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# POPULAR ASTRONOMY

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LANGUAGE. AMPLY ILLUSTRATED.

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## CELESTIAL PHOTOGRAPHY AT A HIGH ALTITUDE.

H. C. WILSON.

During the past summer it was the writer's pleasure, with Professor Payne, to spend the months of July and August in the foot-hills of the Rocky Mountains in Montana, experimenting in celestial photography. One of the main objects of our expedition was to determine whether or not there might be great advantage for photographic purposes, especially the photography of the faint nebulous regions of the sky, in the high altitude which we could reach there over our moderate altitude on the Minnesota prairie. We wished to determine this by taking photographs of the same objects, with the same apparatus, using the same quality of plates, developed by the same person in as nearly the same manner as possible in both locations. The last condition could not be quite exactly fulfilled, because we could not transport our dark room, and the development at the temporary station had to be done without some of the conveniences which are to be found in a permanent dark room.

The location chosen was at Midvale, Montana, a station on the Great Northern Railroad just at the east edge of the first spur of the Rockies. Through the courtesy of the officials of the Chicago Great Western and the Great Northern Companies our party of four and baggage were transported free of charge to Midvale. Other interested friends contributed toward our expenses, but the fund was not large enough to permit us to go far from the railroad and to establish our station on the summit of one of the mountains as we might have desired. Considering the necessity of being near water and fuel, and of protection from the wind, as well as the convenience of being near a railroad station, we selected a small plateau 1,235 feet distant and a little north of west from the railroad station, surrounded by low hills

ain peaks a few miles to the west shielding us from the prevailing west winds.

A part of this plateau and of the mountain range is shown in the engraving Plate XIX. Our sleeping tents are seen to the right of the center and the telescope near the right edge of the picture. The height of this plateau above sea level, as determined by a series of levels from a mark established by the U. S. Geological Survey, is 4,790 feet. A small mountain stream runs by the camp, in a channel approximately fifty feet deep, and our kitchen and dark room tents were located in the valley close to the stream. As a side matter I may state that this stream was well stocked with fine speckled trout, which was quite an important matter for our commissary department.

The high mountain in the central background of the picture, known as Mt. Henry, is between five and six miles distant. The top is a ridge nearly a mile long and very narrow. The general altitude of the ridge is about 8,400 feet and the sharp peak at the left end is about 8,850 feet above sea level. The round peak to the right and in front of Mt. Henry is a little over four miles distant and about 7,800 feet above sea level.

We should have liked to establish our station on one of these peaks, but the difficulty of transporting our heavy apparatus and supplies and the necessity of permanent shelter which would cost much more than our funds would warrant, prohibited the entertainment of such a desire. During August, when the smoke from forest fires filled the valleys and shut us off entirely from our work, we often wished we could have been located on the highest peak, which on the day we ascended it was quite free from smoke while the valleys were full.

The summits of these mountains are bare of vegetation, with the exception of some small mountain flowers and mosses which grow between the pieces of broken rock. Fuel and water would have to be carried up from one to two thousand feet.

Starting from Northfield on the morning of June 30, we had a delightful trip across Minnesota, North Dakota, and Montana, reaching Midvale on the morning of July 1. The drop off here was something of a shock, although we knew what to expect, for there is no village,—nothing but the necessary railroad station houses for telegraph operators and section hands, with one ranch in sight. After a few hours spent in examining the ground we selected our location and began to set up camp. On July 8 the instruments were in adjustment and the first photograph was taken on that night.

The telescope and cameras, as set up at the camp, are shown in Plate XX. The day on which this photograph was taken, our last day but one at camp, was very smoky, so that the mountains are scarcely visible in the background.

We took with us the entire outfit of our 8-inch photographic telescope, with attached cameras, except the pier on which it is mounted. In place of the pier we set up two 10x12-inch pine timbers seven feet long, setting them 3½ feet in the ground and boxing in between them a well for the fall of the clock weight. These timbers formed a very steady support for the instruments and seemed to remain quite stationary during the two months although they were newly sawn out of green wood. In the engraving the reader will readily recognize the two telescopes of equal length, the 6-inch camera, of 36 inches focal length, projected in the picture against the lower part of the guiding telescope, and the 2½-inch camera, attached to the larger telescope near the upper end.

The telescope, as shown in the picture, was entirely out of doors and the only protection for it was an oilcloth cover which was wrapped carefully about the instrument when it was not in use. Fortunately there were no violent storms and very little rain during the two months. Fully half of the nights in July and nearly all of those in August were clear, except for the smoke from the forest fires. On every clear night the air was exceedingly quiet so that the telescope was seldom disturbed by a breath of air. During the day the wind was frequently quite strong and on a few cloudy nights it was such as to prevent our sleeping well in the tents. Several times the clouds which were running thick during the day would clear away just before the time for us to begin work at night and come on again in the morning. A very marked phenomenon on a few nights was the dissolving of great clouds, which rolled over the mountains toward us threatening to stop our work, but which entirely disappeared before reaching the zenith.

As a rule the ordinary clouds ran much higher than the mountain tops,—several thousand feet higher, I should judge,—but on two or three occasions when the weather was stormy they enveloped the mountains and sometimes detached clouds floated through the passes about 2,000 feet below the highest peaks. Twice fresh snow was deposited on the higher mountains, and once a tornado was seen passing several miles away.

Judging by the naked eye views of the sky the atmosphere ap-

peared strikingly more transparent than it does ordinarily at Northfield. Many more stars were visible at a glance, and the familiar stars appeared more brilliant. Near the horizon the difference was very marked, but perhaps that does not give a fair comparison, for the horizon all around us was elevated some degrees. In the direction of the mountains the elevation was over seven degrees.

During the clear days one could look close to the edge of the Sun and not notice much glare around it. The Moon stood out sharp and distinct so that some of the familiar craters could be recognized with the naked eye. The Milky Way stood out more in relief, the great patches being broken up into lesser ones more noticeably than here at home.

The color of the sky instead of being darker, as was anticipated from there being less suspended matter to reflect diffused starlight, was of a perceptibly lighter blue. The increased brightness of the sky did not, however, seem to diminish the apparent brilliancy of the stars. The impression given the writer was that of space not empty but filled with faintly luminous matter, not uniformly bright but with slight variations all over the regions distant from the Milky Way, and everywhere exceedingly transparent to the light of the stars.

In the great bright cloud of the Milky Way between  $\beta$  and  $\gamma$  Cygni one could count easily 16 or 17 stars besides the bright ones  $\eta$  and  $\chi$ , while at Northfield it is difficult to distinctly see 8 or 9 with the naked eye.

Our first photographic experiments were upon the familiar object known as the America Nebula in the constellation Cygnus. This is a large diffuse nebula in the bright patch of the Milky Way about  $3^\circ$  east of  $\alpha$  Cygni. It has been several times photographed by Wolf, Roberts and Barnard, and there are several excellent reproductions of it in *Knowledge*, notably the numbers for October and December, 1891 and July, 1902\*. It was named the "America" Nebula by Dr. Wolf, who noticed on his first photograph of it, on Dec. 12, 1890, a striking resemblance between its outlines and the map of North America. The writer also had obtained photographs with both the  $2\frac{1}{2}$ -inch and 6-inch cameras on the night of June 21, 1895, with an exposure of four hours, so that it is quite a fitting object for the purposes of comparison as well as being in one of the regions described by Herschel as filled with very extended nebulosity.

\* See also *Monthly Notices R. A. S.* Nov. 1902, and *Celestial Photographs* by Isaac Roberts, Vol. II., Plate 24.

The negative from which Plate XVIII was prepared was obtained at Midvale, Montana, July 9, 1904, with a 2½-inch Darlot lens and three hours exposure. The reproduction is enlarged to nearly three times the scale of the original and only the central portion, which is comparatively free from distortion, has been included in the engraving. The area of sky covered in the engraving is about 14° long and 10° wide. The bright star image 1½ inches to the right from the center is that of  $\alpha$  Cygni. The star  $\xi$  Cygni is in the dark space to the left of the nebula, about  $\frac{3}{8}$  inch below and  $\frac{1}{4}$  inch to the left of the center;  $\nu$  Cygni is an inch below the lower point of the "America" nebula,  $\pi^2$  is just at the upper left hand corner of the engraving, while  $\gamma$  lies quite a little outside the lower right hand corner.

Not only is the region having the shape of North America full of nebulosity but a large area to the west of it is strewn with patches of faint light, and to the north and northwest it is impossible to tell where the nebula ends in the mass of faint stars. To give an idea of the faintness of this nebulosity let me say that an equally strong image of the outer loops of the Orion Nebula can be obtained with the same lens with an exposure of less than ten minutes.

More striking even than the nebula and the cloud of stars are the dark spaces and lanes or channels in the midst of the star masses. One of the darkest spaces of the northern half of the Milky Way lies just at the left of the "America" nebula. It is very conspicuous to the naked eye on any clear moonless night just now, being overhead in the early evening. Two rather bright stars lie close to its center line but faint stars are remarkably few. At the right of the nebula the spot corresponding to the Gulf of Mexico, in fact the whole "Atlantic coast line," is remarkable for the absence of stars. On the north is a row of approximately parabola shaped bays encroaching upon the nebula and the star cloud and connecting with them a crooked dark channel runs to the north edge of the plate. Across the left hand portion of the plate are other remarkable arrangements of star clouds and dark channels which are well worthy of study.

At Midvale three photographs of this region were taken with the 2½-inch camera with exposures of one, three and four hours respectively. Plates were exposed at the same time in the 6-inch camera and the 8-inch telescope. Unfortunately in handling the large plates exposed in the 6-inch camera, in the small and inconvenient developing box which we had at the camp, I at first fogged them slightly, so that they are not suitable for reproduc-

tion, and the scale of the picture given by the 8-inch is too large for such faint nebulosity to make much impression on the plates.

The three plates exposed in the 2½-inch camera are all good and show the same general outlines of the nebula. The density of the negatives seems about proportional to the duration of exposure. With the longer exposures the fainter portions of the nebula are filled in and the outlying patches are enlarged. Both the three and four hour exposures appear to give all of the nebulous area shown in the reproduction of Dr. Wolf's photograph in *Knowledge*, Dec. 1, 1891, which was taken with a portrait lens and an exposure of thirteen hours.

My first impression on developing the one hour exposure was that it was equal to the four hour exposure at home, but a careful comparison of the plates shows that the gain is not nearly so great. At first sight the three hour photograph at Midvale appears to be equal to the four hour at home. There is a slight difference in the development of the two negatives, and allowing for this I conclude that one hour of exposure at Midvale will give about the same result as two hours at Northfield.

I reach the same conclusion by comparing a two hour exposure made on the great star cloud between  $\beta$  and  $\gamma$  Cygni made at Midvale with a four hour exposure made at Northfield in 1894 and one of two hours made since our return, with the same instrument. A comparison of the photographs taken with the 6-inch Brashear camera confirms the conclusion that in the increase of altitude of nearly 4,000 feet there is a decided gain in the impression made upon a photographic plate by stars and nebulae with a given duration of exposure.

Plate XXI has been prepared from a negative exposed for two hours, at Midvale, on the night of July 20, 1904, with the 2½-inch Darlot lens. In reproduction the photograph has been enlarged nearly three diameters and only the central portions are retained in the engraving. The area of sky covered by the engraving extends from near  $\beta$  Cygni at the lower right hand corner to near  $\gamma$  Cygni at the upper left hand corner, thus including the major part of the great star cloud of the Milky Way lying between the two stars named. Neither of these stars are included in the picture,  $\gamma$  lying  $\frac{1}{4}$  inch above and  $\frac{1}{2}$  inch to the right of the upper left hand corner and  $\beta$  being  $\frac{2}{3}$  inch below and an inch to the left of the lower right hand corner of the plate. Within the area shown Heis' Atlas gives 2 stars of the fourth magnitude, 12 of the fifth and 17 of the sixth. It is, however, difficult on an ordinary night for a person with average eyesight

to distinguish more than 8 or 10 of the stars, the fainter ones being hidden in the glow of the thousands which are just a little beyond the limit of vision.

In this great star cloud too are seen the curious dark patches and lanes, to which attention was called on Plate XVIII. Two explanations are offered for these, the one that they are really, as they appear, vacant spaces void of stars, through which we see into empty space beyond, the other that they are produced by the intervention of enormous clouds of dark matter between us and the stars of the Milky Way, absorbing and cutting off their light. The latter view was strongly advocated some thirteen years ago by Mr. A. C. Ranyard, then Editor of *Knowledge*, but is not generally accepted among astronomers.

During our stay at Midvale, we made exposures, on two nights each in July, on Herschel's regions Nos. 43 and 45,  $\alpha 20^{\text{h}} 53^{\text{m}} 15^{\text{s}}$ ,  $\delta + 16^{\circ} 44'$  and  $\alpha 20^{\text{h}} 57^{\text{m}} 34^{\text{s}}$ ,  $\delta - 1^{\circ} 34'$  and also, on two fairly clear nights in August, on the region No. 48 near  $\epsilon$  Pegasi. The plates all show feeble variations in density of the skylight in the regions indicated by Herschel, but we have not yet found time to copy them and bring them out with sufficient intensity to decide whether the duplicate plates agree in detail or not. We hope to find time to make this test during the coming month.

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#### THE MATHEMATICAL THEORY OF ECLIPSES.

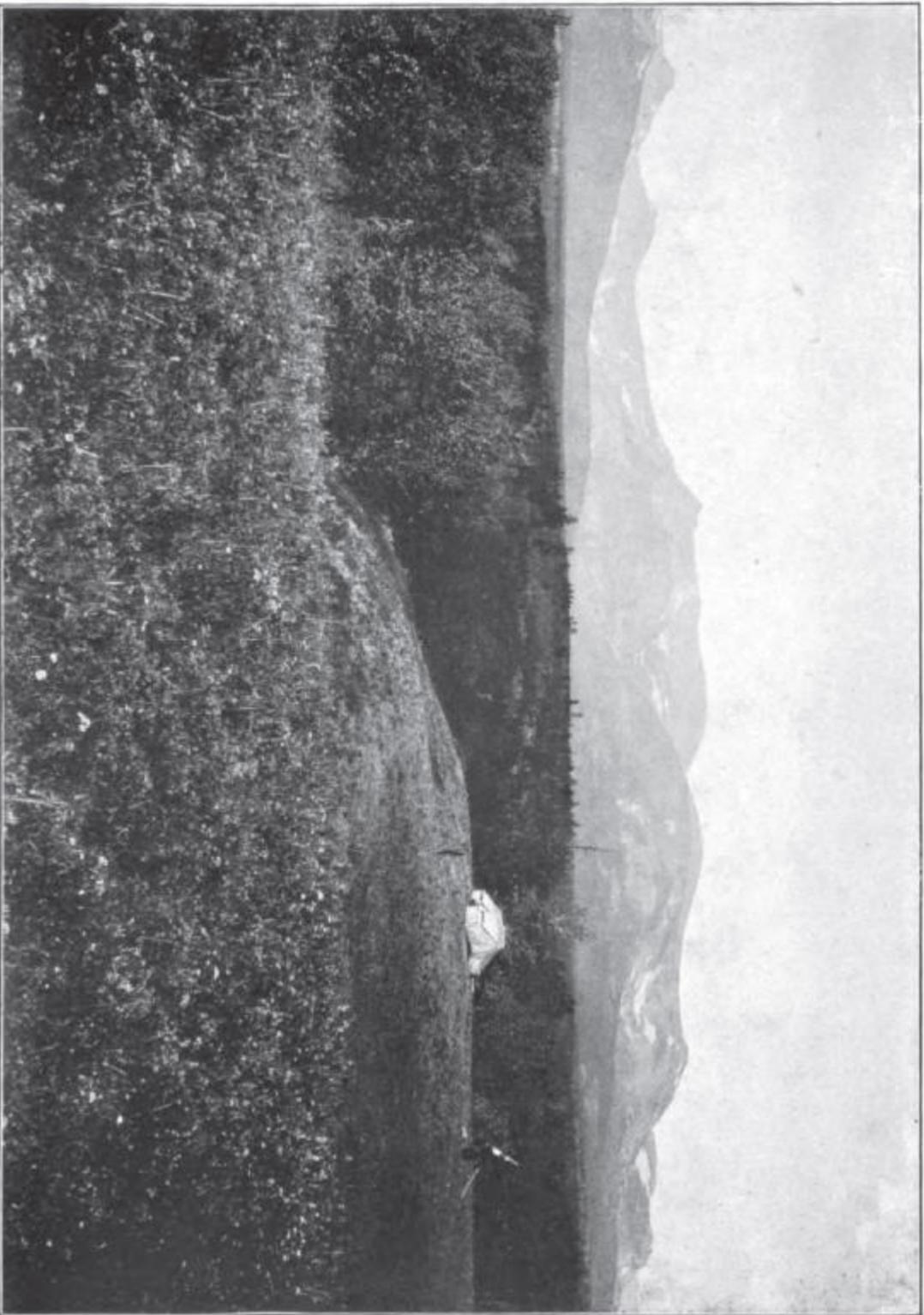
WM. W. PAYNE.

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"The mathematical theory of eclipses according to Chauvenet's transformation of Bessel's method, explained and illustrated" is the full title of one of the most important and useful books for the student in practical astronomy that has been published in many years. The author of the book is Roberdeau Buchanan who was assistant in the Nautical Almanac Office, Washington, D. C., for twenty-three years and is also author of a small book, titled "A treatise on the Projection of the Sphere." The publishers are J. B. Lippincott Company, Philadelphia.

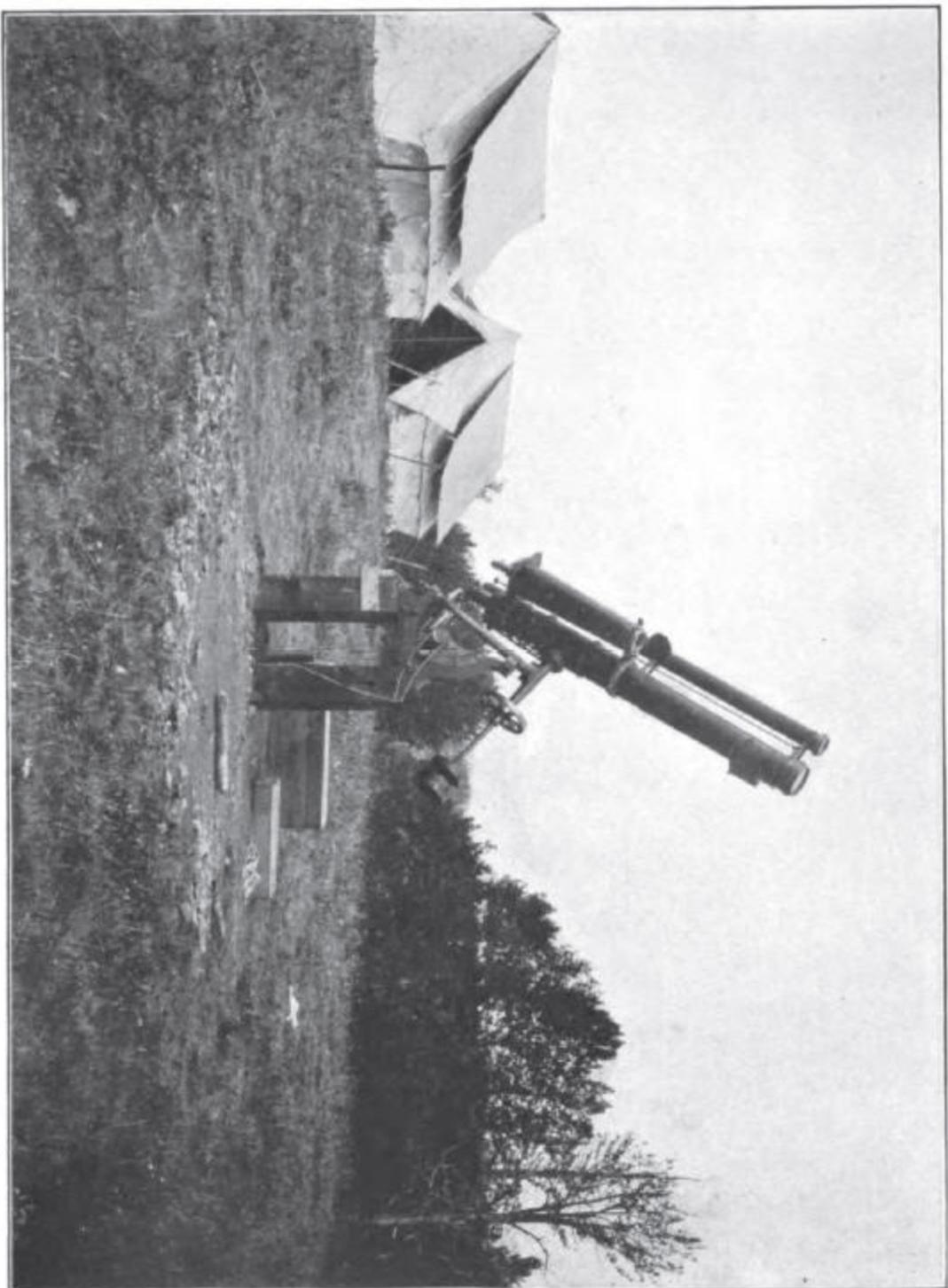
This new book which bears impress of March 24, 1904, contains 247 pages, finely printed on heavy book paper, in clear type of about the same size as that used in Chauvenet's Spherical and Practical Astronomy, published more than forty years ago by the same well-known printing house. Its indexes, tables and illustrations are evidence that its author knows well, in the line of this work, how to arrange reference matter for the con-

PLATE XIX.



THE CAMP OF PROFESSORS PAYNE AND WILSON AT MIDVALE, MONTANA.  
POPULAR ASTRONOMY No. 118

PLATE XX.



THE 8-INCH PHOTOGRAPHIC TELESCOPE AND ATTACHED CAMERAS AS MOUNTED AT MIDVALE, MONTANA.  
POPULAR ASTRONOMY No 118

N.

S.



THE MILKY WAY BETWEEN  $\gamma$  AND  $\beta$  CYGNI.

Photographed with a 2½-inch Darlot Lens at Midvale, Montana. Exposure 2 hours.