No. 11, 1.9 grades; No. 96, 2.5 grades; No. 119, 1.5 grades. During 30 minutes No. 11 increases in light 10.9 grades, or at the rate of 21.8 grades per hour; No. 96, 12.8 grades, or at the rate of 25.6 grades per hour; and No. 119, 8.6 grades, or at the rate of 17.2 grades per hour. The greatest rapidity is in the case of No. 96, which increases, during 5 minutes, at the rate of 30 grades, or at least two and a half magnitudes per hour, and during 30 minutes at the rate of more than two magnitudes per hour. This rate of change appears to be the most rapid of any known variable. The Algol variable \( U \) Cephei, which perhaps undergoes the most rapid change of any star not found in clusters, changes at the rate of about one and a half magnitudes per hour, during the half hour of its most rapid increase and decrease. The total times of increase for the three stars, 70 minutes, 60 minutes, and 80 minutes, are 10, 8, and 11 per cent., respectively, of their entire periods. Near the beginning and end of increase, however, the rate of change seems to be relatively slow. If we allow one and a half grades for each of these periods of slow change, making three grades in all, we find that the remaining increase, amounting to more than four fifths of the whole change in light, takes place for the three stars in 42 minutes, 34 minutes, and 54 minutes, respectively, that is, in about 6, 5, and 7 per cent. of the respective full periods. In the case of No. 96, this increase is about ten times as rapid as the corresponding decrease. In general it may be stated that the length of periods and the form of light curves are similar to those of many of the variables in \( M \) essier 5, and in \( \omega \) Centauri (Astrophysical Journal, 10, 255). It will be noted that the periods of these three stars in \( M \) essier 3 are about one half a day. Several other variables in this cluster appear to have approximately the same period.

Edward C. Pickering.

June 18, 1900.

THE YERKES OBSERVATORY OF THE UNIVERSITY OF CHICAGO.

BULLETIN NO. 15.

PHOTOGRAPHS OF STAR CLUSTERS MADE WITH THE FORTY-INCH VISUAL TELESCOPE.

The objective of the 40-inch telescope is corrected for visual observations, the minimum focus corresponding to about \( \lambda 5800 \). The color curve is very steep from \( \lambda 4800 \) toward the violet, and the difference
in focus between D and K amounts to about 130 mm. It is thus eminently unsuited for photographic work with ordinary plates sensitive to blue light. The expedient of providing a third lens, of large aperture, to be placed in front of the 40-inch objective for the purpose of uniting the blue rays in a common focus, although successfully employed in the case of the Lick telescope, was not adopted for several reasons. The principal objections to such a correcting lens include its great weight and cost; the serious increase in absorption for the shorter wave-lengths; and the inconvenience arising from the change of focus, which brings the focal plane of the triple combination far up in the tube. Small correcting lenses, placed near the principal focus, have been employed with excellent effect in photographing the more refrangible regions of stellar spectra. On account of the small field of such lenses they cannot be used to photograph large groups of stars. In solar photography with the spectroheliograph, although violet light is employed, no difficulty is experienced from the steepness of the color curve, because the sensitive plate is exposed to a single line in the spectrum, and shielded from all other radiations. It remained, however, to perfect a method by which the advantages arising from the great focal length and high separating power of the 40-inch objective could be realized in direct stellar photography.

In 1892, while photographing the Moon with the 12-inch telescope at the Kenwood Observatory, Mr. G. W. Ritchey suggested that the 40-inch Yerkes telescope, then in process of construction, could probably be used to advantage for similar work. In an article on astronomical photography published about that time he explained the use of a color screen, in immediate contact with the plate, for cutting out the more refrangible rays, and pointed out that isochromatic plates, then only recently obtainable in commerce, should in large measure compensate for the loss of blue light. In 1897 some excellent photographs of the Moon were obtained by Mr. Ellerman and the writer with the 40-inch telescope, using a thin yellow screen in front of isochromatic plates. These photographs are very sharp, and compare favorably with negatives taken with the Lick telescope and 33-inch correcting lens. The investigation could not be continued at that time, on account of the pressure of other work. So far as is known no attempt has hitherto been made to utilize a visual telescope in this way for

1 See this Journal, 10, 94, 1899.
2 First Annual Report of the Director of the Yerkes Observatory, p. 9.
PHOTOGRAPH OF THE CLUSTER MESSIER 13
TAKEN WITH THE 40-INCH YERKES TELESCOPE BY G. W. RITCHEY
photographing faint objects, such as the fainter stars, star clusters and nebulae.

This work has recently been taken up by Mr. Ritchey with the 40-inch telescope, and he has already obtained excellent results. Special color screens of thin plate glass, coated with very transparent collodion of a delicate greenish-yellow tint, were prepared under his direction by the Carbutt Dry Plate Company. Short exposure photographs of stars, made on isochromatic plates in immediate contact with the absorbing screen, were so successful as to show beyond doubt the feasibility of photographing faint stars with long exposures. A special plate-holder, provided with screws for moving the plate with guiding eyepiece in two directions at right angles to each other, was designed by Mr. Ritchey, and constructed in our instrument shop under his supervision. As the apparatus was intended primarily for experimental purposes, and especially for photographing star clusters, a yellow screen only three inches square (about 14' of arc) was employed. The guiding eyepiece (power about 1000) which is used in conjunction with a right-angle prism, stands just beyond the edge of the sensitive plate. It is supported on a slipping piece, and can be moved in two directions so as to permit a suitable guiding star to be found. In its focal plane are two fine cross-hairs intersecting at right angles, and illuminated by a small incandescent lamp controlled by a rheostat. In the exposures so far made no difficulty has been experienced in guiding with a twelfth magnitude star.

Plate XVIII is a reproduction (enlarged 22 diameters) of a photograph of the great cluster in Hercules, Messier 13, obtained by Mr. Ritchey on August 9, 1900, with an effective exposure of ninety minutes. The original negative shows by actual count about 3200 stars, a large proportion of which are lost in the reproduction. In spite of the fact that the Moon was nearly full, and that a part of the exposure was made through passing clouds, the plate was but little fogged after a half hour's development. The diameter of the smallest stars does not exceed one second of arc, and faint double stars of but little more than 1" distance are clearly separated. With such excellent definition, and in view of the fact that stars as faint as the sixteenth magnitude appear on the plate, it is evident that the 40-inch telescope with this inexpensive attachment may fairly be regarded as a very efficient photographic instrument. As there is no reason to doubt that fields fifteen inches square can be photographed with a larger plate-holder, it appears