THE 100-INCH HOOKER TELESCOPE OF THE MOUNT WILSON OBSERVATORY.

GEORGE E. HALE, Director.

After a series of tests extending over several months, the 100-inch telescope of the Mount Wilson Observatory has been found to be a complete success. The construction of this instrument, begun several years ago, was necessarily an experiment, as it was by no means certain, after the optical and mechanical difficulties had been overcome, whether the atmosphere would be sufficiently tranquil to permit clearly defined images of celestial objects to be obtained with so large an aperture. Mount Wilson, situated in the favorable climate of Southern California, where the best of results have been secured with telescopes up to 60 inches aperture, is a site as promising as any that could be found. But as observations with smaller instruments are insufficient to settle the question, the actual performance of the telescope could not be predicted with certainty.

The tests, which permit the performance of the new instrument to be directly compared with that of the neighboring 60-inch telescope, show that the full gain in light-gathering power, to be expected from the increased aperture, has actually been attained. The 100-inch telescope thus collects nearly three times as much light as the 60-inch telescope, and concentrates it in images so sharp that the gain in brightness is fully utilized. This means that the atmospheric conditions on Mount Wilson have proved to be good enough to meet the very severe demand.

The sharpness of astronomical photographs obtained with the 100-inch telescope may be judged from some large pictures of the moon, which bring out very small details. These were taken with the combination of mirrors that give the telescope an equivalent focal length of 134 feet. Photographs of small nebulae taken at this focus also show details of structure of great interest.
Plate XLIX

Photograph of the Moon taken with the 100-inch Reflector of the Mount Wilson Observatory; Equivalent focal length 134 feet.

Popular Astronomy, No. 270.

Courtesy Maria Mitchell Observatory • Provided by the NASA Astrophysics Data System
It will naturally be the policy of the Observatory to apply the 100-inch telescope chiefly to the study of faint and difficult objects beyond the reach of our smaller instruments. Hitherto most of the observations have been made with the aid of spectrographs attached at the 134-foot focus. The great light-gathering power permits the spectra of extremely faint stars to be photographed with moderate exposures. In this way the motions of faint stars in the heart of globular clusters and in the star-clouds of the Milky Way can be measured. By applying Adams' spectroscopic method of measuring the distances of stars, it will also be possible to distinguish between stars that are faint because they are small or feebly luminous and those that are actually bright but are rendered faint by their great distance.

A few results already obtained through the study of faint stars with the 100-inch telescope may be of interest. For the first time, except in the case of new or temporary stars, the unknown gas nebula, the most conspicuous of the elements constituting the irregular cloud-like nebulae, has been found to be present in the atmosphere of a star (R Aquarii). This star is a faint reddish object, which varies greatly in brightness in a period of about a year.

A faint variable star in the constellation Taurus, associated with one of the few nebulae known to vary in brightness, has been found to have an extensive atmosphere in which brilliantly luminous clouds of calcium vapor are conspicuous. Another peculiarity of this star is its extremely high temperature when near its maximum brightness.

The faint companions of close double stars, when studied spectroscopically with the new telescope, have already yielded interesting results. Such systems are of great interest in the study of stellar evolution, but the fainter members, especially when very close to their bright companions, have previously been beyond the reach of our spectroscopes.

These examples will suffice to illustrate the present work of the 100-inch Hooker telescope, named for the late John D. Hooker of Los Angeles, donor of its optical parts. Several new classes of observations will soon be made with the aid of special appliances now nearing completion.
THE REFORM OF THE JULIAN CALENDAR.

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ROSCOE LAMONT.

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The average length of the Julian year is 365 1/4 days, which is about 11 1/4 minutes greater than the tropical year. Since there are 1440 minutes in a day, the number of years that must elapse before the excess amounts to one day will be found by dividing 1440 by 11 1/4, which gives 128. Therefore at the end of 128 years the time of the equinox would be one day earlier in the calendar. When the Julian calendar was established in the year 45 B. C. the equinox occurred about March 24, and in 325 A. D. it came about March 21. At this rate, in a little over 10,000 years the equinox would fall on the first of January, and in 22,000 years the fourth of July would come at the time of the winter solstice. This would not do at all, and in order to prevent any such occurrence the calendar was reformed again.

But the idea of the reformers was to restore the equinox to March 21, the day on which they supposed it came in the year 325, when a Council of the Church was held at Nicaea, in Asia Minor, which made a decision as to the time of celebrating Easter. One sect of the Christians, following the Jewish practice, observed the fourteenth day of the moon, on whatever day of the week it came, which fell on or next followed the date of the equinox; but the greater number condemned this practice, wishing to have nothing in common with the Jews, who boasted that without instruction from them the Christians wouldn't know when to celebrate Easter. When the Nicene Council was held the Romans placed the date of the equinox at March 18, and the Alexandrians at March 21, but modern astronomers who have written on this subject say that the equinox in the year 325 came on March 20. The Alexandrian determination appears to have been accepted, and the rule laid down that Easter was to be celebrated on the first Sunday after the fourteenth day of the moon which falls on or next after March 21, the date of the equinox, the computation to be made by the Church of Alexandria, the most skilled in the science of astronomy, and the Church of Rome to make it known. The Romans, however, continued to make their own computation, for Hefele, in his History of the Church Councils, says that in the very next year, 326, the Romans celebrated Easter on a different day from the Alexandrians, and that the same thing happened in the years 330, 333, 340, 341 and 343. But though councils might by decree fix the equinox at March 21, it none the less continued to come one day earlier in the month every 128 years, falling on March
The Reform of the Julian Calendar

11 in 1582 when the reform of the calendar was carried into effect, and to restore the date to March 21 the omission of ten days, or, better, the dropping of ten monthly dates, was necessary.

The question of the reform of the calendar had been discussed for more than three hundred years before it was carried out, and for a much longer time it had been known that the Julian year exceeded the tropical and that, therefore, the date of the equinox was retrograding. In a work by Boni de Luca, written in the year 1254, quoted by Duhem in his System of the World, is the following:

"It is known that when Christ was born the winter solstice fell on the day of the birth of the Lord, and then the days began to increase, and the summer solstice fell almost on the day of the nativity of Saint John the Baptist, the eighth day before the calends of July, when the days began to decrease. Therefore John says of Christ: It is necessary that be increase and that I decrease. But now the solstices and equinoaxes have retrograded ten days, and that has happened on account of the error of our calendar, since the solar year is not completed in 365 days and 6 hours, but it lacks eight moments which are the fifth part of one hour. Thus in five years we are in error one hour, and in one hundred twenty years we are in error one day, and unless the error is corrected the festivals of spring will be found in the summer."

In the thirteenth century Roger Bacon, in a work transmitted to Pope Clement IV, proposed the reform of the calendar, saying:

"Julius Caesar, learned in astronomy, regulated the calendar as well as it was possible in his time, but he did not determine the true length of the year, which he placed at 365¼ days, which quarter of a day he combined every four years and in bissextile years computed one day more than in common years. It is found, however, by astronomical methods that the length of the solar year is not so great by almost the 130th part of one day, and, therefore, in 130 years one superfluous day is counted, which, if taken away, would free the calendar from this error."

Dealing with the subject again in another part of his work, he finds the error of the Julian year to amount to one day in 125 years, and he explains in the following way how this was determined:

"For Ptolemy, in the one hundred fortieth year from the Incarnation, found the vernal equinox to be on the eleventh of the calends of April (March 22), and the winter solstice on the eleventh of the calends of January (Decembr 22), as appears from the Almagest. But from this place in the calendar to the ides (13th) of December where the solstice now is there are nine days. Since the determination of Ptolemy 1127 years have elapsed, the present year being 1267, and 1127 divided by 9 gives 125 and 2 over. Therefore the date of the solstice and equinoaxes one day in 125 years."

In the histories of the calendar reform by Ferrari, Hagen and Kaltenbrunner, the names of more than twenty writers are mentioned who suggested methods of correction, and the question was considered by most of the Church councils that were held in the fifteenth and sixteenth centuries.

The French Cardinal Pierre d'Ailly, reformer and astrologer, who predicted in the year 1414 that in 1789 there would be great alterations and remarkable changes, especially in laws and religion, if the world
was then in existence, in writing on what needed reform did not over-
look the calendar.* Cardinal d'Ailly's work was presented to the Coun-
cil of Constance in 1417. He considered the error of the Julian year
to equal one day in 134 years, and he therefore proposed to omit one
day after every such period, but if the 134th year was not a leap year,
then the year nearest the 134th which would ordinarily be reckoned as a
leap year was to consist of 365 days, and he said that in gratitude for
this correction that year would deserve to be called the year of jubilee.
He did not advocate the omission of any days to restore the equinox to
its place in the time of Julius Caesar or when the Nicene Council was
held. To drop one day whenever the small excess of the calendar over
the tropical year has accumulated to one day (in 128 years) would be
the most accurate method of correction, although the omission of inter-
calations in centurial years, according to the plan adopted, is simpler
and more convenient.

The most famous astronomer of his time was Johann Müller of
Königsberg, commonly known as Regiomontanus from his birthplace.
In 1474 he published his Calendarium giving the time of the occurrence
of solar and lunar eclipses for many years in advance, with diagrams
showing their magnitude. In Thacher's Life of Columbus there is a
photograph of a page of this calendar, and it was by means of the work
of the Königsberg astronomer that Columbus on his fourth voyage,
when stranded on the Island of Jamaica, was able to predict the lunar
eclipse of February 29, 1504, when he told the Indians that because of
their refusal to supply him with provisions God would punish them, and
show his anger by giving the moon a bloody hue that very night, a
drawing of this particular eclipse being one of those reproduced by
Thacher. Pope Sixtus IV resolved to make his Pontificate illustrious
by reforming the calendar, and having created Regiomontanus Bishop
of Ratisbonne, invited him to Rome in 1475 to engage in the work.
Regiomontanus, however, died the next year in Rome at the age of
forty, some authorities say of the plague and others that he was poi-
soned, and, Dreyer says, "the chance was thus lost of getting the pro-
posed reform accomplished while the whole of Christendom still ack-
nowledged the supremacy of the Pope."

In Marzi's work, "The Question of the Reform of the Calendar in
the Fifth Lateran Council", published in Florence in 1896, a full
account is given of the efforts made at that time to bring about the re-

*The Cardinal made another pretty good hit, writing in 1418: "From the
astronomical conjectures set forth it is not possible to conclude anything with
certainty, but yet from these and other considerations above mentioned, it may
be inferred as probable that in a century from the present year there will be vio-
ient contentions about laws and sects, and especially about the law and Church
of Christ." An astrologer might consider this as foretelling, after a look at the
stars, the Protestant Reformation which began in 1517. As an astrological proph-
et the Frenchman was in a class by himself, although if the number of times
he missed were counted his average would probably be low.
form. This council met in Rome in 1512, and Paul of Middelburg, a city in Holland, was the prime mover in the matter of correcting the calendar. Letters were sent to the various rulers of Europe asking for advice and assistance. Pope Leo Tenth wrote to Henry the Eighth, King of England (to whom he gave the title of Defender of the Faith—taken away later), and pointed out the errors in the calendar, telling him that the moon was five days old when the church calendar said it was only one, and that this error was known not only by the Church, but also by the perfidious Jews and other heretics who laugh about it, and exhorting his majesty in the Lord to send his most famous theologians and astronomers to the council to devise an adequate remedy, so necessary, and bring the matter at last, with the Lord's aid, to a final decision. Nothing was done, however, the reason being given by Copernicus, who, during the council, was asked for his opinion on the subject. In the dedication to Pope Paul III of his work "On the Revolution of the Heavenly Bodies," published in 1543, Copernicus says:

“For not a great while ago, under Leo Tenth, when the question of reforming the Ecclesiastical Calendar was discussed in the Lateran Council, it then remained undecided merely because the length of the year and months and the motions of the sun and moon were thought to have been not as yet sufficiently determined. Since that time I have directed my attention to observing these more accurately, spurred on by a most illustrious man, Paul, Bishop of Fossembrone, who was then in charge of the matter.”

During the Council of Trent, which began its sessions in 1545, Pitatus of Verona submitted a plan for correcting the calendar in which he proposed something new. According to the astronomical tables long in use, the difference between the Julian and the tropical year amounted to one day in 134 years, and Pitatus observed that the omission of three days in 400 years would be practically the same as omitting one day every 134 years. He therefore proposed that three centurial years in every period of four centuries should be common years. His plan was to make the years 1600, 1700 and 1800 common years, 1900 leap year, 2000, 2100 and 2200 common years, 2300 leap year, and so on. He further proposed to restore the equinox to the day on which it fell when the Julian calendar was established by the omission of fourteen days, the seven months containing thirty-one days to be reduced to thirty days each for two years.

Pitatus also recommended the correction of the lunar cycle, and while his plan was a little complicated, it practically amounted to omitting one day from this cycle every 304 years, as had been proposed a number of times before. The lunar cycle was a period of 19 years, containing 235 lunar months, after which the new and full moons returned to the same day of the year, and this cycle was used by the Church in determining the date of Easter. But 19 Julian years exceed 235 lunar months by about an hour and a half, and this excess amounts to one day in 304 years. In the Church calendar the agreement was considered to be exact, and the new and full moons were indicated as
recurring, after a lunar cycle, at precisely the same times, and, therefore, after 304 years the astronomical new moon occurred one day earlier than the new moon of the calendar. Since the Nicene Council over twelve hundred years had elapsed, and the calendar moon had fallen behind four days and more, as the Pope informed Henry the Eighth, and to enable it to keep pace with the moon of the heavens Pitus proposed to shorten its course, or to omit from the lunar cycle, at stated intervals, enough days to equalize the times of revolution of the calendar and the celestial moon.

The Council of Trent, which came to an end in 1563, considered the question of the reform of the calendar, but charged the Roman Pontiff with its accomplishment. One of the members of this council became Pope in 1572 under the name of Gregory XIII, and during his reign the work was undertaken and carried to completion, and the calendar called the Gregorian.

A commission was appointed to consider all matters connected with the reform, among the members being Cardinal Sirleto of Calabria, named as president; Clavius, a German, who later wrote a large work explaining and defending the new calendar; the Spaniard Ciacconius, whose learning was so great that he was called the Varro of his age, and Ignatius Dante, a Dominican friar, who constructed a meridian line and gnomon to give the Pope ocular proof that the equinox came on March 11. The commission, after examining various plans submitted to it, gave the preference to one that had been worked out by a Calabrian named Lilius, and this was sent, in 1577, to the Christian Princes and most celebrated universities for their approval or amendment. Two methods were suggested for restoring the equinox to March 21 if this date should be decided upon: First, by having no leap years until a sufficient number of days had been dropped; second, by the omission of ten days at one time in the year 1582. The letter transmitting this plan of reform concluded as follows:

"Deliberate, therefore, mathematicians, who are trained by the contemplation and meditation of celestial things, and with your whole mind and care engage in this common cause, and diligently examining and considering the matter, either approve this plan proposed by Lilius or candidly make known one that may seem to you better, and be pleased to communicate with us. For it will be shameful to us all to longer allow Christians to remain in a grave error and in ignorance of the greatest things. The opinions of Princes and of your learned men will therefore be expected, and the plan that appears most suitable and convenient to the greater part of them, the Pontiff will approve and follow as the highest judgment of the whole Christian world."

A summary of the replies received is given by Kaltenbrunner. The theologians of the University of Paris desired no change at all made. They preferred to let matters remain as they were rather than have the calendar reformed by astronomers who were believers in astrology. Some of those who had proposed methods of reform were noted as astrologers, as the German Steffler, whose work on the calendar was
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published in 1518, and Cardinal d’Ailly, a former Chancellor of the University of Paris, whose work on astrology was well known, a copy of the edition of the year 1490 being in the Library of Congress.*

Fabricius, professor of mathematics in the University of Vienna, gave an opinion on the subject. He approved the reform, but was opposed to correcting the lunar cycle, preferring to abandon all cyclic reckoning for astronomical calculation. He did not approve the introduction of the reform over a period of forty years, and also believed that the omission of a number of days at one time would cause too great confusion in worldly matters and too great a disturbance of the Church year, and advocated the shortening of the various months in the year in which the change was made. He could not understand why they should wait until the year 1582 to carry out the reform and proposed the year 1580, for the sooner it was made the better. He also advocated the omission of thirteen days, as it would be much more appropriate to restore things as they were in the time of the beginning of the Roman monarchy and the Christian Church.

The reply received differed widely, no two agreeing, and Hagen says that almost every imaginable proposition was made except the abandonment of the seven-day week. The commission, therefore, took its own counsel and adopted the plan of Lilius with some changes. It decided to restore the equinox to March 21, the reason being given by Clavius, the leading member of the commission, the expounder and defender of the calendar. In his work, published in 1603, he says:

“Since the greater part of the martyrs, teachers, confessors and virgins, whose festivals the Church piously celebrates in grateful remembrance, lived about the time of the Niece Council, the martyrs a little before under Decius and Diocletian, most cruel persecutors of the Church of God, the confessors in the time of the Council, or a little after in the times of Basel, Gregory Nazianzus, Chrysostom, Ambrose, Augustine, Jerome, Leo, Gregory the Great, and when lived the recluse of Egypt, the monks of Palestine, and the anchorites under the hermits Anthony and Hilarion, it would not be possible to restore the equinox to a more appropriate time than its time when the Niece Council was held, in order that the days of the festivals of the saints may recur and be celebrated yearly at the proper time; that is, not far from its place when they lived on earth and made the Catholic Church illustrious by teaching and example. For if it were restored to its place at the birth of Christ, or retained where it was found before the correction, the times of all these saints would be disturbed and disarranged.”

The commission made its report in 1580, on the day of the Exaltation of the Holy Cross (which is given in the Church calendar as Septem-

*Stoefler, finding that a conjunction of Mars, Jupiter and Saturn was to take place in the sign of Pisces in 1524, predicted that a great deluge would overwhelm the world at that time. The prediction caused great alarm and the price of boats went up, a Frenchman of Toulouse constructing an ark in which to escape in the manner of Noah, but that year turned out to be unusually dry. Paul of Middelburg (prominent in the Lateran Council), in order to tranquilize the people, published a book in 1523, dedicated to Pope Clement VII, in which he maintained that no flood would occur the next year, but that on the contrary there would be less rain than usual. This prediction, fulfilled as it was, brought him great fame and honor.
ber 14), and recommended the omission of ten days in the month of October, 1581. This was not done, however, as the Papal Bull, abolishing the old calendar and directing the adoption of the reformed one, was not issued until early in 1582. A translation of this is in part as follows:

"Approval of a calendar recently restored for celebrating the festivals of the Holy Roman Church at their proper time, and also for reciting the divine offices, and adorning the old calendar. Pope Gregory XIII, servant of the servants of God, for perpetual remembrance of the matter.

Among the weighty cares of our pastoral office, that is not the least which, reserved to the Apostolic See by the sacred Council of Trent, has been brought, God helping, to the end desired. 
1. The fathers of this Council, although to their other meditations they added the care of the Breviary also, nevertheless, as lack of time prevented action, referred the whole matter, by decree of the Council, to the authority and judgment of the Roman Pontiff.
2. When, therefore, we turned to this study and care, a book was brought to us by Antonius Lilio, doctor of arts and medicine, which his late brother Aloysius had written, in which by a new cycle of epacts invented by him, conforming to the established rule of the golden number and adapted to the length of the solar year, all of which is arranged in the calendar in a system to last for all ages, he was able to make the correction in such a way that the calendar seemed to be set forth for posterity without any change. This new and comprehensive plan for correcting the calendar we sent a few years ago, in a small volume, to the Christian Princes and most celebrated universities, in order that a matter which is common to all might be accomplished by the common counsel of all. When they replied concurring, which we greatly desired, induced by the consent of all, we summoned to the fostering city, for the correction of the calendar, men the most skilled in these matters; whom long before we had delegated from the first nations of the Christian world. They with much time and care devoted to this study, and selecting and examining cycles, both old and new, which they diligently compared, by their own judgment and that of learned men who have written of this matter, they chose, in preference to others, the cycle of epacts, some even adding that it seemed, after thorough consideration, to be especially suitable for the perfecting of the calendar.
3. Considering, therefore, that three things are required to be joined together and established for the right celebration of the festival of Easter according to the sanctions of the holy fathers and of the ancient Roman Pontiffs, especially Pius and Victor First, and also of the great Ecumenical Nicene Council and of others: First, a fixed place of the vernal equinox; second, the correct position of the fourteenth day of the moon which falls either on the day of the equinox or next follows it; lastly, the first Sunday which follows the same fourteenth of the moon—we wish not only to restore the equinox to its former position, from which it has receded about ten days since the Nicole Council, and to bring back the paschal moon to its place of that time, from which it is distant more than four days, but also to provide a plan by which hereafter the equinox and the fourteenth of the moon shall never be removed from their proper place.
4. Therefore, that the vernal equinox, which by the fathers of the Nicole Council was established at the twelfth of the calends of April, may be restored to that place, we direct and command that from the month of October, in the year 1582, ten days be omitted, from the third day before the nones to the day before the ides, inclusive, and the day which follows the feast of Saint Francis, accustomed to be celebrated on the fourth day before the nones, be called the ides of October.
5. In order that the equinox may not again recede from the twelfth of the calends of April, we direct that every fourth year continue to be bissextile (as is the custom) except in centesimal years, which formerly were always bissextile and which we wish the year 1600 to be. After it, however, the centesimal years which follow successively shall not all be bissextile, but in every 400 years the
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first three centesimal years shall not be bissextile, but every fourth centesimal shall be a bissextile year. Thus the years 1700, 1800, 1900, are not to be bissextile. In the year 2000, however, according to the custom, a bissextile day is to be intercalated, February containing 29 days, and the same order of omitting and intercalating the bissextile day every 400 years shall be observed perpetually.

12. We, therefore, as a matter which belongs to the Sovereign Pontiff, by this our decree confirm and approve the calendar, now corrected and perfected by the boundless graciousness of God toward His Church.

To no man, therefore, is it permitted to disobey this page of our precept, mandate, statute, will, probation, prohibition, sublation, abolition, exhortation and rogation, or even with rash daring to oppose it; but if any one should venture to attempt this, let him incur the indignation of the omnipotent God and of His Blessed Apostles Peter and Paul.

Dated at Tusculum in the year of the Incarnation of our Lord one thousand five hundred eighty-first, the sixth of the calends of March, of our Pontificate, year ten.

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Page of an Old Calendar.
The year of the Incarnation began March 25, and the date is therefore February 24, 1581. In the year beginning January 1, the date is February 24, 1582. It is somewhat curious that in the edition of the Papal Bulls published in Rome in the eighteenth century, the date of this one directing the adoption of the reformed calendar is given in the margin as February 13. Those in charge of the publication could not have understood the meaning of the words sexto calendas Martii (the sixth day before the calends of March). This incorrect date has misled some writers, the German historian Ranke, in his History of the Popes, giving the date as February 13, and quoting as his authority the publication mentioned above, Ranke evidently not reading the date at the end of the papal decree, but taking the wrong date given in the margin.

A page of a calendar published in Rome in 1582, containing the month of October, is shown in facsimile, that month having but twenty-

one days. There was no interruption in the days of the week, Thursday, October 4, being followed by Friday, October 15. It will be noted that the dominical letter changed after the omission of the ten days. The dominical letter for 1582 was G, October 1 was on Monday, and the following Sunday was the seventeenth, opposite which is C which became the dominical letter for the remainder of the year.

To explain the method of correcting the Ecclesiastical Calendar by means of the cycle of epacts and their use in finding the date of Easter would be a tedious and difficult task. In some of the replies to the papal letter sent out in 1577, it was suggested that Easter be celebrated on a fixed Sunday in the year, instead of making it a movable feast depending on a fictitious moon, but Clavius said, in discussing this matter, that a custom so ancient ought not to be changed without grave reason. And he computed the dates of Easter until the year 5000, according to both the Gregorian and the Julian calendar, thus relieving any one else of the labor of doing it or of understanding his explanations.