

BIOGRAPHICAL MEMOIR

OF

JAMES EDWARD KEELER,

1857-1900.

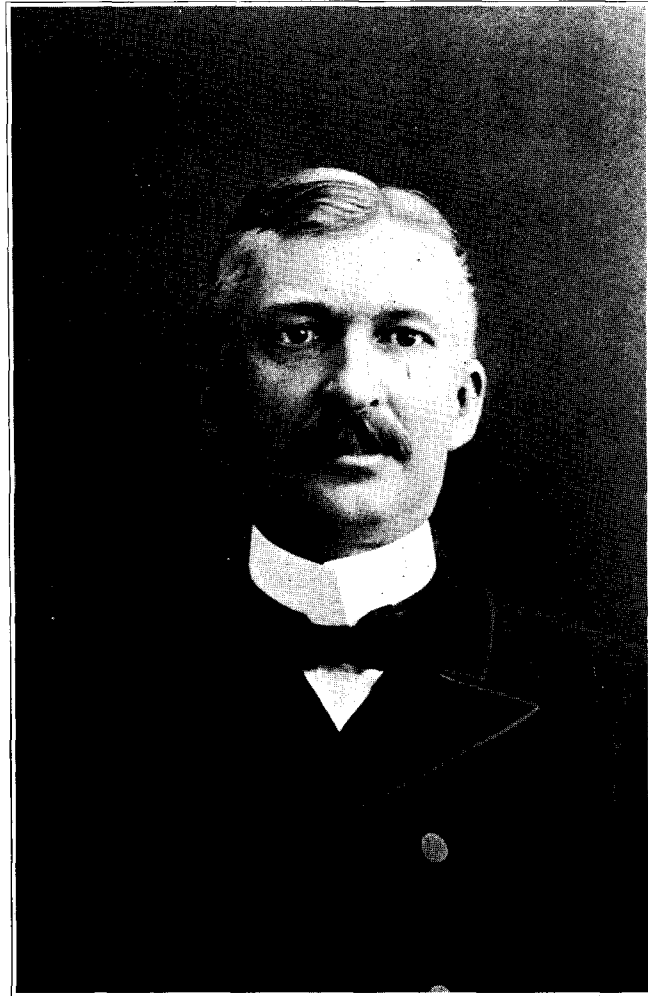
BY

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JAMES EDWARD KEELER was born in La Salle, Illinois, on September 10, 1857.\* His father, from whom he inherited his extraordinary taste for mechanical pursuits, and to whom he also owed his early instruction in the use of tools and the design and construction of innumerable conveniences of daily life which proved so invaluable to him in later life, William F. Keeler, was an officer on the *Monitor* at the time of its famous engagement with the *Merrimac*. His mother was the daughter of Henry Dutton, formerly governor of Connecticut and dean of the Yale Law School. Through this inherited association with New Haven he possessed an acquaintance and relationship with several families prominent in the society of that city, which, happily for them and for himself, he had an opportunity to cultivate later in his life.

In 1869 Mr. Keeler removed with his family to Mayport, Florida, and here Edward, as he was always known to his intimate friends, commenced that extraordinary education which proved so perfectly adapted to his exceptional genius. Mr. Keeler found it necessary in a community where neighbors were few and the conditions of life were largely those of a new and unsettled country to do a large part of his work as architect and builder with his own hands, and in this work we are assured that his young son assisted with the keen interest and eminent success which rendered him so useful a few years later to those who could command his services as an assistant in scientific work.

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\* Biographical notices of Mr. Keeler have been published by Professor W. W. Campbell, director of the Lick Observatory; by Professor G. E. Hale, director of the Yerkes Observatory, and by Chancellor J. A. Bra-shear, of the Western University of Pennsylvania. From these the present writer has drawn freely, and from the notice by the first-named writer the account of Mr. Keeler's activity as director of the Lick Observatory is taken without change, since no one else is so perfectly acquainted with this chapter of his life. The list of the published writings of Mr. Keeler is taken from the twelfth volume of the *Astrophysical Journal*, and was also prepared by Director Campbell.

It was in the boy's eighteenth year that his interest in astronomy had grown to such a point that he could be content with nothing less than an observatory of his own. He purchased lenses for a two-inch telescope with money which he had earned by his own efforts and mounted them himself. His journal records that the lenses, ordered from a dealer in the north, came to his hands on November 29, 1875, and that he first directed the telescope to the stars on the 12th of the next month, when he saw the ring of Saturn for the first time. This marks the beginning of a career as an observer which was unhappily cut short just at a time when he may fairly be thought to have reached his highest and most fruitful degree of skill. It is worthy of remark that the surviving "Record of Observations made at the Mayport Observatory" contains beautifully colored sketches of Jupiter, Saturn, Venus, Mars, the Orion Nebula, and of the moon, which are the forerunners of the famous and unequalled drawings of the great planets which were made a dozen years later with the Lick telescope.

This youthful activity was, however, something more than the merely playful exercise of intellectual faculties such as is often exhibited by clever boys, and which, admirable in itself, is little likely to lead to a lifelong devotion to science or to permanent additions to the sum of human knowledge. In Keeler's case we do not have to look far for signs which mark a true and rare superiority, for in his records of observations we find data of a numerical character which imply an abstract interest in science at once separating him from those who can hardly hope to find more than a pastime in science. His next step, in 1877, separates him from the pure amateur, for the construction of a meridian instrument, which he made from a marine spyglass with the tools at command in his own home, marks a mind which demands much more from science than amusement. A description and sketch of this instrument by Keeler himself is published in the twelfth volume of the Publications of the Astronomical Society of the Pacific, and its perusal will go far to show the rare ingenuity of its maker as well, it seems to the writer, as the admirable fitness of the early education of the youth for the work which lay before him.

This was nearly the end of Keeler's work among such limited surroundings, for his talents were soon to be recognized by a wise

and generous man, who proved his lifelong friend and adviser, and who procured for him an opportunity to exhibit to competent and appreciative men his rare qualities and promise. Mr. Charles H. Rockwell, of Tarrytown, New York, had invited a class of young ladies at a private school in Tarrytown to visit his well-equipped observatory to view some of the more interesting astronomical objects, in accordance with a generous custom. His attention was attracted by one of the young ladies remarking that Saturn was familiar to her from having seen it through her brother's telescope at home. The young lady was Keeler's sister, and her remark interested Mr. Rockwell to such a degree that he was led, not only to inform himself farther about the young man, but to secure for him an opportunity to pursue a university training in the north. Rarely has such interest been more wisely accorded or more nobly received. One of Keeler's most admirable traits, known to all his intimates, was his unassumed and constant affection for this older and generous friend.

Mr. Rockwell took young Keeler to the Sheffield Scientific School of Yale University in the first case in order to enter him there as a regular student, but he was advised to place him as a special student at the Johns Hopkins University, where the highly irregular training and preparation acquired by the candidate could be more readily adapted to the requirements, less rigidly fixed in the new university, for effective college training. It was here that the present writer became intimately acquainted with Keeler, and it is from this long intimacy that he will find something to write concerning his personal characteristics, after having reviewed his scientific history and work.

Mr. Keeler's university career was not only a successful one, but it was also an extremely happy one. He possessed the power of making friends among his older associates as well as with the men of his own age, and the college work, which he did well and with ease, afforded him the keenest pleasure. His interest in his chosen science never flagged, although it was never allowed to interfere with other duties which belonged to him as a candidate for an academic degree. Even at the end of his freshman year he had a delightful opportunity to occupy himself again with his favorite observations as a member of Professor Holden's expedition from the Naval Observatory which observed the total eclipse of July 29, 1878, at Central City, Colorado, and

which counted Mr. Rockwell and the writer among its members. A sketch and description of the corona on this occasion constituted the first of Keeler's published papers.

In the spring of 1881 Professor Langley requested the Johns Hopkins University to recommend a suitable man for the place of assistant in the Allegheny Observatory. Of two candidates highly recommended Keeler was chosen because one of his instructors emphasized the fact that it was always easy to find just what he did not know, by which it was intended to describe in an epigrammatic way his remarkable intellectual candor. Indeed, this was one of the most constant and delightful characteristics which belonged to him to the end of his life. No one could be more modest and unassuming in all intellectual matters; so much so that only those who were long and intimately associated with him were likely to recognize his real mental superiority.

The years from 1881 to May of 1883 were spent at Allegheny as Professor Langley's assistant, interrupted only by the famous trip to Mt. Whitney, when his chief made his famous determination of the solar constant. During this period he not only acquired a highly cultivated skill in the use of Langley's delicate and difficult investigations in the domain of radiant energy, but he also made many friends, who added to his pleasure and efficiency in the years later when he became the director of the Allegheny Observatory. After a year spent in study at the Universities of Heidelberg and Berlin, at the latter of which he made an investigation of the absorption by carbon dioxide of radiant heat with the use of Langley's newly invented bolometer, he returned to Allegheny. Here he remained from June, 1884, to April, 1886, assisting Professor Langley in his famous researches on the radiation of the moon and on the infra-red portion of the solar spectrum.

Early in 1886, on Professor Holden's recommendation, Mr. Keeler was appointed assistant to the Lick trustees. He arrived at Mt. Hamilton on April 25, 1886, and immediately proceeded to establish the time service. The telegraph line to San José was perfected; the transit instruments, the clocks, and the sending and receiving apparatus at both ends of the line were installed. The signals were sent out on and after January 1, 1887—north to Portland, east to Ogden, and south to San Diego

and El Paso. In addition to the time service, he assisted the trustees in installing the various instruments.

When the observatory was completed and transferred to the regents of the University of California, on June 1, 1888, Mr. Keeler was appointed astronomer, the original staff consisting of Astronomers Holden, Burnham, Schaeberle, Keeler, and Barnard and Assistant Astronomer Hill.

Professor Keeler was placed in charge of the spectroscopic work of the observatory. The large star spectroscope, constructed mainly from his designs, has no superior for visual observations. Of the many results obtained with this instrument, we may mention the observation of Saturn's rings and Uranus, with reference to their atmospheres; of the bright and dark lines in the spectra of  $\gamma$  Cassiopeiæ and  $\beta$  Lyræ; of the color curve of the 36-inch equatorial, and of the spectra of the Orion Nebula and thirteen planetary nebulae.

His beautiful observations on the velocities in the line of sight of these fourteen nebulae mark a distinct epoch in visual spectroscopy. His memoir on the subject took its place as a classic at once. The probable error of the final result for each nebula, based on the mean of several observations, is only  $\pm 3.2$  kilometers per second. Attention should be called to one extremely important fact established by these measures, viz., the velocities of the nebulae in their motion through space are of the same order of magnitude as the velocities of the stars.

The recognition of the fact that a great refracting telescope is also a most powerful spectroscope for special classes of objects, by virtue of the chromatic aberration of the objective, is due to Professor Keeler. Among the first objects observed with the 36-inch equatorial were the planetary nebulae and their stellar nuclei. The observers were struck with the fact that the focal length for a nebula is 0.4 inch longer than for its stellar nucleus, a discrepancy which Professor Keeler at once explained by recalling that the star's light is yellow, whereas that of the nebula is greenish-blue.

Astronomical readers will remember Keeler's splendid drawings of the planets Saturn, Jupiter, and Mars, made with the assistance of the 36-inch telescope during 1888-1890. His faithful and artistic drawings of Jupiter have no equal.

He was in charge of the very successful expedition sent by

the Lick Observatory to Bartlett Springs, California, to observe the solar eclipse of January 1, 1889.

Professor Keeler resigned from the Lick Observatory staff on June 1, 1891, to succeed Professor Langley as director of the Allegheny Observatory and professor of astrophysics in the Western University of Pennsylvania. The Allegheny Observatory has perhaps the poorest location of any observatory in this country for spectroscopic work, but in spite of this disadvantage, Keeler's investigations continued and promoted the splendid reputation established for the observatory by his predecessor. He comprehended the possibilities and limitations of his situation and his means and adapted himself to them. His spectroscopic researches were largely confined to the orange, yellow, and green regions of the spectrum, since these would be less strongly affected by the smoky sky for which that vicinity is famous.

The Allegheny spectroscope, designed and constructed soon after his acceptance of the position, contained several valuable improvements. The use of three simple prisms in its dispersive train was a departure which has been followed with great advantage in many later instruments. With this instrument he made an extensive investigation of the Orion Nebula and the stars immersed in it, establishing the fact that the nebula and the stars are closely related in physical condition.\* His beautiful observations of Saturn's rings, proving that they are a cluster of meteorites—myriads of little moons—have never been surpassed in interest in the entire astronomical field. These observations are so well known to every one interested in astronomy that a single sentence suffices. He proved spectrographically, using the Doppler-Fizeau principle, that every point in the ring system is moving with the velocity which a moon would have if situated at that distance from the planet. Professor Keeler's main piece of work at the Allegheny Observatory, on the spectra of the third (Secchi) type stars, remains unpublished, but the measures and reductions are left in an advanced stage.

The regents of the University of California appointed Professor Keeler to the position of director of the Lick Observatory on

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\* Simultaneous observations of the same object made at another observatory led to the same conclusion.



March 8, 1898. The ties which bound him and his family to Allegheny were difficult to sever, but the greater opportunities offered by the instruments and the atmospheric conditions at Mt. Hamilton decided him in favor of accepting the appointment. He entered upon his new duties on June 1, 1898.

Without making any rearrangement of the work of the staff, but affording them every possible encouragement to continue along the same lines, Professor Keeler arranged to devote his own observing time to the Crossley reflector. He recognized that the instrument was not in condition to produce satisfactory results. He made one change after another, overcoming one difficulty after another, until, on November 14, he secured an excellent negative of the Pleiades, and on November 16 a superb negative of the Orion Nebula. The enormous power of the reflector in nebular photography was established, and he entered upon the programme of photographing all the brighter nebulae in Herschel's catalogue. More than half of the subjects on the programme have been completed. The observatory possesses a set of negatives of the principal nebulae which is priceless and unequaled. These photographs have already led to many discoveries of prime importance, and they furnish a vast amount of material for future investigations of questions bearing especially upon the early stages of sidereal evolution. The photographs record, incidentally, great numbers of new nebulae, as many as thirty-one on a single plate covering less than one square degree of the sky. A conservative estimate places the number within reach of the Crossley reflector at 120,000, of which only ten or fifteen thousand have thus far been discovered.

It has previously been supposed that the great majority of nebulae are irregular and without form, and that only a few are spirals. Professor Keeler's photographs have recorded more spiral nebulae than irregular ones. This discovery bears profoundly on the theories of the cosmogony, and must be considered as of the first order.

The honorary degree of Sc. D. was conferred upon Professor Keeler in 1893 by the University of California. He received the Rumford medal from the American Academy of Arts and Sciences in 1898, and the Henry Draper medal from the National Academy of Sciences in 1899. He was elected a member of the National Academy of Sciences at the April meeting in

1900. He was also an associate of the American Academy of Arts and Sciences, a fellow and foreign associate of the Royal Astronomical Society, a fellow of the American Association for the Advancement of Science, a member and officer of the Astronomical and Astrophysical Society of America, an honorary member of the Toronto Astronomical and Physical Society, the president of the Astronomical Society of the Pacific, a member of the Washington Academy of Sciences, and various other organizations.

It appears that Professor Keeler had long been a sufferer from a mild form of heart weakness; to run even fifteen steps caused him great physical distress. It is feared that on Mt. Hamilton he worked beyond his strength. He went away from the observatory on July 30, in the best of spirits and with no anxiety, to secure medical treatment and to spend a brief vacation in the northern part of the state. Increasing difficulty in breathing led him to seek skilled treatment in San Francisco on August 10. His dangerous condition was recognized on August 11, and on the 12th a stroke of apoplexy proved fatal.

When the dangerous weakness of his heart was discovered by the physicians, Professor Keeler's main regret was that he would have to leave Mt. Hamilton and its opportunities in order to live at a lower altitude. It is known that he had planned his work with the Crossley reflector far into the future. A small spectrograph which he was most anxious to employ on certain interesting spectra was completed on the day of his leaving the observatory.

Professor Keeler married Miss Cora S. Matthews at Oakley plantation, Louisiana, on June 16, 1881. He left two children.

To those who knew Keeler during the formative period of his life, either when a lad at Mayport or when more mature at the university, many delightful characteristics are inseparably connected with his memory. Perhaps those who were incapable of understanding his scientific aspirations were more impressed by his unfailing good humor, his gentleness and kindness, and by a very exceptional sense of the humorous, which not only contributed greatly to his enjoyment of life, but gave him the appearance of being an eminently happy man. His interest in life was keen and rational. With perfect adaptability to the circumstances of the moment, he seemed to find not only sources

of pleasure in them, but the kind of opportunities for intellectual occupation which is indispensable to minds of his type. The writer carries in vivid recollection his story of a trip from Mayport to the north in a small vessel, when he astonished the master by determining the place at sea by observations on stars at night, while the navigator had supposed that an observation of the sun was always necessary. To such a man children afforded endless delight, and doubtless many others can recall scenes where he utilized his extraordinary skill with the pencil as a means of entertaining them, when it was difficult to determine whose laughter was the more merry and infectious.

As a worker in science, his achievements were highly interesting. Although remarkably ingenious in devising expedients to meet his ends, he was never carried away by an admiration for his own creations, but was ever ready to reject any plan for a better one; in short, he always seemed to attain the very best expedient which inevitable conditions imposed. His work impressed the observer as so much like play that it was always a surprise to find that it generally proved an important contribution to science. Never hurried, never anxious, to watch him was a pleasure and to work with him was an inspiration. Apparently careless of scientific honors, such came to him in extraordinary abundance, and a longer life would surely have brought him fame to which we can set no probable limit.

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