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A TRIBUTE

As this issue of the BULLETIN goes to print the Nation thrills to the heroic deeds performed by the crew of the Aircraft Carrier "Franklin" as they brought their ship through one of the worst bombardments ever dealt to any boat. And we are proud as we hear the news that her Chaplain, Lt. Commander O'Callahan, has been recommended for the Congressional Medal of Honor. We shall never know the full measure of his valor, beyond the line of duty, during those dark hours and days, as the Franklin fought for its very life, before finally steaming into home port under its own power. This is the first time, we believe, that any Chaplain of the United States armed forces has been recommended for the top honor which our Country has to bestow. Fr. O'Callahan is a member of the American Association of Jesuit Scientists, and at the time of his enlistment was a Professor of Mathematics at Holy Cross College, Worcester, Mass. It is, indeed, a pleasure for the BULLETIN to take this occasion to offer its humble meed of tribute, not only to Fr. O'Callahan, but to all the members of the Association, who are rendering outstanding service to our Country in all branches of the service. Unfortunately, no complete list of its Chaplains can be published at the present time, but we do know that they have played no inconsiderable part in winning the reputation for gallant service enjoyed by our Chaplains in this war. Although the burden of wartime education fell heavily on the science departments, Superiors were patriotically generous in releasing these men to carry the benediction, peace and consolation of Christ to the boys on the firing line. The BULLETIN, in the name of the Association, salutes them. We are proud of our brother members and their magnificent work in this newly offered way of maintaining and spreading the Kingdom of Christ on earth.

SCIENCE and PHILOSOPHY

TIME AND ITS MEASUREMENT*

REV. JOSEPH P. KELLY, S.J.

Time is one of the fundamental units in physical science. It is a unit of measure, the measure of the "times" or durations of other physical phenomena. It is the measure of objects vastly different in themselves, e.g., the duration of the war, the period of class, the length of a physical or chemical experiment, the interval of meeting among friends. All such events have "time" or exist in time and we measure these times. The abstract notion of time is of little value for measurement. For, it is neither long nor short, rapid nor slow. It is merely the numeration of the parts of motion according to the order of succession. To become useable, we select a definite, physical time or rather some physical motion. Since local motion is most common and best known to us, the choice naturally falls on a particular, local motion. The rotation of the earth on its axis is the basic reality of time. For greater convenience, the "second" of time has been chosen as the fundamental unit of measure of time. (1). The process of comparing any interval or duration of motion with the chosen standard, is the measure of time. The unit itself, like all units of measure, is outside the object measured. The "second" and all other derived units, and called "extrinsic" time. The time measured, as a quality or property of the object, is called "intrinsic" time. It belongs to the body and can be predicated of it. Since measurement plays such a predominant role in science, the measure-aspect of time is of much importance to the scientists. Hence, the necessity of an accurate determination of the unit of measure. Generally, the scientist does not concern himself with the internal natures of physical bodies, not with the intimate nature of time. Newton, in his discussion of time, asserts that he is not trying to define time. He makes the distinction between "absolute time which flows equably without regard to anything external and by another name is called duration," and "relative, apparent or common time which is commonly used instead of true time; such as an hour, a day, a month, a year." (2). Many scientists of to-day would disagree with Newton

*This is the second in a series on the subject "The Concept of Time." cf. This Bulletin Vol. XXII, Page 36.

(1) The "second" as a unit of time, is defined as 1/86,400th part of the mean solar day.

(2) Newton's "Principia." p. 6. Revision of Motte's Translation. Cajori. Univ. of California. 1934.

in his concepts of time. Certainly the notion of absolute time seems foreign to the Relativity Theory.

Qualities of Units of Measure

In the choice of a standard of measurement we must have constancy, uniformity and invariability as qualities of the standard. If these are lacking one sees readily that chaos would result. Science would be in a much confused state if each country had its own norms or if each scientist employed different units of measure. There would be no systematic knowledge. Who could understand the physical laws of gravity, heat, motion, etc., if each discoverer proclaimed them according to his personal system of measure? What would happen in the construction of a skyscraper or an aeroplane if the architect and the builder followed different foot-rules? It requires little imagination to realize the confusion that would follow if the meaning of the units of the C.G.S. system were to change from one generation to another. In the rotation of the earth we have a constant and uniform standard and naturally suited as the unit of time. The further divisions into hours, minutes and seconds are convenient for the smaller activities of life. One would not measure a thirty-day vacation in seconds or minutes. In all these instances, what we actually compare in the physical reality, is the motion or duration of one thing with the duration or motion of the earth. Although time and motion are one in basic reality, they are different in formal concept, as was explained in the previous article. The physical rotation of the earth is one thing when considered as motion and another when considered as time. Motion in itself is a quality that constitutes a being in a state opposite to that of rest. This of itself has nothing to do with time. When the astronomer discusses the motion of the earth as a part of the moving solar system, he prescinds from the aspect of time. Likewise, when the physicist treats of bodies in a state of motion, he frequently does so without reference to time. Newton's first Law of Motion, as a physical principle, does not include time, as is clear from Newton's explanation. (3).

From a comparative study of time as based on motion, it follows that no one, particular motion in the physical order is privileged above others as a norm or measure of time. No one motion necessarily demands that it be chosen in preference to all others. All systems of measure are arbitrary; perhaps it would be more accurate to say that the choice of any system of measurement is arbitrary. The choice depends on the suitability of the units and human convenience. This is true for time. Since some units are more suited than others our choice naturally falls on them. No one would assert that the C.G.S. system is *in itself* better than the F.P.S. system. The fact that both are accepted and widely

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(3) Newton's "Principia." p. 13. op. cit.

employed demonstrates this. The attempts to have the C.G.S. system universally adopted in scientific circles is for greater human convenience and uniformity rather than for the intrinsic value of the system. The history of measurements shows us how great a variety of measures have been in use among men, with convenience and practical value, although without the precision that characterizes the more modern units of measure. The ancients lived well enough with the lunar month as a standard of time. Precision does not change the nature of the unit of measure; it merely refines it. "There is no one manner of measuring Time," says Poincaré, "which is more true than any other. The one generally adopted is more convenient." (4). "In the concrete there are an indefinite number of movements in us, heart beats, breathings, and external motions in local space, quantitative and qualitative. Hence, measures of motions are as numerous as the motions themselves." (5). Scholastic Philosophy has always recognized this aspect of the philosophy of measure. About four hundred years ago, Suarez, wrote: "It follows, that by nature, there is no motion or succession that is *necessarily* the measure of any other motion, but it depends on the free choice and ingenuity of man. Some things are by nature more apt and suited for measuring others, such as the motions of the heavens; the basis and foundation for its acceptance, as a measure, is a real property of the things itself. Its institution as a norm of measure depends on the intellect of man." (6). One recognizes that in the choice of systems of measurements, there is an arbitrary element. Yet, it is not a mere haphazard affair but the choice is guided by the qualities of the objective reality under consideration. In our present day the question of a redivision of the year has been agitated. It has been proposed that a more uniform year of thirteen months would solve many problems. Suppose that a redistribution of the months becomes legal by an act of Congress, it would perhaps be much more convenient to accountants and stylemakers, but one might well call in question any advantage from the point of view of intrinsic value. The story is told of Galileo that while attending the services one evening in the Cathedral of Pisa, he was distracted in his prayers by the pendulum-like swing of the great lamp. With only a pulse beat as a norm of measure, he noted that the time of each swing remained the same, although the amplitude diminished. He had discovered an important, physical law. Modern science would readily accept the law in principle but would demand something more precise than Galileo's subjective norm of measure. Generally speaking, a mathematical formula will give us a more accurate determination of a physical law, in its quantitative aspect, but it does not improve on the principle of the law, unless one holds that the essence of a law of nature lies in its quantitative expression.

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(4) Poincaré, "La Valeur de la Science." p. 44.

(5) Nys. "La Notion de Temps." p. 45.

(6) Suarez. "Disputationes Metaphysicae." Disp. 50; Sect. X. No. 8.

Times in Actual Use

Although the rotation of the earth is the objective basis for time,—one complete rotation constitutes the day and one complete revolution in its orbit around the sun is one year—the more minute determination of these depends on the norms and conditions of measurement. Thus we have, Sidereal Time, True Solar Time, Mean Solar Time, Standard Time, etc., etc.

The Sidereal Day is the measure of the earth's rotation with respect to the stars or more exactly with respect to the Vernal Equinox. This is the point at which the sun crosses the celestial equator on its apparent northward journey, on or about March 21st. The method of determining the Sidereal Day is to select a meridian, e.g., the meridian of Greenwich, zero degrees longitude, and note the interval between two successive passages of this meridian across the Vernal Equinox. This interval is called the Sidereal Day. It is considered the most accurate method of determining time. The same method would obtain for the measure of the Sidereal Day at any other point on the earth, e.g., if the longitudinal meridian of Washington were chosen, the Sidereal Day of Washington and of all other places on this meridian would be thus determined. "Since the earth rotates at a sensibly uniform rate, all sidereal days are of the same length" (7). The Sidereal Day is divided into twenty-four hours, these into minutes, and further into seconds.

True Solar Time is measured in a similar manner, but with reference to the sun. A meridian is chosen, again the longitudinal meridian of Greenwich, and the interval between two successive passages across the center of the sun is measured. This is the True Solar Day. Due to the apparent eastward motion of the sun, the Solar Day varies slightly at different seasons of the year, and is slightly longer than the Sidereal Day. Since the Solar Days are not uniform, it has been found convenient to take the average length of all the Solar Days, as a norm. This is called the Mean Solar Day. "If we imagine a fictitious sun moving eastward uniformly at the average rate of the actual sun, then Mean Solar Time is defined by the rotation of the earth with respect to this fictitious sun. All mean solar days are of the same length with respect to the sidereal day as a standard and the mean solar time is the time in ordinary use." (8).

It is evident that according to our methods of measuring time, only all cities and towns on the same meridian of longitude have the same time. In a country as extensive as the United States the variations of times for different localities caused much confusion and inconveniences for business and travel. A more uniform system was necessary

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(7) Moulton, "Astronomy." p. 159.

(8) Moulton, "Astronomy." p. 155.

so that inhabitants of the same region could regulate social and business life on the same basis of time. The country was divided into four regions or zones and a uniform time adopted for each zone. This is called the Standard Time for each region. It was legally adopted in 1884. Thus we have Eastern Standard Time, Central Standard Time, Mountain Standard Time and Pacific Standard Time. The theoretical division is a zone of fifteen degrees of longitude, equivalent to one hour of time. The basic Standard Time, universally accepted, is that measured with respect to zero degree longitude, called Greenwich Time. All other Standard Times are either reckoned from this or measured at each 15th degree, east and west of the meridian of Greenwich, to the International Date Line, at the 180th longitudinal meridian. Thus Eastern Standard Time is measured at the 75th degree, west longitude, and is five hours earlier than Greenwich Time. For countries east of zero degrees, (Greenwich), standard times would be measured in a similar manner but the time would be one, two, etc., hours later than Greenwich Time. The terms, "earlier" and "later" are used in this sense, that if we designate the noon-hour of Greenwich as a point of reference, it would be before-noon in countries west of the meridian of Greenwich and after-noon in countries to the east. Geographically, the standard zones extend 7½ degrees to the east and to the west of the time meridian. Thus, Eastern Standard Time is measured from the 75th meridian, but the Eastern Standard Zone extends from 67½ to 82½ degrees, west longitude. Central Standard Zone from 82½ to 97½ degrees, west longitude. In actual practise, these divisions are not followed exactly. They vary for business reasons or because of the locations of large cities and important railroad terminals. War Time, now in common use, is one hour later, (by the clock), than Standard Time.

The above enumeration shows that we have a goodly variety of times. In all cases, the objective reality, which is the foundation of time, is the motion of the earth on its axis. Diverse points of reference and methods of measurement produce different "measured" times. The choice of method is arbitrary, suited to human convenience and needs. No one time is of itself more correct than any other. Each is correct in its proper sphere.

Measurement and Knowledge

In this discussion of Time, we have emphasized the measurement-aspect, because measurement plays a dominant role in the physical sciences. In the last century, Maxwell wrote: "As science has been developed, the domain of quantity has everywhere encroached on that of quality, until the process of scientific inquiry seems to have become simply the measurement and registration of qualities combined with the mathematical discussion of the numbers obtained." Among present-day physicists, we find the echo of these convictions. "There is only one sure guide towards further development, (of physical science), and that is measurement, together with any logical conclusions that can be drawn from the concepts attached to this method." (9). One of the common modes of distinguishing philosophy from science is to say that the former is qualitative and the latter is quantitative. It would seem but natural and logical that the physical sciences which stress the quantitative, should develop into a science of measurement. "Physics is an exact Science and hence depends on measurement." (10).

We define measure as that by which the quantity of an object is known. (11). To measure is to compare one quantity with another and thus derive some knowledge of the second. The quantity applied is called the standard or unit of measure. By comparing things of the same order with the standard we learn their relation to the standard. We measure them. To find the length of a table, we apply a foot-rule or meter stick to see how many times the foot-rule is "contained" in the table. In like manner we measure volumes or other extended quantities, as is evident from a consideration of the units of the C.G.S. system. These are quantitative in themselves and measure similar quantities in other physical beings. The same principles of measure apply to the "derived" units as to the fundamental. For different properties we employ different measures. Cubic centimeters do not meaure linear dimensions nor the times or durations of phenomena. Measures are distinct from the objects measured. Physical phenomena are objectively distinct from the process of measurement. An object is not simply its measure. Weight alone does not tell us whether we are measuring a particle of gold or of iron; a volume of water or sulphuric acid. The weight may be the same in all cases but no one would identify gold with iron. Now this in no way calls in question the validity of measurement knowledge nor its importance in physical science; it is *one of many ways* of deriving cognition of the physical universe. But its validity and value will very often depend on previous judgments that are quite independent of any measuring process. Before applying a standard of measure, one must judge antecedently that the object is capable of measurement and that it demands a particular form of measurement. For example, one must judge that a body has length and is capable of linear measurement before choosing the unit of length. The very choice of standards presupposes such judgments. Unless these cognitive acts are valid, independently of any measuring process, the measurement itself may prove invalid. From whence it follows that bodies are not simply their measurement, and there is an objective distinction between physical bodies, their properties and the measurement of these bodies and properties. True knowledge may be

(9) Planck. "The Universe in Light of Modern Physics." p. 78.

(10) Planck. op. cit. p. 7.

(11) These notions on the Philosophy of Measure are based on Suarez, "Disputationes Metaphysicae," Disp. XL. Sect. III.

had either through the process of physical measurement or from other sources which in no way depend on the measurement process. We cannot agree with those who would try to maintain that measurement-knowledge is the *only* source of valid knowledge. This position was held much more strongly a generation ago than it is to-day. Though it may be a useful limitation in scientific investigation it cannot be accepted as a universal principle for human knowledge. This seems to be what Eddington had in mind when he wrote: "We recognize that the type of knowledge after which Physics is striving is much too narrow and specialized to constitute a complete understanding of the environment of the human spirit." (12).

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(12) Eddington. "New Pathways in Science." p. 316.

MATCH VENDORS AT THE STOCKROOM WINDOW

What a nuisance the lighting of Bunsen burners in laboratory has been in the past! Students are prone to light one burner from another and sometimes spill over tripods and apparatus in the stretching process. Who has not seen the contents of a drain or crock flash up because the unwary has dropped a glowing scrap of filter paper into such a receptacle? Part of laboratory discipline is education in regard for others through the principles of common safety. At Holy Cross we once got sick and tired of providing matches to the students for personal use "on his breakage allotment" because of the bookkeeping, the hazards of storage and because of the fact that the student would never be having matches anyway. We are now sick and tired of asking the student to provide his own matches especially in these trying days when he has to stand in line for his "Camelfields" even without free matches. Penny match vendors have been located at each of the stockroom windows. Instructors try to see to it that genuine matches are used in lighting up. If the student hasn't the penny, he can borrow one. If he has a dollar to change, we can change it perhaps. But in pennies! The device is popular. It makes for safe storage and minimum bookkeeping. It works.

B.A.F.

ASTRONOMY

OCCULTATION OF STARS BY THE MOON

By Rev. James K. Connolly, S.J.

Introduction

The following article attempts to collect in one place the practical information required by a person who may propose a program of occultation observation. Such a person need not be, officially, an astronomer and is not here assumed to be. The convenience of such a prospective observer guided the choice of subject matter. Hence no claim is made for originality, novelty or absence of previous publication. The compiler himself owes most of the matter in one form or another to the instruction of Reverend Thomas D. Barry, S.J.

One who proposes to observe occultations must know when to look for one, how to observe it and how to reduce the observation to results in the standard form. So one treats the prediction, observation and reduction of occultations. The treatment of each point will be divided according to the brightness of the star observed. The treatment of stars down to magnitude 7.5 is relatively simple. Below this magnitude the treatment is considerably different and considerably more difficult.

Prediction of Occultations

Stars Brighter than 6.55 Magnitude: The American Ephemeris,[1] "AE" predicts the time at which such stars are occulted at three standard stations in the United States. For an observer in the east the useful prediction is that given for longitude 72.°5, latitude 42.°5. The time given in the prediction is Universal Time, "UT," (Civil time of the meridian of Greenwich) of occultation at the standard station. To find UT at which an observer elsewhere should observe the occultation, solve:

$$UT = UT_{(\text{Standard station})} + a(n-n_0) + b(p-p_0)$$

Where UT is required observer's time

$UT_{(\text{Standard station})}$ is time listed for the occultation in AE "Occultations Visible in Long. 72.°30′, Lat. 42°30′ "ca. page 370.

a and b are constants listed for each star in this same section of AE

n_0 and p_0 are longitude and latitude of standard station

n and p are longitude and latitude of observer.

(1) Superintendent of Documents, Washington, D. C., Price $2.00 (Cloth)

Standard time of observation is found by subtracting from the observer's UT, five hours if the observer is in the E.S.T. zone, six hours if the observer is in the C.S.T. zone and so on.

One must be careful about dates. UT 3^h, May 20, is E.S.T. 22^h, May 19. The AE also gives in the same place, in the column headed "P," the position angle of the occulted star, for convenience in locating it. The vertex of the position angle is at the center of the moon. One side is a line from the center of the moon to the north point of the moon. The other side is a line from the center of the moon to the star at the instant of occultation. The north point of the moon is the point nearest the north star. Position angle is measured from the north point, through west to south. If a prism eye piece is not used the north point of the moon will be at the bottom of the field of view. If the prism eye piece is used the north point may be almost anywhere in the field. Swing the telescope a little toward the north star and the last point of the moon to leave the field of view is the north point.

Stars 7.5 Magnitude and Brighter: The British Nautical Almanac[2] "NA" predicts the times for which such stars are occulted for an observer at Montreal, among other places. The time given is UT for occultation at Montreal. The procedure for finding standard time of occultation for an observer elsewhere is the same as just described for the AE. Position angle is also given.

Stars Fainter than 7.5 Magnitude: If one has a telescope which can be used with stars below magnitude 7.5 and one wishes to observe the occultations of such stars a good deal more work and equipment is involved. To predict these occultations graphically one needs star charts which are complete down to the magnitude to be observed. For moderate sized telescope the Bayer-Graff or Bonner Durchmusterung charts are excellent. The observer of these fainter stars will also, later, need access to star catalogs to identify the stars he has observed. If some observatory will identify the stars for him he need not possess the catalogs himself.

The method of prediction is this: One computes the apparent position of the moon for four or five instants during the period of observation. These points are plotted on a piece of translucent paper and joined by a line to represent the path of the moon. The paper is placed in the proper position on a star chart and a scale model of the moon, a circle of correct size, is moved along the line. If, in moving the circle, a star is covered that star will be occulted and the approximate time can be noted from the position of the moon with respect to the plotted points.

The computations are made on days beginning a day or two after new moon and continuing till first quarter. After first quarter the

(2) H. M. Stationery Office, Adastral House, Kingsway, London, W.C.2, or American booksellers.

light of the moon will be so great as to blot out the fainter stars which alone need this method of computation. The computation can be arranged conveniently in columns containing, respectively (1) Local Standard Time, (2) UT, (3) the right ascension of the moon for each hour, (4) the local sidereal time of each hour, (5) the hour angle of the moon for each hour, (6) the declination of the moon for each hour, (7) the moon's parallax in right ascension and (8) in declination for each hour, (9) the apparent right ascension of the moon and (10) the apparent declination of the moon for each hour. In what follows the above numbers will be used in referring to the columns.

COLUMN 1. These hours of local standard time should cover the period from about one hour after sunset to the hour nearest moon set. The time of sunset and moonset for each day is ordinarily in the newspaper for that day in the weather report section. Or the times of sunset and moonset may be found from the tables of AE giving this information. It is sufficient to find time of sunset for one day since it does not change significantly in a week.

COLUMN 2. UT is found by adding to local standard time, five hours for an observer in the E.S.T. zone, six hours for those in C.S.T. zone and so on for the other zones.

COLUMN 3. Right ascension of the moon is copied from the AE for the time and date of column 2. WATCH DATES. Take RA only to nearest tenth of a minute of time. Column 6 should be filled in at this point.

COLUMN 4. Local sidereal time is found by (1st) Converting observer's longitude in degrees to equivalent angle in hours, minutes and tenths of a minute; (2nd) Looking up in first table of sun in AE, sidereal time of 0^h UT of following day and subtracting the longitude previously expressed in time. This difference gives local sidereal time of 1900 in E.S.T. zone, of 1800 in C.S.T. zone and so on. To find the local sidereal time of the other hours listed in column 1, add 1 hour 0.2 minutes for each hour following the one first found and subtract the same for each preceding hour. The 0.2 minutes is due to the difference between a sidereal and mean solar hour.

COLUMN 5. Hour angle of the moon. Subtract column 3 from column 4.

COLUMN 6. Declination of the moon is copied from the AE for the time and date of column 2. Take declination only to nearest tenth of a minute of arc.

COLUMN 7. Parallax of the moon in right ascension. The determination of this quantity requires a nomograph whose construction will be found in a paper by Reverend Thomas D. Barry, S.J., in Popular Astronomy, Vol. XL, No. 5, May 1932. The construction of the figure will be explained in an appendix. Supposing the nomograph to be at hand. A straight edge (any ruler) and stylus are needed. A sewing needle pushed into a block of wood about the size of a lead pencil makes a good "stylus." Lay the straight edge across the diagram so that it intersects scale (1) at the declination of the moon and scale (2) at the hour angle. Put the stylus at the intersection of the straight edge with the blank scale (3). Swing the straight edge around the stylus until it crosses the parallax scale (4) at the proper value of the moon's horizontal parallax. (Found for 0^h UT of date following local date about page 150 of AE). The parallax in right ascension will be read from scale (5) to minutes and tenths of a minute. This value is plus if the hour angle is negative and vice versa.

Column 8. Parallax of the moon in declination. This is found from another nomograph the use of which is similar to that of column 7. The straight edge is laid so as to intersect scale (1) at the proper hour angle and scale (2) at the proper declination, and the stylus is placed at the intersection of the straight edge with the blank scale (3). Then the straight edge is swung around the stylus so as to cut scale (4) at the value of the moon's horizontal parallax and the parallax in declination is read from scale (5) to the nearest minute. The parallax in declination is negative if the latitude of the station is north of the declination of the moon. Otherwise it is positive.

Column 9. Apparent right ascension of the moon. Add column 7 (it's ordinarily negative) to column 3. This changes the right ascension of the moon as it would appear from the center of the earth (column 3) to the right ascension it appears to have from the observer's actual position (column 9).

Column 10. Apparent declination of the moon. Add column 8 to column 6.

To Draw the Moon's Apparent Path: There will be required the values of precession in right ascension and declination, from the year of the star chart's publication to the year of observation, for the region of the sky being observed. This precession per year can be found from tables (e.g., NA for 1931, pages 720 and 721. These tables may be repeated annually.) From column 3 of computations find a value of RA which is nearly a mean of the values given in that column. Find the corresponding value of precession in declination from the last column of the table. The sign of this precession is given at the bottom of the table.

With the value of declination in column 6 of the computations corresponding to the "Mean" value of RA which was taken from column 3, find in table precession in RA. If the declination is minus (south) use as argument in finding precession in RA the previously chosen value plus or minus twelve hours. Do *not* use this changed value of RA in determining the sign of the precession in declination. Sign of precession in RA is always plus. Multiply the values of precession found in the table by (Current year—publication year of star chart)/60 and note result somewhere, as total precession to date.

On a sheet of good paper which will stand a good deal of handling draw a rectangle (or sector, for high declinations) the size of a section on the star chart 20 minutes of RA by 5^0 of declination. Fill in on this figure lines for every minute of RA and $15'$ of declination. Place over this figure a sheet of translucent paper (e.g., Mimeograph stencil backing paper). Trace the outline of the figure on the translucent paper and mark the corners with the coordinates of the square on the star chart in which the moon's apparent RA and declination fall. With the tracing paper still in position mark the moon's position as given in column 9 and 10 of the computations. Connect the points so plotted with a light line. With the paper still in position mark off the total precession to date, previously found. The total precession in RA will be marked on top or bottom line of figure, measured from right edge toward left. Total precession in declination will be marked on right or left edge of figure. If precession is plus, it will be marked off from bottom line toward top and vice versa. Plus precession lowers the traced figure on the star chart.

The star chart containing the coordinates of the corners of the traced figure is now brought out. The tracing is fitted into place according to the coordinates at its corners and then shifted to the right until the precession mark lines up with the 20 minute RA line on the chart, then shifted up or down (as the precession is minus or plus) till the declination precession mark coincides with the declination line on the chart. This moves the moon's path backwards to the position it would have occupied in the year the chart was published and corresponds to moving the star field forward from that date as precession actually has moved the star field.

To find what stars should be occulted by the moon, take a sheet of transparent plastic and draw on it a circle which represents the moon to the scale of the star charts. A fair scale would be a diameter of $31'$ of declination at declination 15^0 on the star chart used. Place this plastic sheet over the tracing sheet properly positioned on the chart and move the center of the moon circle along the moon's path. Move in the direction of increasing RA. Any stars which are touched by the circle in such movement should be occulted. To find the time of occultation, hold the moon circle so that the star is tangent to its edge. The position of the center of the circle with respect to the plotted hour marks allows the time of occultation to be estimated to about three to five minutes. In practice the predictions do not seem to be dependably accurate to much better than this. Such uncertainty is small drawback since the dark limb of the moon is ordinarily visible when observing these stars. Record the time of occultation and the position angle at the occultation should occur. Mark on the tracing paper the stars which will be occulted, number them and make an observation schedule giving this number of the star, its time of occultation, its position angle and its magnitude.

The stars predicted by any of these methods can be observed at either eclipse or reappearance, i.e., one may time either immersion or emersion, or both. These observations are not all of equal value nor does their observation demand equal experience. There follows a classification of stars in different magnitudes according to what, in the opinion of the compiler, is the order of priority of observation. The order is based on an attempt to balance value of observation, ease of observation by a moderately experienced observer, and ease of reduction.

First in this combined order of ease and value are dark limb immersions down to magnitude 7.5. The NA restricts its prediction of stars of this magnitude in the following manner.

New moon plus or minus 24^h no prediction

New moon plus or minus 48^h down to magnitude 1.9 magnitude

Full moon plus or minus 24^h predicts down to 3 magnitude

Full moon plus or minus 48^h predicts down to 5 magnitude

Full moon minus 72^h predicts down to 6.6 magnitude. There are also restrictions according to the altitude of the occulted star and the altitude of the sun. Apart from these restrictions NA predicts all dark limb immersions down to 7.5 magnitude. Omitting a day or so before and after full and new moon the AE predicts down to 6.55 magnitude.

Second in this order of combined ease and value of observation are dark limb immersions down to about magnitude 9. With good seeing and a fair telescope a ninth magnitude star can be observed to about first quarter of the moon. So compute predictions from a day or so after new moon, up to first quarter.

Third in the order of priority, according to one's devotion, from the NA and AE lists are

a, Dark limb emersions of stars down to 7.5 magnitude

b, Bright limb immersion of stars down to 4.5 magnitude

c, Bright limb emersions of stars down to 3.5 magnitude.

The magnitudes here given are the NA limits. The AE predicts a, b, c down to 6.5 magnitude.

It should be observed that observation of bright limb phenomena is here put third in order of priority, not because of its intrinsic value, but because of a combination of a lesser value and greater difficulty of accurate observation.

The NA restrictions of prediction given in the second section exclude some really possible observations. With good seeing a 7.5 magnitude star can be observed 24 hours before full moon. But there are not many such and the utility of making predictions for the periods not covered by the NA, between quarter and full moon, is doubtful. The AE will contain prediction, particularly of bright limb phenomena, which are excluded from the NA.

Observation of Occultations

If the telescope is to be used in an observatory, no special preliminaries need be observed except to open the dome some time before the scheduled time, in order that the temperature inside the dome may be equal to that outside. A difference in temperature will result in disturbing air currents through the opening in the dome.

In case a portable mount is to be used the procedure will be about as follows. The mount will almost certainly be a tripod of some kind. Set up the tripod in a place as sheltered as possible from the wind but with an unobstructed view of the moon. Place the legs of the tripod so that any connection between them is taut and so that one of the legs is on the side toward the moon. This will assure freedom of movement for the observer in the space between the other two legs. Make sure that the latitude setting of the mounting is set to the latitude of the observer. (If the telescope is on an alt-azimuth mounting nothing can be done about this latitude adjustment). Set the place of the mounting approximately level, and tighten nuts on tripod legs. Or, if the mount has spirit levels, tighten nuts on tripod legs, set spirit levels parallel to levelling screws and level mount as one would a surveyor's transit. The higher end of the polar axis of the telescope should point closely to the north star (Polaris). The instrument is now ready for use,—if the lens cap is off.

Next locate the moon in the field of view and focus on the craters visible on the surface of the moon. The star should then be visible at the correct position at the right of the moon. (If it's an immersion, if it's not too early and if no right angle prism is used). If the telescope has clamps and slow motion the clamps may now be set and further adjustments made with the slow motions as needed.

In case the dark limb of the moon is visible it will be unnecessary to keep the eye glued to the eyepiece, until the star is seen very close to the moon. Practice will determine when continuous watch should be started. When the dark limb is not visible, it will ordinarily be a case of observing an AE or a NA star and the former should be correct to better than a minute (for New England) and the latter correct to within a few minutes. So watching need not be continuous for more than three or four minutes. If the occultation is grazing, (position angle near 0^0 or 180^0) it may be well to start a little earlier. When the occultation occurs (and it will be sudden, if it is an immersion) the procedure then depends on the equipment available. If one has a good clock and chronograph one merely taps the chronograph key. If one lacks a chronograph but has a good clock, one starts a stop watch when the star occultation occurs and as soon as possible stops the watch on some integral minute of the good clock. Note with especial care the minute reading of the clock when the watch is stopped. It may seem a very careless thing to do, but one can easily mistake by a minute the instant at which the watch is stopped. If no good clock is available a Telechron may serve if it can be compared with a time signal the hour before and the hour after the observation. By a good clock is meant, in this context, one that can give the correct time to better than a second, to a tenth of a second is preferable. An unchecked Telechron is not good to this tolerance.

The stop watch is read and subtracted from the clock reading. The clock correction, obtained from time signals and interpolated to the time of occultation is applied to the clock time minus watch. If the clock is fast, subtract the correction; if slow, add it.

(To be continued)

RECENT INDEXES IN CHEMISTRY

"Patent Index for Chemical Abstracts, 1907-1936." This compilation was announced by Edwards Brothers, Inc., Ann Arbor, Michigan in August, 1943, and, after a survey of demand for the work, the price was set at $15.00. Publication has been delayed.

The "Fifteen Year Collective Index of the Analytic Edition of Industrial and Engineering Chemistry" has been announced for February 15, 1945. It will not be a mere compilation of previous annual indexes. Page-size will conform to that of the current analytic edition, and it will contain over one-hundred pages in columnar form similar to that used by Chemical Abstracts. The post-publication price has been set at $2.25.

"Chemical and Metallurgical Engineering Annual Indexes" for the years 1943 and 1944 have to be requested specifically by the subscriber and are available "as long as the supply lasts". Write to the Index Editor, Chemical and Metallurgical Engineering, 330 West 42nd St., New York 18, N. Y.

"Chemical Reviews" still has its ten-volume quinquennial index bound with the last issue for a given run. The latest appeared with volume 30, 1942.

"Journal of Biological Chemistry", now in its 158th volume, still offers indexes from volumes 26 through 125, each index covering 25 volumes. These may be bought from the Williams and Wilkens Co., Mt. Royal & Guilford Ave., Balto. 2, Md.

Harpes Chemical Laboratory
St. George's College
Kingston, Jamaica

CHEMISTRY

CHEMISTRY AT ST. GEORGE'S COLLEGE PAST, PRESENT AND FUTURE

By Rev. Joseph A. Martus, S.J.

The first chemistry class to be held at St. George's College was conducted in January, 1935, by Fr. John A. Blatchford, S.J., over a lecture desk of slate taken from a dismantled billiard table. The lecture-room was located in what was formerly the old club-house, and before that one of the college buildings. Twelve boys comprised the first class, and, in contrast to the make-shift lecture desk, had for experimental work an 18 ft. standard laboratory desk, adequately stocked and fitted, and imported from the Kewaunee Co. in the U. S. A. It is certainly a far cry from the dark, rickety old club-house of those early days to the present excellent and commodious laboratory, built and outfitted with careful planning and patience. However, those early days are not so far away that the above-mentioned incunabula are now museum pieces; for the laboratory desk is one of the three, it is hoped soon to be four, desks in use at present, while the old slate table serves as a work-bench in the stockroom.

St. George's College began chemistry when the Board of Education demanded that a grant-aided school, to receive a grade-A grant, should have a suitable science course and laboratory. To fulfil that requirement the headmaster, Fr. Leo Butler, S.J., had Fr. Blatchford inaugurate the chemistry course and prepare the students in chemistry for the Cambridge Senior Examination. This is an examination for secondary school pupils, comparable in subject matter and difficulty to the American College Board Examinations. Also, boys who wished to prepare for medicine in English universities were required to pass at least the Cambridge Senior Examination in chemistry, and therefore St. George's had to make provision for the embryonic doctors among its scholars.

The first chemistry department in the old club-house was soon found to be inadequate, and Fr. Kelly, Superior of the Mission, and Fr. Butler formulated plans for a building, extensive enough in size and equipment adequately to handle the then present demand for chemistry, and also the largest possible growth of the college. It was providential that Fr. Blatchford spent his regency at Loyola in Baltimore under Fr. Harry McLaughlin, S.J., who was supervising at the time the erection of the very excellent science laboratories at that college. From this experience Fr. Blatchford undoubtedly gleaned many fine ideas concerning a well-fitted chemistry laboratory and was an invaluable aid to Frs. Kelly and Butler in designing and equipping the building. The cornerstone was laid in 1938 and the completed structure dedicated in March 1939 by His Lordship, Bishop Thomas A. Emmet, S.J., to the memory of Fr. John Harpes, S.J., who had built the present St. George's College building twenty-five years before.

Fr. Blatchford planned the new laboratory not only for "Senior Cambridge" chemistry, but also for "Higher School" chemistry, a course and examination which has no exact equivalent in the American system of education. The preparation of this latter chemistry examination, to confine ourselves to this subject out of the several electives taken, requires two extra years of study and the syllabus includes a more intensive study of inorganic chemistry, a laboratory course in qualitative and volumetric analysis, and courses in physical and organic chemistry. The inorganic chemistry, qualitative and volumetric analysis are taken at a level comparable to that in the American college pre-medical course, the organic chemistry at a somewhat lower level, and the physical chemistry in an elementary though fundamental fashion. The examination is regarded as "rather stiff."

To finance the purchase and arrange the transportation of all the apparatus and chemicals necessary for eighteen lockers in all branches of this "Higher School" chemistry course, and for forty-eight lockers in the "Senior Cambridge" course, was by no means an overnight job. What with the advent of the war and consequent delay in shipping, the normal lengthy period required for the arrival of freight was considerably increased. However, today the laboratory, a very model of excellence in construction, apparatus and equipment, stands as a tribute to the careful, patient and long-visioned planning of Fr. Blatchford. It is interesting to note here that Fr. Blatchford also inaugurated the Physics course in January 1941, which Fr. Dutram took up in the September of that year; in the same term he began the Botany course, to be taken over by Fr. Hennessy in September of the same year. In 1938 he erected an amateur radio station at St. George's College, at present is operating the lone seismology station on the Island, and also devotes a portion of his time to an orchard of tropical fruit trees, whose excellent fruits, at least those which escape the acquisitive fingers of our native help, grace in due season our humble board.

But for all this wise and generous planning in the construction of the Harpes Chemical Laboratory, its designers little dreamed of the rocket which was to burst on the scene of the Jamaican educational world in September 1942. In that month St. George's College opened its doors to an adult education program, the Extension School, a project sponsored by Fr. Superior, V. P. Thomas J. Feeney, S.J., and the first of its kind to be attempted in Jamaica. Elementary chemistry, under the direction of Fr. Blatchford, was among the subjects offered, and the curriculum allotted to the course two periods a week for a term of ten weeks. Chemistry soon proved very popular, especially for those who wished to prepare themselves for medicine or higher chemistry in England, Canada or the United States. Fr. Blatchford conducted the evening classes for two years and was able to bring a group through elementary chemistry, qualitative and volumetric analysis. During this time he carried his normal teaching schedule in the day school and when in September, 1944, it became feasible to offer organic chemistry and increase the chemistry schedule to five evenings per week, Fr. Blatchford relinquished the evening school and the writer was assigned to this job and that of teaching the Higher School chemistry as well.

Some thirty people, both men and women are enrolled at present in the elementary course, consisting of two periods per week, and about twenty, all that can be accommodated, attend the advanced course for three periods a week. A ten-week term is not sufficient time to cover all the chemistry normally taken in those courses, so that the class period runs variably from one to one and a half clock hours, and the laboratory period from one and a half to two clock hours. St. George's College does not offer these courses with credit, though some universities, such as McGill in Canada, have in certain instances accepted the courses and given their own credit for them. In preparation for studies in the English universities a student in Jamaica can concern himself or herself with passing the various "external" examinations and not worry at all about having a certain number of credits. Thus the Extension School is still a new venture in Jamaican higher education; in the broader world of education it has no recognized standing, other than what can accrue to it by the successes and achievements of its alumni and alumnae.

What the future will hold for St. George's College Extension School is, at a risk of being banal, as much a mystery as any other future event. That in its short years of existence it has been a boon to education in Jamaica and given many people the chance and encouragement further to educate themselves, all of its students will testify. That, given men, money and time, it can grow to a greater height and blossom into a Jesuit college such as we are familiar with in the States, it would be temerarious to deny. Certainly the men on the staff recognize the chance and are anxious to grasp it. And it seems quite certain that it can develop along traditional Jesuit lines with a very great and profitable emphasis on the science subjects: Physics, Chemistry and Biology.

In chemistry alone there is a fine opportunity to offer, besides the usual academic courses, specialized courses in sugar chemistry, agricultural chemistry and perhaps in other fields of industrial application. No one is in the field in Jamaica and we are the first to scratch the surface. Uncertainty arises from several sources, to mention only two: First, the desire on the part of many students to pass the above-mentioned external examinations from Cambridge University as the be-all and end-all of scholastic attainment, and the highly spurious distinction accorded to these examinations, which, in the mind of the Kandel Commission, an educational survey group headed by Doctor Kandel from Columbia University, have little or nothing in common with the life of the average Jamaican; secondly, there is strong talk at present being bruited about concerning a West Indian University, and Jamaica, as the largest British island posssession in the West Indies, will make a strong bid to have it located in Jamaica. This will undoubtedly mean competition, unless we are so firmly entrenched in the field that no one can afford to ignore us. The task of building from the ground up is not a new one, but it will be such a task, and not a wordy concatenation of diaphanous dreams. It has the intriguing aspect that here we have a wide field for development. There are quite a number of vocations on the island, besides medicine and nursing, that require a thorough knowledge of chemistry, and if we can continue to attract students in greater numbers to our science courses, we could easily supply existing needs and also newer fields of chemical endeavor.

The use of earphones in conductivity work may become nerve-wracking at times even in a sound insulated room. By substituting a Cenco 82121 Rectifier Unit in series with an L & N 2420 D.C. Galvanometer (with internal illumination, mirror and ground glass scale) this difficulty is also obviated, at least within the precision required of the student. The galvanometer mentioned is relatively expensive for such a purpose; but it is to be found in many a laboratory—, and for a good part of the year it may be idle. It can be set up as safely in use as on the shelf. A common door bell transformer provides a convenient source of current for the lamp terminals.

Oil for oil baths in organic laboratory is not necessarily to be chosen on the basis of high flash point alone. Some samples of lubricating oil, recommended in the laboratory manuals, fume badly at temperatures near that of boiling water, and far below the flash point. A recent inquiry about this at Holy Cross reminded us that SOCONY'S Alaska Cylinder Oil (flash 300° C; fuming only slightly at 210° C.) is as ideal today for general use as it was back in 1929. Hormone, 3, 136 (1929).

METEOROLOGY

THE PIONEER FORECASTERS OF HURRICANES

By the REV. WALTER M. DRUM, S.J.

(*Continued from March issue*)

We have thus far said little about the hurricane warnings of Fathers Vines and Gangoiti. Is it true that the discoverer of the laws of the cyclone kept all his knowledge to himself? Was "the issue of warnings of hurricanes a most radical change introduced by the U. S. Weather Bureau?" Had the inhabitants of Cuba been "accustomed to hear of these phenomena only upon their near approach?" No! Most emphatically, No!

It is not certain when Fr. Vines began the warning service. The earliest extant printed record of any forecast by him bears the date Sept. 11, 1875; he saved many lives during the hurricane of Sept. 12-14, 1875. On Sept. 14, 1876, he forecasted a violent hurricane and its trajectory. One ship, *The Liberty*, disregarded his authority and was wrecked in the path he had pointed out. No passengers were lost; all had believed Fr. Vines' forecasting of the hurricane. Does this fact lead us to consider that the Cubans were "accustomed to hear of these phenomena only on their near approach?"

On Oct. 19, 1876, *La Voz de Cuba* sent out an extra to say: "We have just received from Rev. Fr. Vines, the learned director of the Meteorological Observatory of the Royal College of Belén, the following important communication that we hasten to make known to the public before the time of our evening edition. . . . We are very near to the vortex of a hurricane." The paper then quoted the Jesuit, who located the hurricane, told how the wind would continue N. E., then would come a calm that should not be trusted, and thereafter the wind would shift with sudden and terrific force to S. W. All were urged to make preparation for the cyclone. The storm came exactly as predicted by Fr. Vines. *La Voz de Cuba* and *Diario de la Marina* were loud in praise of the protector of the city. Does this fact bear out the assertion that "it was difficult to interest the people in the warning service?"

The people of Cuba were so interested in his warning service, that as early as 1877 Fr. Vines was able to organize a system of substations at various points in Cuba and other islands of the Antilles.

These stations made simultaneous observations, and wired the results to Havana. During the year 1877, Fr. Vines announced the path of a cyclone before it was felt in the Barbadoes. The cyclone reached the Barbadoes in the evening and Granada during the night of September 21st; St. Vincent, the night of 22nd; Santiago de Cuba, the 24th; it then spent itself in the South of Cuba. Fr. Vines announced the storm at 4 P. M. of the 21st. On the 22nd, he sent word to Porto Rico that the hurricane had passed the night before at fifteen miles per hour on its way from Granada to St. Vincent, and would not touch Porto Rico. At the same time he wired full information about the storm to Santiago de Cuba, and added: "It will reach you on the 24th; be on your guard." Everything happened according to the Father's forecast. The people of Cuba and Porto Rico were enthusiastic in praise of the Havana Jesuit. The *Buletin Mercantil* (Oct. 5, 1877) of Porto Rico said: "Fr. Vines, whose voice has for us the authority of an oracle, calmed our souls by his timely notice. He well deserves the European reputation that he enjoys. Spain should be proud of him."

From this time on, the Observatory's warning service has been most extensive. Twenty-eight bulky volumes full of clippings from Cuban and United States papers show the interest taken in communications of warning or other forecasting that emanated from Belén. And it must be remembered that Fr. Vines gave his great aid to navigation and commerce in the most disinterested way; he neither asked nor accepted a *peseta* in return for his services. His motives were clearly set forth on July 18, 1886, in the plan of meteorological improvements proposed to the Havana Chamber of Commerce. "For my part," he writes, "I am desirous only of serving all so far as service is rendered possible by my poor health and the limited means at my disposal; nor do I wish other recompense, after that which I hope from God, than to be of use to my brethren and to do my little share for the advancement of science and the good of humanity."

The number and value of the services done by Fr. Vines for the good of humanity may not be overestimated. Far back in the year 1879, on October 14th, we find recorded forty three communications from him to the press, either by telegram or by cablegram. These communications represent the Father's forecasting in a single day. From the year 1887, we find constant reference to the forecasts of Fr. Vines in *La Voz de Cuba* and the *Diario de la Marina*.

The telegram goes faster than the fastest wind. Fr. Vines was, therefore, long desirous to receive speedy information from every point in the hurricane zone of the Antilles. At last his hope was fulfilled. On October 13, 1886, a committee of the Chamber of Commerce of Havana called on the Jesuit to thank him for past services. An outcome of that visit was that the Chamber of Commerce and several other private concerns very willingly stood the expense of the plan that Fr. Vines was trying to carry out. By 1887 there was complete organization of information-stations at all necessary points in the hurricane zone,—at Trinidad, the Barbadoes, Antigua, Martinique, Porto Rico, Jamaica, and Santiago de Cuba. No cyclone could now come into the Antilles or from therein without being located by Belén. The *Pilot Chart* of October, 1889, says: "As Havana has very complete telegraphic communications eastward, early and reliable information is received of every hurricane that is likely to reach that port or any of the adjacent waters."

Can it be that the writer, who has wronged the Observatory, never heard of this wonderful work done by Fr. Vines? Has he not read or studied any of the Father's fourteen special treatises and numerous quarterly reports of magnetic and meteorological observations? Why, meteorologists of the United States have been unanimous in their praise of Belén!

The *Pilot Chart* for Sept., 1889, says: "This morning the meteorologist at Havana, 900 miles away, reports the cyclone's movement, guided by the motions of the upper clouds . . . The chief signal officer is pleased to acknowledge the ability and zeal of Fr. Vines."

The *Times-Democrat* of New Orleans, in one of its September numbers of 1890, soys: "A Havanese meteorologist, who has made *observations and forecasts gratuitously for a quarter of a century* . . . Padre Vines, a celebrated Jesuit priest in Havana . . . is regarded by navigators and meteorologists all over the world as one of the most correct and reliable weather scientists of the age . . . During the hurricane season his opinion is anxiously sought after . . . It has been a *general custom for years for the Padre to inform the agents* of various lines of the condition of the weather just prior to the departure of the vessels. During the many years that this excellent work has been performed, it has on many occasions resulted in saving lives and a great deal of valuable property." In another number, the same paper says: "Padre Vines, for all that long period, without a thought or a hope, or even a possibility of a reward, but simply for the love of humanity, has continued his labors, and given the result of them gratuitously to the masters of the vessels and others whose business is affected by meteorological variations . . . A man who has done so much for the interest of American shipping and shipowners, as has been done, for sheer love, by Padre Vines, deserves at least a recognition by our government." Yes, such a man deserves at least to be spared the slur which has been cast upon his reputation by anyone who writes that "the issue of warnings of hurricanes was a most radical change" introduced into Cuba by our government meteorologists.

The sentiments of the foregoing citations are those of many of our government officials.

After the downfall of Spain's supremacy in Cuba, the Jesuit Observatory was very much hampered. It was denied the free use of telegraphic wires. All privileges hitherto enjoyed by Belén were transferred exclusively to government employees. Popular discontent and complaints of ship-companies then showed our government the standing of the Jesuit meteorologists in the community, and brought to Belén the most courteous and cordial treatment. We shall cite the opinions of a few of our officials.

In 1894, Fr. Gangoiti wrote Mr. M. W. Harrington, ex-Chief of the Weather Bureau of the United States, that the reports of Belén to Washington would no longer be required, because one who signed himself "Weather Bureau Observer" was then making weather-reports in the daily press of Havana. Mr. Harrington made answer: "I have the honor to inform you that Mr. N. is not an observer of this Bureau and has no authority from this office to send cablegrams. It is hoped

that you will reconsider your decision and telegraph reports to the Bureau, under the arrangements previously made, as it is thought that your facilities for getting information of hurricanes occurring in the West Indies are such as to make your reports very valuable to this Bureau. Your telegrams of Sept. 20th and Oct. 4th, were the first notifications we received of the storms of those dates."

The present Chief of the Weather Bureau, Prof. Willis L. Moore, wrote on May 12th, 1897: "As the hurricane season is approaching, I write to ask if you will be able during the coming season to telegraph me information, as you have heretofore done, of the occurrence of hurricanes in the West Indies? Please accept my sincere thanks for your services last year in this connection. Will you kindly inform me what regions in the West Indies you are in communication with and are liable to receive reports from as to the existence of these storms?"

Evidently Mr. Moore did not consider that the Jesuits of Belén were "accustomed to hear of these phenomena only at their near approach."

After our officials had succeeded in improving the sanitation of Havana, General Ludlow reported: "The labors of the College Observatory are of immense value at this time in connection with the work of sanitation as well as of science generally."

While General Brooke was Governor-General, Mr. H. H. C. Dunwoody, who was then in charge of the telegraphic service in Cuba and had for twenty five years been employed in our Signal Service, visited Belén and there stated that, if our observatory of Washington excelled in the number of its instruments and the worth of its equipment, the Jesuit observatory of Havana excelled in the perfection and exactness of its published works.

Such very cordial relations existed between our meteorologists and Belén, that Mr. Moore, the Chief of the Weather Bureau of Washington, wrote Fr. Gangoiti a glowing tribute to the work of the Jesuit observers in Havana, and on his own initiative stated that it would be his most earnest wish to recommend to the Secretary of Agriculture of the United States that the Observatory of Belén be the official center of our meteorological service in Cuba. He wrote to Fr. M. Gutiérrez-Lanza, S. J., on Oct. 15th, 1901, that when Cuba became free we should certainly have to hand over to some Cuban institution the care of the weather reports that was then exercised by the Weather Bureau. He also said, in this letter, that he had recommended to Secretary Wilson that the Observatory of Belén be the Weather Bureau's successor and forecaster in Cuba. Mr. Moore actually set about to carry his plan into action, but failed of his purpose. Secretary Wilson and he recommended Belén to the Cuban Government. The press of Cuba desired that the Jesuit Observatory be give official character. The Cuban Government took no heed, and went its own way.

Mr. W. M. Black, while at work on the improvement of sanitary conditions in Havana, obtained all his meteorological data from the Jesuits. He took their records of maximum daily, monthly and annual rainfall; of maximum deviation of hurricanes; of magnetic variations, and such like climatological elements.

To anyone who will look over the many documents published by Fr. Gutiérrez-Lanza, there cannot remain the last doubt that our officials have by no means thought Cuba in need of a "radical change" from the methods of Jesuit meteorologists.

Officials of many other countries could also be cited in praise of the work of Belén. M. Saussine, Professor of Physical Science in the Lycée of St. Pierre, Martinique, wrote to the Fathers in 1894: "Here in Martinique, on the occasion of the cyclone that has just passed, we have been astonished at the quickness of your information and at the accuracy of your forecasts."

We shall advance only one more example of the accuracy of the forecasts of the pioneer forecasters of hurricanes. It is a splendid example, an example that comes home to us Americans, and drives us to the conclusion that the United States Weather Bureau's branch office did introduce a "radical change" by its issue of hurricane warnings, but the change was radically for the worse and not for the better. Better for us would it have been, if the pioneer forecasters of hurricanes had been trusted and no Weather Bureau observer had been sent to Havana. We refer to the sad destruction of Galveston.

On September 1, 1900, a cyclone of little force appeared in the eastern part of the Caribbean sea, crossed the center of the Island of Cuba, moved on W N W, passed South of Florida, acquired full force and terrific intensity in the Gulf, and on September 8th, swept down on the helpless city of Galveston.

The United States Weather Bureau observer, on September 5th, announced that the hurricane was E ¼ NE of Havana with a course N ¼ NE, and would spend itself in the Atlantic.

That very day, Fr. Gangoiti published the announcement that the cyclone was South of Florida. On September 6th, at noon, he stated through the press, that the storm was in the Gulf and W S W of Tampa. On September 8th, at 4 P. M., while Galveston was being torn to very pieces, he published his report that the currents on the right of the storm had been felt in Georgia and Alabama during the morning of September 7th, and in Louisiana during the evening of the same day; and that the very centre of the hurricane had reached Texas the morning of September 8th. By September 10th, no word of the Galveston catastrophe had yet reached either the United States Weather Bureau or Belén. At 8 A. M. that morning appeared Fr. Gangoiti's press notices of clear signs that the tempest had grown very much fiercer and had probably struck Texas. These notices the Father ends by saying that the Washington *Weather Maps* will settle whether his forecast or the Weather Bureau's was right. In grim array with Fr. Gangoiti's report of September 10th, stands this fatal forecast of the United States Weather Bureau observer: "This morning at the Weather Bureau we have noted slight indications that in the W N W is forming an atmospheric disturbance *scarcely worth mentioning*." The Galveston storm went on, and our Weather Bureau observer thought it "an atmospheric disturbance scarcely worth mentioning." No wonder, then, that he found "it was difficult to interest the people in *his* warning service."

A few hours after these two characteristic reports appeared, the sad news of Galveston's fate began to arrive by cable. Later on both the *Pilot Chart* (October, 1900) and the *Weather Maps* traced the trajectory of the Galveston storm exactly as it had been followed by Fr. Gangoiti in the press of Havana. The Cuban papers turned such a stream of ridicule on our Weather Bureau observer as to force him to send them no more forecasts. For a whole month the Havana press kept up its affectionate praise of Fr. Gangoiti, and bitter invective against the "radical change" introduced by our official.

Not till 1902 did the Cuban Branch Office of our Weather Bureau again take up the publication of hurricane warnings, and its forecasts were thereafter those of the Central Office of Washington. It is noteworthy that every such warning published by our agent in Havana during 1902 and 1903 was contradicted by Fr. Gangoiti and turned out to be a false alarm.

Naturally enough the Cubans have not forgotten the efficiency of Belén and the inefficiency of the Weather Bureau observer. They were aroused to indignation by the report we criticise.

El Commercio says of this report: "The statement is bold,—nay more, it is insolent in view of the dreadful event at Galveston which the wise meteorologists of the United States could not foresee, suspect, or forecast. . . . Cuba has never fared so ill; for it has ever had really wise men like Fr. Vines and Fr. Gangoiti to forewarn the inhabitants of the dangers that threatened.

El Nuevo Pais said: "The Weather Bureau thought the storm shut in by the Atlantic; the modest savant of Belén insisted it would penetrate into Texas."

Many other papers called attention to the great "radical change" introduced by our Weather Bureau into Cuba,—the failure to locate a hurricane aright, and especially the failure properly to trace the trajectory of the Galveston storm. All urged that the loss of life at Galveston would have been undoubtedly less had the Weather Bureau issued such warnings as the people of Cuba look for and receive from the Observatory of Belén.

Among the prominent men who voiced the tone of the Cuban press and cried down the statement that we are criticising, were Sr. D. Antonio Gonzalez de Mendoza, Chief Justice of the Supreme Court; Sr. D. Rafael Montoro, Minister Plenipotentiary to London; Robert Mason, English Consul in Santiago de Cuba; the Southern Pacific Shipping Co.; the Plant Steamship Line, and others.

Facts and citations could be multiplied almost indefinitely. We hope that what we have given will go far to save the fair name of the Observatory of Belén, and to show that for thirty years the Cubans had been thankfully receiving Jesuit forecasts before our Weather Bureau observer found it "difficult to interest the people in *his* warning service," and introduced the "radical change" which has brought out into clearer view the debt that Cuba and the whole world owe to Fathers Vines and Gangoiti, the pioneer forecasters of hurricanes.

(End)

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