cult double stars, which are the ones that include all of the rapid binaries. In this field of work the visual and the photographic methods are not competitors. The reason is simple enough. The eye can see as double what the photographic plate, used in an instrument of practicable dimensions, would certainly record as single. The images of the components of a close double star as formed by the objective of the telescope are very near each other. Thus, the scale for the 12-inch telescope of the Lick Observatory is 1/1100th of an inch to 1″, and that for the 36-inch refractor 1/297th of an inch to 1″. Under the most favorable circumstances the eye is able to detect the elongation produced by the partial overlapping of equal stellar images when their centers are not more than 1/5000th of an inch apart. The photographic plate does not possess resolving power to this extent. The silver grains in the film have dimensions probably twice as large. Besides, for objects such as double stars, photographic images not larger than the silver grains cannot be realized. The light spreads through the film, the area over which the photographic action extends becomes enlarged, the image of a bright star obliterates that of its faint companion, and in the case of close and equal pairs the images of the two components are merged together and lose their identity.

MT. HAMILTON, CALIFORNIA, May 29, 1900.

THE ORBIT OF *T CYGNI.* (A. G. C. 13.)

BY R. G. AITKEN.

The companion to *T Cygni* was discovered by ALVAN G. CLARK in October, 1874, with the 26-inch telescope now mounted at the Leander McCormick Observatory. The first measures were secured in the same year by NEWCOMB, with the 26-inch refractor of the Naval Observatory, and by DEMBOWSKI, with an instrument of only seven inches aperture. The latter observer demonstrated the existence of relative motion in this system by his measures during the few years following discovery, and it soon became apparent that this motion was orbital. Other observers also gave the pair attention until 1880; but from that year until 1889, when BURNHAM began his work with the 36-inch refractor, it was almost wholly neglected. The only observation in this interval (during which the small star described an arc of nearly 100°) that can be used in determining the orbit is one by HALL, on a single night in 1885, to which he appends the note, "Images blazing." Since BURNHAM'S measures in 1889, the star has received sufficient attention, but the measures are not as accordant as is desirable.

An orbit for *T Cygni* was computed by GORE (*A. N.*, 2749) in 1886, using the measures to 1885. The arc, however, was so small that the resulting elements were very uncertain. He found a period of 53.87 years. In 1892, BURNHAM attempted to define the orbit using all the measures to date, including his own in 1892.41. His conclusion was that even then, when the arc described by the companion-star was nearly 180°, the discordance of the early and late measures was so great as to make it impossible to determine where the truth lay. He drew an apparent ellipse, however, which would satisfy the observations very well, provided the CLARK companion were assumed to be attended by a "dark" sun of equal mass revolving with it about a common center of gravity in a hypothetical orbit. The ellipse also satisfied the motion of the visible companion without this assumption as well as any that could be drawn at that time. The elements resulting from it are:—

$$P = 36.5 \text{ years.}$$

$$T = 1893.1 \qquad i = 46°.7$$

$$e = 0.24 \qquad \Omega = 163.6$$

$$a = 0''.94 \qquad \lambda = 164.9$$

Since 1892 the motion of the small star has carried it through an additional arc of more than 50°, giving a total arc of nearly 225° since the first measures. I have therefore thought it possible at this time to make an investigation which shall give results at least approximately correct.

The following are all the published measures of this pair that I have been able to find. Except in the grouping of the first five observations by DEMBOWSKI, the measures to 1892.40, inclusive, are taken as given by BURNHAM in the paper cited.

Date.	θ	ρ	n	Observer.	O - C.	
					Δθ	Δρ
	°	"			°	"
1874.89	162.6	1.11	2	Newcomb....	− 0.6	−0.02
74.90	174.8	1.06	1	Dembowski...	+11.6	−0.07
75.60	171.4	1.35	4	"	+11.3	+0.23
76.79	161.5	1.25	2	"	+ 5.2	+0 15
76 83	166.9	1.62	2	Waldo.......	+10.7	+0.53
76.90	160.2	1.04	2	Hall........	+ 4.3	−0.05
77.70	155.3	1.25	8	Dembowski...	+ 2.4	+0.17
78.41	150.0	1.06	1	Burnham....	0.0	+0.01
78.54	147.5	1.09	3	Dembowski...	− 2.0	+0.05
78.76	158.8	1.09	2, 1	Hall........	+10.2	+0.05
79.50	148.3	0.90	2	Burnham.....	+ 2.9	−0.10
79.75	147.3	0.98	6, 5	Hall.........	+ 3.1	−0.01
80.77	137.4	1.04	1	Frisby........	+ 1.8	+0.10
83.88	159.2		3	Seabroke....	−41.0	
85.52	116.3	1.08	3	Tarrant.....	+15.2	+0.48
85.74	100.7	0.62	1	Hall	+ 2.4	+0.03
86.78	80 ±	0.5 ±	1	Hough.......	− 3±	0.0 ±
87.76	56.4	0.4 ±	1	"	−10.3	−0.1 ±
89.49	36.5	0.50	4	Burnham.....	− 1.1	−0.04
90.54	20.5	0.54	3	"	− 1.9	−0.05
91.49	12.4	0.61	3	"	+ 1.3	−0.04
91.70	9.3	0.52	3	Hall.........	+ 0.7	−0.13
92.41	2.3	0.61	3	Burnham.....	+ 0.6	−0.08
92.72	358.4	0.60	3	Comstock....	− 0.3	−0.11
94.77	344.4	0.78	5	Barnard.....	+ 1.9	−0.01
95.71	335.1	0.86	2	Comstock....	− 0.8	+0.06
95.73	332.6	0.29±	3	See..........	− 3.2	−0.51±
96.55	333.6	0.79	3	Aitken.......	+ 3.4	−0.02
96.64	340.9	0.48	2, 1	Lewis........	+11.4	−0.33
96.67	330.9	0.69	3	Comstock....	+ 1.6	−0.12
96.82	332.1	0.73	6	Hussey......	+ 3.8	−0.08
97.57	322.4	0.68	3	Aitken.......	− 0.7	−0.12
97.72	326.4	0.94	3	Doberck.....	+ 4.4	+0.14
97.81	328.5	0.72	5	Hussey......	+ 7.1	−0.08
98.49	316.6	0.77	4	Aitken.......	+ 0.2	−0.01
98.82	311.2	0.58	1	Lewis........	− 2.7	−0.20
99.73	308.8	0.80	6	Aitken.......	+ 2.0	+0.06
99.86	310.0	0.85	3	Hussey......	+ 4.2	+0.11

In forming annual means from these observations, the incomplete measures were disregarded; also the results obtained by Waldo, by Tarrant, and by Lewis in 1896. The arithmetical mean of the measures in each year was then taken, all the observations being regarded as of equal weight. The resulting positions are:—

DATE.	θ	ρ	n	OBSERVER.	O-C.	
					$\Delta\theta$	$\Delta\rho$
1874.90	166°.7	1″.09	3	N-Δ.........	+3°.5	−0″.04
1875.60	171.4	1.35	4	Δ............	+11.3	+0.23
1876.85	160.8	1.14	4	Δ-Hl.........	+4.8	+0.05
1877.70	155.3	1.25	8	Δ............	+2.4	+0.17
1878.59	151.7	1.08	6, 5	Δ-Hl-β......	+2.4	+0.04
1879.69	147.6	0.96	8, 7	β-Hl.........	+3.0	−0.03
1880.77	137.4	1.04	1	F............	−1.8	+0.10
1885.79	100.7	0.62	1	Hl............	+2.4	+0.03
1889.49	36.5	0.50	4	β.....	−1.1	−0.04
1890.54	20.5	0.54	3	β............	−1.9	−0.05
1891.60	10.8	0.56	6	β-Hl.........	+1.0	−0.04
1892.56	0.4	0.61	6	β-C	0.0	−0.10
1894.77	344.4	0.78	5	Bar...........	+1.9	−0.01
1895.71	335.1	0.86	2	C.............	−0.8	+0.06
1896.72	332.2	0.73	12	C-Hy-A.....	+3.2	−0.08
1897.72	326.3	0.77	11	Hy-Dob-A. .	+4.2	−0.03
1898.56	315.5	0.73	5	L-A.........	−0.4	−0.05
1899.77	309.2	0.82	9	Hy-A........	+2.7	+0.08

It is apparent that no ellipse can be drawn that will represent all of these positions with satisfactory accuracy. To satisfy the law of areas even approximately, some of the distance measures must be considered to be in error. I finally decided to assume that DEMBOWSKI had overmeasured the distance considerably in the years 1875–76–77. That this assumption is allowable, will, I think, be admitted when the size of DEMBOWSKI'S telescope is considered in connection with the difference in brightness of the two components of this pair, and the discordance of recent distance measures made with instruments of large aperture. With this assumption, it became possible to draw an ellipse that would represent with reasonable accuracy the majority of the measures.

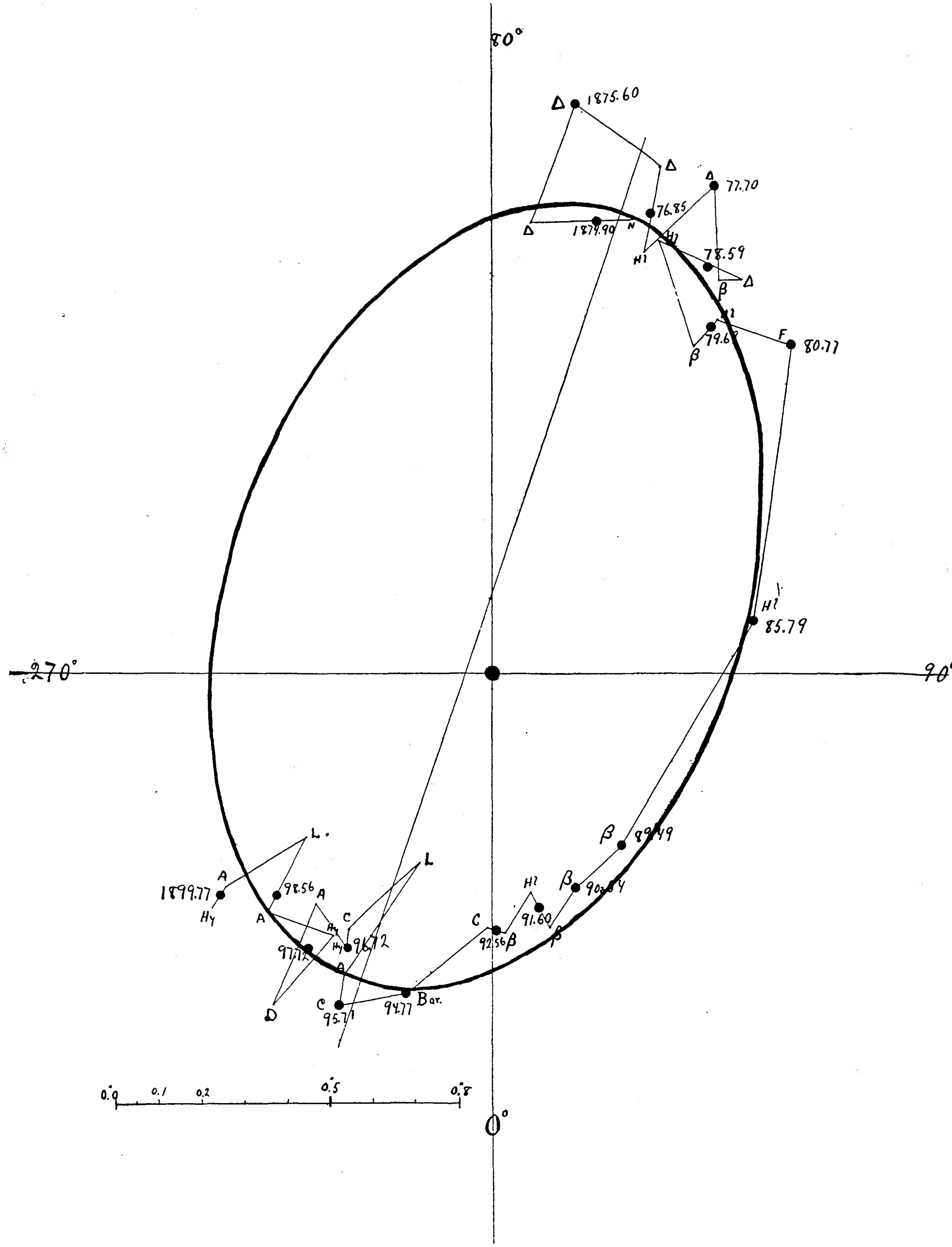
This ellipse gives by the graphical method, the following set of elements:—

$P = 45.1$ years.

$T = 1892.33$ $\qquad i = 52^\circ.2$

$e = 0.20$ $\qquad \Omega = 158\ .8$

$a = 0''.97$ $\qquad \lambda = 144\ .5$



180°
1875.60
77.70
76.85
1879.90
78.59
79.6
80.77
85.79
270°
90°
89.49
90.
91.60
92.56
1899.77
98.56
96.72
97.72
95.71
94.77
B ar.
0.0
0.1
0.2
0.5
0.8
0°

APPARENT ORBIT.

Length of major axis = $1''.96$
Length of minor axis = $1 .20$
Position-angle of major axis = $165^\circ.0$
Position-angle of periastron = $2 .4$
Distance of star from center = $0 .18$

In the diagram accompanying this paper, the small black circles represent the annual means upon which the apparent ellipse is based, and the vertices of the broken line the results obtained by the respective observers. The discordant character of the observations is manifest, as well as the general agreement with the computed positions.

In the two preceding tables the columns following the names of the observers give the residuals in angle and distance.

To test the accuracy of these elements by future observations, I have computed an ephemeris for the next five years:—

Date.	θ	ρ
1900.75	$298^\circ.2$	$0''.71$
1901.75	288 .9	0 .68
1902.75	278 .8	0 .66
1903.75	268 .1	0 .64
1904.75	257 .1	0 .64

LICK OBSERVATORY, March 23, 1900.

NOTE.—I have just received the *Astronomische Nachrichten*, 3629, which contains Professor T. J. J. SEE's "Researches on the Orbit of *T Cygni.*" Professor SEE has in the main used the data given above, though the early observations are combined differently. He has also, apparently, used the results obtained by WALDO and TARRANT; but by some oversight has not used the measures by BARNARD in 1894, HUSSEY in 1896 and 1897, LEWIS in 1896 and 1898, DOBERCK in 1897, and AITKEN in 1897 (twenty-five observations in all). In place of the unpublished Lick Observatory measures in 1899, he has used the unpublished Naval Observatory measures for practically the same epoch.

As Professor SEE's elements differ decidedly from those given above, I copy them here together with his ephemeris, for purposes of comparison. They are:—

$P = 57.25$ years.
$T = 1890.25$ $\qquad i = 55^\circ.6$
$e = 0.370$ $\qquad \Omega = 161^\circ.4$
$a = 1''.16$ $\qquad \lambda = 121.8$

APPARENT ORBIT.	EPHEMERIS.		
Length of major axis = 2″.18	1900.70	307°.0	0″.84
Length of minor axis = 1 .25	1901.70	301 .3	0 .82
Position-angle of major axis = 165°.6	1902.70	294 .9	0 .81
Position-angle of periastron = 24° 8	1903.70	288 .6	0 .80
Distance of star from center = 0″.30	1904.70	282 .0	0 .80

From a comparison of two sets of ephemerides, it is apparent that the measures of the next two or three years will show which orbit is nearer the truth.

April 5, 1900.

THE DEVELOPMENT OF ASTRONOMY IN AMERICA.

Reprinted from *Nature* (London), April 12, 1900.

Sixty years ago the United States had scarcely a single observatory properly equipped for the pursuit of astronomical studies. To-day that country is possessed of the finest observatories in the world, manned by observers of the greatest skill, who devote themselves untiringly to the advancement of the oldest of the sciences.

The success of the American astronomers during this short period has been remarkable. To them we owe important discoveries and precious records in nearly every branch of theoretical and practical astronomy, and especially of late years in the department of astronomical physics. It is impossible here to recount the whole fruits of their labors, but it is worth while to recall a few of the results which we owe to their industry.

The first striking discovery in America was that of *Hyperion*, the seventh satellite of *Saturn*, by G. P. BOND, in 1848. In the same line of work, HALL was rewarded in 1877 by the discovery of the tiny satellites of *Mars*, and more recently BARNARD astonished the world by his detection of the fifth satellite of *Jupiter*, while PICKERING claims to have established the existence of a ninth satellite of *Saturn*. In planetary studies generally, the Americans have been well to the front, and we have seen the unusual spectacle of a powerful refractor primarily devoted with marked success, by Mr. LOWELL, to the delineation of the surfaces of our nearest planetary neighbors. Numerous measurements of the dimensions of the various members of the solar system have also been made, and the theory of their motions has