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GEORGE C. COMSTOCK & ALBERT S. FLINT

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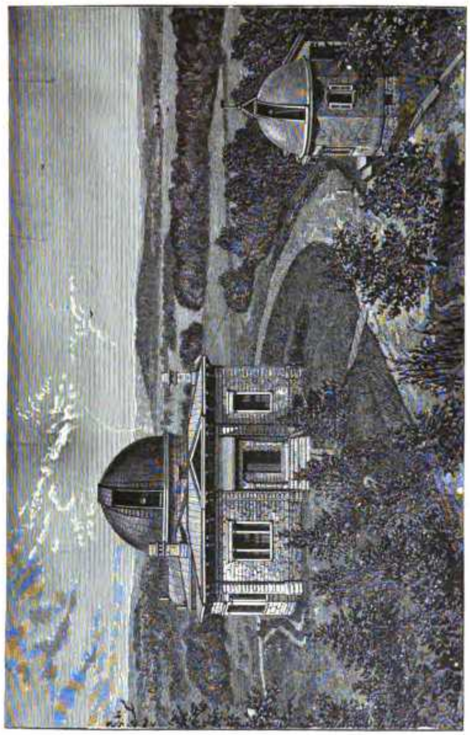

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The Washburn Observatory,

FOUNDED BY

Cadwallader C. Washburn.

Born 1818; Died 1882.

INTRODUCTION.

The immediate incentive to the following investigations was the suggestion by M. Loewy of the extended use of the equatorial telescope and its adaptation to new lines of research through the introduction of reflecting surfaces in front of the objective. A comparison of the following pages with M. Loewy's printed papers will show that in many respects I have deviated widely from his methods in the application of the principle suggested by him, and it seems proper to state that this deviation arises mainly from the circumstance that I have independently worked out what seemed to me advantageous methods in ignorance of his development of the subject, his papers not becoming accessible to me until after I had become committed to methods and an instrument of my own design.

For pecuniary aid in the construction of this instrument I am indebted to the trustees of the Watson fund of the National Academy of Sciences, who placed the sum of eight hundred dollars at my disposal for this purpose. I take this opportunity of expressing to the gentlemen composing the board of trustees of that fund, Messrs. Simon Newcomb, B. A. Gould and Asaph Hall, my thanks for the confidence thus extended to my attempts at applying what was then a new and untried method of research.

The fundamental idea of the prism apparatus designed by M. Loewy and described in a series of papers published in the *Comptes Rendus de l' Académie des Sciences, Vol. CIII., et seq.*, is that if two reflecting surfaces be placed in front of the objective of a telescope in such a manner as to reflect into the objective images of different portions of the heavens, the angular distance separating any pair of stars whose images are thus formed in the telescope, may be found by adding to twice the angle between the reflecting surfaces the angular distance between the images of the stars. This latter quantity may be determined with great precision by means of a filar micrometer, but the angle between the reflecting surfaces does not admit of very precise determination, and the observing programme proposed by M. Loewy is a purely differential one, from which the angle between the reflecting surfaces is eliminated.

It is evident that if instead of two mirrors, three or any greater number be employed and be so placed as to make approximately equal angles one with another, the mean value of the angles formed by the several pairs of mirrors will be determined by purely geometrical considerations, *e. g.* in the case of three mirrors this angle will be 60°, and if each pair of mirrors be employed in the determination of the micrometer distance between the images of the stars as seen in the field of the telescope, the absolute angular distance between the stars will be 120° plus the mean of the three measured distances. The distance between any pair of stars approximately 120° apart may therefore be measured by employing three mirrors; and it may be noted that no other distance admits of such a determination, since if four mirrors be employed the corresponding distance becomes 180°, and it is practically impossible that both stars should be simultaneously visible, and *à fortiori* for any greater number of mirrors.

All of the observations which it is the purpose of the present memoir to set forth and discuss are measurements of the angular distance between stars approximately 120° apart, and such a distance will hereafter be denoted by the symbol Δ.

In my first design of an instrument adapted to observations of this kind, the reflecting surfaces were the silvered faces of an equiangular glass prism supported in front of the objective of an equatorially mounted telescope, with the axis of the prism perpendicular to the line of sight. The theory of the apparatus, hereafter developed, indicates the following requirements which must be satisfied by the mechanical construction.

(*a.*) The prism must admit of rotation through 360° about a line approximately coincident with its own axis.

(*b.*) The axis of the prism must admit of rotation through 360° about a line approximately coincident with the line of sight of the telescope.

(*c.*) The prism must be so supported that neither of these rotations shall have any systematic effect in distorting the figure of the reflecting surfaces.

(*d.*) It is obviously a matter of practical convenience that the rotations (*a*) and (*b*) should be effected from the eye end of the telescope, and I adopted this as a further condition to be satisfied.

The apparatus was to be attached to the six-inch Clark equatorial telescope in the "Student's Observatory" of the University of Wisconsin. This telescope was formerly the property of Mr. S. W. Burnham, and its optical excellence may be inferred from the large amount of double-star work, both measurement and discovery, done with it by Mr. Burnham. The objective has a clear aperture of 152 *mm.* and a focal length of 2,384 *mm.* It is mounted in a wooden tube carried by a light equatorial mounting of the ordinary Clark type, and is provided with an excellent driving clock. The filar micrometer which constitutes an essential part of the apparatus is described in a subsequent section devoted to its investigation.

The equiangular glass prism which was to furnish the reflecting surfaces was prepared for me by Mr. J. A. Brashear, who informs me that he experienced great difficulty in figuring the surfaces by reason of changing temperature distorting the edges of the prism more rapidly than its central portions. "Our standard test plate is one half inch thick, the prism being so heavy the effect of merely opening a door could be seen in less than fifteen seconds, and the only way we were *sure* of the surface was to leave the test plate on prism for a night, light the sodium flame and test immediately."

Since distortions of this character finally compelled me to abandon the use of the prism and to substitute for it another device, a summary description of this part of the apparatus will suffice.

The prism was a single block of glass, each of whose silvered faces was 128 *mm.* square, save that the corners were rounded off to prevent chipping. The prism was supported by brass cheeks let into and cemented to its triangular bases, and to each of these cheeks there was attached by suitable adjusting screws a circular brass plate with an aperture 5 *mm.* in diameter drilled in its center. By means of the adjusting screws these apertures were to be brought into the axis of the prism, and were to form the bearings for a pair of pivots supported near and in front of the edges of the objective of the telescope. These pivots constituted an axis about which the prism was to be rotated by an endless cord extending to the eye end of the telescope.

The distance of the pivots in front of the objective was very approximately 150 *mm.*, and they were supported by a brass casting whose form and position with respect to the telescope are shown in the plate giving a general view of the telescope and dome. By means of four capstan-headed adjusting screws placed 90° apart the casting was attached to each of two stout metallic rings firmly bolted to the upper end of the telescope tube, and by means of these screws the prism could be brought into a position symmetrical with respect to the line of sight of the telescope. No part of the supports of the prism came in contact with the objective or its cell.

To secure a rotation of the prism about the line of sight (Condition *b*) the original connection between the telescope tube and the declination axis was replaced by a simple form of heliometer cradle with handles for rapid and slow rotation of the tube. A divided circle reading to minutes of arc was attached to the eye end of the tube in order to measure the amount of rotation of the telescope in its cradle. Since this rotation corresponds to and is measured by an angle which in the theory of the apparatus is represented by the symbol P, this circle will be called the P circle. Although the cradle was provided with ball bearings for the support of the telescope, the motion of the tube proved to be rather stiff, and was the source of some inconvenience in the conduct of the observations.

It will be recognized from the preceding description that the two faces of the prism which are employed as mirrors in any given observation, stand over opposite halves of the objective, and it is well known that this unsymmetrical distribution of the incident light will produce errors in the measured distance between the star images unless the micrometer threads are placed exactly in the focal plane of the objective. In order to control the focal adjustment of the telescope with all possible precision