disk, and the shadow of the second satellite projected on the red spot. The shadow on the red spot was not quite as black as the shadow on the disk. Two dusky spots are shown in belt No. 3.

Oct. 10, 1881, shows the great red spot and a peculiar spur under it, which was first seen by the writer on Sept. 9, 1880. Also a minute black spot in the north polar region, and two oval white spots south of the great red spot.

April 5, 1884, shows the belt system, the great red spot, group of white spots south, three very minute white spots on the equatorial belt and three dusky patches on belt No. 2.

It shows also, when compared with the previous sketches, very plainly the widening of the equatorial belt on the south margin.

During the past fourteen years, the equatorial belt and the great red spot did at no time come in contact. Although the belt drifted as far south as the center of the red spot yet they remained separate.

The belt south of the red spot also moved north, but at no time was the spot actually in contact with it. May 2, 1886 shows the ring form of the great red spot, small white spots south, which are seen at every opposition, the equatorial belt, the fainter belts and the shadow of the second satellite.

The ring form of the great red spot was first seen by the writer on Feb. 27 1885, and this form continued with greater or less distinctness during the opposition of 1887.

DEARBORN OBSERVATORY, Northwestern University,
Nov. 8, 1894.

THE GREAT PHOTOGRAPHIC NEBULA OF ORION, ENCIRCLING THE BELT AND THETA NEBULA.

E. E. BARNARD.

Experiments With a Very Small Lens in Photographing Very Large Nebulæ, etc.

I have recently been experimenting with a small short-focus lens. Some of the results are very interesting.

This lens belongs to a cheap (oil) projecting latern and is 1½ inch in diameter and 3½ inches focus (from the rear lens). It gives a field of about 30°, only one-half of which, however, is at all flat—but on this portion the stars are fairly good. The scale is about 10°.3 to the inch.

The ratio of the aperture to the focal length is 1 : 2.3 while that of the Willard lens is 1 : 5.

This large light ratio makes the lens very suitable for certain work where the smallness of the scale is not objectionable—or is really desired,—such for instance as very large diffused nebulosities, large comets, the Milky Way, etc. It will doubtless be also admirably suited for photographing meteors—catching from its great light ratio and large field many meteors that would be entirely missed by such telescopes as the Willard lens.

So far I have made nearly 20 photographs with this lens, which for identification I shall call the "lantern lens."

These exposures range from one second up to four hours.

On account of this light ratio the diffused light of the stars scattered over the sky also photographs, so that very prolonged exposures are only possible with it when the sky is free from milkiness—or whiteness. Its penetrating power is not far from that of our Willard lens.

When the moon is very young, the dark or earthlit portion can be photographed with it in from 1 second to 3 seconds.

The cloud forms of the Milky Way, such as those in the region of M11, are well shown in from 10 to 15 minutes.

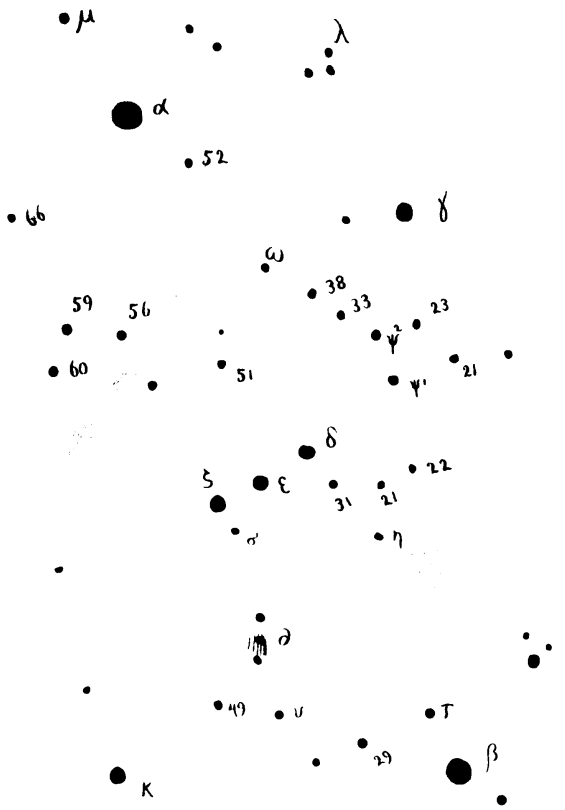
An exposure of one hour showed all the great mass of nebulosity near Alpha Cygni, and doubtless 15 or 20 minutes would show it clearly.

One hour showed the full extent of the great Andromeda nebula, and I have no doubt but that it could as well be shown with far less than half that time.

Four hours' exposure was given on the region about the Pleiades. Besides showing the nebulosities of the cluster it showed also the large diffused nebula N. G. C. 1497. This nebula, which was discovered by me with the 6-inch Cooke equatorial of the Vanderbilt University, Nashville, Tenn., on Nov. 3, 1885, was photographed by Dr. Archenhold in October, 1891 (See *A. N.* 3082). I have a fine photograph of it with the Willard lens with three hours' exposure, and of which I shall have more to say in a later paper. The impression with the lantern lens is very strong and does not materially differ (except in point of size) from that with the Willard lens. The nebula is a very singular object, however, and well worth study. It is somewhat over 2° long and seems to be quite complicated in structure.

Probably an exposure of less than half an hour would show this object with the lantern lens. By the way, Dr. Archenhold is wrong in speaking of this object as having been discovered by

PLATE XIV.



THE GREAT PHOTOGRAPHIC NEBULA IN ORION.

POPULAR ASTRONOMY, No. 14.

photography. Visually, on account of its very diffused nature, it is a very faint object in any telescope.

The most interesting, however, of these lantern lens pictures, are two of the constellation of Orion (for it takes in nearly the entire constellation).

These were made 1894, Oct. 3 and Oct. 24, with 2 hours', and 1 hour 15 minutes' exposure, respectively.

To my surprise these pictures showed an enormous curved nebulosity encircling the belt and the great nebula, and covering a large portion of the body of the giant. A description of this nebula would not only be complicated but it would fail, also, to give any impression of its form and magnitude; I have, therefore, made the enclosed drawing of it which will show at once its exact location and form. The drawing is on nearly twice the scale of the original negative and the stars are taken from Proctor's Chart.

After I had made this drawing and partly written this paper, I remembered having seen somewhere that Professor W. H. Pickering had once spoken of a great nebula shown on his photographs of Orion and previously unknown. I have looked up his paper on the subject and find it in the *Sidereal Messenger* for January, 1890 (vol. 9, p. 2). I will quote here what Professor Pickering has to say concerning this remarkable object:

"An interesting structure brought out upon our plates is a large spiral nebula whose outer extremity starts in the vicinity of γ Orionis. It passes about four degrees north of ζ, extends to γ thence to β, then north to η, with an outside stream lying nearly north and south, and preceding β about four degrees. Another stream lying nearly east and west precedes η about the same amount. This nebula is about seventeen degrees in length, by nearly the same in breadth, and surrounds a cluster of bright stars including the belt and sword handle, and extending towards γ. The region containing the nebula is noticeably lacking in stars brighter than the eighth magnitude, but contains the very bright stars γ and β. It is possible that a plate with double our present exposures, which we are soon going to try, will fill the space between η and ζ, thus making the great nebula the inner termination of the spiral. This nebula is shown by three different exposures and is very distinctly marked."

Professor Pickering's photographs were made at Wilson's Peak in southern California (altitude 6250 feet) with a Voightländer portrait lens of 2.6 inches aperture and 8.6 inches equivalent focus, with an exposure of three hours. Stars from the 11th to the 12th magnitude were well shown.

In the present pictures the shorter exposure shows the nebula best; this was perhaps due to a darker sky.

On my drawing, I have marked a portion of the nebulosity, from 1° to 2° east of Tau, with dots, as it is so feeble at this point that I cannot be certain of it. Two other portions, very slightly uncertain, I have also marked with dots; these, however, I am confident exist on the negatives. The rest of the nebula is well shown. It is brightest near 56 and 60 Orionis. Its extreme diameter is about 14° or 15°. Compared with this enormous nebula the old θ, or so-called "great nebula," is but a pigmy.

That this object shown on my plates is the same photographed by Professor Pickering in 1889 there is no doubt, as will readily be seen upon comparing his description with my drawing. The present photographs therefore, fully confirm the pictures of 1889. This confimation is all the more valuable as it was unconsciously and independently made.

MT. HAMILTON, 1894, Oct. 27.

MARS.

PERCIVAL LOWELL.

ATMOSPHERE.

Man generously furnished Mars with an atmosphere without waiting to learn whether nature had done so or not, much as the same thoughtful donor provided him beforehand with a brace of moons; such appurtenances seeming part of any properly constructed planet. The one gift appears to have been more thoroughly sanctioned than the other. For the moons when finally seen accorded admirably with their myths; while the atmosphere, from our purely local standpoint leaves something to be desired—more of it chiefly.

Vital, indeed, not only to life on a planet but to the very life of the planet itself, if we define life broadly as a chain of changes, atmosphere is. Without it change would soon come to a standstill for want of means to work with. So soon as that was friable had crumbled to pieces under the Sun's fierce heating of the surface, change would stop and the planet roll a mummy world through space, like our own ghastly attendant, the Moon.

This fact alone suffices to show that Mars possesses an atmosphere. Effectively enough, the very first change detected on the