THE LICK ASTRONOMICAL DEPARTMENT

OF THE

UNIVERSITY OF CALIFORNIA

BY

MILICENT W. SHINN.

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THE UNIVERSITY OF CALIFORNIA. II. THE LICK ASTRONOMICAL DEPARTMENT.

I.

The Lick Observatory is in a sense the crowning possession of the University. From the scholar's point of view it is eminent over the other departments in being the single one that is mainly given up to original research. From the popular point of view it is magnificent in the possession of the largest telescope on earth. It gratifies the pride of the State keenly to know that pilgrims from foreign lands count it one of the things that must be seen in California. No Philistine doubt of the utility of pure science can stand against this pride; and a public that has seen the time when it was half-ready to pull the courses at Berkeley to pieces in contempt of "unpractical learning," has never asked, "What practical use in knowing of a fifth moon of Jupiter, or a shadowy duplicate streak across Mars?" Doubtless the fascination of the heavens — of mystery, exploration, and discovery — has had much to do, also, with the interest in the Observatory; the diligence and skill with which its results have been made known to the people has counted for much; and none of the thousands who have visited the summit of Mount Hamilton can have failed to come away in some degree awed by the singularly visible form science takes on in that great dome in the heart of the wilderness, lifted up between the sky and the tumbled sea of mountain tops.

In spite of the pride in it at home, and its good name abroad, the Lick Observatory is not a rich institution. Mr. Lick's gift was $700,000. It was at first believed that $300,000 of this could be saved for endowment, but as the work of building and equipping on the mountain-top progressed it became evident that this would be impossible; and in fact, when all was done, the Observatory had cost about $600,000, leaving about $100,000 for endowment. The interest on this fund was supplemented by an appropriation from the general revenues of the University. This diversion of money from the main work of the University to a branch that had been expected to be dependent on its own revenues was not accomplished without opposition, but, I think, is generally acquiesced in now as necessary to any adequate use of the Observatory property. It is not, however, by any means a desirable way for the income of the Observatory to be permanently derived: there should be a separate endowment sufficient for all needs. Even with this help the full use of the resources of the Observatory cannot be had, for lack of a sufficient staff. The latest report gives the following comparison of the working force in several observatories: —

Lick Observatory	6
Greenwich Observatory	20
Harvard "	40
Paris "	17 astronomers, and many computers.
Pulkowa Observatory	16
Rio Janeiro "	16
Washington "	19

Yet, the report adds, "at least as much is expected from the Lick Observatory as from any of these establishments."

The income of the Harvard College Observatory was stated by its latest report at $33,507 from funds, $64,958 from all sources. The average appropriations for salaries and current maintenance of the Washington Observa-

tory are stated at $56,000. The Lick Observatory received last year as interest on its funds, $5,100; from the University funds, $21,000.

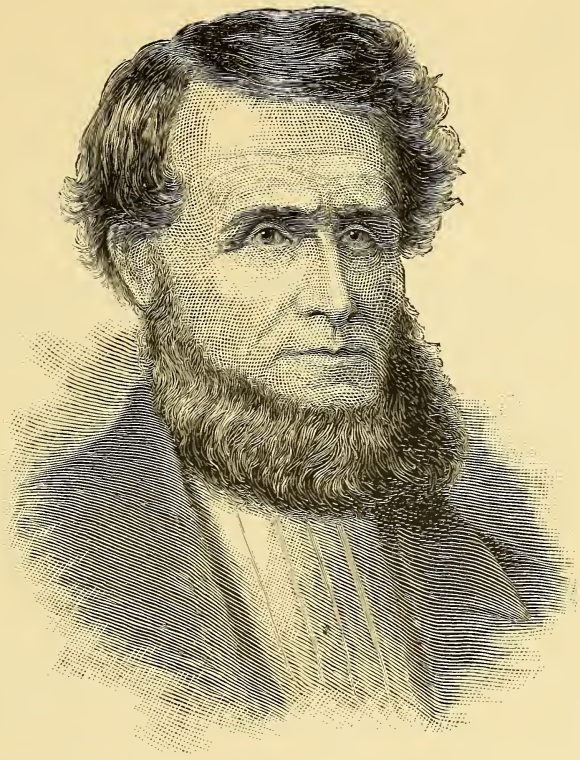
That it has under the circumstances held its own among the observatories of the world, as it has, seems to me a remarkable evidence of the diligence, precision, ability, and efficient adjustment of the work done by every one of the small group of astronomers. I find the Harvard Observatory and the Lick Observatory named together (in a pamphlet concerning the Washington Observatory, put forth by a number of American astronomers) as "the two chief observatories of America." In turning over the great foreign astronomical publications I find the Lick Observatory mentioned with constant respect; its observations texts for the discussions of learned societies and utilized in the work of the great observatories; its astronomers' names signed to frequent communications. Nor this by any means only in matters depending on "the mere brute power of a great telescope," (to plagiarize a clever phrase,) though of course the great telescope is its special distinction. I shall try to give later in this article some summary of the accomplishment of the Observatory so far, and I think it will be seen to be large in proportion to the means that have been available.

It is evident that the current expenses of the Observatory are all that its income could hope to cover. The sending out of a scientific expedition, the purchase of new expensive instruments, or any such outlay, can be accomplished only by means of gifts. And in fact a good deal of what has been done already has been due to the success of the director in interesting wealthy people in the work, and obtaining money for special purposes of this sort. In the four years of the existence of the Observatory nearly $10,000 has been thus given; and now Mrs. Phœbe Hearst has given a fund, which will yield at least $2,000 a year and will be in part applied to the maintenance of fellowships, thus increasing the staff to some extent; while it can be in part reserved for important special purposes.

II.

No one seems to know how or when the idea of a great telescope entered Mr. Lick's mind. It was there before he took any one into his confidence. He had never looked through a telescope; had never seen a real telescope, so far as any one knows. He was entirely ignorant of astronomy, and not even in an unlearned way an observer of the skies,— in early talks about his plans, for instance, he wished to be shown the moon in Professor Davidson's telescope out of his north windows. In some way, however, through chance readings, a sense of the glory of astronomical discovery had laid hold upon him, and the first persons with whom he talked of the disposition of his fortune found the plan of the telescope already firmly fixed in his mind.

James Lick was of "Pennsylvania Dutch" origin; he was brought up in the narrowest circumstances and with the narrowest intellectual opportunities; was in early manhood a mechanic in and near Pennsylvania, then spent most of his mature years in business in South America. He came to California in 1847 with a good deal of property, invested early in real estate, and at the age of seventy-seven found himself the owner of several millions, almost alone in the world, and failing in bodily powers; it was inevitable that he should ponder much on the disposition of his money. He had no belief whatever in personal immortality,— he was, in fact, a man of most marked disbeliefs in religious matters, recognizing Thomas Paine as his leader in thought,— but he had a great desire for that immortality in men's memories that follows the few



Engraved from Painting at the Lick Observatory.

JAMES LICK.

famous ones of earth, and he proposed so to dispose his millions as to win it. He did not at first altogether realize that in this aspiration he that saveth his life shall lose it; nor how impossible it is, in this stage of the world's progress, that a memorial should bring glory to a man's name unless at the same time it is of great service to mankind. His first will left as the main bequest a million dollars for statues of himself and his parents, to be erected on the heights overlooking the shores of the ocean and bay. Yet he was more than indifferent to having his portrait painted, and a passion for statuary for its own sake — abundantly shown in the minor bequests — probably entered into his desire to have his bodily presentment thus kept for all time.

In 1873 he began to take into his confidence a few acquaintances, and ask their judgment of his plans. Although he had lived a very isolated life, and had no near friends, he was in his way attached to the Pioneer Association and had made acquaintances there, and he had a liking for the Academy of Sciences and some sympathy with its pursuits.

In February, 1873, he quite unexpectedly offered the Academy a piece of land on Market Street, the site of its present building. Professor George Davidson, then president of the Academy, called to thank him, and Mr. Lick then told him of his purpose of leaving money for a great telescope. It could not have been far from this time that he spoke of his intentions to Mr. D. J. Staples, whom he knew through the Pioneer Association, and showed him his will. Mr. Staples became from that time one of his principal advisers in matters con-

cerning the trusts in general, as Professor Davidson was with regard to the telescope. There were others, however, with whom he talked, and it is quite impossible to trace the influences that finally shaped his benefactions; for he had a way of consulting one and another, and quietly comparing notes on their advice, without letting either one know what he was saying to the other; and in general I should judge that where their advice agreed, he took it; where it did not, he followed his own way.

Mr. Staples felt it his duty to tell Mr. Lick frankly that his bequests for statues of himself and his family would be utterly useless as a memorial; that the world would not be interested in them; and when Mr. Lick urged that such costly statues would be preserved for all time, as the statues of antiquity now remained the precious relics of a lost civilization, answered, almost at random, "More likely we shall get into a war with Russia or somebody, and they will come around here with warships and smash the statues to pieces in bombarding the city."

Mr. Lick was struck by this, and after a few moments' consideration asked, "What shall I do with the money then?"

Mr. Staples thought it too important a question to answer hastily, and after talking with Mr. Ralston, the banker, he brought together at Mr. Ralston's home a small group of careful men,—among whom were Mayor Selby, President Gilman, and Doctor Stillman, to consider it; out of this conference came most of the suggestions that Mr. Lick later adopted. There were points in the will that Mr. Lick's advisers felt sure would injure its validity, and he consented to draw a second will, and finally a deed of trust. These things, however, concern rather the story of the trusts in general than that of the telescope.

The first will had contained a bequest for this; and whatever other provisions were changed, this was never questioned by any one, nor changed except as, under the influence of Professor Davidson, the amount was increased. Mr. Lick had no knowledge whatever of any of the auxiliaries needed by a telescope, or of the purposes of astronomy beyond bare discovery; and all this was left to Professor Davidson to outline to him in the few months of their conferences. Out of the very interesting verbal narrative that Professor Davidson has given me of this episode, he is willing to have in print at present only so much as is contained in the following memorandum, which he wishes me to leave in his own words:—

I am not willing, at this time, to write the narrative of my relations with James Lick from February, 1873, to August, 1874, but I give very briefly the following items of interest:

James Lick originally intended to erect the Observatory at Fourth and Market streets. His ideas of what he wanted and what he should do were of the very vaguest character. It required months of careful approaches and the proper presentation of facts to change his views on location. He next had a notion of locating it on the mountains overlooking his mill-site, near Santa Clara, and thought it would be a Mecca,—but only in the sense of a show.

Gradually I guided his judgment to place it on a great elevation in the Sierra Nevadas, by placing before him the results of my experimental work at great elevations, as well as the experience of other high-altitude observers. At the same time, by my presentation of facts and figures of the cost and maintenance of other observatories, he named the sum of $1,200,000 in one of his wills, as the sum to be set aside for founding the James Lick Observatory, and for its support.

In making him acquainted with the size and performance of the telescopes of the larger observatories, I naturally mentioned the great reflector of Lord Rosse. That seemed to fire his ambition, and at the next interview he insisted on a refractor of six feet in diameter. It required long and patient explanations to get him down to forty inches, which was the diameter we finally adopted.

In October, 1873, I obtained his permission to make known to the California Academy of Sciences the main facts of his intention to place the largest refracting telescope that could be constructed at an elevation of 10,000 feet in the Sierra Nevadas. I have not the announcement within reach, but it wa published in the *Alta California* late in October, I think the 21st. A short time before that I had con-

fidentially made the facts of Lick's intention known to Leland Stanford and his wife.

An eminent astronomer had nearly frustrated the whole project, by urging Mr. Lick to adopt a reflecting telescope instead of a refractor; but he had a remarkably clear mechanical mind, and I had very little trouble in satisfying him of the weakness of the suggestion.

Before I went to Washington for consultation with other observers for the Transit of Venus expeditions of 1874, Mr. Lick held to the decision of the refractor at a great elevation, and details had been decided upon, although he had several times changed his will in other matters. Before departing I showed him that by the Code of California he could not then devise by will to any corporate body, and urged him to make a Deed of Trust.

Upon my return I found he had made the Deed of Trust, and that some of the Pioneers had prevailed upon him to locate the observatory on the north shore of Lake Tahoe; and had prevailed upon him to reduce the $1,200,000 to $700,000.

When he again changed his views, and determined to locate the observatory on the vastly inferior site of Mount Hamilton, I declined further conference with him.

The whole of my intercourse with him was full of curious and interesting, and sometimes dramatic, incidents, that have never been sought by any one professing to write the history of the Lick Observatory.

Photo by H. E. Mathews.

AN OCEAN OF FOG BELOW MT. HAMILTON, LOOKING NORTH.

The trust deed was dated July, 1874; for over a year and a half Mr. Lick had been continuously occupied in consultations and plans as to the exact disposal of the money. He now began to occupy himself with the carrying out of his favorite purpose, the erection of the telescope. The deed did not bind him positively to the Tahoe site, and his mind lingered about nearer ones, for he had from the first been reluctant to have

Photo by H.E. Mathews.

THE OBSERVATORY FROM THE EAST.

the observatory so far from routes of travel ; he wished it to be as much visited, as constantly before the eyes of people, as possible. He found advisers who favored various nearer sites,—chiefly on the ground of the severity of the winters at Tahoe ; and during the summer of 1875 he had his agent, Mr. Fraser, examine and report on a number of these sites, Mount Hamilton among them. Mr. Lick had been a citizen of Santa Clara County until 1873, and had property there, and when Mr. Fraser reported that Mount Hamilton was the most accessible and the most convenient for building, and when the county agreed to construct a road to the summit, he decided finally to place the Observatory there.

It is something over 4,200 feet high, and as it was the first great astronomical establishment to be placed at any considerable height, it was talked of all over the scientific world for this, as well as for the great telescope. An article in the *Edinburgh Review* gives Mr. Lick great credit for having "felt instinctively," though without astronomical knowledge, what the astronomers were just coming to perceive,— that the great need of their science was high altitude observations ; and for having been "from the first determined" upon taking the pioneer step in this direction. In fact, it had taken a great deal of pressure, not from Professor Davidson only, for Mr. Staples and doubtless others said much to him on this point, to prevent the location of the Observatory between Pioneer Hall and the Academy of Sciences Building, under the fogs of the peninsula, and amid the

jarring of drays. Professor Davidson, however, had set his heart upon so much more — an elevation of not less than 9,000 feet — that he could not reconcile himself to what he felt the loss of an unprecedented scientific opportunity. And in fact the Lick Observatory may soon be surpassed in its advantage of heights, also, the freedom from fogs on the one hand, storms on the other, may be expected to be greatest, and the number of clear nights in the year the highest. These are points, however, for astronomers to settle. Certainly Mount Hamilton has been praised over and over as the best site in the world so far occu-

Photo by Taber.

THE ROAD TO MT. HAMILTON.

altitude by others, as it is already by several observing stations. I do not know that it follows that it will be surpassed in the excellence of its "seeing," for I find that astronomers do not agree as to the supreme value of high observing stations; for stellar observations, it is said, rarity of air is not so important as steadiness, which does not necessarily depend on height; at medium pied by any great observatory. Professor Burnham's visit in 1879, while it was still a wilderness, his sojourn on the mountain in a temporary dome, and his enthusiastic report on the conditions, are within every one's memory. In the three fall months of his stay forty-two nights were "first-class," — a higher proportion perhaps than at any other time of year; but observers in Wash-

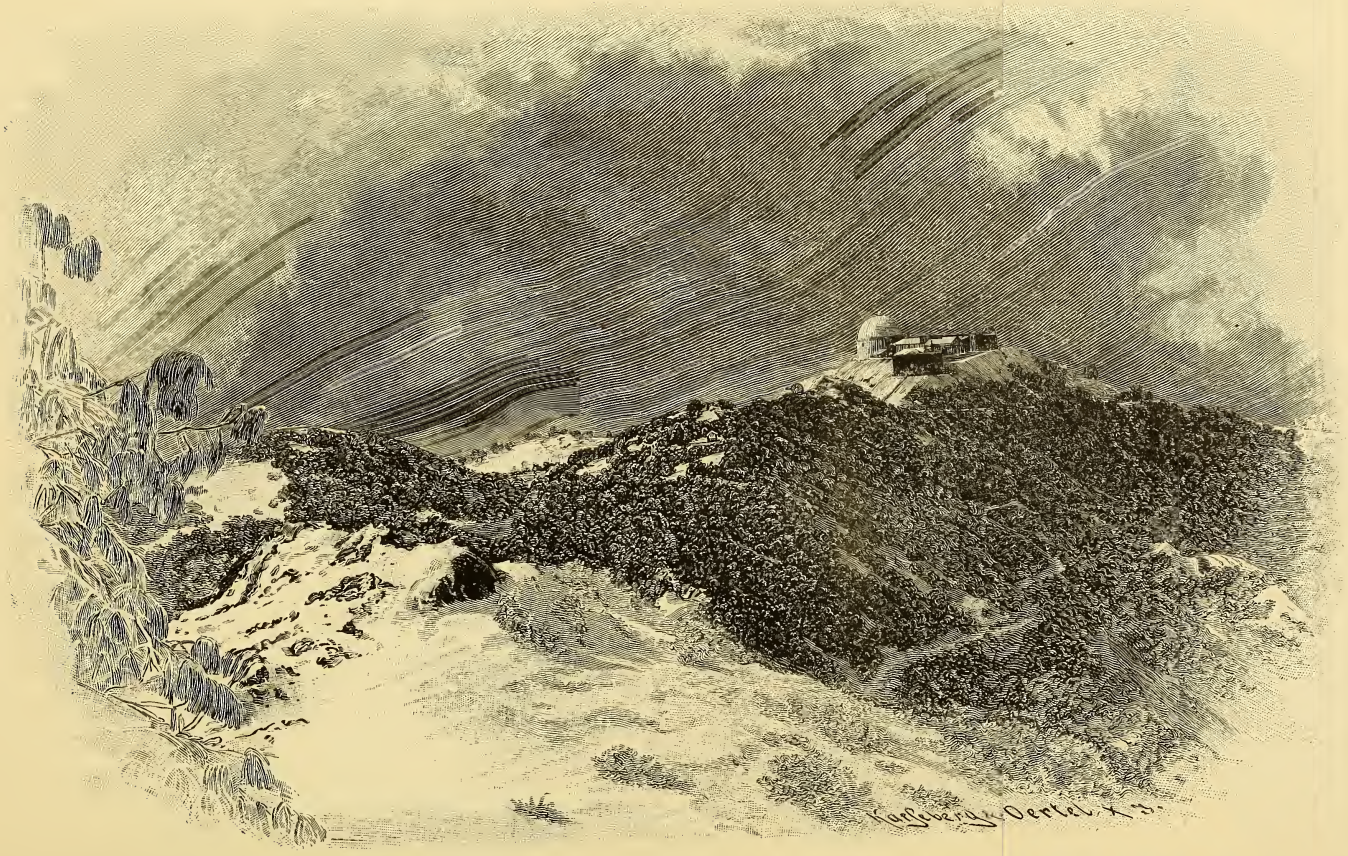
ington have been known to have but thirty-eight very good nights in a year.

While Mr. Lick was settling the question of the site, the trustees began to consider that of plans. They consulted Professor Newcomb, of the United States Naval Observatory at Washington, and during the October of 1874 he and Professor Holden, at that time one of the astronomers of the Washington Observatory, drew the general plans that have since been followed. At the same time, Professor Holden was asked by D. O. Mills, the president of the trustees, to take the directorship of the observatory, and accepted. The whole work of building and equipment was of a sort to require supervision from an astronomer, besides an amount of personal attention which it was hardly possible for Mr. Mills to give. Professor Holden was a young man for such a place,— twenty-eight years old,— but he was a man of whom a great deal was expected, energetic and brilliant, and of good training. He had been a year one of the astronomers in the Washington Observatory and Professor of Mathematics in the Navy, before that for two years a lieutenant in the Engineer Corps and instructor at West Point, where he had graduated with distinction, after taking a scientific degree at the Washington University of St. Louis. But he was not destined to enter upon the duties of director till many years later; for in 1875, some dissatisfaction having arisen between Mr. Lick and certain of his trustees, he sought to recall and remake the trust deed, succeeded in doing so through the legal services of Mr. Felton, and in September, 1875, made a new trust deed, in which he reserved the right to change the trustees. The only other change made by this deed was, that the observatory was to be turned over ultimately to the University instead of the Academy of Sciences. I have been told of a personal incident that Mr. Lick gave as a reason for this change; it is not unlikely that Mr. Felton's influence also, which was always for the University, had something to do with it.

Under the new deed Mr. Lick appointed a board, of which Captain Floyd was the president; and a year later replaced it by a third, retaining Captain Floyd as president, however. A month later, October 1, 1876, Mr. Lick died, at the age of eighty. He had ended after all by leaving no provision for his own tomb; but he is said to have spoken of wishing to be buried at the Observatory; and in 1887 his remains were carried to the mountain and placed in a mausoleum, under the pier of the great telescope.

In the same year, 1876, Captain Floyd being in London met Professor Holden, who had been sent by the government to examine and report upon the South Kensington Loan Collection of Scientific Instruments, especially improvements in astronomic and geodetic instruments. This acquaintance resulted in Professor Holden's becoming the scientific adviser of the board through the whole process of construction; he completed the specifications for the buildings according to the original plan, took part in the vast correspondence that was carried on with astronomers and opticians all over the world, and later attended to the purchase of most of the instruments. For three years nothing but planning and correspondence could be done, for the trust was kept at a standstill by the danger of a litigation that might have ended in the loss of the whole. Claims were, however, happily compromised, and in 1880 work was begun on the mountain.

To place buildings so substantial and extensive on a bare peak twenty-six miles by mountain road from the nearest town, was, of course, no slight undertaking, as 72,000 tons of rock had to be removed to get a level space large enough for the building, and two sum-



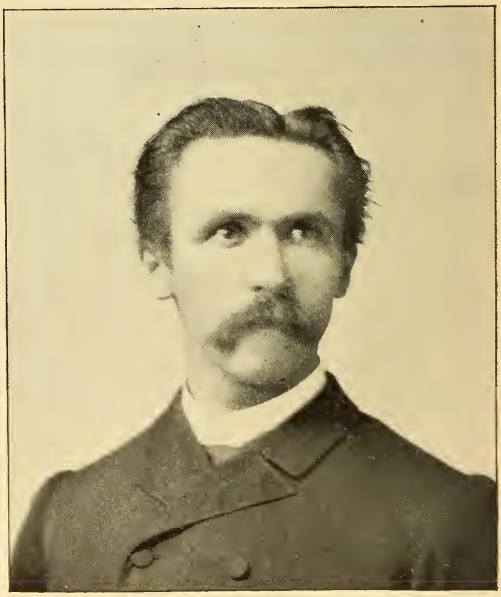
Meyer, in *Himmel und Erde.*

LICK OBSERVATORY IN WINTER.

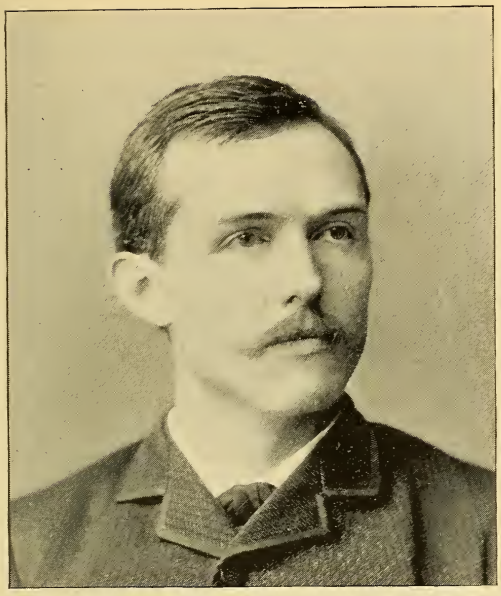
EDWARD S. HOLDEN.

mers were consumed in this task. Santa Clara County had promptly and efficiently fulfilled its promise, and one of the finest of mountain roads,— firm, even, and so beautifully graded that there is not a place in it where the stage-horses need break their trot,— awaited the beginning of work on the Observatory. In five years all the buildings were ready, except the great dome, which had to wait till the telescope was ready.

Mr. Lick's deed had provided for "a telescope superior to and more powerful than any telescope yet made, with all the machinery appertaining thereto, and appropriately connected therewith, . . . and also a suitable observatory." When these words were written, the largest refracting telescope in the world was the 26-inch one of the Naval Observatory, made by Alvan Clark & Sons, and erected in 1873. But while the Lick trusts were at a standstill three more large glasses were made, the largest one 30 inches, made by the Clarks for the Imperial Observatory at Pulkowa, Russia. 36 inches was the largest lens the Lick trustees could get the Clarks to contract for ; so at that size the order was given, $50,000 being the contract price. Every one will remember the somewhat dramatic story of this glass : how Feil & Co. of Paris, undertook to cast it for the Clarks, and sent the flint-glass over safely in 1882, but cracked the crown-glass in packing ; how the elder Feil having retired, the sons tried in vain for a couple of years to get the great glass block safely cast, and at last went into bankruptcy ; how the elder Feil came to the rescue, took charge of the business again, and near the end of 1885 shipped to the Clarks a perfect block. Professor Newcomb, who visited Europe to investigate this matter of glass disks, made an interesting report on the process of making, which I have seen quoted. The difficulty is to get the glass of perfectly even texture throughout, and this can never be hoped for on the first annealing ; veins must be cut out, the block reheated, pressed together, and again annealed, each trial consuming months.



J. M. SCHAEBERLE.



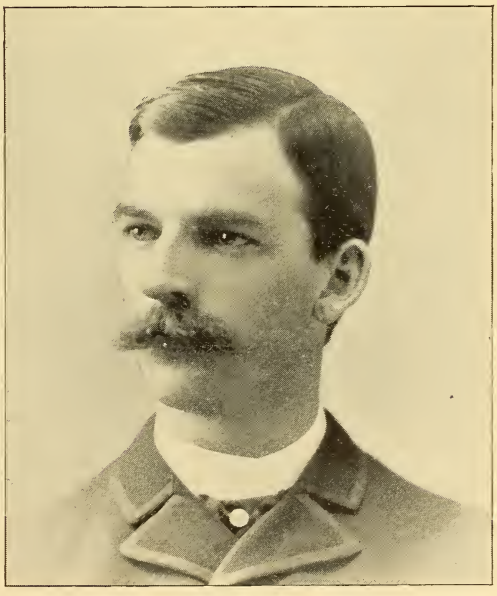
E. E. BARNARD.

The Clarks then took a year for the "figuring," — the delicately precise shaping of the lenses to the most perfect collection of light, so delicate that the last stages are done with the thumb and palm of the hand.

The mounting was made by Messrs. Warner and Swazey, of Cleveland, and the great dome by the Union Iron Works of San Francisco. Of the mechanical excellences of the work much has been said in many journals; and although some adjustments were necessary before everything worked smoothly, I believe the work has all proved to be on the whole wonderfully perfect and wise. The great telescope, with its accessories, cost about $200,000.

Professor Holden made three visits, the first in 1881, to attend to the setting up of the meridian circle, and observe the transit of Mercury; and in 1882, Professor Todd, of Amherst Observatory, observed the transit of Venus here, and obtained excellent results. In 1885 Professor Holden came to the State as president of the University and director of the Observatory, and for the next three years made vacation headquarters at the mountain, and was able to be in constant communication with the trustees in San Francisco.

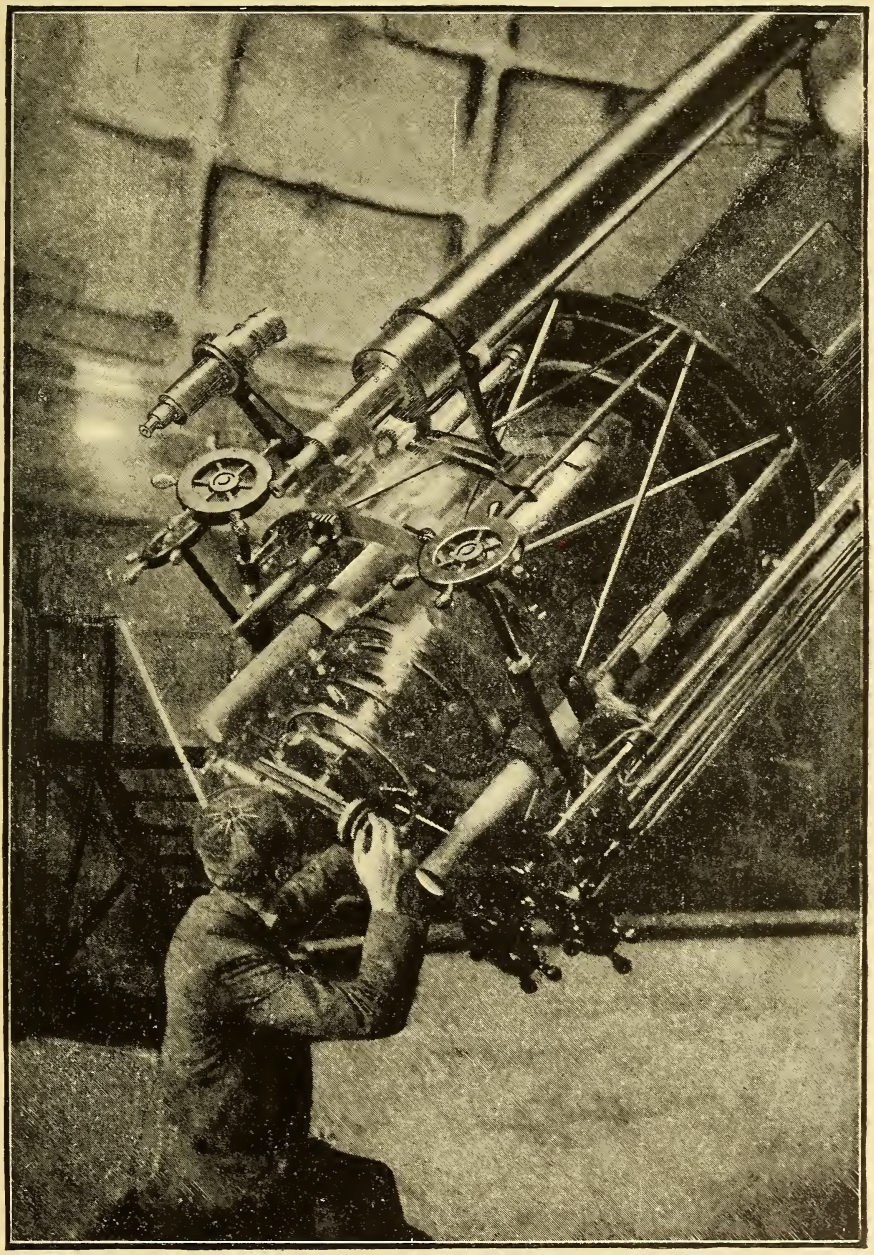
In 1888 the Observatory was formally turned over to the University regents, and its staff of astronomers was appointed. Professor Holden, as a matter of course, was retained as director; he had been called to the University with that understanding. The fourteen years that had passed since his relation to the Observatory began, had been so occupied as to give him in unusual degree an "all-round" acquaintance with the practical and theoretic questions of his science. He had remained five years in the Washington Observatory, and had been successively in partial charge of each department of astronomical work, and in each had been employed not only in observing, but in calculating and in the study of results; and had made as librarian, bibliographer, and writer, an unusual aquaintance with the literature of



W. W. CAMPBELL.

the science. He had in 1881 been called to the directorship of the still unfinished Washburn Observatory, at Madison, Wisconsin, and had organized it efficiently and given it a good standing. In 1878 he had been in charge of the United States Eclipse Expedition to Central City, Colorado; in 1883 of the United States Eclipse Expedition to the South Pacific Ocean; and in 1884 of the Division of Meteorology of the Northern Transcontinental Survey. Without having attained brilliant distinction in any one department of his science, he was an astronomer of recognized merit in all, as evidenced then or soon after by honorary degrees from several universities, and membership in a long list of scientific societies in America and Europe; one of these at least, that of associate membership in the Royal Astronomical Society of England, an honor enjoyed by scarcely a dozen American astronomers, and a practical guarantee of standing. "The first requisite for the director of a great observatory" (I quote a private letter from an astronomer) "is to have a very clear notion of just what kind of work ought to be done, how it should be done, and then to give all the aid in his power to the investigator. In all these particulars Professor Holden seems to be just the right man in the right place." In carrying on the external relations of the Observatory, also,— relating it to other observatories, in this country and abroad, seeing to it that knowledge of its work is thoroughly and to the best advantage disseminated,— Professor Holden has been a successful director; aided in this by a really fine literary power and a wide general cultivation. Of difficulties just now discussed by the papers, concerning the adjustment of internal relations, I do not think it suitable to say anything here. It is unfortunate that any one should have tried to adjust them through the press: Mr. Alvan Clark might as well have tried to figure the great lens with a Corliss engine. This much should be said: whatever difficulties have occurred have been aggravated first by the want of a permanent president in the University, which raises questions of authority, and second by the inherent difficulties of settling novel questions of administration in a novel situation. This is the first great, permanent observatory thrown so on its own resources, far from university or city surroundings, and without the relief of contact with other than the one line of thought. Nor is the situation of a remote military post analogous, for definite military precedents there settle everything,— a system impossible in a branch of a modern university, manned by scientific men, of independent thought and distinction.

The appointment of his colleagues was left to Professor Holden. He selected J. E. Keeler, now director of the observatory at Alleghany, Pennsylvania, S. W. Burnham, E. E. Barnard, and J. M. Schaeberle. Besides these, the only full astronomers, holding rank as professors in the University, have been Henry Crew, now of Northwestern University, and W. W. Campbell, appointed last year. Of those astronomers who are not now on the staff, I must not pause to speak, except in the case of Professor Burnham, who has been connected with the Observatory until very lately. His somewhat unique position among American astronomers deserves mention. He is not only one of the self-created men of science who have not been so very rare in America (the story has been told in print and is not unfamiliar), but he is an instance in what I think must be a rare degree of the attainment of eminence through concentration of effort on a single line. Professor Burnham is not only a specialist in being an observer merely, unfamiliar with the other sides of astronomical science, but as an observer he is almost exclusively a specialist in double stars;



EYE END OF THE GREAT EQUATORIAL. PROFESSOR KEELER.

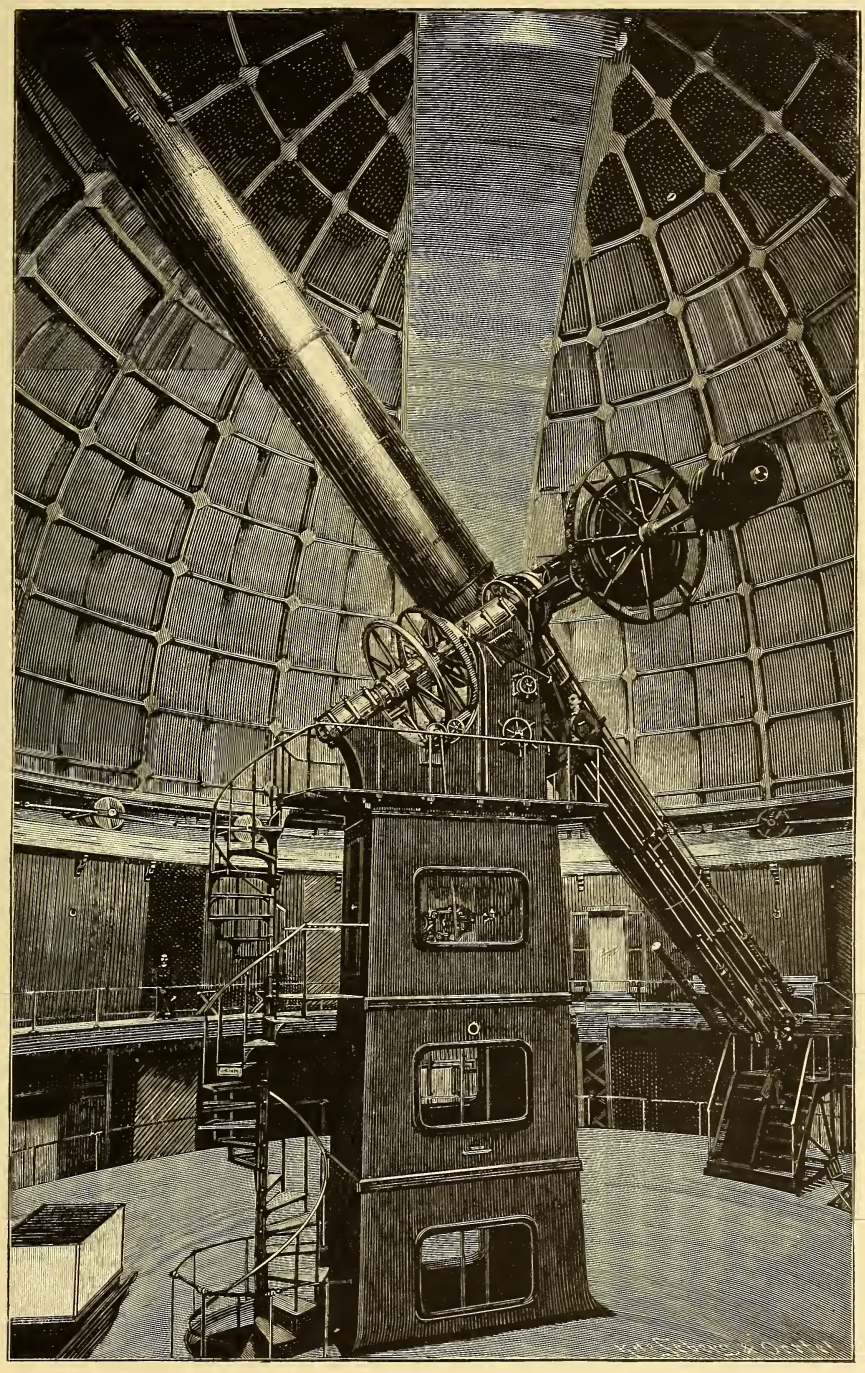
and in discovering and measuring these he has no rival. While he was at Mount Hamilton, this branch of observation naturally became very prominent, and the great telescope was given up to it for more than a third of the time.

Professor Barnard also is a self-taught astronomer, and while not a specialist in so intense a sense as Professor Burnham, he is primarily an observer. His keen vision, great power of eager and yet patient and laborious attention, and doubtless other elements in his work that astronomers could define, give him in especial the name of "genius" among his colleagues. Just now the most brilliant and generally interesting feat the great glass has yet accomplished, the discovery of the fifth moon of Jupiter, has brought Professor Barnard the more into note. Before this, however, he had made some remarkable observations on comets, following them to unprecedented distances and detecting their approach before any one else. In 1891 he discovered all the five comets of the year, including two new ones; in all, he has discovered nineteen comets in ten years. Besides these most striking observations, "Professor Barnard has made a very large number" (I quote a newspaper account by Professor Holden) "upon the physical appearance of the planets Venus, Jupiter, and Saturn, upon the zodiacal light, etc., upon meteors, lunar eclipses, double stars, occultations of stars, etc., and he has discovered a considerable number of new nebulæ also."

Professor Schaeberle is an astronomer of full university preparation, trained thoroughly and soundly on all sides of his science, and in those allied sciences that university preparation includes. A graduate of Michigan University in 1876, he was instructor in practical astronomy in the observatory there, refusing calls elsewhere, till he came to Mount Hamilton in 1888. He has discovered two comets, made long series of meridian circle observations and very extensive calculations concerning asteroid and comet orbits, and has done much work in physical and mathematical astronomy. His theory of the causes of the sun's corona was the text of a recent discussion in the Royal Astronomical Society of England, and if finally accepted will be to those who value the interpretation of the universe more than the collection of its facts, the most solid and important contribution to science yet made by the Observatory. Professor Schaeberle has just put forth tentatively a theory which seems to account for the "canals" of Mars and their duplication with a rational simplicity: if we regard the bright portions of the planet as water, and the dark as land, instead of *vice versa* as at present, he points out, the "canals" may not improbably be mountain chains, some of them parallel chains, as on the earth.

Professor Campbell has been in the observatory only a year, but has forwarded its work much by introducing the photography of spectra with the great telescope. He has also studied the orbits of comets, and published last year a text book of astronomy for university use, which, I am told, has been well received. He is a Michigan University graduate of 1886; was professor of mathematics in the University of Colorado, then succeeded Professor Schaeberle as instructor in astronomy at Michigan University.

The present distribution of work among these astronomers is given by the official report as follows: The great telescope is used for photography two nights in the week, by Holden and Colton (assistant astronomer and secretary); two for spectroscope observations by Campbell and Townley (Hearst Fellow); two by Barnard and Schaeberle for miscellaneous observations; Saturday night is given up to visitors. The 12-inch telescope, the 6½-inch telescope, the comet-seeker and photographic tel-



Meyer from *Himmel und Erde*, Berlin.

THE GREAT EQUATORIAL.

escope, are used by Barnard, and by others when not in use by him. The meridian circle is in charge of Professor Schaeberle; the time service, of Professor Campbell, but most of the work is done by Mr. Townley. The meteorological and earthquake instruments are in charge of Mr. Colton. Professor Holden, besides the general charge of the establishment and of forwarding each one's work, the work in photography, and until Mr. Townley was appointed as the first Hearst Fellow, in spectroscopy, has most of the work of librarian, the scientific correspondence, and the editorial charge of the publications of the Astronomical Society.

The Observatory, as turned over to the University, had a site of 1901½ acres, since increased to 2581½ acres; this is mainly made up of State and national grants, for most of the mountain-top was fortunately public land. One object in getting so large a reservation was to guard against brush fires, by which the buildings at one time were threatened. The main building consists of two domes, connected by a hall 121 feet long, along the west side of which are study and work rooms. The great dome, 78 feet in diameter, occupies the south end of the leveled platform; it moves on the top of a tower, whose foundations are set deep in the rock. The moving parts weigh nearly 89 tons, but so perfect is the mechanism — operated by a small water-engine — that one may see the vast concave swing around at the pressure of a child s hand. The floor works up and down by a hydraulic arrangement devised by Sir Howard Grubb; this arrangement to a great extent takes the place of an observer's chair. The monster tube, fifty-seven feet long, and four feet in diameter at the center, is mounted here on an iron pier thirty-eight feet high. It is provided with "finders" of six, four, and three inches in diameter. When it is used for photography, an additional single lens, 33 inches in diameter, is placed in front of the two lenses that form the visual objective, and the instrument is turned into a great camera. The eye end is provided with mechanism by which the observer as he sits can do most of the handling necessary; with a micrometer, and a frame to which spectroscopes, photometers, or enlarging cameras, can be attached. The Observatory has besides the great equatorial a 12-inch one, which occupies the 25-foot dome at the north end of the platform, a 6½-inch one, and a 4-inch "comet-seeker." Behind the main building is the meridian circle house, which contains a fine Repsold meridian circle and a 4-inch transit and zenith telescope. The Observatory is besides well equipped with spectroscopes, chronographs, clocks, meteorological instruments, and complete earthquake apparatus. These buildings, with a small photographic laboratory, take up the leveled space. On the side of the peak a large brick dwelling-house for astronomers finds place, reached by a bridge to its upper story; and below, on the saddle between two peaks (the mountain has three), gathers quite a village of subsidiary cottages, workshops, etc. Beyond these is a small dome for photographic work, the gift, with its telescope, of Regent C. F. Crocker.

When the late Mr. Newall, of England, presented his 25-inch refractor to Cambridge, his son, who was to be its astronomer, made a tour of the great observatories of the world, and came all the way to California to study the equipment of the Lick Observatory and the mounting of the great telescope. The Earl of Rosse visited and examined it in 1891; Professor Auwers, of the Royal Academy of Sciences of Berlin, and Professor Vogel, Director of the Potsdam Observatory, are to do so soon, on a tour of inspection with reference to a great telescope for the Prussian government. The satisfaction the astronomers feel in showing the Observatory and its

VENDELINUS.

From Drawings twenty-fold enlarged from the Negative made at the Lick Observatory, August 31, 1890, at 14 h. 27 m., P. S. T., by Professor L. Weinek, Director of the Observatory of Prague.

equipment to these competent judges is unmistakable. It certainly seems, even to the guest ignorant of astronomy and astronomical instruments, a most intelligible satisfaction. The whole place is fascinating, exceedingly, — the road thither, winding up from one stage to another of mountain outlook, through the amazing medley of loops and turns by which it preserves its easy grade, mounting at last and circling the sides of the peak itself; the fine, firm, dignified building, before whose broad entrance one is finally set down; the shining orderliness and perfection of everything; the sense of being islanded above the world, the distance and seclusion, and yet the intimate nearness to the whole world of science; the cordial hospitality of every one there; the vast, dark dome by night,—"as big," some one with me said, "as the sky looks to most people,"—with the great tube spanning the darkness, directed steadily and silently against the sky, like a powerful cannon, lying in wait to storm its immemorial secrets.

III.

Mr. Lick's deed prescribed that the Observatory should be "made useful in promoting science." Whether through the alliance with the University or by Professor Holden's original plan, it has taken on also a function of diffusing knowledge and aiding education in the State. I do not know if any other great observatory in the world takes on itself any such function, at least to any such extent. In the first place, there is the surrendering of one night in the week to visitors. This does not mean that a few stray pilgrims make their way to the shrine in the wilderness. It means that stage after stage from San José rolls up,—twenty in a procession, sometimes,— and the little group of astronomers receives with unflinching courtesy the hundreds of passengers, and with a system and deftness that is really wonderful marshals them through the Observatory, explaining patiently its leading points, until far on in the night. 22,496 guests are recorded in four years, —some of them by day, to be sure, when the Observatory is always open. No other observatory in the world offers such privileges to visitors. The Astronomical Society of the Pacific is an efficient means of diffusing astronomical interest and knowledge. It seems to be an unusually vigorous and well-knit organization, publishes a bi-monthly journal, skillfully edited to be of interest to astronomers and unlearned members alike, has branches in Eastern States, and some five hundred members scattered all over the world. And in addition, through newspapers and magazines, full explanations of the work and statements of the general results reached in the Observatory have been given forth as fast as they reached definable shape. No one that knows much of the time and skill such publication demands can look over the quantity that has been done without wonder and respect.

The Observatory has from the first planned for graduate students whenever the accommodations permitted, and nine in all have studied practical astronomy there; of these, five were professors from other institutions, who came for further study of some special sort. It is the intention to make more and more of this graduate work, and already no student need leave California to get the highest training in astronomy. The Harvard and Washington observatories give no instruction, and there is no reason why the California University graduate school should not become the source to which observatories all over the country will look for their young astronomers. The director has been unusually diligent and successful — as any one may learn by an examination of the reports, periodicals, and other sources of first-hand information available — in bringing for-

MARE CRISIUM.

From Drawing by Professor L. Weinek from the Negative taken at the Lick Observatory on August 23, 1888.

ward the younger men about him and making their successes known; and I am told by competent and disinterested authority that the system of giving credit to individual observers in announcing the results of the Observatory work is very liberal at Mount Hamilton, as compared with that of other observatories. The really promising young astronomers from the graduate school will profit by this system.

What has the Lick Observatory done thus far for "the promotion of science?" It is a question that a mere onlooker

cannot possibly answer except by a re-summary of the summaries already put forth, and confirmed by the notices of astronomical periodicals : —

Solar Eclipses of Jan. and Dec., 1889. —At the January eclipse Professor Barnard, and the Amateur Photographic Association, more or less under his direction, took many fine photographs of the corona, which demonstrated the existence of an "extension" of the outer corona. The eclipse of December was observed by Professors Burnham and Schaeberle, who went to South America at the expense of Regent C. F. Crocker. The photographs of these two eclipses are recognized as among the best photographs of the corona ever made. Two books have been published by the Observatory containing the results of these two eclipses.

It was from their evidence that Professor Schaeberle was led to his theory of the corona, mentioned above. In April, 1893, the next total eclipse of the sun takes place ; this theory, by which, if it is sound, the general features of the future corona can be *now* foretold, will then have a practical test. A party under Professor Schaeberle will go to Chile, to observe the eclipse.

Observations of the Planets and Satellites.—The planets have been steadily watched and studied, measures and drawings of them made, and enlarged photographs of Jupiter taken at regular intervals, thus recording all changes in the surface. These photographs, taken by Professors Holden and Campbell, are the subject of a paper before the Royal Astronomical Society, by A. Stanley Williams, who praises them all highly, and says of one that it is perhaps the finest and most interesting photograph of Jupiter ever obtained. Much time has been spent in examining the planets Mars, Uranus, and Neptune, in search of new satellites. Jupiter has been disadvantageously situated, but is now coming steadily into better position, and will be more and more studied : last summer Professors Schaeberle and Campbell made some interesting discoveries as to the forms and motions of the moons ; and in September came Professor Barnard's famous discovery of the small inner moon.

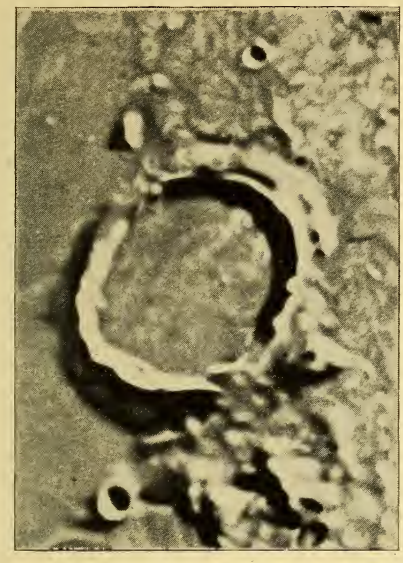
Double Stars.— In this department the Lick Observatory has easily led thus far, and Professor Burnham catalogued 198 new double stars there. His resignation will make the subject less prominent in future work.

Meridian Observations.—These series of observations, carried on by Professor Schaeberle with the meridian circle, are first to determine the positions of stars to join together the systems used in the nautical almanacs of the different nations; second, to determine the *refraction* of the stars. A former series of similar observations is being reduced by computers in the East, at the expense of Miss Bruce of New York, and Professor Mendenhall of the United States Coast Survey.

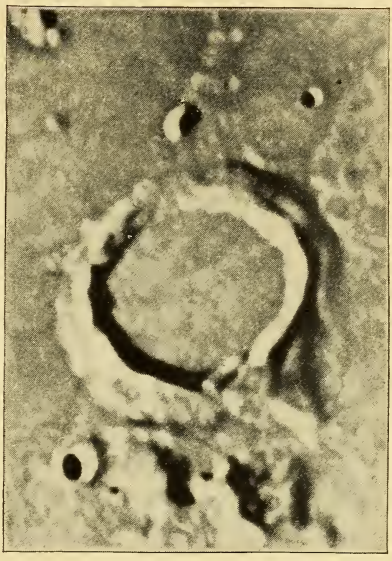
Absorption of Photographic Rays.— Professor Schaeberle, from observations by Professor Campbell and himself, has determined the amount of this absorption by the air at different altitudes,— a datum necessary in fixing the photographic magnitudes of stars, and never before definitely determined. This memoir is about to be published by the University in book form.

Comets.— Professor Barnard's notable observations, which give the Lick Observatory the lead in this direction, have been mentioned above.

Star-Clusters and Nebulæ have been regularly studied and photographed, and in the case of the cluster in Hercules a novel peculiarity of structure has been ascertained. Professor Barnard has taken some important photographs, showing the real shapes of nebulæ. Professor Holden's paper on Helical Nebulæ has been translated into German, and received with much consideration.



ARCHIMEDES, AUGUST 15, 1888.



ARCHIMEDES, AUGUST 27, 1888.

From Drawings by Professor Weinek, enlarged ten times from negatives made at the Lick Observatory in August, 1888.

Moon Photographs are regularly taken with the great telescope, and it is the intent to continue till a complete set has been obtained for every hour or so of the moon's age. Changes on the moon's surface can thus be detected. These photographs have been mechanically enlarged on glass by Professors Burnham and Barnard, and they are now sent regularly to Prague, to Professor Weinek, who makes enlarged drawings of parts of the surface, which are printed in heliogravure, at the expense of Walter Law, of New York. These drawings are studied by Professor Weinek and Professor Holden with great care, and Professor Weinek has discovered many new features in this way. Doctor Otto Boedicker, astronomer of Lord Rosse's observatory, Doctor Ebert of Erlangen, and Doctor Franz of Koenigsberg, are also making special studies of them.

Milky Way.— The Milky Way also is to be studied by means of photographs, which Professor Barnard is now taking, attention having been directed to the promise of excellent results through some most successful ones that he had made. The comet lately discovered made its impression on one of these plates, and was thus first recognized as a stranger.

Spectroscopy.— Professor Keeler made some remarkable spectroscopic observations, by which he established (for the first time) the motions of nebulæ in the line of sight. When Professor Campbell succeeded to the work, he adapted the spectroscope — intended for visual observations — to photographing spectra, and the results showed enormous advantages in this method. To this is largely due the unrivaled success of the Lick Observatory in studying the new star in Auriga. The greatest number of lines in its spectrum reported from other observations is three ; Professor Campbell has measured fourteen. During the time this star was very faint, the photographic observations of the Lick Observatory were the only ones by which it could be followed. They alone showed its neb-

ular character, and since its extraordinary change into a true nebula, they have been the only ones that kept account of its motions — showing that it has been moving away from us, and is now approaching, probably revolving in a vast orbit — and of its nature, indicating that planetary nebulæ owe their genesis to such new stars; both most important steps in our knowledge of stars.

A review of the publications of the Astronomical Society will show many minor or subsidiary inquiries going on at the Observatory. The secretary's report to the regents shows that from June, 1888, to September, 1892, there have been 462 papers published by the as-

1892, Aug., 14 d., 11 h., 15 m. P. S. T. W. W. Campbell.

1892, Aug., 17 d., 11 h., 15 m. P. S. T. W. J. Hussey.

SKETCHES OF MARS SHOWING CANALS.

tronomers and students—more than two a week. Some of these have been brief scientific memoranda; many of them long and arduous papers.

Two things will be noticed in looking through this summary of the scientific work. First, the great importance of the photographic method. This is a new aid to astronomy, which the Lick Observatory has been one of the first to appreciate, and which it has unrivaled facilities for using. The power it gives to *record* a fleeting phenomenon, to sit down and study it at leisure, and to send it for confirmation to another observer, even the other side of the world, makes it of inestimable value. Second, the co-operative relation with other observatories. It has not been the general policy of observatories to give out their results promptly, and help each other in making use of them. The Lick Observatory, by a division of labor that to some extent makes it a gatherer of raw material, to be worked up in places where more help is available, has been of service to these other observatories, received great service from them, and hastened the advance of science, a few months sufficing to have thoroughly studied, interpreted, discussed, and settled, some point that might have had to wait years, had each observatory depended on its own resources. As has been said, if the four distinguished foreign astronomers now engaged in special studies of the moon negatives were on the staff of the Lick Observatory, they could hardly utilize its advantages and help its work more.

In addition to all the purely scientific work, the Observatory regulates the time service for the Pacific States, sending out daily signals to all the railroad stations; and several minor services of the sort have been rendered.

That the Lick Astronomical Department has done a surprising quantity of work in the four years, cannot be questioned. One is disposed to think after reviewing it, that too much has been done rather than too little. The great ambition of all the astronomers to force the Lick Observatory instantly into the world's front rank, in spite of limited means and small staff, by a quantity of work that would demand attention, and of such sort as would bear the judgment of the first European scholars and societies,—this seems to me to have kept the work at a high pressure that has told somewhat on the men. We must be grateful, however, that the grade of the work has been kept high. It is most easy and tempting in a new institution to make concessions from an excellence that one's public will never miss; and all the evidence shows that the Lick Observatory has not done this.

Milicent W. Shinn.