hours. The spiral form is clearly shown, while the extent of the nebula is greatly increased.

Prof. E. E. Barnard, with the 6-inch Willard lens of 30 inches focus at the Lick Observatory, has enormously extended our knowledge of these great diffuse nebulosities. It is quite impossible in the limits of this article to deal with these in detail, but the extraordinary form of the nebula round 15 Monocerotis, the enormous diffuse nebulosities in the constellation Cepheus and round the Pleiades, the tremendous extensions of the Orion nebulæ shown in his numerous articles in *Astronomy and Astrophysics* and the *Astrophysical Journal* since 1893, are all magnificent examples of the use of the portrait lens in photographing nebulæ; and one can have no hesitation in saying that without the portrait lens we should still be in ignorance of many of these wonderful objects. But Barnard has gone beyond the portrait lens, and has used the lens of a cheap oil lantern, the effective aperture of which is about 1½ inches, the focal length being 3½ inches, ratio 1 to 2·3. This gives a field of 30 degrees practically flat, the scale of the photographs being 10·3 degrees to 1 inch on the plate. Twenty photographs in October 1894 (*Astronomy and Astrophysics*, vol. xiii. p. 811) fully brought out the value of this instrument. One hour's exposure gave all the Andromeda nebula; thirty minutes gave all the diffuse nebulosity round the Pleiades photographed by Archenhold in four hours, and by Barnard with the Willard lens in three hours. The most valuable of all results, however, were those with Orion, obtained on October 3 and 28, 1894, with exposures of 2h. and 1h. 15m. The extensive spiral detected by Pickering in 1889 is fully shown in correct proportion, and "no description can give any idea of the form and magnitude of this nebula." Extending over 17 degrees in length and nearly the same in breadth it includes almost all the stars of the constellation, and forms in fact a robe for the body of the giant. The well-known "great nebula of Orion" is but a pigmy compared with the greater nebula revealed by Prof. Barnard's plates, and it is not too much to believe that longer exposure will probably fill the whole constellation with nebulosity, and show that the great nebula is simply the inner termination and the brightest part of the enormous spiral.

An English amateur, Dr. E. M. Sheldon (*Journal of the British Astronomical Association*, vol. v. p. 397), using a lantern lens similar to that used by Prof. Barnard, photographed this enormous spiral in Orion with 1¼ hours' exposure, in February 1895. Four hours on the constellation Cygnus with this lens gave all the nebulæ on Wolf's photograph taken with 13 hours' exposure.

The nebulosities in the Pleiades have attracted great attention since they were first photographed by the Brothers Henry at Paris in 1885. These nebulæ have always been remarkable from their intimate relations with individual stars in the cluster —"Maia is a diamond clasp on a curving plume, Electra extends a tentacle towards Alcyone, while Merope has a sweeping gauze trail and probably a nebulous satellite." In striking contrast to this we usually have in other regions of the sky stars and nebulæ intimately mixed, although frequently on recent photographs wisps of nebulæ are found joining stars, so that the structures appear to resemble festoons of pearls on a gauzy string. The most recent photographs of the Pleiades by Barnard at the Lick Observatory, taken 10h. 15m. exposure with the Willard (6-inch) lens; by Mr. H. C. Wilson, with a similar lens and 11 hours' exposure; and by Dr. Max Wolf, have revealed an enormous extension of the Pleiades nebulosity. The whole area is now 158 square degrees, and there are indications that even this is not the real limit, and that more prolonged exposures will give still greater extension, probably joining up the whole of the nebulosity into an enormous spiral similar to that covering the constellation Orion.

Other photographs exhibiting the same class of structure have been obtained of the region round Antares with 7½ hours' exposure by Prof. Barnard at the Lick Observatory. At first sight this new nebulous mass would easily be mistaken for the Pleiades Nebula, and it is a remarkable and very significant fact that both these masses and all other great nebulosities in the Milky Way either occupy vacancies amongst the stars, or are on the edges of such vacancies; and that in their immediate neighbourhood the stars exhibit long vacant lanes and other remarkable features, indicating that the nebula, stars, and vacant lanes are but different features of some vast and at present imperfectly comprehended system of celestial grouping.

The first results obtained by Prof. Bailey, at Arequipa, with the Bruce photographic telescope of the Harvard College Observatory have lately been recorded. This portrait lens, the largest in the world at present, has an aperture of 24 inches and a focal length of 135 inches, so that while the scale of the photographs is equal to that of the international star charts (1 minute of arc to 1 millimetre), the light-gathering power of the telescope is three times as great, and exposures with this instrument need be only about one-third of those required with the standard international telescopes to achieve the same results. But the Bruce telescope has a further advantage over the standard instruments. Its effective field is 25 square degrees (14-inch by 7-inch plates are used), whereas the effective field of the international instruments is only 4 square degrees in area. The daring experiment of Prof. Pickering in devising, and Mr. Alvan Clark in constructing, this enormous portrait lens has been completely successful (although several eminent astronomers on this side of the Atlantic doubted whether such an instrument could be constructed), and as a result we have an instrument which can do all the international work on less than 4000 plates and with very much reduced exposure. Prof. Pickering does not at present intend to duplicate the work of constructing the photographic chart of the stars, but will confine the instrument to nebulæ and special regions of the sky, and, with the aid of a 24-inch object prism, to spectrum photography. The published preliminary results are of very great value.

This article ought not to be concluded without mention of the fact that more than one astronomical photographer is of the opinion that some of the nebulosity shown upon pictures obtained with small portrait lenses is not real, but due to diffused starlight. A warm controversy has taken place with reference to this point, but this is not the place to present the views of the two parties. It has been shown in this article that large instruments, such as those used for the International Chart, with long focal length but restricted fields, can give us pictures full of delicate details of bright nebulæ, and these photographs are of extreme value; but we must look to the portrait lens for the larger details and for the fainter nebulosities which are absolutely beyond the reach of any photographic object-glass or mirror. There can be no rivalry between the two classes of instruments; each is perfect in its way, each will mislead if solely relied upon. Photographs of the same nebulæ, both with long focus object-glasses or mirrors and with portrait lenses, are necessary, and must be used to supplement each other, if we are to get correct ideas of the phenomena of stellar distribution and the connections between nebulæ and stars. The "best instrument to use" is not a matter of personal experience nor of individual opinion: the optical and photographic laws bearing on the subject are well known, and the practical limits of atmospheric definition and instrumental construction are within sight. The ideal instrument for photographing nebulæ will probably combine large aperture, short focal length, and the large flat field of the portrait lens; will be, in fact, a glorified portrait lens: there are optical reasons why neither the object-glass nor the mirror can be wholly satisfactory. While waiting for this instrument, every possessor of an ordinary rectilinear lens with an ordinary camera can, by strapping his camera on to an equatorially mounted telescope and using infinite patience, materially advance our knowledge of nebulæ by means of photography.

R. A. GREGORY.

## *PHOTO-MICROGRAPHY WITH HIGH POWERS.*

PHOTO-MICROGRAPHY has for some years past advanced but slowly, although its present status as a means of delineating minute structure is undoubtedly much higher than it has ever been. In optical appliances the improvements have been many, the most notable being the introduction of apochromatic objectives. Their greater aperture and freedom from effects of the secondary spectrum have combined to render it possible to obtain good results with much greater ease than formerly. Some of the photomicrographs obtained, however, in the early days of microscopy are even now hardly excelled, although they were produced at the cost of enormous labour, and required extraordinary skill on the part of the operator, with the apparatus then available. The production of satisfactory photographs, when the magnification exceeds one thousand diameters, has always been a matter of some difficulty. One of the greatest of these has been the want of a source of illumination which should be of sufficient intensity without a considerable increase in the size of the illuminating surface. Various attempts have been made to adapt the oxy-hydrogen light for the purpose; but there always remains the objection, that however small the incandescent portion of the lime may be, it does

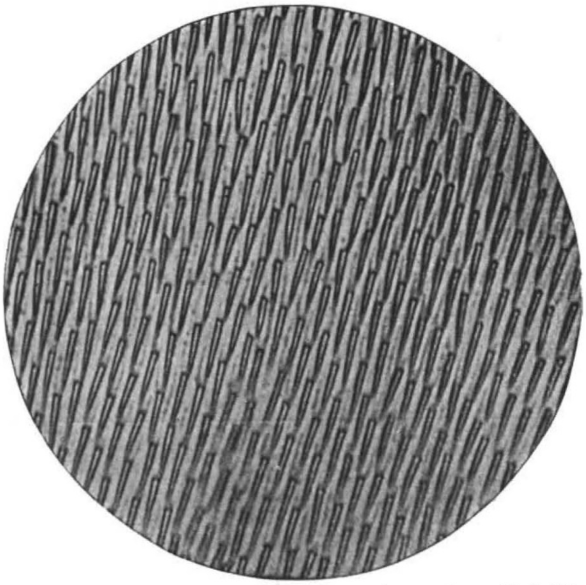

FIG. 1.—Surface markings on Podura scale. Photographed with Swift's 1/12-inch apochromatic, projection ocular 2, and central cone. Magnification, 2500 diameters.

not emit light of equal intensity over the whole of its surface. This can at once be seen if an image of the lime be projected on to a screen. The result is uneven illumination, a defect so often seen in high-power photographs, when the image of the radiant

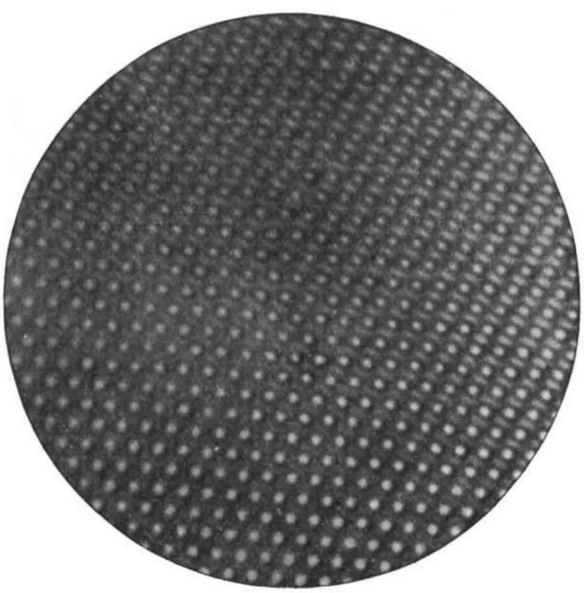

FIG. 2.—*Pleurosigma angulatum*. Photographed with Winkel's 1/20-inch homogeneous immersion, projection ocular 4. Central cone and malachite-green screen. Magnification, 5000 diameters.

is projected by the achromatic condenser across the object, or what is known as "critical illumination."

The electric arc is the light which approaches most nearly to an ideal illuminant. The source of light is extremely small, but the intensity is great, and the incandescent surface is, if working under proper conditions, homogeneous. It has until recently been impossible to so control the arc that these conditions could be obtained with certainty. In all forms of lamp, whether hand-fed or automatic, the difficulty has been to maintain a constant position and condition of the crater on the positive carbon. This can be done by having a simple form of hand-feed apparatus with a pin-hole camera attached, through which an image of the carbon points is projected on to a ground-glass screen. Reference lines are provided on this screen, so that the length of arc and position of the positive crater can be continuously observed. The arrangement was exhibited at the two conversazioni of the Royal Society last year, and has been fully described before the Royal Microscopical Society. With such a form of arc-lamp absolute centration of the light can be secured and maintained without reference to the microscope, after the necessary position of the image of the arc on the screen of the pin-hole camera has been once obtained. The accompanying illustrations have been reproduced from photographs taken with the arc-light so arranged. Fig. 1 shows the surface markings on a Podura scale, magnified 2500 diameters. Fig. 2 is a frustule of *Pleurosigma angulatum*, magnified 5000 diameters. In neither photograph is there the slightest sign of de-centration, and in both cases centration was maintained entirely without reference to the microscopic image.

J. EDWIN BARNARD.
THOMAS A. B. CARVER.

## A METHOD OF MEASURING WIND PRESSURE.[1]

THERE are few physical problems of greater immediate and obvious practical importance, than that involved in the measurement of air pressures under complex conditions of motion, and there are few problems which present greater difficulty, or—what is worse—uncertainty. It may be comparatively easy to obtain under any particular set of circumstances evidences of barometric variation by means of some indicating instrument, apparently suitable for the particular purpose, but it is a very different matter to decide how far the quantitative result is unaffected by actions set up by the instrument itself. Thus the record of the pressure plate gives information which is of little, if any, value in relation to the distribution of pressure over a large building; while the barometer itself is capable of giving misleading indications, whether it is too effectually protected from external influences, or too much exposed.

For measuring the wind pressure at any point of a structure of considerable size, a receiver or collector is required, with a convenient gauge connected by a tube. It is essential that the collector should not itself give rise to compressions or rarefactions affecting the gauge. To the invention of such an instrument Prof. F. E. Nipher has devoted much attention, and his final apparatus seems to fulfil its purpose admirably. Two equal thin metal discs, 2·5 inches in diameter, having bevelled rims, are screwed together, so as to leave a small space between, into which a connecting tube is passed through the centre of one of the discs. The end of the tube is flush with the inner surface, and the interspace is filled up with a certain number of layers of fine wire screen, which project at least half an inch beyond the edges of the metal discs. When this simple device is placed in a stream of air, it is found that the effects of rarefaction and compression, set up at different parts of the porous screen, completely neutralise each other, so that the pressure at the mouth of the tube is the same as the true intrinsic pressure of the external air. This property of the collector was severely tested by thrusting it out of a carriage window in a train which was travelling at the rate of sixty miles an hour: no effect on the gauge could be noticed, although the instrument was sufficiently sensitive to show instantly the effect of placing the hand at a tangent to the edge. The gauge which Prof. Nipher employed was a water manometer consisting of a cylindrical vessel partly filled with water, with a straight glass tube leading out from the bottom and inclined at 5 in 100 to the horizontal. The open end of this tube was in communication with a collector of the form suggested by Abbe so as to secure a standard pressure of comparison.

1 "A Method of Measuring the Pressure at any Point of a Structure, due to Wind blowing against that Structure." By Francis E. Nipher. (*Transactions* of the Academy of Science of St. Louis, vol. viii. No. 1.)
2 Report of the Chief Signal Officer, 1887, 2, 144.