smell so etarnal bad burnin', I'd th'ow the thing in the fire once fer all. What I 'm studyin' over now is, ef I ought n't to do yer jes as your ma mus' ha' done yer many a time when you got yer ugly tempers on—jes like I 'd do my own chile ef I had one. I 'm considerin' turnin' you right over my knee an' spankin' yer good; that could n't do yer no harm, an' it might—ach! Don't you speak a word, Dan'l Whip!»

Reuben Grey withdrew from the window as softly as he had come. He stepped from the house to the road, and with the same unnecessarily cautious step he crossed the town, seeking his mare and buggy at the horse-rack. Then he carefully counted over the packages of groceries, to find the number correct. As he drove down the road from Riverton, Reuben Grey was whistling softly and happily to himself.

Whether Sarah decided to spank or to spare Daniel Whip, he had no curiosity to learn. «Anyhow,» he ruminated, «he knows now she kin and may, an' that 's the whole p'int.»

Margaret Sutton Briscoe.

A GREAT MODERN OBSERVATORY.

HARVARD'S ASTRONOMICAL WORK.

COMETS are responsible for many things. During seventeen centuries they gave rise to every sort of superstition and fanaticism, absolutely defying the advance of intelligent thought. In the tenth century comets were supposed to be rapidly foretelling the end of the world; and, while presaging the downfall of emperors and great men, they frequently shone upon illustrious death-beds, perhaps to light an otherwise dark pathway to the other world.

Although a dawning belief in the natural cause of comets seems to have made its way slowly into the still credulous seventeenth century, it was stoutly fought by the ecclesiastics, and popular terror at the appearance of these strange celestial «monsters» had hardly abated, nor were «pestilence and war» less to be feared from the shaking of their «horrid hair.»

But in our own century and country a comet is responsible for something altogether admirable, fanning into constant conflagration a quiet interest in astronomy, which, smoldering for years, might have so continued many more but for its inspiring advent.

The history of astronomy in the United States is coeval with the origin and development of the Harvard Observatory. In 1761, long before an American observatory was thought of, John Winthrop, professor in the college, was sent to Newfoundland to observe the transit of Venus, on June 6 of that year; and in 1780 another expedition, under Professor Samuel Williams, was sent to Penobscot to observe a total eclipse of the sun. While in 1805 John Lowell, an uncle of the founder of the Lowell Institute, made a futile attempt to have an observatory built at Cambridge, no committee was appointed to investigate the proposition until 1815, this being the first corporate act looking toward an astronomical observatory in the United States. Even then, finding the cost so great that the project seemed infeasible, nothing was done for a quarter-century more; but on his accession to the presidency of Harvard, Josiah Quincy took the initial step in 1839 by inviting Mr. W. C. Bond, who for nineteen years had been faithfully observing at Dorchester, to remove his entire interests to Cambridge, and there continue his work «under the auspices of the university.»

Four years later the great comet of 1843 flashed into the New England sky. Irresistibly attracted to the new observatory by this celestial visitor, the people of Boston found it quite insufficient to afford an answer to their eager questions. At once subscribing a fund of $25,000, an instrument of equal size with the largest in the world was speedily ordered in Germany. This is the present 15-inch refracting telescope, with which, on September 19, 1848, Mr. Bond made a genuine discovery—an eighth satellite of Saturn, the New World's first addition to the solar system.

This brief sketch of the early astronomy must suffice. To show the significance of Harvard's work in the «new astronomy,» a glance at the development of celestial photography is essential; and this comes most appropriately, for it is matter of history that stellar photography had its actual origin there.

When, on that July evening in 1850, the Bonds, father and son, had a daguerreotype plate set in the focus of the equatorial as an interesting experiment, and succeeded in obtaining upon it an image of the star Vega, it is not probable that the full significance of what they had done, in all its immense possibilities, could have shadowed their thought even as a presentiment. But it was the entering wedge for methods entirely new.

Seven years later the son, Mr. G. P. Bond, subsequently director of the observatory, conducted the research to a successful issue with the then new collodion plates; and his papers upon the experiments are now classic, forming the foundation of modern celestial photography.

Passing over his directorship and that of his successor Joseph Winlock, the year 1877 is reached, and with it the appointment of the present director, Professor Pickering.[1] His plan for research at the observatory always embraces far-extending fields. If a special method of studying a particular star is found to be best, even the minutest scrutiny of that object alone is not thought sufficient, but materials are collected for a complete investigation of all stars in that class. Safe and accurate generalizations are thereby possible, and each piece of work is exhaustive in itself. For example, in an investigation of the apparent brightness of stars, Lindemann at Pulkowa employed 628 stars; at Cambridge the corresponding observing-list is based on 20,982 stars. The same comprehensive method characterizes all the Harvard work; it is a matter of principle to go through with an almost endless amount of routine to insure reliability and completeness. Of course it is possible to solve such problems only by employing many assistants —willing hands and skilful brains directed from a centrally active intelligence.

The great government observatories at Berlin, Paris, and Greenwich are also in the main occupied with a fixed routine of observation in the «astronomy of precision,» as it is called; but Harvard, not duplicating their labors, pursues instead a routine not yet part of the government programs.

Physical astronomy has always held chief place in the activities at Cambridge, and Professor Pickering's aim is in no sense to change this character, but rather to amplify it in the direction already indicated by the early work of the Bonds; and the financial resources of the observatory have, strangely enough, kept remarkable pace with the growing demands of scientific progress. The invested funds for its maintenance have increased more than $600,000 during Professor Pickering's administration.

The most recent large gifts are the Henry Draper Memorial; the Boyden Fund, for making observations on mountain-peaks, above the mists and unsteadiness of the lower atmosphere; the great photographic telescope and the fund given by Miss Bruce; and the Paine Fund, one of the largest gifts ever made to astronomy. There is temptation to linger over these subjects in detail, full as they are of interest, and each so different from the others; but the limits of the article forbidding an extended consideration, I shall speak of them in order and as briefly as may be. It is almost impossible, however, to describe any considerable portion of the Harvard program independently of the Draper work.

When, in 1882, Professor Pickering began to photograph spectra of stars, he had been preceded only by Dr. Huggins in England and Dr. Henry Draper in America.

The brilliant labors of Dr. Draper, rudely interrupted more than fourteen years ago by his death, are now continued by others at the Harvard Observatory through the generous and constant liberality of Mrs. Draper, who established in 1886 the Henry Draper Memorial, that noble monument to one of

[1] Edward C. Pickering, born in Boston in 1846, taught physics at the Massachusetts Institute of Technology before he was of age, and from 1868 to 1877 held the full professorship in that department, where he instituted the plan of providing apparatus for the use of the students, that they might themselves experiment, and no longer stand passively watching an instructor. His chief scientific researches during these years were upon the polarization of light and the laws of its reflection and dispersion. He also devised a new form of spectrum telescope, and while making other inventions found time to accompany the eclipse expeditions of 1869 and 1870 to Iowa and to Spain.

Professor Pickering has devoted his attention largely to determining the relative brightness of the heavenly bodies by novel instruments of his own devising. With one of these, technically called the meridian photometer, the light of every star as it crosses the meridian (or «culminates,» in scientific phrase) is critically compared with the pole-star, an invariable standard. Also, by another light-measuring instrument, Professor Pickering and his assistants have already completed a twelve years' series of the eclipses of Jupiter's satellites, and a second cycle is already well advanced, which is further supplemented by the photographic method, also of Professor Pickering's invention, whereby the exact time of a satellite's eclipse is more precisely recorded than ever before. Ultimately this significant research will afford a new value for the distance of the earth from the sun.

But his most picturesque discovery is apparently anomalous. He has determined the form of the orbit of a star which has never been seen and probably never can be. Its existence is proved by the variations which it causes in the brightness of its nearest celestial neighbor. Professor Pickering in 1886 received the gold medal of the Royal Astronomical Society.

America's greatest investigators. For the first three years it was largely devoted to the photographic study of stellar spectra; and while this is still the chief interest, the scope of the photographic work has been extended to include other physical properties of the stars. As the investigations also relate to the fundamental laws regulating the formation of the stellar universe, the field of its activity becomes almost boundless, and the far-reaching prophecies of the younger Bond as to the applicability of photography to astronomy have been verified beyond even his most sanguine dream.

Upon her marriage with Dr. Draper in 1867, Mrs. Draper (daughter of the late Courtland Palmer of New York) began a coöperation in his labors at once intelligent and peculiarly helpful. Dr. Draper never went to his observatory without her, although it was two miles from their home; and when the work was interrupted by passing clouds they often revisited it during the night. Mrs. Draper's continuance of her husband's investigations is therefore doubly graceful and appropriate.

Three important telescopes were brought from Dr. Draper's observatory to Cambridge —his 28-inch reflector (the largest instrument of this type ever constructed in America), the 15-inch reflector, and the 11-inch refracting telescope, with which, by mounting four huge prisms, each nearly a foot square, in front of the object-glass, the star-images are so much spread out that «spectra of large dispersion» may be photographed. Mrs. Draper has also presented an 8-inch photographic telescope to replace the Bache glass of the same size, which was taken to Peru to interrogate the Southern stars.

Mr. Edison, who was a friend of Dr. Draper, and accompanied him on his eclipse expedition to Wyoming in 1878, has presented the Henry Draper Memorial with a dynamo for volatilizing terrestrial substances, that their spectra may be compared with the component elements of celestial objects.

It should not be forgotten that photographs of stars are not the same as photographs of the spectra of stars. The former are merely minute opaque spots on the glass negative; the latter are striped bands or ribbons, and it is these stripes and their position relatively to the red or violet end of the spectrum which tell the astronomer whether the star may have hydrogen in its constitution, or iron, calcium, or other substances.

It often becomes desirable that, for purposes of study or comparison, these small spectrum photographs should be enlarged; and at Harvard a method has been introduced whereby details may be brought out which ordinarily are lost or are seen only in the original negative. There is extraordinary correspondence between spectra of stars and the sun, the sequence being complete from the blue to the red stars, the sun occupying an intermediate position in the series. This result has been reached by a careful study of the spectra by Miss Maury, a niece of Dr. Draper. And just here some interesting questions in cosmogony suggest themselves: Are the stars cooling or growing hotter? Are they new or old? And wherein consists the mysterious brotherhood of stars uncounted millions of miles apart, that their constitution is in so many cases identical? This fact is shown by the coincidence of hundreds of lines in the enlarged spectra; but not the explanation.

A magnificent result of this memorial work is the Draper Catalogue, published in 1890. It has been in charge of Mrs. Fleming, a widely known assistant in the observatory, with a force of six computers toiling for three years under her supervision. Ten thousand stars of the firmament are conscientiously catalogued, on a basis of over 27,000 spectra, all of which have been examined, measured, noted in manuscript volumes, computed, and carried through the press, forming a large quarto of nearly four hundred pages. The spectra of over 20,000 stars, to include fainter ones and to cover the entire sky, have lately also been classified for a revision and extension of this great catalogue, which constitutes perhaps the most marvelous of all «inventories of God's property,» as Thoreau was wont to say. From inception to finish it is a splendid monument to the munificence, precision, and industry of woman.

Ordinarily a single great research like this would be thought enough for the lifetime of one astronomer; but the applications of photography have made possible the employment of so many assistants in executing the comprehensive plans of one director that his life is virtually lengthened almost indefinitely.

Some discouraging pessimist once busied himself with estimating the actual working-hours in a long life, finding that six years of continuous labor embrace the average allowance. Professor Pickering, however, in the active coöperation of so many intelligent lives with his own, has discovered a veritable elixir of youth.

In addition to the superb Draper Catalogue, more popular results have not been wanting.

Double stars revolving round each other are always of interest, the shortest hitherto known period of revolution having been about twelve years. But systematic comparison of photographic spectra of a given star, taken at short intervals, has revealed two great binaries, one of which has the wonderfully short period of four days, and is so closely double that no telescope will probably ever reveal the separate components. In speaking of this marvelous discovery, Professor Lodge says: «If β Aurigæ does not constitute a satisfactory memorial, I am at a loss to conceive the kind of tombstone which the relatives of a man of science would prefer.»

I have already spoken of Mrs. Fleming, whose eminence in original investigation is attested by the frequent appearance of her name in the scientific publications of Germany, England, and America. Her photographic study of the variable stars exhibits unusual capacity for delicate and precise research. All of the spectrum photographs taken with the 8-inch telescopes have been carefully examined by Mrs. Fleming, who makes annually many discoveries of objects having remarkable spectra. Her new method of recognizing variable stars by peculiarities of their spectra at maximum has led to the instant detection of many such objects, the variability of which may then be verified at once from an examination of the photographs already taken, without waiting for the next clear night or good opportunity, or perhaps even another season.

The regular series of negatives began in 1885, and comparison with all previous plates enables immediate confirmation of the discovery if real. An identification of the objects photographed is made by placing the glass plates over the famous charts of Argelander's stellar «Durchmusterung,»[1] both being upon the same scale. All spectra possessing unusual interest are at once marked, and recorded in a book for future reference. Suspicious objects are thus tabulated, and more than twelve thousand have already been found. Obviously, anything new may perhaps be recognized and at once classified without another observation. It is as if the whole sky were laid on one's desk for verification—an unimpeachable record of our firmament bequeathed to posterity. There are now at the Harvard Observatory over seventy thousand photographs, seven or eight thousand being obtained in a single year.

As one result of photographic methods, the main work of this department may be done in the daytime and at any distance from the point where the pictures were made.

The location of observatories is often determined by politics and other irrelevant matters, without regard to intrinsic fitness. When once a site, buildings, and instruments are provided, governments or donors are quite satisfied, and observations must thenceforth be conducted there, regardless of climatic disadvantages. There are few marked exceptions to this unfortunate rule.

Not infrequently a good observing-station is bad for all the subsequent necessary work, —computing, printing, and so on,—because it is apt to be at a distance from merely material conveniences. This consideration, of course, influences the location of observatories near cities.

Astronomically speaking, Cambridge itself —level, gleaming with electric lights, full of old trees, and near the slowly winding Charles, ever loath to leave its salt meadows —is hardly the ideal place for a working observatory. The great dome crowns one of the few low hills, the beauty of which ought to compensate even the most mathematical astronomer for the sad fact that he is not airily perched upon some mountain-top. The beautiful grounds where birds sing and pines murmur, with the garden of rare rhododendrons abloom in the sunny springtime, give little hint of the wide-reaching activities centering here, and extending quietly, yet ceaselessly, over the world and into the infinite spaces.

But the astronomical department of Harvard is much more comprehensive than is apparent from a visit to its Cambridge headquarters. The Boyden Fund established accessory stations in the clear and steady atmosphere of southern California and Peru, while the general organization and management are conducted with the greatest facility from the home observatory, thus combining both advantages with great efficiency.

The subject of mountain observatories has always attraction for the general public as well as for the specialist. For many years it has been supposed that astronomical work at high elevations would be more satisfactory than that prosecuted near sea-level, because less liable to atmospheric disturbance. From time to time experiments have been generally confirmatory of this theory. But a practical determination to prove the question systematically was first evinced by Mr. Uriah Atherton Boyden, a wealthy Bostonian, who

[1] The name given to a famous catalogue, with accompanying charts, of 324,000 stars in the Northern heavens—a colossal piece of astronomical work.

died in 1879, leaving a bequest of $230,000 for «the establishment and maintenance of an astronomical observatory on some mountain-peak.» After discussion as to the best means of carrying out his desire, Mr. Boyden's trustees finally turned the fund over to the Harvard College Observatory.

Professor Pickering, sometime president of the Appalachian Club, had in 1883 read a paper setting forth the advantages of mountain observatories. It was eminently fitting that, in the wide scope of the Harvard researches, opportunity should thus be offered for the necessary critical tests.

The first experiment was upon Wilson's Peak in southern California, where an observatory was maintained during 1889 and until August, 1890. The instruments located there brought good results, although the advantages of that climate were not so great as had been anticipated. Another attempt about the same time in Peru resulted more satisfactorily. The Chosica station presented enough of ideal hardship to satisfy the most enthusiastic astronomer. Upon a mountain over 6600 feet high a few devoted observers nightly photographed the wide-spreading sky, even if the next morning's breakfast were problematical; they accumulated valuable data of the Southern heavens, even if water and building-materials were securely lodged eight miles away. But with the approach of the cloudy season in November, 1889, the gentle suggestions of nature forced the observers to retire under the filmy veil which gradually covered Mount Harvard and its instruments.

Using this interval to explore other possible sites, the astronomers extended their search along the coast as far as Valparaiso. A station was occupied for a time in the Chilean desert of Atacama, perhaps the driest region of the earth. Even there, however, clouds came up from the ocean at evening, and the present site at Arequipa was finally chosen. Although one more clear season was spent at Chosica, the instruments in November, 1890, were removed to the new location on the line of the Mollendo Railway. Arequipa, the largest city but one in Peru, is 8000 feet above sea-level. The railroad, however, more aspiring still, attains the extraordinary altitude of 14,600 feet, the highest point reached by any railway in the world.

Here, surrounded by archæological remains of great interest, and with snow-covered mountains over 20,000 feet in height as a daily view from their windows, Professor W. H. Pickering and his assistants found a situation worthy of their fine instruments and the magnitude of their plan. From both the Peruvian stations much valuable material has already been obtained.

Most astronomical works so far published, like the «Durchmusterung» and the catalogues of Dr. Gould, are necessarily incomplete, since each relates mainly to a single hemisphere. Now, by means of the two stations, one at Cambridge and one in Peru, both under the same director, research upon all the stars of the entire heavens is completed in a harmonious whole. Thus the special significance of the Harvard station in the Southern hemisphere is apparent. There is, of course, coöperation between the two great English observatories at Greenwich and the Cape of Good Hope, although each is conducted by a separate director and has its own plan of work; but the entirety of coöperation is reached only by the Harvard system, through which investigations prosecuted in observatories of both hemispheres have been carefully planned by a single head.

On the Peruvian chart-plates more than six hundred clusters and nebulæ appear; on the spectrum-plates, over one thousand. Of course many of these are already known. The manuscript records accumulate with astonishing rapidity: nearly fifty volumes have already been received relating to the visual brightness of the Southern stars. Studies of the lunar streaks and of variable spots on the moon, of Jupiter's satellites and of the markings on Neptune, have also been made; and the peculiar fitness of Arequipa for a permanent observatory of high elevation is amply proved.

This station, now combining both Boyden and Draper interests, was fortunately located for increasing our knowledge of the planet Mars, whose near approach to the earth in 1892 could not be at all well studied from our Northern observatories. Professor W. H. Pickering employed the great 13-inch telescope assiduously, measuring nearly a hundred salient points for a future areography, discovering forty minute and very dark areas provisionally designated lakes, and determining anew the polar flattening of Mars, which appears to be greater than theoretical indications, and is possibly due to an excess of cloud in the equatorial regions of the planet. Luminous projections beyond the apparent disk of Mars, doubtless atmospheric clouds, were objects of special scrutiny. But most important of all, the reality of a multitude, or network, of dark and narrow streaks, nearly straight, and called canals by their discoverer, Professor Giovanni Schiaparelli of Milan, was not only verified, but the steady atmosphere of Arequipa made it possible to obtain satisfactory measures of their precise location on the globe of Mars. Great areas of this neighboring world may now be more accurately indicated upon a map of the planet than regions of our terrestrial poles.

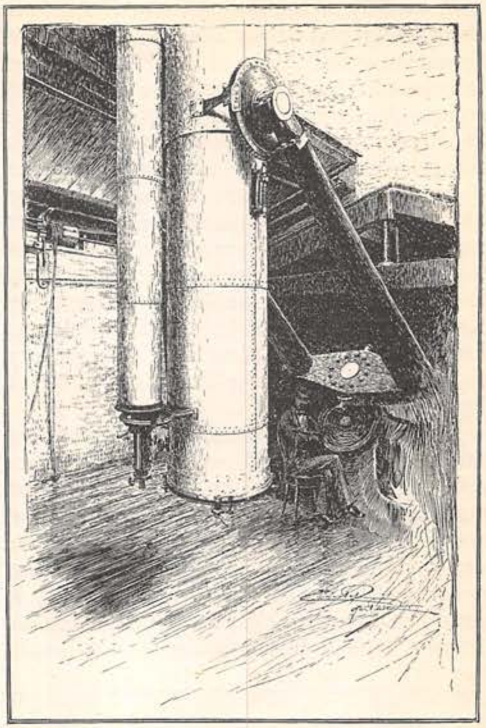
The origin of the new Bruce telescope is not without interest. Photographically, an 8-inch glass has been found fully equal to one of fifteen inches used visually. In November, 1888, Professor Pickering issued a circular proposing to establish the Boyden station on Mount Wilson, and to maintain there, if sufficient additional funds could be obtained, a large photographic telescope to be used in three ways: for visual purposes, as an ordinary telescope of twenty-four inches aperture and a focal length of seventeen feet; as a single photographic lens of like dimensions; and as a photographic doublet covering a very large field, with a focal length of eleven feet.

With this extraordinary instrument contributions to stellar astronomy of the utmost significance could be expected, increasing enormously in value year by year.

In response to this circular, Miss C. W. Bruce of New York, a cousin of the late Miss Catherine L. Wolfe (well known by her generosity to the Metropolitan Museum), presented $50,000 to Harvard College Observatory for such a telescope. This great gift was not to be used in trying a mere experiment, but the successful 8-inch Draper glass was its model.

A vast extension of the photographic research—already well advanced with the Bache and Draper telescopes, from each of which about two thousand plates are annually received—now constitutes the particular work of the Bruce glass. Mr. Clark, the builder, has completed his labors upon it; and the telescope, after being tested at Cambridge, was shipped last year to Peru, where the Southern stars are now being charted to the seventeenth magnitude. Preliminary tests reveal a power of photographic registry beyond the reach of the largest visual telescopes. A huge prism in front of the glass adapts it for spectrum photography, thus affording a double opportunity for its success, and the Bruce telescope may reasonably be accounted the most powerful instrument in the world.

The wide liberality of Miss Bruce toward astronomy has not been confined to the Harvard telescope. During 1890 she offered a fund of $6000 for celestial research in general. Of this gift Professor Pickering was the almoner, and in response to his circular to all astronomers eighty-four replies were received. While they gave a distinct idea of the present needs of astronomy, it was, of course, impossible to assist every applicant. Many a pathetic tale of high devotion to a non-remunerative science might be read between the lines of these communications. Truly «the ‹patines of bright gold› with which Urania's treasure-chests overflow are not of terrestrial coinage.» A skilful astronomer is often attached to an institution lacking entirely the funds to enable him to carry out cherished plans; or another may be privately at work, but hampered by inability to purchase necessary instruments or to publish important results. Fifteen astronomers received substantial aid from Miss Bruce's fund. Only the importance of the work was considered, and the benefaction was wisely and liberally bestowed without regard to terrestrial locality. Astronomers all over the world—in the United States, in Norway, Spain, Russia, and Germany—were thus benefited. «The same sky overarches us all.»



DRAWN BY ERIC PAPE.

THE BRUCE PHOTOGRAPHIC TELESCOPE,
NOW CHARTING THE SOUTHERN HEAVENS IN PERU.

Upon the death of Mr. Robert Treat Paine, more than a quarter of a million dollars was bestowed upon the observatory, the income from which was wholly available for the first time during 1893. One of its oldest and most interested friends, a member of its visiting committee from the time of its organization over forty years ago, he was a diligent observer of astronomical and meteorological phenomena, and it was largely in consequence of his interest that Professor Pickering decided, several years since, to extend the scope of the meteorological work, though it is secondary and largely by coöperation. Especially may be mentioned the significant researches of the Blue Hill Observatory, maintained by the wise liberality of Mr. A. Lawrence Rotch.

Observations of atmospheric conditions are regularly carried on at the Peruvian establishment, and a line of meteorological stations is now in operation from the coast across the Andes to the valley of the Amazon. They include stations at Mollendo, 100 feet above sea-level; at La Joya, 4150 feet; at Arequipa itself, 8060 feet; at Alto de los Huesos, 13,300; Mount Blanc station on the Misti, 15,600; and one in the Chacani ravine, 16,650 feet elevation. Notwithstanding its great height, the last station is easily reached by a mule-path, and observers may pass the night in a small hut erected for their convenience. Until very recently this was the highest meteorological station in the world; but after making a careful examination of the volcano El Misti, a sharp and isolated peak, Professor Bailey has succeeded in establishing a station upon its top, 19,200 feet above the sea. This, too, is entirely accessible by a path, while self-recording instruments register the temperature, pressure, moisture, and the velocity and direction of the wind at this unparalleled height. Farther down, again, are two more stations—at Cuzco, 11,000 feet, and Santa Ana, 3000, completing the chain.

The teaching of modern astronomy is preëminently the doctrine of change and motion. Poetic as it is to speak of the constancy of the stars, the more the astronomer finds out about them, the more he is forced to admit their periodic fluctuations. Even the idea that they are absolutely stationary in position, as implied in the name «fixed stars,» has to be abandoned, since it is found that many hundreds of these luminaries have motions of their own large enough for us to measure, notwithstanding their inconceivably great distances from us; and it is a reasonable physical inference that all the brilliant bodies of the universe are in motion, obedient to the law of gravitation, slowly or swiftly, through interstellar space.[1]

DRAWN BY ERIC PAPE.

HARVARD METEOROLOGICAL STATION, CHACANI, PERU. ELEVATION, 16,650 FEET.

But among the countless myriads which dot the nightly heavens, and the

[1] Professor Todd gives me this striking illustration of the distance of a so-called «fixed star,» based on the well-known «Century Dictionary» (with its twelve hundred three-column pages in each volume), taken in connection with that swift voyager light, which travels with such celerity that it could go fifteen times round the equator of the earth while you read a single dictionary line (of which there are one hundred in each column). Now let us suppose that a well-known star is suddenly blotted out of the firmament,—the great star Sirius, for example,—and that at the instant of its extinction you begin to read rapidly «The Century Dictionary,» reading day and night, week-days and Sundays and holidays, continuously and without intermission, just as starlight itself does not stop to rest, once having left its birthplace. How many pages will have been covered before the astronomers here on the earth will miss the conspicuous luminary from our brilliant winter skies? Or how many volumes? Perhaps you guess that the entire six volumes of that colossal work would be completely read through before it would be known on our globe that the dog-star had gone out? But even this conjecture would give only a faint notion of the inconceivable spaces with which the astronomer has to deal in measuring the distances of the stars; for to us the chief star of Canis Major would continue to burn in its accustomed place until you had finished 360 volumes like those of «The Century Dictionary.»

DRAWN BY HARRY FENN. ENGRAVED BY C. W. CHADWICK.

THE BOYDEN STATION AT AREQUIPA, PERU. ELEVATION, 8060 FEET.

millions more revealed by the telescope, a totally new star is now and then discovered; some particular area of the celestial vault, hitherto the blackness of darkness, suddenly flames with the luster of a brilliant star—a new sun. The number of such phenomena recorded within historic time has not been large—less than a score in two thousand years. One very curious fact, not yet explained, is that they have been for the most part in the Milky Way. But the irregular distribution in time is even more apparent. To be sure, the centuries have shown vast variation in the degree of interest in astronomy manifested by their peoples, and the means of permanent record, too, have greatly improved. At times several centuries have passed with no new star handed down into the astronomy of the future, while, on the other hand, the annals of the last thirty years contain seven, which have been critically interrogated for all the additional light which their peculiar behavior might afford in the elucidation of stellar mysteries. The first four stars of this group were the Nova of 1866, in the Northern Crown; the Nova Cygni, discovered by Schmidt in 1876; the new star observed in the great nebula of Andromeda in 1885; and, most famous of all, the Nova Aurigæ of 1892.

On February 2, 1892, word was received at Cambridge that such a new star had been discovered in the constellation Auriga by a Scotch clergyman named Anderson. Turning at once to the splendid series of general photographs of the heavens, invaluable information was at once gathered as to the new star, which appeared on the plates more than six weeks before it attracted Mr. Anderson's attention. Of course Mrs. Fleming's discovery of the Nova Aurigæ might have been a mere question of time when she should have reached, in her regular examination, the first plate containing it; only Mr. Anderson saw it before the plate was reached. The outburst of the star's light was perhaps due to the approach and recession of great masses of hydrogen rushing past each other with the almost inconceivable velocity of five hundred miles per second.

But Mrs. Fleming has since discovered four new stars, one of which at least is of equally interesting character. On the Peruvian plates taken in July, 1893, she found a curious variable of the seventh magnitude in the constellation Norma. The priceless series

DRAWN BY ERIC PAPE, AFTER A PHOTOGRAPH BY PACH BROTHERS.

PROFESSOR EDWARD C. PICKERING, LL. D.

of negatives was again called upon to assist in tracing another new celestial inhabitant, and, questioning them, the answer came that from thirteen negatives of this part of the sky, taken between June 6, 1889, and June 21, 1893, no suggestion of a new star appeared. If existing at all, it must have been fainter than the fourteenth magnitude. But it was found on a plate taken July 10, 1893, and, strangely, too, its spectrum is identical with that of the previous new star, Nova Aurigæ, which proves it actually new, and not merely a variable star of long period.

Another striking recent discovery is that of the sixth new star, which must have shone brightly about nine years ago, but is not known ever to have been seen by any one, and which has since utterly faded from the firmament. It was discovered in December, 1893, by the vigilant eye of Mrs. Fleming, when examining some spectrum-plates of the constellation Perseus that had been taken November 3, 1887. It presents a finely developed spectrum of the type usual in the case of temporary stars, and a comparison with chart-plates of the same region, taken both before and since that date, shows an entire blank. So that here is a unique case: a bright star of the existence of which in the sky at a particular time we are absolutely sure,—even its constitution we know something about,—and yet (herein showing similarity to the theoretical discovery of the path of a star by Professor Pickering) the star itself has never been seen, and never will be seen, by any human eye. Another new star was discovered by Mrs. Fleming on the Draper Memorial plates taken at Arequipa in the spring of 1895. It appeared in the constellation Carina, and in less than three months had sunk from the eighth to the eleventh magnitude in brightness. The last new star was found by the same observer in 1895, in the constellation Centaurus.

Thus, with present photographic processes, glass negatives may take the place of the sky itself. Photography, when joined with astronomy, has been called «the very Ariel of the astronomical Prospero.» With Professor Pickering's photographic lenses a thousand stars have been catalogued within one degree of the north pole, where only forty were known before. It is a wonderful thought that these stars, too faint to be seen at all through any telescope, however powerful, may be caught by the exquisite sensitiveness of a photographic plate.

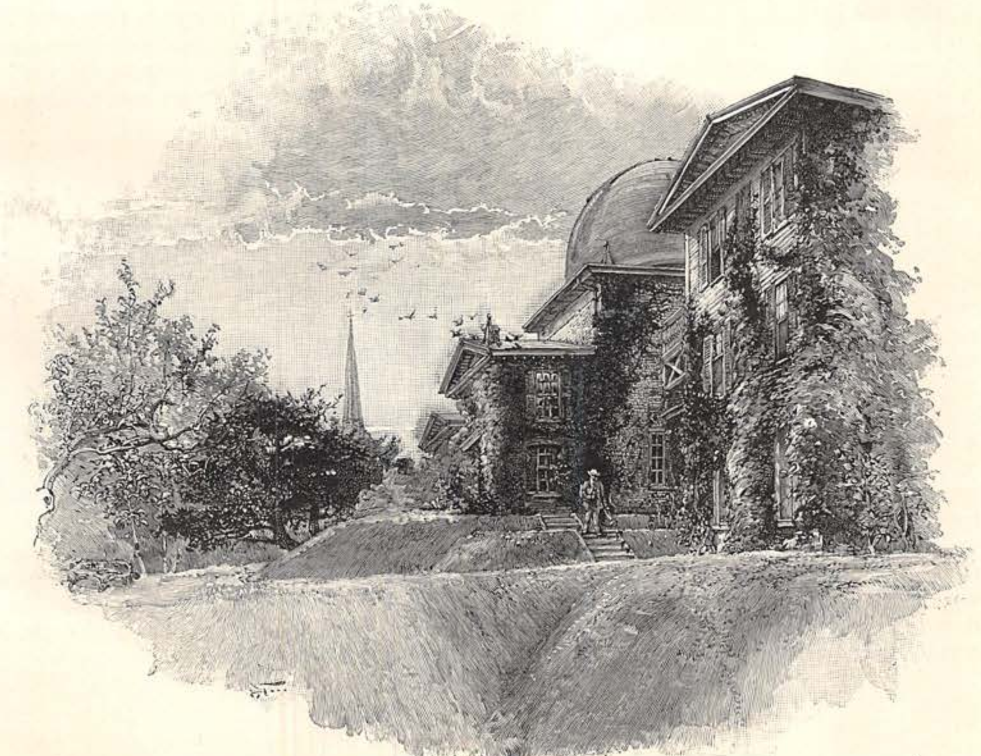
To be sure, this conjunction of photography with the study of the stars obliterates the favorite popular vision of the typical astronomer, up at all hours with eye constantly at a great «optick tube»; if the atmosphere be lower than freezing, or even a New England zero, romantic imagination insists that his heart must be amply warmed by his heavenly enthusiasm. But the elimination of personality makes the records of astronomy indisputable, and renders its pursuit more practical, not to say more comfortable, besides widening its skies beyond comparison. Stellar astronomy, indeed, might continue to progress by the aid of the star-charts and the photographic spectra already collected, even if the sky were now to be clouded for all future time.

The immense increase of glass negatives at Cambridge necessitates the most methodical arrangement. They are kept in cases marked with series and numbers. Misplacement is even worse than a book on the wrong shelf in a great library. Indeed, as years go on, the accumulation of plates must be treated more and more by library principles, and subjected to the same rigorous methods. These invaluable records of the sky were formerly stored in the main observatory, but during 1893 a fire-proof brick building was completed, and thirty thousand glass negatives were transferred to its safe-keeping without serious accident, although their weight was nearly ten tons.

Space does not remain to treat amply of the telescope-houses, embodying the most approved methods of observatory construction (with a minimum of material at relatively trifling expense), nor of the novel types of instruments in detail—the great meridian circle, with which Professor Rogers has labored so faithfully on precise positions of stars; the Russian transit, with its «broken telescope,» which served as the model of those built for the government expeditions to observe the recent transits of Venus; of Professor Pickering's «horizontal telescope,» an advantageous type for winter use, enabling the astronomer to remain in a warm room with the image of any star brought to him always in one position, the task of observation thus becoming easier and more comfortable; or of the great equatorial, which the public in general conceive to be accessory to the nightly scene of principal achievement, but which is now quite secondary. There is no attempt to amplify the visual part of the work, and this classic telescope has been used more for ascertaining the physical properties of heavenly bodies than for the measurement of their positions and distances; in other words, its service is rendered to the «new astronomy» more than to the old. Determinations of the brightness of double stars, satellites, and small planets have been made—researches of recognized value. Now, however, it is used chiefly for measuring the light of Jupiter's moons and of the variable stars.

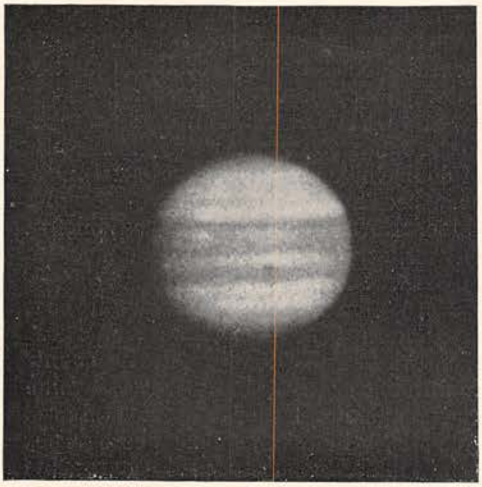
More generally interesting will be the great library (with perhaps a single exception, the finest of its type in the country), containing nearly twenty thousand volumes and pamphlets. Under the same roof are the collections in astronomical photography—prints exhibiting all stages of progress in the art as applied to the study of the heavens; and pictures of the fainter moons of our planetary system, very difficult to see with any telescope, but which photography, with the advantage of long exposure, has rendered as evident as a printed page.

One of the pleasant places in which to linger and learn at the great Chicago Exposition was the space devoted to the exhibit of



DRAWN BY HARRY FENN. ENGRAVED BY J. TINKEY.

HARVARD COLLEGE OBSERVATORY.



ENLARGED FROM A HARVARD PHOTOGRAPH.

JUPITER.

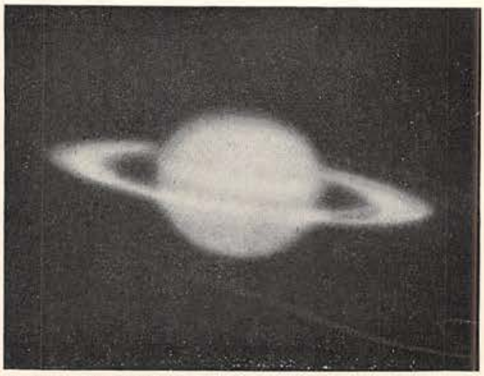
the Harvard Observatory. Charming photographs, not only of celestial objects, but of buildings and scenery, including the wonderful mountain-ranges of South America, tempted the visitor to forget for the time the multitudinous collections outside.

Harvard's record in recent total eclipses of the sun is worthy much more extended notice, but a glance may be given at its achievement. In 1886 an expedition was sent to Grenada, in charge of Professor W. H. Pickering, to observe the eclipse of August 29. When nature herself seems to hold her breath to watch, the merely spectacular is so absorbing that great devotion to scientific detail is necessary in order to obtain a record of an eclipse worth the having. But in spite of certain obstacles, Professor Pickering made on that occasion a contribution of recognized worth to our knowledge of the sun. The eclipses of 1887 and 1896 in Japan, and of 1889 in west Africa, offered Harvard opportunity for coöperation with the government and other expeditions in charge of Professor Todd; and a large amount of specialized apparatus for research upon the corona was contributed by the observatory, which would not otherwise have been in the field. During the eclipse of January 1, 1889, visible in California, Professor Pickering secured exceptional photographs of the sun's corona. The Harvard astronomers in Peru were already very near the scene of action when the lunar shadow swept across South America, April 16, 1893. An expedition from Arequipa was established at a silver-mine near Valleñar in Chile. The sky was brilliantly clear, and the corona was very satisfactorily observed and photographed, though no long streamers were seen.

Space has not been left to speak of the careful time-signals transmitted for so many years as a part of the daily program, or of that interesting investigation, the search for a lunar satellite—a moon of a moon.

A new and useful department has been added to the observatory within recent years. Kiel, in Germany, is the European center for the distribution of astronomical announcements from all over the world; Cambridge is the American counterpart. Discoveries made in the United States are telegraphed to Harvard, thence to Kiel, and so to all Europe. And when, some bright night, a wandering comet or other strange visitor may be detected from a remote corner of Germany or Russia, Kiel is at once notified, then Cambridge, and the next morning all American astronomers know where to look for the newcomer.

So in these modern days, when even the stars are linked in an organized human system, and celestial messages continually tell of activities millions of miles away, it seems possible to apprehend the wide breathing-space of infinite distances, where star speaks to star across the dark void in rhythmic, intelligible music.



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SATURN.

Mabel Loomis Todd.