THE SPRINGFIELD TELESCOPE MAKERS &
THE HARTNESS HOUSE INN *presents*

Binary & Multiple Star Astronomy

The Hartness House Workshop

July 24, 2014

Translated from the 1856 Tulse Hill Observatory logbook of William Huggins, pioneer of astronomical spectroscopy:

Astri gemelli, pinti in
giallo, in arrurro, in
verde, in vermiglio,
in vivido rosso di
porpora! -- Rifletti [...]
ai gemelli astri, rossi e
verdi -- o gialli ed
azzuri -- quale
maravigliosa varieta di
luce non daranno essi ad
ogni pianeta, che loro
gira intorno. Oh
delizoso contrasto, e
giocondo
avvicendamento! -- Un
rosso e verde giorno,
alternato con altro
bianco, e colle tenebre.

Double stars -- of orange
blue, green, crimson,
rich ruddy purple!
Think, quote he, of twin
suns, red, and green -- or
yellow, and blue -- what
resplendent variety of
illumination they may
afford to a planet
circling about either --
charming contrasts and
grateful vicissitudes -- a
red and green day,
alternating with a white
one, and with darkness.

THE HARTNESS HOUSE WORKSHOP

July 24, 2014

8:30 – 9:00 **Registration and Coffee**
Host Dan Lorraine, Seagrave Memorial Observatory, Skyscrapers, Inc.

9:00 – 9:05 **Words of Welcome**
David Tabor, President, Springfield Telescope Makers

9:05 – 9:10 **Introduction**
John W. Briggs, HUT Observatory and Springfield Telescope Makers

9:10 – 9:45 **Polaris, A Door to Measuring Large Delta-m Doubles**
James Daley, Springfield Telescope Makers

9:45 – 10:30 **Design Study, Restoration, and Recreation of the Clark Corporation Filar Micrometer of University of Maine**
Allen Hall and Richard Parker, Seagrave Memorial Observatory, Skyscrapers, Inc.

10:30 – 10:45 **S.W. Burnham and the Centennial of the Burnham Double Star Catalogue**
William I. Hartkopf and Brian D. Mason, Astrometry Department, U.S. Naval Observatory

10:45 – 11:00 **Coffee Break**

11:00 – 11:45 **Speckle Interferometry: What is it? What's it Good For?**
William I. Hartkopf, Astrometry Department, U.S. Naval Observatory

11:45 – 12:30 **The Spangled Banner Goes Speckle: Charles E. Worley, Master Observer at U.S. Naval Observatory, and his Transformation of a Classical Observing Technique**
David DeVorkin, Smithsonian National Air and Space Museum

12:30 – 1:30 **Lunch**

1:30 – 2:30 **Open House at the Hartness-Porter Museum of Telescope Making**
Berton C. Willard, Museum Curator, Springfield Telescope Makers

2:30 – 3:15 **The *Washington Double Star Catalog* Neglected Doubles Project: Making a Modest Telescope in an Urban Setting Scientifically Relevant**
Brian D. Mason, U.S. Naval Observatory; President, IAU Division G Commission 26, Double and Multiple Stars

3:15 – 4:00 **The *Journal of Double Star Observations:* A Publication for Amateur Astronomers**
R. Kent Clark**,** University of South Alabama; Editor, *JDSO*

4:00 – 4:45 **Seven Decades of Astronomy and Optics: From Knife-Edge to Interferometers; From Earth to Space**
Joseph B. Houston, Jr., Past President, SPIE; Houston Research Associates
(Presented for Mr. Houston by J. W. Briggs.)

4:45 – 5:00 **Break**

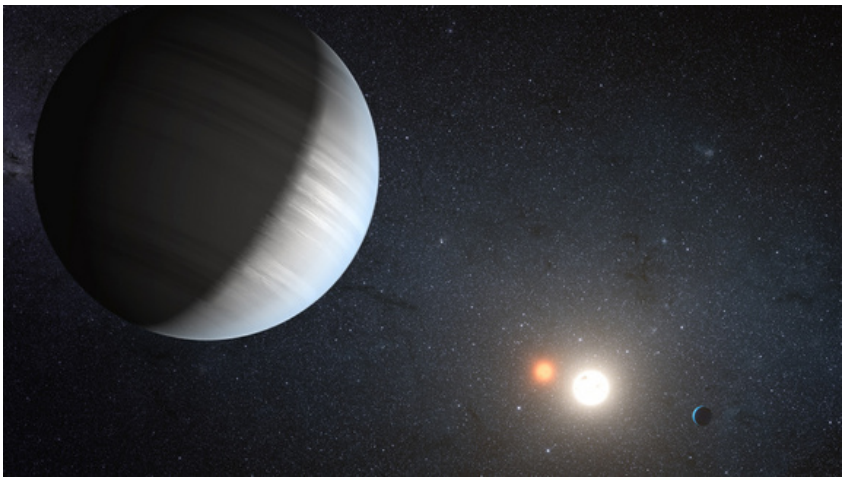
5:00 – 6:00 **Cocktails at the Telescope Tavern of Hartness House Inn**
Fruit and Cheese hosted by the Antique Telescope Society

6:00 – 7:00 **Banquet at Hartness House Inn**

7:00 – 8:00 **Seeing the Unseen: A Century of High Angular Resolution Astronomy from Mount Wilson**
Professor Harold A. McAlister, Director, Center for High Angular Resolution Astronomy, Georgia State University, and Director and Chief Executive Officer, Mount Wilson Institute

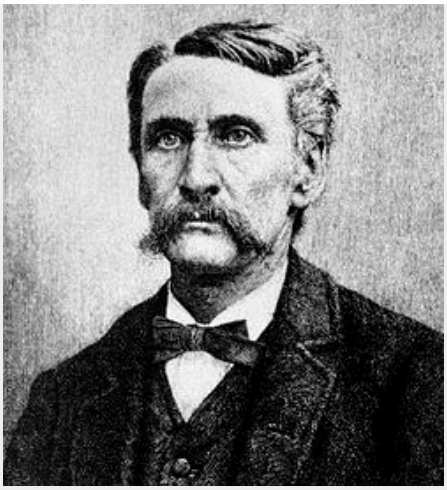
8:30 PM **Evening Open House at Hartness Observatory**
Weather permitting, this event will include evening observing and will be open to workshop participants, members of the Springfield Telescope Makers, and guests. Our hosts are Berton C. Willard, Curator of the Hartness-Porter Museum of Amateur Telescope Making and David M. Groski from the Springfield Telescope Makers.

Also weather permitting, outside the Hartness Observatory there will be a demonstration of a Differential Image Motion Monitor system for measuring astronomical seeing as developed for Apache Point Observatory and the Sloan Digital Sky Survey. Facilitating the demonstration by J. W. Briggs is the loan of equipment from Phillips Academy Observatory, courtesy Caroline E. Odden.



Tales from the Golden Age: S.W. Burnham- a Life Behind the Eyepiece

by Neil English & John Nanson



S.W Burnham; the eagle eyed.

Do the words of a poem lose their poignancy once its author departs this world?
Can the limp of 'progress' outshine the 'grand procession' of great accomplishment?
Can a culture, basking in the glory of its own achievement, be made mute by a faithless generation of technocrats?

Can an optical bench test inspire more than a night spent behind the eyepiece of a grand old telescope?

Let us venerate that which is deserving of veneration!
Whose crown shall we adorn with a laurel wreath?
Let us sing again of old dead men
And clear the cobwebs from their medals.
For they have no equal in the present age
No muse to light their way.

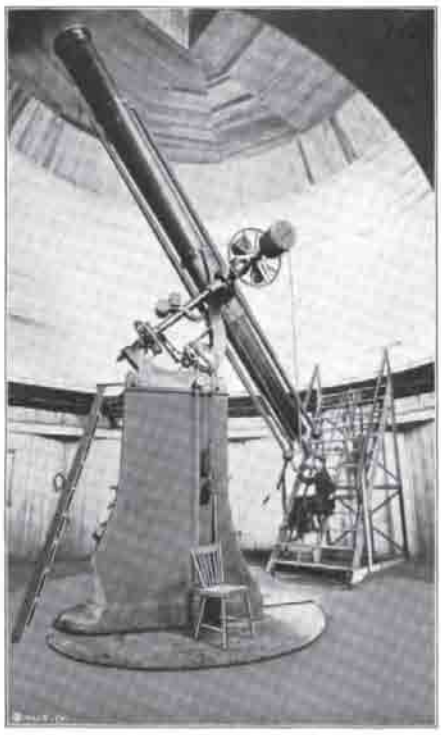
An essay by *John Nanson & Neil English*
Dedicated to Mike Carman (Mikey Cee)

Compared with the Renaissance of astronomical learning wrought by the erection of great observatories across Europe in the 1830′s and 1840's, progress in the United of States of America was slow to blossom. Prior to 1830, America's largest refractor – a fine Dollond – was a mere 5 inches in aperture. Unlike Imperial Britain, whose towns were decorated with public and private observatories – great and small – America was a slumbering giant, blissfully unaware of its destiny to become the leading country in astronomical learning for the next century or more.

It was into a divided nation that Sherburne Wesley Burnham was born on a cold December day on the banks of the Omponpanoosue River in Thetford Township, Vermont. The year was 1838, scarcely more than twenty years before the Civil War broke out. After receiving a good primary education, Burnham, like so many of his contemporaries, had to make do with self education to advance his prospects and to that aim, the young man taught himself stenography – the useful art of shorthand writing – which secured him employment.

At age 20, Burnham left his native Vermont for New York City, where he earned a living as a short hand journalist. Burnham travelled widely in his younger days. At age 23, he visited London where, out of sheer curiosity, he purchased an inexpensive 3-inch refractor on a table-top mount, which he later recalled 'was good for landscape but disappointing astronomically."
After spending some time in New Orleans, he settled in Chicago where in 1866 he purchased a second telescope – a 3.75 inch refractor which he described as, " just good enough to be of some use, and poor enough , so far as it optical power was concerned, to make something better more desirable than ever."

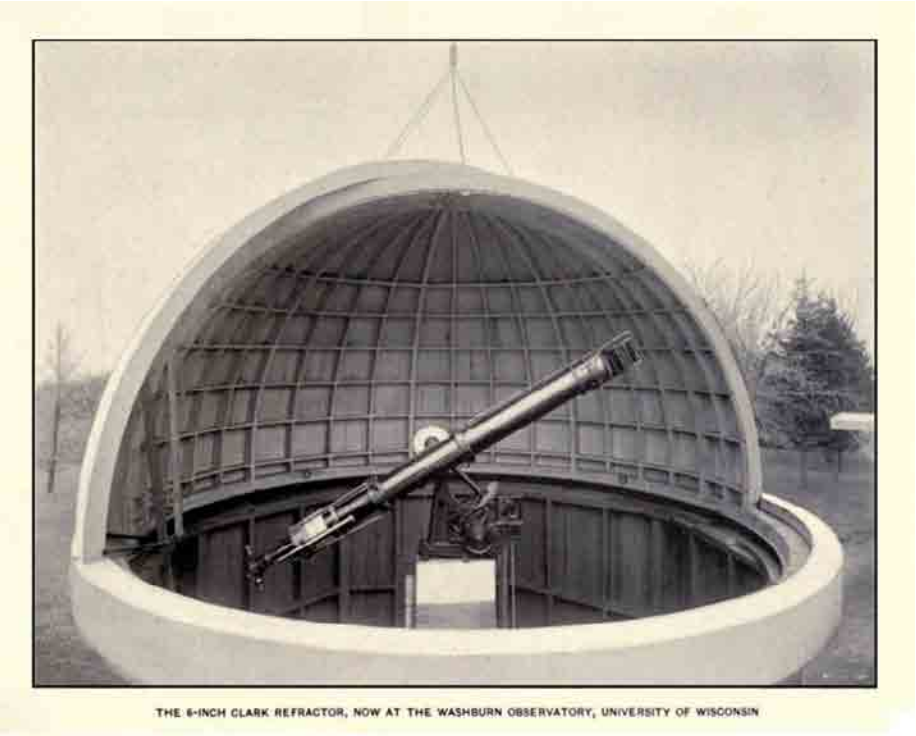
Just why the young man concentrated on double stars remains a mystery but specialise he did. Perhaps one incentive may have been the presence of the newly erected 18.5 inch Clark refractor at Dearborn Observatory, which, by coincidence, was situated just a few blocks from his home. Indeed, we now know Burnham visited the observatory often. It was not long before its director, T.H. Safford, gave the young man the opportunity to use the telescope on occasion to pursue his double star interests, as well as access to its modest library.



THE 18½-INCH CLARK TELESCOPE OF THE OLD UNIVERSITY OF CHICAGO (DEARBORN OBSERVATORY)

While in Chicago, Burnham got married to Miss Mary Cleland, who bore him six children. A seminal period in Burnham's life begun when the famous telescope maker, Alvan G. Clark, went

to Iowa to observe the total solar eclipse which occurred there on August 7, 1869. On his way back to Massachusetts, the younger Clark stopped off in Chicago. Here he was to meet Burnham and, as result, the budding double star enthusiast ordered a 6 inch refractor from the firm, costing him $800. Burnham stipulated that 'its definition should be as perfect as they could make itand that it should do on double stars all that it was possible for any instrument of that aperture to do." We now know that Burnham chose well, for long focus achromatic refractors are the very best instruments for engaging in this type of work. By 1870, Burnham had his new telescope delivered to his home on 36th Street and Vincennes Avenue. After doing some of his own tests, Burnham was relieved to see that the fine Clark telescope matched the keenness of his own vision.



THE 6-INCH CLARK REFRACTOR, NOW AT THE WASHBURN OBSERVATORY, UNIVERSITY OF WISCONSIN

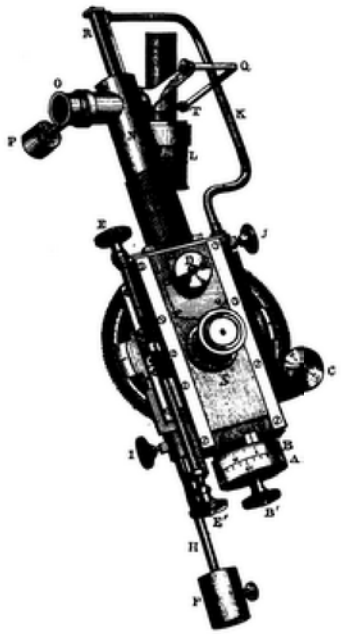
A General Catalogue of 1290 Double Stars Discovered from 1871 to 1899 by S.W. Burnham
Overleaf of p. XIV

Working his paid job for eight hours a day as a shorthand writer, Burnham spent every clear night examining stars for signs of duplicity. He was careful to avoid those already catalogued in Webb and Dearborn's Observatory's archives. On the faithful night of April 27, 1870, the 31 year-old discovered his first new pair (designated beta 40) about 52 arc minutes north of 12 Scorpii, with his 6-inch achromatic refractor.

Burnham went on to discover a total of 437 pairs with the same telescope. These amazing successes brought him to the attention of the great English observer, Reverend Webb, who nominated him for Fellowship of the Royal Astronomical Society (RAS), to which he was duly elected in 1874. The same year, he spent a summer vacation in New Hampshire, where for 10 nights, he had the privilege of using the 9.4" refractor at Dartmouth College Observatory for double star discovery.

172 Mr. S. W. BURNHAM, *Double Star Observations made in 1879*

September 16, 1881. This micrometer was regularly used for some months, and although the illuminating apparatus was somewhat roughly made, and intended only to demonstrate the practical success of this device, it was found to work so satisfactorily in every respect that the micrometer for the 12-inch refractor of the Lick Observatory was constructed after the same plan, and



was used by the writer for some weeks on Mount Hamilton, Cal., in the latter part of 1881. This illuminating apparatus is identical in principle with that previously described, but, as would be expected from the great skill and ingenuity of the firm of Alvan Clark & Sons, by whom it was made, the mechanical construction generally is vastly improved, and the convenience and usefulness of the micrometer increased thereby.

A filar micrometre used by Burnham.

Later in the same vacation, Burnham acquired the use of the great 26 inch Clark refractor – the same instrument used by Asaph Hall, who discovered the tiny asteroid moons of Mars in August 1877 – at the U.S. Naval Observatory. Burnham was awarded the Gold Medal of the RAS in 1894. Commemorating the man's outstanding achievements, Captain W. De Abney said of him, 'If a star deviated on almost infinitesimal quantity from the circular, his eye detected it at once. In 1874, in Washington, on the night of August 11, he scanned some of his old discoveries, with the result that he [added] 14 new pairs to his list. I give one instance, no. 291, in the catalogue, had on some occasion offended his critical eye when he looked at it through the 6-inch, so he turned the 26-inch on it and found that it consisted of two 8.5 magnitude star separated by a distance of only 0.2" '

While visiting the U.S. Naval Observatory, he met and befriended Edward S. Holden (1846-1914) who shortly afterwards became director of Washburn Observatory at Madison, Wisconsin. Holden invited Burnham to work with the observatory's 15.6 inch refractor and spent five months there before moving back to Chicago.

In Holden’s next career move, he was appointed President of the University of California, and the first director of the newly dedicated Lick Observatory, situated atop Mount Hamilton. Burnham had visited the site back in 1879, when he took his 6-inch there for two months to assess the seeing conditions prior to the erection of the large telescopes. He returned again in 1881, together with Holden, to observe the transit of Mercury with the 12 inch Clark, which was housed in a temporary shelter. A proper dome was erected for it in November of the same year.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THE GREAT TELESCOPE OF THE LICK OBSERVATORY.—(From photograph by H. E. Matthews, Secretary of Lick Observatory.)—[See p. 373.]

Once the 36-inch Lick refractor was up and running in 1887, Holden asked Burnham to comeand work at the newly established observatory as its resident double star expert. By the summer of 1888, Burnham had settled his family in San Jose, near the western foot of the mountain. Maintaining his well paid job as a shorthand writer, Burnham would join the staff of Mount Hamilton at weekends. And it was here that he met the young Edward Emerson Barnard, with whom he struck up a deep friendship that was to last the rest of his life.

No. β	Star Catalogue.	R. A. 1880.	Decl. 1880.	Position Angle.	Distance.	Mags.	1879+	Notes.
		h. m. s.	° ′	°	″			
739	0' Arg. 1542...	2 19 33	−30 24	263·9	2·06	8·0.. 9·0	·675	
				262·3	2·20	.....	·684	
				267·3	2·13	8·3.. 8·5	·692	
740	β 307	2 40 29	+29 41	110·±	0·3±	7·5.. 7·5	·711	
741	S. 423.....	2 51 58	−25 27	152·6	0·66	7·8.. 7·8	·689	A and B
				156·2	0·43	7·5.. 7·7	·692	
				158·6	0·50	7·5.. 8·0	·701	
				165·3	0·69	8·0.. 8·0	·703	
				221·0	28·62	8·0	·692	A B and C
				221·9	27·03	7·8	·701	
742	.....	3 17 ±	+48 50:	.....	.....	8	.....	
743	Arg. (51°) 802.	3 46 36	+51 54	260·±	1·2±	8·2..·9·0	·747	

740. (β 307.) With this instrument, in 1874, I detected a minute star about 15″ distant, in the direction of 315°, and it was afterward measured by Baron Dembowski, by Prof. Hall with the Washington 26-inch, and by myself with the Chicago 18½-inch. On several occasions, on Mt. Hamilton, I suspected the large star to be a very close double. It seems impossible it should have been overlooked with the great refractors mentioned above, and possibly the supposed elongation may not be real, but it should be carefully examined before being rejected. If a night sufficiently perfect can be found, I hope to try it with the 18½-inch, and give the result before this catalogue is printed.

741. (S. 423.) This wide pair has long been known. It was first observed by Sir James South, and subsequently by Sir John Herschel, at the Cape of Good Hope, Jacob, Powell, Dunlop and others. There is no evidence of material change, as a comparison of some of the measurements will show.

	°	″	
South, . .	P=219·1	D=27·75	1824·9
Herschel, .	221·3	28·62	1835·9
Jacob, . .	220·7	27·19	1846·8
Burnham, .	221·4	27·80	1879·7

With the 6-inch it was at once seen that the larger star of this pair was itself a close double. The mean result of the four measures is:

P=158°·2 D=0″·57 1879·7

742. Suspected to be a close pair, but not verified.

743. Rather a difficult pair of small stars, 2½′ north of the 6½ magnitude star, Lalande 7128.

Nr.	Designation	RA. 1880	Dcl. 1880	Pos.	Dist.	Mags.	Discovered	Notes
336	L 18173	9h 6m10s	—16°19′	240°	1″2	8.0...9.0	Mch. 27	The wide and unequal pair, 1m36s following and 3′ north, is H 4182.
337	L 18502	9 16 54	—17 23	320.	10.	7.0...9.5	Mch. 27	The south following of two stars.
338	L 18518	9 17 16	—14 59	270.	7.	8.5...9.5	Mch. 27	Faint pair.
339	L 18737	9 25 16	—15 13	220.	1.1	8.0...9.5	Mch. 27	Five pair of small stars.
340	Lamont 624	11 23 49	+ 3 51	7.6	3.96	8.0...10.0	May 2	Rather difficult; measured by Dembowski May 26th.
341	Hydrae 348	12 57 19	—19 56	140.	1.	6.0...6.0	May 29	A fine close pair, and not difficult. In some of the Catalogues this is rated as high as 5th magnitude.
342	O. Arg. S. 12741	13 8 49	—18 17	35.	4.	7.8...9.0	May 29	A considerable distance south following 54 Hydrae.
343	Centauri 219	13 45 8	—31 1	120.	1.2	6.0...8.5	April 20	This beautiful pair is readily seen, notwithstanding its low altitude. It is near the well known pair ι Centauri, and is Nr. 4624 of the B. A. C.
344	O. Arg. S. 13285	13 52 23	—24 58	130.	3.	9.0...9.0	May 14	The wide pair 3m9s preceding is H. N. 59.
345	Lac. 6051	14 34 39	—29 11	150.	1.	7.0...7.0	May 30	Close and rather difficult pair.
346	Librae 23	14 41 49	—16 50	250.	1.	7.0...8.0	May 16	Distance may be slightly underrated. This is L 26940.
347	Centauri 330	14 47 18	—32 49	340.	10	6.0...10.0	May 12	Large star appeared reddish. This is B. A. C. 4912.
348	2 Serpentis	14 55 40	+ 0 20	130.	0.5	6.0...6.0	May 16	A splendid close pair, and not very difficult under the best conditions. A mean of four measures of the angle by Dembowski July 7th gives, P = 117°2. One of Sir William Herschel's wide pairs, H VI. 51, is erroneously called a 2 Serpentis. It is 1 Serpentis, a star 4m 17s preceding and 1′17″ south. It has a 10 mag. companion of Class VI in the direction of about 220°.
349	L 27579	15 2 52	+ 2 9	50.	3.	7.5...11.8	June 7	Excessively unequal and difficult.
350	B. A. C. 5020	15 8 29	—27 9	170.	1.3	6.5...8.0	May 23	Very fine southern pair.
351	O. Arg. S. 14417	15 10 20	—15 8	300.	5.	8.0...11.6	May 23	Companion very faint, but bears magnifying well.
352	O. Arg. S. 14427	15 10 43	—26 33	170.	10.	8.5...9.5	May 29	In the vicinity of Nr. 350.
353	Redhill 2307	15 13 55	+85 57	300.	2.	9.0...9.0	April 21	One of the components of a wide pair.
354	O. Arg. S. 14797	15 36 0	—25 2	280.	6.	7.0...9.0	May 12	Very easy double.
355	L 29506	16 4 14	+45 42	100.	0.4	7.0...7.0	May 18	Excessively difficult pair 56s preceding Σ 2015. Elongation slight on the best occasions. Probably the the most severe test for a small aperture of the close pairs in this list.
356	O. Arg. N. 16336	16 29 51	+69 12	270.	5.	8.5...10.0	May 6	A little following, and 10′ north of 15 Draconis.

Mount Hamilton measurements conducted by Burnham with the six inch refractor. Note the separations!!!

Barnard was considerably younger than Burnham but was already aware of his legendary status as a double star observer. Prior to their meeting, Barnard expressed some degree of anxiety at the prospect of being introduced to the great double star discoverer. Indeed, according to William Sheehan's biography of Barnard, *The Immortal Fire Within*, Barnard had actually dreaded meeting Burnham for the first time.

'Somehow I have always pictured to myself the astronomers of whom I have heard but not seen,' Barnard later recalled. 'These mental pictures almost always proved to be wrong when I finally

met the man.' Barnard had imagined Burnham to be 'a large heavy-set man with a stern countenance – one you would not feel at home with. 'What gave me this impression I do not know,' he continued, 'I was young then and knew nothing of people in general, and I had associated a great name in any calling with a bearishness of manner that would be intolerable.' Barnard couldn't have been more wrong about the double star wizard. When he finally arrived at Mount Hamilton during the first week of August 1888, Barnard found him to be a small man, with a slight build and large, bright blue eyes. He was covered in dust from the long stage ride to the mountain observatory. And contrary to what he had expected, Barnard found him, 'one of the kindest of men – more human than any man [he] had ever met.'

Although both men were gifted observers by any standards, their personal habits couldn't have differed more. Barnard neither smoked nor consumed intoxicating beverages. Burnham, on the other hand, smoked cigars incessantly and enjoyed a good glass of wine. What's more, whilst Barnard became impatient and frustrated by the onset of cloudy skies, Burnham was more philosophical about the vicissitudes of the weather, turning instead to a book or a card game to pass the time. Generous to a fault, Burnham would often give Barnard some of his time at the large telescopes.

The four years Burnham spent at Lick were the most productive in his career. With the 12-inch and 36–inch Clark refractors, the number of pairs he discovered rose to 1,274, many of which were incredibly tight – smaller than 0.2" separation and often of very unequal brightness. When conditions were favourable, Burnham would work like a Trojan through the entire night. At midnight, they'd gather in one or the other's office to share some coffee and a light snack of crackers and cheese. Having refreshed themselves, they then resumed their vigil of the heavens with the great telescopes.

Although observing was high on Burnham's professional agenda, updating the records of the libraries at Lick also preoccupied him. This usually involved revising all catalogues of double star measurements conducted north of declination -31 degrees, which he had begun some two decades before with his own 6-inch refractor.*

Burnham's relationship with Holden (as did Barnard's) became increasingly strained and the demands of his young family eventually forced Burnham to return to his post as a clerk with the U.S. and District Court, where he enjoyed a much better salary than he had as an astronomer. But that was not the end of his association with the great American refractors.

In 1894, when the Yerkes Observatory at William's Bay was being built, he once again accepted a staff appointment. When the 40-inch was finally dedicated in 1897, Burnham would work during the week in Chicago and on weekends take the train to William's Bay to observe through the great refractor. He continued to commute back and forth for a further five years, after which time he resigned his day job to devote himself full time to his astronomical work. Burnham used the 40-inch refractor to obtain thousands of new measures of neglected pairs. These new measures formed the corpus of Burnham's magnum opus, published in two volumes, *The General Catalogue of Double Stars*, which contains data on 13,665 double and multiple star systems. This great work proved invaluable for calculating their orbital characteristics. Burnham

himself did not perform this work, leaving the mathematical details to astronomers with a keener bent for calculation than himself.

THE 40-INCH CLARK TELESCOPE OF THE YERKES OBSERVATORY
MOUNTED BY WARNER & SWASEY

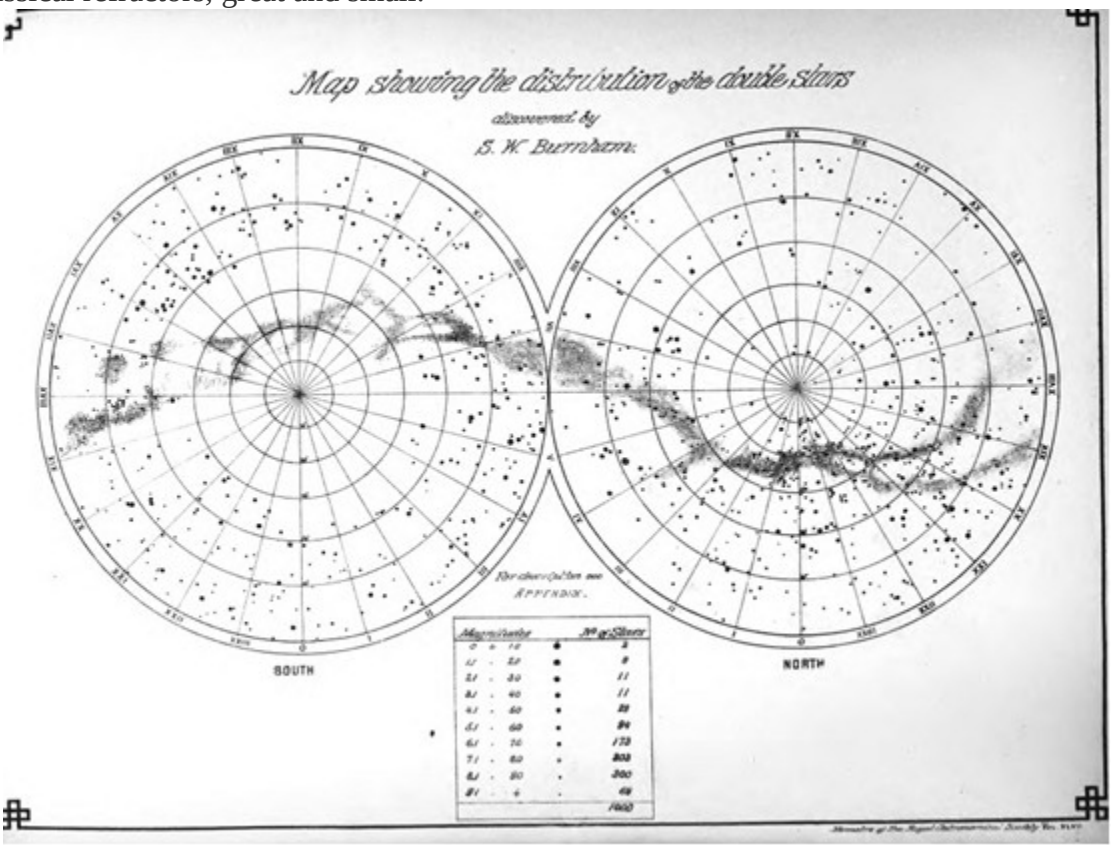
Burnham was a visual observer through and through, who had a clear idea of what he wanted to do and what he wished to avoid. Indeed, we now know Burnham resisted the changes that were underfoot at the Observatory. Although a keen landscape photographer, he was skeptical of the idea that photography could ever supplant the skill of a visual observer. 'I think you'll find photography is not going to revolutionise anything,' he once told Holden, 'and a great many people might waste time that they might better employ.' Neither did Burnham express any great interest in the new astrophysics that was rapidly changing the astronomical culture of his day.

The wreathed observer spent his last few years at Yerkes, studying faint optical companions of many naked eye stars in order to establish whether they were gravitationally bound systems or merely optical doubles, aligned by chance in the direction of the brighter star. These observations served as the basis for establishing their true proper motions over time. Burnham remained at Yerkes until 1913. In the years that followed, his health declined and on the morning of March 11, 1921, he passed away quietly after a long illness. The flags flew at half mast that day at Yerkes.

The death of Sherburne Wesley Burnham deeply affected his best friend, E.E. Barnard, whose wife, Rhoda, suffered a stroke later the same year, dying five days after the episode. Barnard lasted another two years before giving up the ghost.

In an age where amateur astronomers have in many ways lost their way, the life of S. W. Burnham, the consummate amateur – an amateur who didn't really want to turn professional – remains a great inspiration, for he demonstrated that good eyesight and hard work can bring an

entire field of astronomical enquiry almost to its knees. His adventures with a modest 6-inch Clark refractor showed that the regnant priests of double star astronomy – the Herschels and the Struves (who used considerably larger instruments) – had missed many systems in their surveys. His life and work remain to this day an outstanding example of what can be achieved with a suite of classical refractors, great and small.



A closer look at Burnham's work

For living proof of that last statement, we need look no further than Burnham's discoveries with the six inch f/15 refractor he commissioned from Alvan Clark in 1869. Those discoveries were published in nine separate catalogues between 1873 and 1880, which are referred to on pages ix and x of Burnham's 1900 work, *A General Catalogue of 1290 Double Stars Discovered from 1871 to 1899*. A few examples provide solid evidence that the praise for Burnham's 'critical eye' referred to previously by Captain De Abney during the 1894 RAS Gold Medal award ceremony was well deserved.

On first glance at the initial page of the sixth instalment of pairs discovered with the six inch (published in *Astronomische Nachrichten*, November 1875), a roving eye is quickly drawn to the second and third catalogue entries. The first, which is Burnham's catalogue number 302 (now referred to as β302, or Bu 302), lists magnitudes of 7.0 and 8.0 separated by 0.71". The pair below that, number 303 (now β303, or Bu 303), is listed with magnitudes of 7.5 and 8.0 and a separation of 0.59". If you scan through the other eighty-eight stars in that list, you'll find a surprising total of four evenly matched pairs (primary and secondary of same magnitudes) *with separations of 0.4"*, three evenly matched pairs *with separations of 0.5"*, one pair separated by 0.7" with two magnitudes of difference, and one pair separated by 0.8", also with two magnitudes of difference.

A further glance through the forty-two doubles stars discovered at Mt. Hamilton with the six inch in 1879 while Burnham was inspecting the site of what later became Lick Observatory (now available in *A Collection of Articles on Double Star Observations* through Google books) shows similar results: one pair of 7.5 magnitude stars separated by 0.30" (Bu 307/740), four pairs in the 0.39" to 0.43" range, ten pairs in the 0.50" to 0.56" range, and eight pairs in the 0.60" to 0.74" range.

Lacking a suitable micrometer for the six inch refractor, Burnham sent his discoveries to the Italian astronomer Baron Ercole Dembowski for both separation and position angle measurements. Although Dembowski developed his double star measuring prowess with a non-driven five inch refractor, by the time he began assisting Burnham he had graduated to a seven inch Merz refractor on an equatorial mount. The Baron's measuring abilities, well known and respected in Europe, were acknowledged in 1878 when the Royal Astronomical Society (RAS) awarded their Gold Medal to him.

However, Burnham was particularly adept at estimating position angles and separations with his six inch refractor, which he demonstrated in an 1880 correspondence published in the *Monthly Notices of the Royal Astronomical Society* (MNRAS). Comparing his estimates to Dembowski's measurements, Burnham stated for 38 stars of between 0" and 1" of separation, his mean error of separation came to 0.11", and for a total of 37 stars in that same category his mean error for position angle was 10.2 degrees. Of 84 stars between 1" and 5" of separation, his mean error of separation was 0.45", and on a total of 74 of those stars the mean position angle error was 8.3 degrees.

One of the many frustrations encountered by Burnham was the absence of a comprehensive double star catalogue, without which it was difficult to know whether the pairs found during his celestial excursions had previously been discovered.Although he later addressed that glaring problem with his two volume *A General Catalogue of Double Stars within 121° of the North Pole*, published in 1906, until then he relied on the records collected in the libraries of the various observatories in which he exercised his skills.

He vented his frustrations with one of those sources in 1880, when he bravely published 'An Examination of the Double Star Measures of the Bedford Catalogue' in the *Monthly Notices of the Royal Astronomical Society* (June 1880, pp. 497-531). In it he noted there were persistent errors in Admiral William H. Smyth's *Bedford Catalogue* on those stars not previously measured by earlier observers, such as William and John Herschel, James South, and F.G.W. Struve. After personally measuring and observing 126 stars of that group, Burnham pointed out Smyth's measured errors amounted to an average of 25" in separation and seven degrees in position angle, and commented, 'That the measures of Smyth are but little, if any, better than mere eye-estimates, made without wires in the field, cannot be seriously doubted, to say nothing of the measures of stars which, from their occupying different places, could not have been seen at all.'
However, if there was one thing both Burnham and Smyth shared, it was admiration for the remarkable beauty of double stars. While Smyth is well known and admired for his lyrical descriptions of the stellar world, Burnham's enthusiasm for the aesthetic qualities of double stars has escaped attention.Descriptions such as 'elegant', 'splendid close pair,' 'very delicate object,'

and ‘beautiful pair in a low power field’ can be found scattered throughout the comments he attached to his six inch catalogues.

That Burnham was a meticulous observer is beyond doubt thanks to the detailed notes he attached to his catalogues. One in particular stands out, which also shows he was no more immune to the frustrations caused by atmospheric conditions than we are today. In 1871, using the six inch Clark, he discovered the well-known secondary of Rigel (Beta Orionis) was elongated. His notes for three separate observations, along with his estimate of separations, state ‘seems elongated (.666”),’ ‘certainly elongated (.681”)’, and ‘well marked (.684”)’. He later followed up those observations with the 18 ½ inch refractor at Dearborn and found that BC pair to be no less difficult: ‘. . . but at all times it appeared either round or very doubtful.’ Additional observations by R. G. Aitken between 1898 and 1904 with the 36 inch refractor at Lick Observatory eventually confirmed the duplicity of the secondary, although with no lack of difficulty owing to separations that varied between 0.10” and 0.30”. Burnham summed up his experience with the difficult pair this way: ‘This is the most difficult and troublesome star I have ever attempted to observe.’

That ‘difficult and troublesome star’ is now enshrined in modern star catalogues with the designation Bu 555 (BC). It stands as a fitting monument to Sherburne Wesley Burnham’s skill, persistence, and enthusiasm for the wonderful world of double stars.

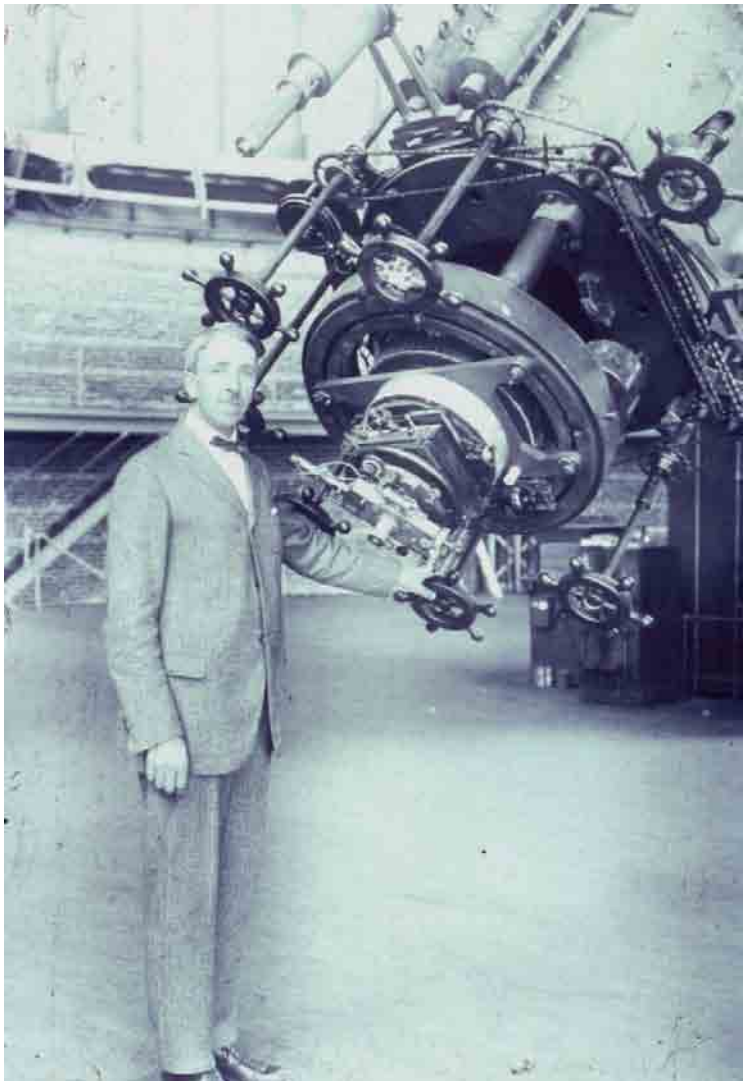
* Burnham’s 6-inch Clark, and the small dome it was housed in, was transferred to the Student’s Observatory of the University of Wisconsin sometime around 1881 or 1882. The instrument and its mechanical parts have been on display at Chicago’s Adler Planetarium since 1984.

The original version of this article, with references, is available at Neil English's website:http://neilenglish.net/s-w-burnham-a-life-behind-the-eyepiece/
The quotations from the Huggins logbook are detailed in *Unravelling Starlight, William and Magaret Huggins and the Rise of the New Astronomy,* by Barbara J. Becker (Cambridge, 2011).

Translated from the 1856 Tulse Hill Observatory logbook of William Huggins, pioneer of astronomical spectroscopy:

Sterne werden immer scheinen,
Allgemein auch zum Gemeinen;
Aber gegen Maß und Kunst
Richten sie die schönste Gunst.

Stars will always shed their light
Upon the world all through the night;
But to measurement and art
Their greatest favour they'll impart.



A staff astronomer stands with the Warner & Swasey filar micrometer that was original equipment on the 40-inch refractor at Yerkes Observatory

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