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THE ALLEGHENY OBSERVATORY IN ITS RELATION TO ASTRONOMY[1]

WHEN I last visited the Allegheny Observatory, in 1869, I found very different conditions from those that prevail to-day. As a boy, I had learned that Pittsburgh was at the junction of the Allegheny and Monongahela Rivers, and I was glad to verify it by actual inspection from the door of the observatory. To-day these rivers are not in sight. The little thirteen-inch telescope appears to have attained dimensions and to have acquired appliances beyond our dreams in those days. In one respect is the observatory unchanged. I find a young and enthusiastic director, full of new ideas and, I hope, aiming to make this observatory the greatest in the world. My good friend Langley was then thirty-four years old. His work on the sun, continued through his life, was in its infancy. He tried to persuade us that the smoke hanging over Pittsburgh was especially advantageous for his line of work, since it cut off the irregularities due to the heat of the sun when the sky is clear. Within limits, this is true.

The early history of the Allegheny Observatory is unique, and in some respects stormy. The first director became obsessed with the idea that the telescope must be preserved, but not used. This view he maintained with the aid of a shotgun. He became insane, and wrote a poem. Far be it from me to suggest any connection between these two facts. In this poem, he predicted that the object glass of the telescope would be stolen. Strangely enough,

[1] An address delivered at the dedication of the new Allegheny Observatory, August 28, 1912.

this prediction came true, and more strangely still, in spite of this prediction, it was proved conclusively that he had nothing to do with the theft. The object glass was carried off and held for ransom by persons who greatly overestimated its value. Langley gave a most interesting account of his experiences with the thieves. He was supported by the trustees of the observatory in maintaining that not a cent should be paid unless the thief could be punished, otherwise no large lens in the country would be safe. Finally he met the thief by appointment, one evening, and as they walked up and down a wooded path, the thief remarked, "You are a gentleman, and I am a gentleman; we must trust one another." Finally, the lens was returned uninjured, without ransom.

Langley's invention of the bolometer opened a line of research which has continued to the present time. He displayed consummate skill and ingenuity in its development, and extraordinary patience in overcoming the numerous difficulties which presented themselves. Even in those early days he was deeply interested in the problems of artificial flight. We were often together in the woods or mountains and whenever he saw a hawk, or other large bird soaring, he would stop and watch it, saying, "Some day we shall do that." His discovery of the internal work of the wind was one whose importance does not seem yet to be appreciated. It still seems possible that practical results may be obtained from it. The credit for the invention of the aeroplane is due, in a large measure, to him, and he was bitterly hurt at his treatment by the public press after the destruction of his first aeroplane. Later experience shows that another trial might have proved an entire success.

My acquaintance with his successor, Keeler, was much less intimate, but close enough to recognize his charming disposition and rare talents. Astronomy suffered a heavy loss in his early death. In his work here, and on Mount Hamilton, he has left among others two researches with the spectroscope which have become classical. First, the brilliant proof that the rings of Saturn are composed of minute portions revolving independently around the planet. Secondly, a determination of the motion in the line of sight of gaseous nebulæ. This appears to be the best solution yet found of this problem. It is remarkable that no one has repeated and continued it. Keeler measured only ten of the two hundred nebulæ now known to be gaseous.

The work of Wadsworth was more in preparation than in obtaining results, while that of Acting-Director Brashear has been overshadowed by an enthusiasm which has not only rendered this new observatory possible, but will be of the greatest value to it in the future, and inspires us all to renewed efforts by his unflagging zeal.

The present director, Professor Schlesinger, can give you a better description of his work than I can. But as I fear that he may not do justice to its quality, a brief account of it may not be out of place here. Half a century ago, the character of the work done by astronomers was very different from that undertaken at the present time. It then consisted almost entirely in a study of the positions and motions of the heavenly bodies. In fact, if an astronomer had a large equatorial telescope, he generally devoted himself to measuring the relative positions of the components of double stars, and if he had a meridian circle, he measured the positions of large numbers of stars, and determined day by day the exact time. At the larger observatories the position of the moon and other objects in the solar system were determined. A few far-seeing men of genius like Argelander, the Herschels and the Bonds undertook other lines of work, but the last half of the nineteenth century saw the birth of a new science, astrophysics, which relates to other properties of the stars, such as their brightness, size, color and spectrum. Astronomy may, therefore, be divided into two classes, the astronomy of position and astrophysics, which Langley called the old and the new astronomy. Two years ago, forty of the leading astronomers of Europe visited this country to attend the meeting of the Solar Union, at the Mount Wilson Observatory, in California. On the way, many of them attended the meeting in Cambridge of the Astronomical and Astrophysical Society of America, now in session here. One of the most eminent of these astronomers, while complimenting us highly on American work in astrophysics, pointed out that of the forty-eight papers read at the meeting, but one related to astronomy of position. You are fortunate in having as director of the Allegheny Observatory an astronomer who has distinguished himself in both departments of the science. A very interesting problem in astronomy of position is a curious motion of the earth by which the latitude of any given point is continually changing by a small amount. If we found the average position of the North Pole and built a circular fence around it seventy feet in diameter, the pole would wander about the enclosed space, describing an irregular spiral, but never going outside of it. Last year the pole appears to have been nearer the fence than at any time during the last quarter of a century, or since the discovery of this motion. A number of stations are now maintained by the International Geodetic Association, at which continuous measures are made of the position of the pole. The accuracy of these measures is such that its position is known within one or two feet. For four years Professor Schlesinger took part in these measures at the station in Ukiah, California. He thus familiarized himself with some of the most accurate methods of measurement of position known.

One of the most important problems before astronomers at the present time is to determine the distances of the stars. The only direct method of finding the distance of an inaccessible object is to measure the change in its apparent position as seen from different points. Fortunately, we can apply this method to the stars, since the earth is more than ninety million miles from the sun, and by its revolution around the latter its position is changed by nearly two hundred million miles. It is quite impossible for the mind of man to conceive of such a distance, but vast as it is, it is almost inappreciable compared with the distance of the stars. Few of them are less than a million times as distant as the sun, and the greater portion of them are probably thousands of times as distant as the nearest. The apparent change in position of the nearest star, as the earth moves two hundred million miles, would equal the height of a man at a distance of two hundred miles. In other words, the problem is like measuring the height of a man two hundred miles away. Various methods have been tried, but the most accurate of all appears to be that employed by Professor Schlesinger. He finds the height of the man with an uncertainty of only one inch! The method he used, when he was at the Yerkes Observatory, consisted in taking photographs with the forty-inch refractor of that institution, the largest telescope of its kind in the world. By using plates sensitive to the yellow rays, he obtained very minute images of the stars, which could be measured with the greatest accuracy. The results for a large number of stars measured in this way indicated a probable error of only a hundredth of a second of arc.

The criticism that, in America, we were not doing our share of the study of the position of the stars, seemed to be a just one. Accordingly, as president of the Astronomical and Astrophysical Society of America, I appointed a committee to remedy this defect as far as possible, and selected Professor Schlesinger as its chairman. Some of the results so far obtained will be announced at the present meeting of the society. Besides the work already described, admirable results in astrophysics have recently been obtained at the Allegheny Observatory by the director, in measuring the motion of the stars in the line of sight, a problem now receiving more attention than any other in many of the principal observatories of the world. Of this problem, it is sufficient to say that to obtain results of the accuracy attained elsewhere, it is necessary to have a telescope of the largest size, a spectroscope of the most approved form, and measures and reductions of the photographs of the greatest possible accuracy.

You will thus see that, as already stated, you have secured an astronomer and placed him in charge of your observatory, who has shown great skill and efficiency in both the old and the new departments of astronomical research. You have before you a beautiful and suitable building and an equipment of instruments of the highest grade. All of those conditions are most favorable, but the future success will now depend largely on you. Allegheny is doubtless a very different place intellectually from what it was when Langley was here, but one of his principal sources of discouragement was the lack of interest in his work, and a failure to appreciate his success by his friends, with a few notable exceptions. I hope that you will follow the work of the Allegheny Observatory closely, and I am sure that you will find the results of interest and value. A large force of observers and computers is needed to derive the best results from an equipment such as is collected here. The number of officers at several of the largest observatories is thirty or forty, and such a force is required to complete in a reasonable time some of the great problems which now form the most important contribution which can be made to astronomy. For example, suppose that an astronomer has developed by long and careful study the best method of attaining a certain result with an instrument costing many thousands of dollars. He can almost always instruct a younger and less able man than himself to repeat his work on other stars. A research can thus be extended, at small additional expense, to hundreds or perhaps thousands of stars, until the entire available time of the instrument is occupied. In visual observations of the stars, this time is greatly restricted by clouds, twilight, moonlight and other causes, while a photograph exposed for a few minutes may furnish material for weeks of study. After a photograph is measured, there is often a long and laborious computation to be undertaken, which can be carried on by unskilled computers after they have been taught the exact method. The results are of no value unless they are made known to the world by publication. This involves laborious copying, arranging material in suitable form, reading of proof and other work involved in publication, in addition to the actual cost of printing. It is evidently very poor economy to establish an extensive plant, and then fail to work it to its full capacity. A steamer which should be idle for ten or eleven months every year would prove a very poor investment. In astronomy, increasing returns constitute the rule and not the exception, while the methods of securing the maximum efficiency by the principles of "scientific management" may be as successful in an observatory as in an industrial establishment.

An illustration of my meaning is presented by the photometric work at Harvard. In 1879 an instrument was constructed for measuring the light of the bright stars, with telescopes two inches in diameter. With this, during the next three years, a hundred thousand measures were made of four thousand stars, mainly visible to the naked eye. When people asked me if we had the largest telescope in the world, I would answer, "No, but we have the smallest that is doing useful work." Encouraged by the success attained, a second similar instrument was constructed with telescopes of four inches aperture. Since 1882 over a million measures have been made of nearly fifty thousand stars. Three times it has been sent to South America to measure the southern stars, and it is now on its way to South Africa, loaned to an English astronomer. To study still fainter stars a twelve-inch telescope has been mounted, and with this since 1892 I have made seven hundred thousand measures of about forty thousand stars. The results fill ten of the quarto volumes of the *Annals* of the observatory, and furnish a standard scale of magnitude from the first to the twelfth magnitude for stars from the north to the south pole.

An excellent example of organization is furnished by the work of the International Astronomical Society. The great astronomer Argelander proposed to determine the exact places of a hundred thousand northern stars. Seventeen observatories took part, including two in America, Harvard and Albany. In extending the work to the southern stars, Harvard again took a zone. Each zone occupied an observer and a corps of assistants for nearly a quarter of a century. The results of both fill half a dozen volumes of the *Annals* and the cost in salaries alone was about two hundred thousand dollars.

May we see some of the great problems in astronomy solved at the Allegheny Observatory better than ever before, and the work repeated on star after star until the entire field has been successfully covered.

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Harvard College Observatory

THE RESPONSIBILITIES OF AN OBSERVATORY STAFF[1]

It falls to me in these dedicatory exercises to say a few words on behalf of the observatory staff, into whose keeping these fine instruments are for the time being placed. You may be sure that we have given much thought to deciding how we might best fulfill this trust, and it is natural that the same question should be a prominent one in the minds of all those who are interested in the welfare of this institution. We are doubtless all agreed that our observatory has not been erected for the purpose of enhancing the reputation of any individual or individuals, nor to enhance the reputation of the observatory itself, nor of the university of which the observatory is the astronomical department. These things are much to be desired in themselves, and we hope that they may come to pass; but if they do come to pass it must be only incidentally, and nothing of this kind must be allowed to obscure the goal toward which we are striving; namely, to add as much as we can to the progress of our science; or, to use the words that were often in the mouth of the

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