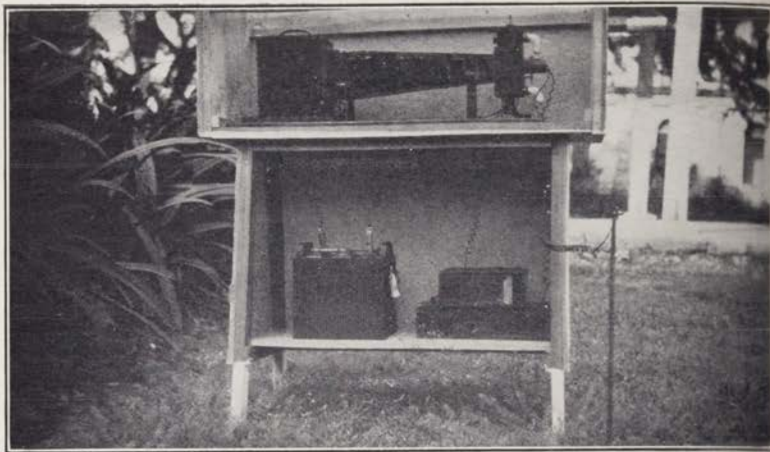
The weather for the two or three weeks preceding May 9th, was certainly good enough for putting our instruments into shape, as there was little rain; but the clouds were quite in evidence, especially in the part of the sky we were interested in. Two days before the eclipse would have been perfect for us, hardly a cloud in the sky. The next day was more misty. Rain that night would have cleared the air, but unfortunately no rain was forthcoming; hence eclipse day was cloudier yet. However, the sun shone brightly at first contact and for fully one hour afterwards, but with clouds near and growing, due perhaps to the cooling air condensing the latent moisture so prevalent in the tropical atmosphere. Cirrostratus of quite some thickness covered the sun at totality, and in fact hid the corona entirely for the last thirty seconds or so of totality. Only until our plates were developed did we know how seriously the clouds had interfered with our success.

But perhaps it would be better now to give the results for each of our instruments separately.

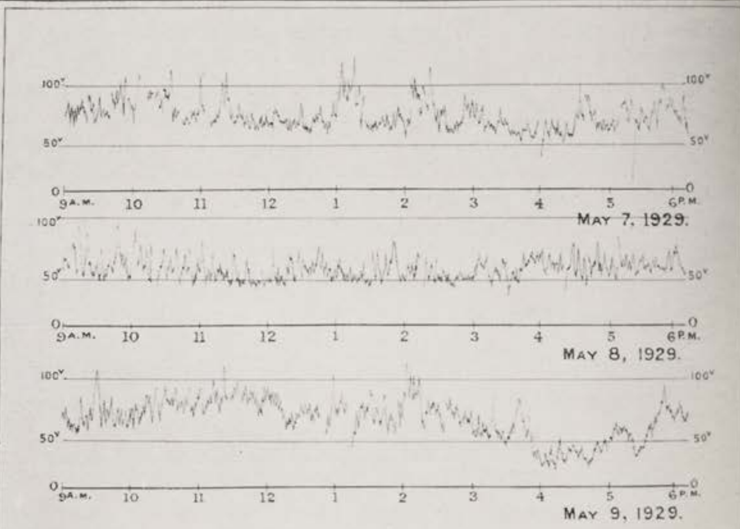
Seven meter camera: Our main camera, of which I took charge personally, was one of seven meters' focal length. The lens was a Zeiss photovisual (triplet), which, though ordered last August, only arrived the early part of April, too late to be given a preliminary trial at home. Fortunately the image of the sun it gave was of excellent quality. The body of the camera was made of celotex to give better protection from the sun. The movable frame to hold the plateholder was rather crude and homemade, but worked effectively. The coelostat with its 20 cm. mirror, lent by the Germans, was an excellent one, ruggedly built with weight-driven clockwork. It had been intended to set the coelstat and lens on a cement pier to avoid vibrations, but the cement man had contracted malaria, and so, under the expert guidance of Mr. Schmidt, the optician and mechanic of the German party, we constructed the foundations of heavy wood, which served the purpose quite as well as cement.

It was very interesting, but a little disturbing, to note the motion of the sun's image before totality due to heat vibrations, a regular period of a couple of seconds being evident, with an amplitude of almost half a millimeter. However, this quieted down as totality approached with lessening heat from the sun. Surprising too to the uninitiated was the decrease of focal length of almost five centimeters from about one hour before totality to totality. The original intention had been to take two exposures without filter, and then spend the rest of the time on two exposures through filters, the one green (Wratten No. 78) using plates specially sensitized for the green, the other red (Wratten No. 25) upon Wratten panchromatic plates, but it was found, a couple of days before the eclipse, that when put in front of the lens, the gelatine filters spoiled the image. Hence a little frame was hurriedly made to place in front of the plateholder, but this of course took more time to set into position; hence pictures only with the red filter were attempted, the red being chosen as being better able to pierce through possible mist and clouds. Six exposures were made, all on panchromatic plates, of two, five, eight and fifteen seconds without filter, and fifteen and forty seconds with red filter. On development, five out of the six showed no result, the sixth showed the moon's image rather faintly but reversed, i. e. dark on the negative instead of light! ! Plates left too long without development in the tropics frequently spoil or invert, but for plates to do this when developed only five days after taking is certainly puzzling. The plates were not developed in Sogod due to lack of proper facilities. No fogging was evident on the plates; evidently something had made the emulsion unstable. This was a big disappointment, but there is this consolation, that, due to the clouds, the pictures would have been useless scientifically anyway. Only two of the German pictures, out of very many taken, show the corona with any worthwhile detail at all.

Four meter camera: The camera box and the four-inch lens were lent us by the Germans. The coelostat was our own, mostly homemade. The mirror was slightly over four inches, and its axis of rotation was the axis itself of a small spring-driven clock. It was nick-

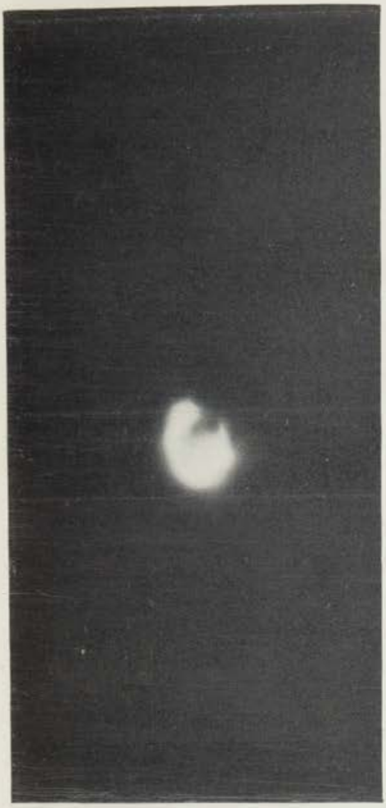


The Wulf Electrometer with one Celotex side removed to show arrangement of apparatus.

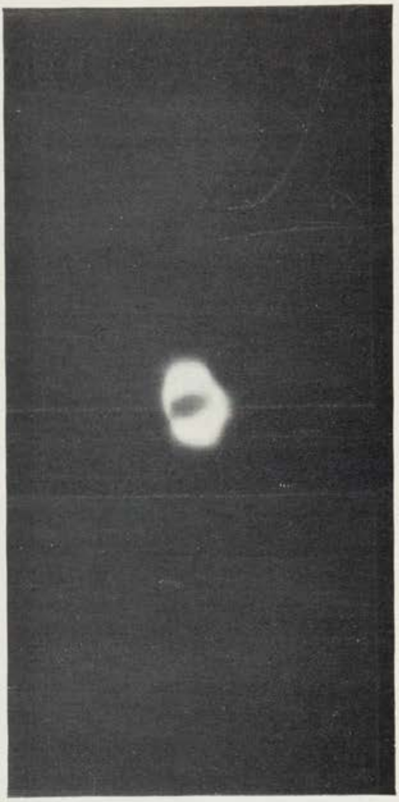


POTENTIAL GRADIENT, ATMOSPHERIC ELECTRICITY ON DAY OF TOTAL ECLIPSE OF SUN, MAY 9, 1929, SOGOD, CEBU, P. I. WITH COMPARISON RECORDS FOR MAY 7 AND 8, 1929.

named by Mr. Schmidt "Lilliput," but it gave a good steady image when protected from the wind. Had the wind remained from the east as on previous days, our windshield would have been successful, but on eclipse afternoon the wind veered to the northwest striking



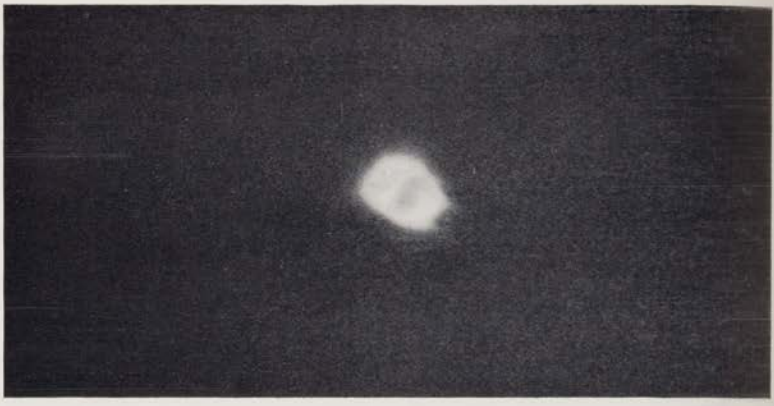
Mirror facing Zenith. In polarized light, vibrating horizontally



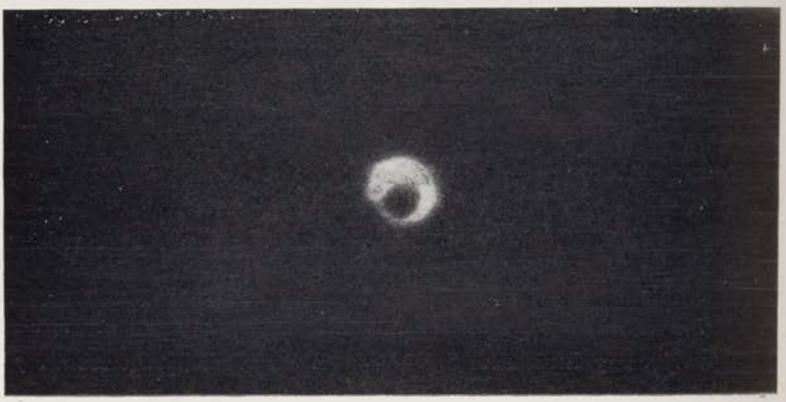
Mirror facing down. In polarized light, vibrating horizontally

the mirror from the only side we could not protect! For this reason, I instructed Mr. Herrera, our mechanic, who was operating this camera, to take no exposures longer than five seconds. As it was, vibration spoiled two of his pictures. His remaining three pictures of about two, four and six seconds' exposure are quite good, considering that they were taken through clouds. They show quite well the great prominence with its flames leaping out fully one hundred thousand miles from the sun; but the clouds prevented much of the corona from registering on the plates. The six seconds' exposure already shows the effect of light scattered from the clouds over the moon's face.

Half meter camera: As a last minute thought, a "bangup" home-made camera was taken along of one half meter focal length, but armed with one of Fr. Algue's four inch objectives, taken from his zenith telescope. Four pictures were taken with this by means of



Mirror facing Southwest. Polarized light vibrating vertically



Mirror facing Northeast. Polarized light vibrating vertically

light reflected at the polarizing angle from a piece of glass blackened at the back. For each of the pictures, the glass was pointed differently. Since a goodly part of the light of the corona is polarized radially, these pictures should have shown the corona of different shapes. Again, the clouds, with their scattering effect, spoiled things, since the pictures show much light irradiated on the moon's disc. However, one or two show peculiar stripes or rays issuing from the sun, but nothing definite can be said due to the clouds. Fr. Risacher kindly operated this camera for us.

Sky Polarization: A Savart polarimeter, mostly homemade, using a pile of plates to get the percentage polarization (cf. Wood's Physical Optics), was pointed at a region of the sky which was rich in polarization at the time of the afternoon the eclipse occurred. Readings had previously been taken on other days to get the normal direction and percentage polarization, at the hours to be studied. A Prof. Borromeo of Cebu was trained to use this instrument. It was found that the direction of polarization of sky light was normal during eclipse time. This was expected, but the possible changes in percentage polarization could not be observed due to clouds which usually cut down the percentage enormously. Hence the very low polarization observed can be naturally explained.

Atmospheric Electricity: The instrument used was a Wulf electrometer, which had been adapted for photographic registration. Daily records were taken for the two weeks or so previous to May 9th in order to get the normal curve. It was found that when the weather was good, the voltage per meter was quite constant, on the average about seventy volts, with, however, the usual jagged ups and downs of some twenty volts or so. On the afternoon of the eclipse, there is noticeable a gradual decline starting at about two p.m. (first contact) to quite low values (25 volts) at about four p.m. with a rise to normal values about six p.m. There is a little additional minimum at almost exactly three thirty p.m., time of totality, followed by a sharp rise of about thirty volts with a following decline of fifty volts by four p.m. Were these effects due to the eclipse directly, i.e. to changes in the ionization of the air due to the gradual withdrawal of the sun's rays, or were they rather due to the clouds, which are often naturally electrically charged, positive or negative? It is hard to say. The results are interesting, however, and the matter should be given further attention at future eclipses. But to get unequivocal results, the day of the eclipse should be fine and clear, and the locality so chosen as to give a good regular normal curve.

Miscellaneous: The time of the first contact was accurately observed by projecting the image of the sun from a three inch telescope upon a piece of white paper. First contact as calculated was 2 hr. 10 m. 29s. p.m. To two of us it appeared to come one second late, but Fr. Risacher thought it might possibly have come exactly on time. Additional evidence that it was actually one second late is the following: Mr. Herrera, at our four meter camera, had his chonrometer correction exactly. Thinking he would not hear Dr. Baade give the signal to start our pictures at totality, Mr. Herrera went by his chronometer and started his first exposure of two seconds exactly at the time calculated for start of totality, i.e. 3 hr. 29 m. 47 s. p.m. His photograph shows the "diamond ring" effect, i.e. a bright, thin semicircle (the photosphere) with a blaze of light at the center from the very thin crescent of the sun still visible.

At Manila, the photographs of various stages of the eclipse (ninety per cent obstruction only) were taken with our 19″ equatorial, and an endeavor was made to calculate from them the time of the first contact; but the time of exposure (even using a small aperture and a quick snap) proved just a little too long, since the plates showed a bit too much of halation to allow of accurate measurement.

So you see that we have very little of any scientific value to show for all our trouble, due to the clouds. The Germans, with all their expensive apparatus, have almost as little. Homo proponit, Deus disponit. Fiat voluntas Dei!

Fortunately, Father Selga had very good weather at Iloilo, and he will write up his own account for you, I am sure. But before he can give the definite results from his pyrheliometers he must await caliabration of his instruments with another one which is coming from Europe and may arrive any day. He took only small pictures of the corona, which were mostly spoiled by some one shaking the camera. He was mainly interested in radiation measures, and these seem O. K. He has further some interesting drawings of the corona made by trained observers, and other data as to shadow bands, etc., but I will let him tell his own story.

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Some Eclipse Hints

(As learned from experience, May 9, 1929)

REV. CHARLES E. DEPPERMANN, S.J.

1) *Coelostat:* It should be of simple type but as rugged as possible. The ones of the Hamburg Observatory are fine, but one thing seemed lacking; they should, if possible, be provided with means to shift more easily the whole instrument in a north and south direction.

A big chance is taken if one uses a light, laboratory coelostat, as it is easily shaken by any wind. Shields are all right, *except* if the wind comes from the direction in which the sun is; no protection to such a wind can be given, as found by experience at Sogod. The coelostats should be run every day for at least a week before the eclipse, and well oiled, to get them running properly. They should be started running at least one-half hour before eclipse time.

2) *Plateholders, etc.* These should be tested some days beforehand to see that they slide easily in the chassis, also that the slides themselves of the plateholders do not stick. If possible, see if your plates fit into the plateholders, some days previous to actual loading. The Germans found some of their plates cut not exactly at right angles, and had to load some plateholders at eleven a.m. after trouble the night before! Take test plates and exposures if possible some days before to see if the emulsion has not spoiled.

The chassis should allow for a change of focus of quite a large range. On my seven meter focal length camera, the focus changed at least four to five centimeters in the hour before eclipse started, decreasing this amount.

3) *Filters:* It would be wise to take some filters along to use in case the sky is rather hazy. The filters (especially a red one) may help much to cut out the effect of haze. But care must be taken to find out beforehand if the filter injures definition. The writer found that the red gelatine filter (No. 25) of the Eastman Kodak Co. spoiled the definition markedly if put in front of the lens, but kept the definition O. K. if plated just in front of the plate. If filters are used in this position, an arrangement should be put on the chassis so that the filters can be slid in and out in a very few seconds, else much valuable eclipse time may be lost.

4) *Tools, etc.* Before packing your instruments, etc., to embark for the eclipse station, assemble the instruments completely and go through all the motions as if on the eclipse day itself, and find out in this way just what things you need. Include extras, and rather err in carrying too much than too little. Don't forget a medicine kit if your station is any way distant from civilization.

5) *Site:* Do not be content with general information as to the probabilities of good weather on the day of the eclipse, but try to get data relative to conditions at the *time of the day* the eclipse takes place, and in the *part of the heavens* where the sun is to be. Some eclipse expeditions have been ruined through neglect of this.

Especially if the eclipse is to be in the afternoon in the hot season, a site should, if possible, be chosen which will mitigate the effects of atmospheric perturbations on the steadiness of the image. As at Sogod, the heated air from the ground, etc., gave rise to periodic perturbations of about half a millimeter at times and period of a few seconds! It might help if the spot chosen be fanned by a little breeze usually, and if the ground from the camera in the direction of the sun slopes downward, so as to have the sun's light path as far from the heat vibrations that usually exist close to the ground, as possible. The camera box must be so made as to avoid mixture of cold and warm air, causing turbulence.

6) *Ground Glass:* It will pay to get as good a ground glass to focus with as possible. It is a great help, since in long focus cameras (cf.2) you cannot just focus once and leave things as they are. Continual refocussing must be done till the last few minutes before actual eclipse time. This cannot be done with a poor ground glass. Mr. Schmitt of the Hamburg Obs. party says, if you have to make one yourself, to use the very finest emery paper, and keep rubbing the glass until you get the right degree of milkiness. If you go too far you will again spoil the image.

7) Develop your plates soon, if you are in a tropical country; otherwise your plates may spoil. But be sure to develop in a well ventilated room, cooled with a fan, and with the developer, etc., cooled to the proper temperature with ice. Use a developer that will bring

out detail, not a contrasty developer, else you will lose the delicate streamers.

As to exposure times, etc., some excellent hints will be found in Transactions of the International Astron. Union, Vol. III, 1928, pp. 60 ff.

8) Get your instruments in shape as soon as possible; you can not tell how a spell of bad weather might set in just before eclipse day. Last minute preparations are always hurried and apt to go wrong.

9) As to a shutter, the simplest and perhaps best method is to have a hinged cap over the objective, which can be opened by means of a string from it back to the plateholder end of the camera. The cap should close of itself by means of a little spring attachment. This advice of course is for cameras of long focus. A little lever arrangement can be made at the plateholder end, so that the string is pulled just enough to open the shutter fully and no more. In the excitement of the eclipse you might otherwise yank the string too hard and injure the shutter, etc.

10) If you are near a road, have the traffic stopped some minutes before totality, as it is surprising how trucks may shake the coelostat mirrors. Also keep spectators at a goodly distance from your cameras. Their walking may shake the mirrors and may make you nervous also. It is best to make the coelostat pier of cement for the sake of stability.

11) If it is desired from large scale photographs of the sun to get the exact time of first contact, the following precautions should be taken: a) (get as sharp a focus as possible; b) be careful not to make the exposure time too long, also halation effects will spoil everything; c) take a series of photographs at not more than one-half to one minute intervals. Extrapolation on a graph with length of chord as one coordinate and time as the other will then give time of first contact. If the photographs are taken at too long an interval between them the graph will be too inaccurate to give the second properly.

These notes are, of course, not meant to be complete eclipse instructions, but are only those which might not perhaps be found in books.

Fifth Annual Meeting of the Jesuit Seismological Association

REV. H. M. BROCK, S.J.

The Jesuit Seismological Association held its annual meeting at St. Louis University, St. Louis, Missouri, on August 4th, 5th and 6th, 1929. This organization, though perhaps not so well known to many of us as the Eastern and Central Sections of the American Association of Jesuit Scientists, is none the less a national one, including all of our colleges in the United States possessing seismological observatories. Since its formation at Loyola University, Chicago, in August, 1925, it has done a good work in coordinating the work of our stations, in publishing reports and in cooperating with the U. S. Coast and Geodetic Survey and Science Service. Fr. J. B. Macelwane of St. Louis University presided at the sessions. He is not only the president of the Jesuit Association, but he has also the distinction of being the president of the Seismological Society of America. The Maryland New York Province was represented by Fr. J. J. Lynch of Fordham University, New York, and Fr. J. P. Delaney of Canisius College, Buffalo, and the New England Province by Fr. H. M. Brock of Weston College, Weston, Mass.

The program gave the following papers for presentation:

"The New Station at the University of Santa Clara," Reverend James B. Henry, S.J.

"The Fordham University Station," Reverend John J. Lynch, S.J.

"The Ozark Seismic Research Program," Reverend James B. Macelwane, S.J.

"The Ohio Earthquake of March 8th, 1929," Reverend James B. Macelwane, S.J.; Reverend Joseph S. Joliat, S.J.

"A Brief Account of the Microseismic Storm of January 26-29, 1929," Reverend Joseph S. Joliat, S.J.

"Some Earthquakes in the Meridian of St. Louis and the Peculiarities Brought Out by Automatic Resolution of the Vibrations," Reverend James B. Macelwane, S.J.

"Heavy Blast in Limestone as Recorded by the Short Period Wood-Anderson Seismographs and the Galitzin-Wilip Seismographs at Florissant," Reverend James B. Maceiwane, S.J., Reverend Joseph S. Joliat, S.J.

The actual records of the blast described in the last paper were shown. The wave, which lasted only a brief interval of time, was clearly indicated by the short period Wood-Anderson Seismographs, whereas the long period instruments gave only a trace. The blast was caused by the explosion of 67,000 pounds of dynamite at a quarry in the limestone bluff on the right bank of the Missouri River at Alton, Illinois. A vast mass of rock was shattered and thrown over the floor of the quarry. The explosion was recorded at the Florissant station about eight miles away. If the exact time of the explosion had been known, the velocity of the wave could easily have been determined. Doubtless notice will be given of future blasts to the director of the station.

An interesting visit was paid to the Florissant station situated at the Novitiate. It is some distance underground to insure constancy of temperature. There are three Galitzin-Wilip Seismographs and two short period Wood-Andersons mounted on a concrete block. The Shortt Synchronome Clock, which marks the time for the five instruments, is of special interest. It was imported from England and there are very few in this country. It represents a distinct advance in horology. It has been carefully tested at Greenwich and Edinborough, and it is claimed that it is superior even to the well-known Riefller clock which has had such a fine record for many years in numerous observatories. The Florissant Station belongs to the department of Geophysics of St. Louis University and is in charge of Frs. Macelwane and Joliat. The routine work of changing and developing records is done by Brother Blum. On the way to Florissant the Alton Quarry was visited and the effects of the big blast observed.

At the meeting held on August 5th Fr. Macelwane was again elected President and Fr. Joliat was elected Secretary-Treasurer to succeed Fr. J. S. O'Conor of the Maryland New York Province, now of St. Louis University, who had held the office since the organization of the association. Fr. Macelwane in his report stated, among other things, that "during the past year cooperation between the Central Station and the U. S. Coast and Geodetic Survey, on the one hand, and Science Service on the other, has been steadily maintained. The stations in Cincinnati, Denver, Fordham, Georgetown and New Orleans sent telegraphic reports, as did also Father Stechschulte for the University of California.

Regular reports were received by mail from Buffalo, Chicago, Georgetown and Milwaukee. They arrived usually in time for inclusion in the preliminary bulletins. Preliminary bulletins giving the tentative epicenter and time of occurrence and a summary of the data from these stations, and from those of the United States Coast and Geodetic Survey and from a number of other stations, including Charlottesville, Harvard, Ottawa and Victoria, and reinterpreting the data to suit the epicenter and the time of occurrence were published for forty-two earthquakes during the year. These preliminary bulletins were mailed within a short time after each earthquake to nearly three hundred institutions in all parts of the world. Reports received from a number of these institutions were distributed to our stations at frequent intervals. All the stations of the association which are in operation except Spokane were visited by the Director of the Central Station at least once in the last two years, and many of them several times.

"It is felt that the work of the Jesuit Seismological Association is attracting international attention. This is due, in the largest part, to the self-sacrificing devotion of the directors of our stations, who deserve unstinted praise. But because of the exacting and routine character of the labors involved, and of the extent of the technical knowledge required, it is not easy to secure permanence. We can only hope to succeed if we urge on all of our superiors the importance of the work and of the results that are being achieved so that men and means may continue to be available."

All those who attended the meeting appreciated the opportunity to become acquainted with some of the departments of St. Louis University and to learn something of the great work it is doing in the middle west. The hospitality of the University and the many kindnesses of Frs. Macelwane and Joliat were also much appreciated.

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Errors in Gibbs-Wilson (Vector Analysis)

REV. FREDERICK W. SOHON, S.J.

For the sake of those of ours that are going into vector analysis I wish to point out two errors in Gibbs-Wilson. There are a large number of small typographical errors in the work that are fairly obvious, as there usually seem to be in most works on vector analysis. But the difficulties here objected to are fundamental.

In the derivation of the Hamilton-Cayley Equation it is argued that the dyadic being equivalent to nine scalars will replace a scalar in any identity. This is not self-evident, but if we point out that the dyadic is commutative with powers of itself and with scalar multiples of the idemfactor it will be be seen that the statement is true, whatever we may think of the reason assigned. Consider now the three identities

$$(\Phi - ZI)_s = \Phi_s - 3Z$$
$$(\Phi - ZI)_{2s} = \Phi_{2s} - 2Z\Phi_s + 3Z^2$$
$$(\Phi - ZI)_3 = \Phi_3 - Z\Phi_{2s} + Z^2\Phi_s - Z^3$$

The substitution of Φ for z evidently gives a false result in the first and second identities, so that it is not apparent why it should be expected to give a true result in the third identity. Moreover we learn that the principle we expected to fall back on evidently holds only for algebraic operations, and here we have operations that are not algebraic. Hence I believe that the proof should be abandoned. The following proof is offered taken from Joly on Quaternions.

The proof is here given in considerable detail.

$$\text{Let } Z = \Phi + aI$$

Then by double multiplication

$$Z_2 = \tfrac{1}{2} Z \overset{\times}{\times} Z = \Phi_2 + a\Phi \overset{\times}{\times} I + a^2 I$$

If we call to mind the following identities

$$\Phi_2 : I = \Phi_{2s}$$
$$\Phi : I = \Phi$$
$$\Phi \overset{\times}{\times} I : I = \Phi : I \overset{\times}{\times} I = 2\Phi : I = 2\Phi_s$$
$$\Phi : \Phi \overset{\times}{\times} I = \Phi \overset{\times}{\times} \Phi : I = 2\Phi_2 : I = 2\Phi_{2s}$$

We obtain the expansion

$$Z_3 = \Phi_3 + a\Phi_{2s} + a^2\Phi_s + a^3$$

Whence

$$Z_3 I = \Phi_3 I + a\Phi_{2s} I + a^2 \Phi_s I + a^3 I$$

But we have the theorem

$$\begin{aligned} Z_3 I &= Z \cdot Z_{2c} \\ Z_{2c} &= \Phi_{2c} + a\Phi_c {}^{\times}_{\times} I + a^2 I \\ Z \cdot Z_{2c} &= \Phi \cdot \Phi_{2c} + a\left[\Phi_{2c} + \Phi \cdot (\Phi_c {}^{\times}_{\times} I)\right] + a^2(\Phi + \Phi_c {}^{\times}_{\times} I) + a^3 I \end{aligned}$$

Since the two expressions for $Z \cdot Z_{2c} = Z_3 I$ are true for all values of a, we may equate the coefficients of like powers:

$$\begin{aligned} \Phi_s I &= \Phi + \Phi_c {}^{\times}_{\times} I \\ \text{whence} \quad \Phi_c {}^{\times}_{\times} I &= \Phi_s I - \Phi \\ \text{and} \quad \Phi_{2s} I &= \Phi_{2c} + \Phi \cdot (\Phi_c {}^{\times}_{\times} I) \\ &= \Phi_{2c} + \Phi \cdot (\Phi_s I - \Phi) \\ &= \Phi_{2c} + \Phi_s \Phi - \Phi^2 \\ \Phi_{2s} \Phi &= \Phi \cdot \Phi_{2c} + \Phi_s \Phi^2 - \Phi^3 \\ &= \Phi_3 I + \Phi_s \Phi^2 - \Phi^3 \end{aligned}$$

or

$$\Phi^3 - \Phi_s \Phi^2 + \Phi_{2s} \Phi - \Phi_3 I = 0$$

To follow the proof in Joly note

$$\begin{aligned} \varphi &= \Phi & m &= \Phi_3 \\ \varphi' &= \Phi_c & m' &= \Phi_{2s} \\ \Psi &= \Phi_{2c} & m'' &= \Phi_s \\ x &= \Phi_s I - \Phi_c \end{aligned}$$

The other objection refers to formula 50. I discussed this formula several years ago in the bulletin of the Missouri Province, and there explained Wilson's defence of the formula. I was by no means satisfied with Wilson's explanation and, after consulting with Father Steele of the English Province on the subject, we decided that the formula could not stand. Wilson obtained it from Föppl Introduction to Maxwell Theory, Teubner 1894, but the formula was omitted from subsequent editions. While Professor Wilson thought the formula could stand, he said that he too would probably omit it from subsequent editions if the publisher allowed it. Hence even if the reader does not wish to take the position that the formula is undoubtedly wrong, he ought at least to heed the unanimous agreement that it is not worth worrying about.

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The 16 Cell Perfect Magic Square

REV. FREDERICK W. SOHON, S.J.

We have previously shown that there is one nine cell magic square, and this square is subject to eight transformations. We shall now show how all the solutions of the conditions for a 16 cell magic square are reducible to the same solution by means of 384 transformations. To do this we must explain the transformations, solve the equations of condition, and show how the transformations are used to reduce the number of solutions.

Let us consider a sixteen cell magic square of the form

A	B	C	D
E	F	G	H
I	J	K	L
M	N	O	P

Two cells (or the numbers in them) that are diametrically opposite and equally distant from the center are said to be complementary, or complements. Thus A and P, B and O, F and K are complementary.

Two rows or two columns whose cells are complementary are said to be themselves complementary. Thus the column AEIM is the complement of the column DHLP.

Two cells in the same row, but in complementary columns, are said to be horizontal alternates. Two cells in the same column, but in complementary rows, are said to be vertical alternates. Thus H is the horizontal alternate of E and I is the vertical alternate of E.

Interchanging two complementary columns is called horizonal alternation, interchanging two complementary rows is called vertical alternation, and performing both is called double alternation. If we perform these operations on the original square given above, we obtain the following:

A	C	B	D
E	G	F	H
I	K	J	L
M	O	N	P

Horizontal Alternation

A	B	C	D
I	J	K	L
E	F	G	H
M	N	O	P

Vertical Alternation

A	C	B	D
I	K	J	L
E	G	F	H
M	O	N	P

Double Alternation

Interchanging two non-complementary rows or columns is called inversion, and in the 16 cell square there arise three kinds of inversion defined as follows:

B	A	D	C
F	E	H	G
J	I	L	K
N	M	P	O

Horizontal Inversion

E	F	G	H
A	B	C	D
M	N	O	P
I	J	K	L

Vertical Inversion

F	E	H	G
B	A	D	C
N	M	P	O
J	I	L	K

Double Inversion

Alternations and inversions are called linear transformations because the same numbers are associated together to form columns and rows as in the original figure. For this reason also the processes are legitimate. In the case of alternation we are allowed four choices, in the case of inversion four further choices, and after this we have the eight superficial transformations, making 128 in all. In order to explain the remaining transformations, we must first explain the theory of supplementary rectangles.

The group of four cells formed by the intersection of two rows with two is called a rectangle. If both rows and columns are non-complementary, the rectangles are alternation rectangles. The rectangle formed by the intersection of the two remaining rows with the two remaining columns is called the supplement of the first rectangle. In the case of alternation rectangles the supplementary rectangle contains the complements of the cells of the original rectangle, and might also be called its complement. In this discussion we are only interested in alternation rectangles. We next prove the theorem that a rectangle is as heavy as its supplement.

Let us consider the rectangle ABEF. Any alternation rectangle can be brought into this position by one of the 128 transformations, and while the theorem is more general, this generality is of no use to us.

$$A + B + D = G + K + O$$
$$E + F + G = D + L + P$$

Adding we have $A + B + E + F \qquad = K + L + O + P.$

This proof is really independent of the position of the rectangle within the square. Hence every rectangle is as heavy as its supplement.

Now alternation rectangles are complementary to their supplements.

$A + P = 17,\ B + O = 17,\ E + L = 17,\ F + K = 17.$ Hence

$$A + B + E + F + K + L + O + P = 68$$
$$A + B + E + F = 34.$$

We have, therefore, the proposition that an alternation rectangle is as heavy as a row. Such being the case, we may use alternation rectangles for columns and rows, and by this means we may define two more transformations, known as transpositions.

A	B	C	D
E	F	G	H
I	J	K	L
M	N	O	P

Original
Square

A	B	E	F
C	D	G	H
I	J	M	N
K	L	O	P

into Rows
Squares

A	B	I	J
C	D	K	L
E	F	M	N
G	H	O	P

Oblongs
into Rows

The addition of these new transformations increases the whole number of possibilities to $3 \times 128 = 384$. We may now give our attention to the algebraic solution.

In a sixteen cell square the sum of a pair of complementary numbers is 17 and the sum of a row or column is 34. The condition concerning complements gives 8 equations, while the summation of columns and rows give 2 more each. They do not give 4 each because the summation of one of two complementary rows implies the summation of the other. The 12 equations leave 4 unknowns to be assigned arbitrarily, but for the sake of symmetry we assign 5, namely I, E, A, B, C. These are connected by the relation:

$$A + B + C = H + L + P = 17 - I + 17 - E + 17 - A$$

whence $I + E + 2A + B + C = 51$.

Then

$$\begin{aligned}
D &= 34 - A - B - C = I + E + A - 17 \\
M &= 34 - A - E - I = A + B + C - 17 \\
F &= 34 - A - B - E = I + A + C - 17 \\
K &= 17 - F = E + A + B - 17 \\
J &= 34 - A - B - I = E + A + C - 17 \\
G &= 17 - J = I + A + B - 17
\end{aligned}$$

We next proceed to the proof that there cannot be an odd row or an odd column. For simplicity let the square be so transformed that the column or row thought to be odd will occupy the position A B C D. Then $A + B$, $A + C$, $A + D$ are all even, and consequently $E + F$, $E + G$, $E + H$, $I + J$, $I + K$, $I + L$ (being the opposite sides of alternation rectangles), will all likewise be even, so that if E is odd F, G and H will also be odd, and if I is odd J, K, and L will all likewise be odd. Since L is odd M is even, $A + M$ is then odd, and therefore $E + I$ is odd so that either E or I must be odd. The result is that we have the eight odd numbers in two rows. But the sum of the odd numbers is only 64 whereas the sum of two rows must be 68. Hence there cannot be an odd column or an odd row. Since the sum of a column or row must be even, every column and every row must contain two odd and two even numbers.

There now remains the problem of assigning values to I, E, A, B, C. By suitable transformation the number 1 can always be brought into the upper left hand corner. Let $A = 1$. By turning the square over on the diagonal through A (transformation D) if necessary, and then using horizontal alternation if necessary, B can be made greater than either I, E or C. Next by transposing either alternation squares or alternation oblongs into rows if necessary, C can be made greater than either I or E. Finally E can be made greater than I by vertical alternation if necessary. We have then

$$B + C + E + I = 49$$

$$B \geqq C \geqq E \geqq I$$

B and C cannot both be odd, because $A = 1$ is odd.
I and E cannot both be odd for the same reason.

There are not many ways of assigning values to these letters:

B	C	E	I		
15 +	14 +	13 +	7	= 49	Rejected, because E and I are both odd.
15	14	12	8		To be investigated further.
15	14	11	9		Rejected, because E and I are both odd.
15	14	10	10		Rejected because $E = I$.
15	13	....	....		Rejected, because B and C are both odd.
15	12	11	11		Rejected because $E = I$.
14	13	12	10		To be investigated further.

No further values can evidently be assigned and at the same time preserve both the inequalities and the total of 49.

If we substitute the values $B = 14$, $C = 13$, $E = 12$, $I = 10$ in the expressions

$$F = I + A + C - 17, \qquad H = 17 - 1$$

we get the same value 7 in each case, so that there remains but a single set of values for B, C, E, and I. A substitution gives us the magic square:

1	15	14	4
12	6	7	9
8	10	11	5
13	3	2	16

which will be subject to the 384 transformations we have just described.