ART. IV.—*Double-Star Discoveries with the* 18½*-inch Chicago Refractor;* by S. W. BURNHAM.

THE new double stars described below were discovered with the 18½-inch Clark refractor of the Dearborn Observatory, on the nights of October 1, 2, 4, 7, 10, 11, 15, 16, and 17, 1876, and are some of the results obtained in the use of that instrument during a period of three or four weeks, the only opportunity the writer has had of using it. The observations here given are not as complete as could be desired; some of the new pairs being only partially measured, and others not at all. A number of other new and interesting pairs were found, but the approximate readings of the circles, roughly noted at the time of finding them, are not sufficient to positively identify them in the star catalogues and thus fix their absolute places; and these with other suspected pairs, and new companions to prominent pairs and binary systems, are necessarily not included in the following list. The intention was to measure, during the course of the work, all new pairs on at least three different nights, in order to give, as accurately as possible, reliable micrometrical results with which future observations might be compared for determining the question of physical relation between members of the systems. This seemed to be the more important from the fact that many of these pairs are too difficult for ordinary apertures, and are practically beyond the reach of most of the well-known double-star observers in Europe; and a considerable time might elapse before the objects would be re-observed elsewhere. It is necessary to state, in explanation of its manifest incompleteness, that the work was unexpectedly, and without notice, terminated by the action of the officers of the Chicago Astronomical Society which has control of the instrument, and no opportunity has been afforded to complete the projected series of observations which was but just commenced. Enough is given, however, to show the value and effectiveness of the telescope in this important branch of astronomical research; and how much might be accomplished for science, if it were used for any other purpose than exhibition to visitors.

The reference numbers attached to these stars are the numbers in my double-star catalogues, seven of which lists, with the stars numbered consecutively, have appeared in the Monthly Notices of the Royal Astronomical Society, Astronomische Nachrichten, and in this Journal.

No. 437=L 4291.

R. A.=$2^h\ 12^m\ 26^s$
Decl.=$+3°\ 39'$

Not measured, but angle and distance estimated as follows:

P=45°± D=5″±

The principal star is about 7½ magnitude, and the companion not brighter than 11 of Struve's scale. The pair of small stars in the field, *sp* is Σ 247 *rej.*

No. 438=Σ 2538
R. A.=19h 27m 3s
Decl.=+36°27′

A and B	P=43°·5	D=6″·32	(1876·8)
A and C	245·2	53·04	(1830·8)
C and D	52·5	6·07	(1830·8)

The three large stars, A, C and D, constitute the double star Σ 2538(=S 719), but the small companion near the principal star is now recorded for the first time, and is probably too minute for ordinary telescopes. The measures given above of C and D are by Struve. These stars seem, by a comparison of Struve's results with those obtained later by Mädler, Secchi and Otto Struve, to be relatively fixed, but some of the measures are not very accordant. By a single observation I found these angles respectively, 237°·1 and 51°·9, but there may be an error of 10° in reading micrometer of the first. There is still another new member of this group, in an exceedingly faint star almost exactly midway between A and C. No opportunity occurred to measure this. Struve gives the magnitudes of A, C and D as 8·2, 8·3 and 8·7 respectively.

No. 439=Arg. (29°) 3845
R. A.=19h 55m 56s
Decl.=+29° 30′

The principal star is about the eighth magnitude (Argelander, 8·1), with a small companion. The measures of one night give:

P=249°·7 D=2″·70 (1876·8)

No. 440=L 38520
R. A=20h 1m 27s
Decl.=+35° 27′

A and B	P=61°·3	D=6″·47	Mags. 7·0 . . 12+	(1876·8)
A and C	25·8	7·75	11·0	(1876·7)
A and D	296·0	11·27	9·5	(1783·7)
A and E	106·8	28·15	11·5	(1876·7)
A and F	32·8	29·45	7·5	(1783·7)
F and G	113·0	10·12	12·	(1876·8)

The large stars (A, D, F), of this interesting group have long been known, and constitute the double star ℍ III. 113 (=Sh 314=Σ 2630 *rej*). The small attendants, C and E, I

found with the 6-in. refractor in 1875. The faint star, G, was discovered by Mr. I. M. Ward of Belfast, widely known for his remarkable acuteness of vision, with an aperture of only 4·2-in. The very minute companion, B, was added with the 18½-in., the whole forming one of the finest multiple systems known. Of the measures given above, D and F are by Sir William Herschel; C and E by Baron Dembowski; and B and G my own results on the occasion last referred to. The relative situation of the stars known to the early observers appears to be substantially unchanged. For A and D Dembowski finds:

P=300°·7 D=11″·12 (1876·7)

By comparing the measures of Sir John Herschel and Sir James South, with the recent observations of Baron Dembowski, there seems to be an error in Herschel's distance of A F;—

P=28·2	D=36″·52	(1823·6)
28·2	35·98	(1876·7)

The relation of the closer stars can be determined only after a series of carefully repeated measures, but it is at least probable that they will be found to have some physical connection.

No. 441=L 39013
R. A.=20^h 12^m 37^s
Decl.=+28° 46′

This is a 7·5 m. star with very small satellite, measured on one night as follows:

P=65°·4 D=5″·87 (1876·8)

No. 442=Weisse xx. 456
R. A.=20^h 13^m 3^s
Decl.=+37° 11′

A fine group consisting of three large stars, each about 8·5 m. with closer minute companions. The following measures were made on this occasion:

A and B	P=104°·1	D=18″·47
A and a	157·5	4·40
A and b	157·±	7·±
A and c	332·5	19·55
B and d	164·3	8·12
B and C	48·6	17·69

There are several other small stars near not measured.

No. 443=L 39293
R. A.=20^h 19^m 12^s
Decl.=+28° 37′

Angle and distance estimated only:

P=120°± D=10″± Mags. 7·5 . . . 11·5

There is a third star following, about 30″ distant.

No. 445=Cygni 287
R. A.=20h 58m 23s
Decl.=+28° 37′

Very unequal pair; the principal star 7 m. in Lalande.

P=90°± D=4″±.

This is L 40821.

No. 446=Weisse xxi. 344
R. A.=21h 15m 44s
Decl.=+32° 56′

A pair of small stars, the larger 9 m. near and south following a bright star.

P=261°·7 D=2″·30

No. 447=Vulpeculae 129.
R. A.=21h 18m 45s
Decl.=+24° 48′

This is a bright star, about 6 m. with a difficult companion in the direction of 340°. Distance not noted, but probably under 5″. No opportunity was afforded to measure or examine it a second time.

No. 448=L 41874
R. A.=21h 24m 35s
Decl.=+44° 24′

There is some uncertainty about the place of this pair. It is assumed to be the above 7 m. star in Lalande, which is nearly in the observed place, but may be a larger star south following. Estimated as follows:

D=2″± Mags. 7·0 . . . 11·0.

A distant companion preceding.

No. 449=Radcliffe 5335.
R. A.=21h 34m 42s
Decl.=+41° 11′

The three larger stars, A, C and E, were discovered by Sir William Herschel (=♅ III. 110), and also entered in the Pulkowa catalogue (=*OΣ* 447). The new members of the system, B and D, are very minute, and might be easily overlooked with even a large aperture. My measures of these, and Dembowski's of C and E are as follows:

A and B	P=19°·1	D=6″·78	(1876·8)
A and C	170·5	13·71	(1866·6)
A and D	248·2	17·94	(1876·8)
A and E	45·7	29·13	(1866·6)

Dembowski gives the magnitudes of A, C and E as 7·0, 10·8 and 7·7 respectively. A comparison of the measures of these

stars with the early observations of Herschel, would seem to indicate considerable change, but this is not confirmed by the intermediate measures of Otto Struve.

Herschel	A and C	P=157°·6	D=13″·90	(1783·8)
O. Struve	A and C	169·4	13·86	(1848·3)
Herschel	A and E	49·4	25·97	(1783·8)
O. Struve	A and E	45·3	29·00	(1848·3)

The close agreement between the measures of O. Struve and Dembowski accords with my own results on the occasion of observing the new companions, when the angles came out 170°·5, and 44°·9, respectively.

No. 450=B. A. C. 7931

R. A.=22^h 38^m 40^s }
Decl.=+38° 50′ }

As a double, this beautiful object is found in the catalogues of both Struves, and Herschel (=Σ 2942=*O*Σ 478=*H* 1802). Struve's magnitudes are 7·0 and 9·2. The colors are very striking, the larger being, according to Struve, reddish gold, and the smaller, ash-color. A third much smaller star was discovered with the 18½ in., and measured once as below:

A and B	P=282°·4	D=2″·66	(1831·6)
A and C	232·0	10·23	(1876·8)

Measures of A and B by Struve. Dembowski gives, P=280°·6; D=2″·80 (1866·6), from which it is safe to infer there is no substantial change in the relation of these stars, and this view is supported by the measures of Otto Struve, Mädler, Dawes, and others. The small star is not a difficult object with the 18½ in., and can perhaps be measured with a smaller aperture.

No. 451=15 Lacertae.

R. A.=22^h 46^m 37^s }
Decl.=+42° 40′ }

This star was seen with a minute attendant, roughly estimated from memory as about 20″ distant. The angle was not noted, and no opportunity occurred to re-examine and measure subsequently.

No. 452=L 44915

R. A.=22^h 51^m 37^s }
Decl.=+42° 22′ }

A fine pair observed about the same time as the preceding, and like that only estimated for the purpose of certain identification:

P=270°± D=6″±

The large star is 6½ or 7 magnitude, and the companion below 12 of Struve's scale.

Chicago, May 5, 1877.